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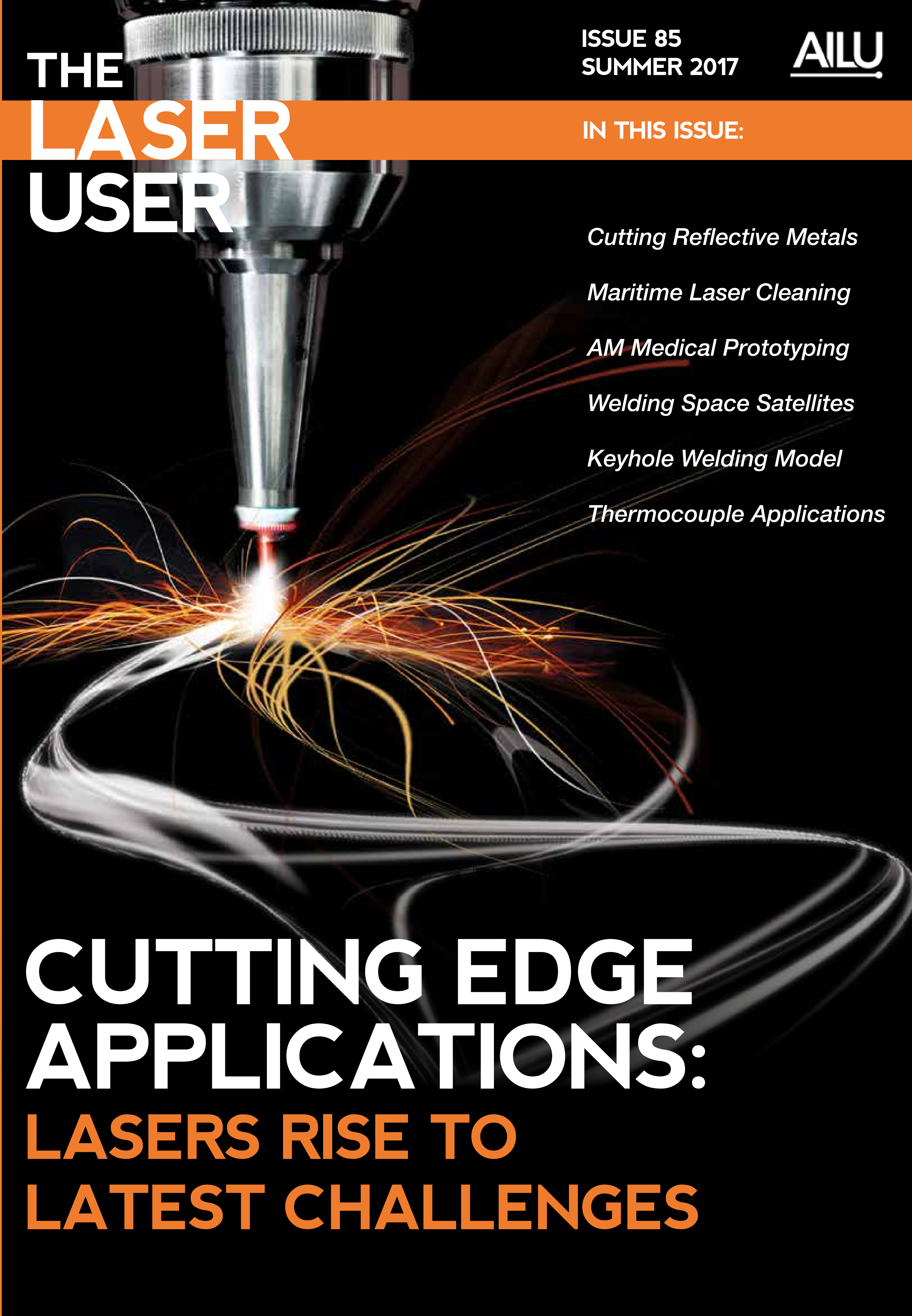
SUMMER 2017

AILU

THE LASER USER



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CUTTING EDGE APPLICATIONS:

LASERS RISE TO LATEST CHALLENGES

THE LASER USER

Editor: Dave MacLellan
Sub-Editor: Catherine Rose

ISSN 1755-5140

The Laser User is the house magazine of the Association of Industrial Laser Users. Its primary aim is to disseminate technical information and to present the views of its members. The Editor reserves the right to edit any submissions for space and other considerations.

Authors retain the right to extract, in part or in whole, their material for future use. The Laser User is published quarterly in February, May, August and November by AILU for its members and is available in print or online.

Cover image: “Light Energy” courtesy of SPI Lasers

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M Squared Lasers Ltd
Anke Lohmann
anke.lohmann@m2lasers.com

P-Laser
Jean Claude Philippron
jc.philippron@p-laser.com

AILU STEERING COMMITTEE 2017-18

President:	Lin Li (University of Manchester)
Vice President:	Jon Blackburn (TWI)
Exec. Director:	Dave MacLellan (Anode Marketing)

Elected until 2020

Shireen Khanum	(GF Machining)
Anke Lohmann	(M Squared Lasers)
Vojtech Olle	(Hamamatsu)
Mike Poulter	(SPI Lasers)

Elected until 2019

Duncan Hand	(Heriot-Watt University)
Louise Jones	(KTN)
Jonathan Lawrence	(Coventry University)
Ian White	(Yamazaki Mazak)

Elected until 2018

Paul Goodwin	(TWI)
Roger Hardacre	(ALT)
Tony Jones	(Cyan Tec Systems)
Adrian Norton	(thinklaser)

Co-opted

Adam Clare	(University of Nottingham)
Mark Millar	(Essex Laser)
Stan Wilford	(IPG Photonics)

Past presidents and founder members are also able to attend committee meetings. Anyone wishing to join the AILU Steering Committee please contact the Executive Director.

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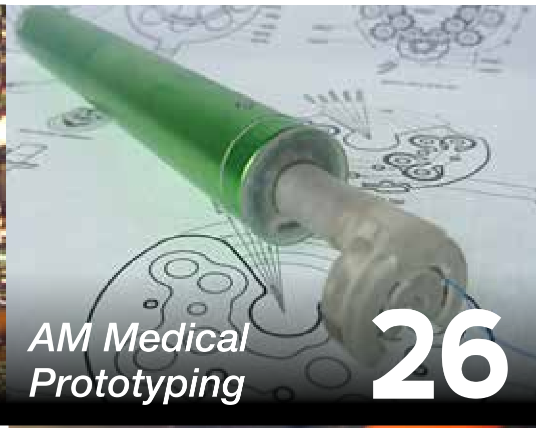
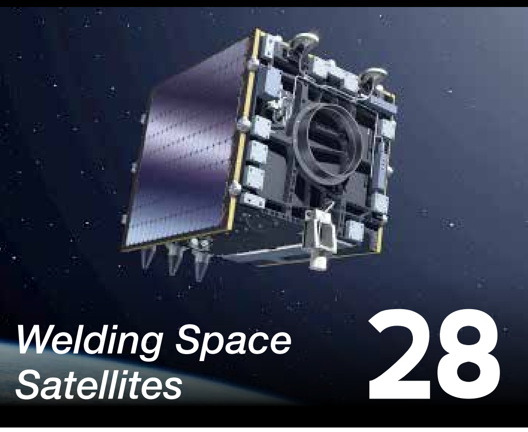
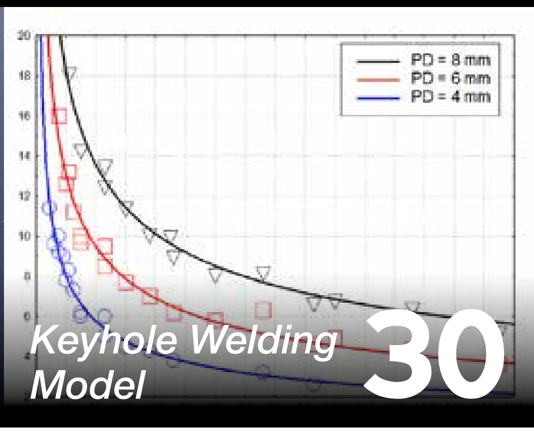






ASSOCIATION NEWS

FIRST WORD

Having recently visited the Laser World of Photonics in Munich, I would echo the comments that Ric makes on this page about how useful it is to go there every 2 years. I met over 50 AILU members and lots of non-members during the 2 days I was there! This visit was, I believe, my 13th since 1991. My impression of the state of the industry from talking to people at the show was one of rationalisation combined with steady growth. There is a clear appetite for mergers and acquisitions with several significant announcements in recent months.

Hot news in Munich was the acquisition of ILT (Innovative Laser Technologies) by IPG Photonics, further emphasising the shift of IPG from laser source manufacturer to turnkey systems supplier. ILT has a medical device focus and builds high precision systems working on smaller components. Coherent, having purchased ROFIN within the past year has apparently still some money in the war-chest to acquire another company or two in coming months. We are waiting to hear the news of who has purchased the sub 1kW CO_2 business ROFIN-Sinar UK, which has been up for sale since the Coherent acquisition was approved. ANDRITZ of Austria also recently acquired the majority share of Powerlase Photonics, and Danish company NKT Photonics, having acquired Fianium in 2016 has also just announced that it is purchasing Swiss company Onefive, a supplier of short and ultrashort pulse laser sources. All this makes for a smaller number of bigger companies and I guess this should be looked at as a healthy sign overall for the industry, even though some people will find the change impacts on them less favourably.

I am looking forward to a busy autumn - don't forget to check out the events page on our website for information on workshops in September, October and November, and updates on speakers. I look forward to meeting you at one or more of our forthcoming events.

Dave MacLellan

AILU Executive Director
dave@ailu.org.uk
07473 121142

INCOMING PRESIDENT'S MESSAGE

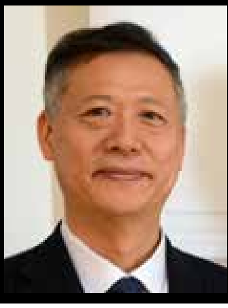
At our recent AILU Steering Committee meeting we discussed a number of new initiatives aimed at moving AILU forward over the next few years. One of these was to improve end-user participation and end-user led events. Jon Blackburn, Vice President of AILU, kindly agreed to lead this initiative and we hope he will get your support. Any ideas and suggestions you have as to how this might be achieved would be gratefully received.

AILU is busy working on another initiative - to establish a student and early career researcher community within the Association. Relevant universities within the UK have been contacted and most have appointed a representative. Their first activity will be to write a column for this magazine, so please look out for a new feature in forthcoming issues. We are hoping to include non-UK universities in this initiative and welcome contributions from them.

Planning for the joint conference with the Japan Laser Processing Society (JLPS) on the Laser Precision Micro-fabrication conference (June 2018, see p. 35) is well underway and a call for abstracts will be issued shortly. This is an important international event with typically 250-300 attendees, and I would encourage AILU members and laser users to take this opportunity to showcase your latest developments in laser micro/nano fabrications and for companies to exhibit your products and services.

AILU is running a number workshops for the remaining months of this year, including Laser Cleaning, the Annual Job Shop Business Meeting and Laser Manufacturing of Lightweight Structures - please see details on page 37. All are very welcome to attend.

This year's ICALEO (International Congress on Applications of Lasers and Electro-Optics) will be held in Atlanta, USA on 22-26 October 2017, organised by the Laser Institute of America. This is a premier laser materials processing conference and speaking as the immediate Past President of LIA, I encourage you to attend. AILU is exploring collaboration opportunities with LIA for developing joint initiatives on on-line laser safety education, details to follow.



Lin Li
lin.li@manchester.ac.uk

RIC'S RAMBLINGS

Dear Readers, just when you thought it was safe…I'm back! Rather than put me out to graze in a large and lush sunny field following my retirement as AILU President, Dave thought it would be a good idea to keep my brain active and give me a slot in the magazine. So here it is, the first edition of Ric's Ramblings.

I thought I would start with Munich – the Laser World of Photonics to be more precise. I was there in June together with what appeared to be a significant fraction of the UK laser and photonics communities – probably one of the best places to meet old friends and build new business opportunities. The show is huge, covering I think six very large halls all packed with the latest and greatest photonics based technologies.

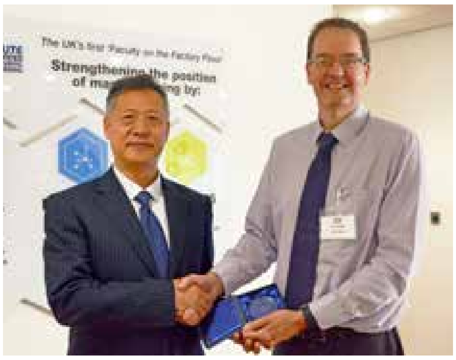
The overall impression from my first day at the show (and you need more than one day to do it justice) was that despite everything going on in the world, this World (the laser world of photonics) is doing very well thank you! If you have not been before I thoroughly recommend a two-day trip - you will be amazed by the vibrant atmosphere and opportunities on offer. After my first day of walking the show I had clocked up over 10 miles – Ric doing a serious ramble!

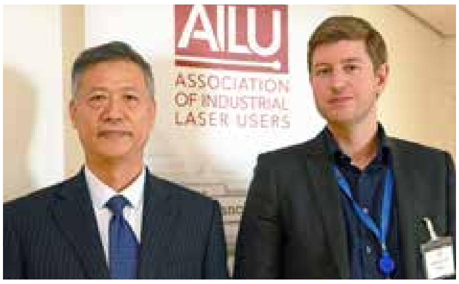
In other news, the new kid on the block funding wise is the Industrial Strategy Challenge Fund (ISCF). This will be a key mechanism for funding Research and Innovation from now on and importantly has "Industry" and "Challenge" embedded not just in its name but in its culture. I recommend keeping an eye open for announcements and calls for projects via Innovate UK, and of course AILU will be signposting opportunities also. One of the key areas being looked at is Digital Industrialisation and Additive Manufacturing, right down our (AILU members) street as producers and users of lasers for manufacturing.

Enjoy the magazine and I hope we all get to see a bit of sun before the autumn kicks in.

Ric Allott
ric.allott@stfc.ac.uk

23RD AILU AGM 18 MAY 2017





Top: Ric Allott hands the AILU Presidency to Lin Li. Bottom: New AILU President, Lin Li and Vice President, Jon Blackburn.

The AILU AGM took place on 18 May 2017 at the Institute for Advanced Manufacturing and Engineering in Coventry. In what was a change-over year for committee officers (which happens every 2 years), Lin Li (University of Manchester) took over from Ric Allott as the AILU President and was joined by Jon Blackburn (TWI) who became Vice President. Ric was presented with a momento in recognition of his successful presidency, which had overseen a period of transition for the organisation.

We welcome 4 new members to the committee; Shireen Khanum (GF Machining), Anke Lohmann (M Squared Lasers), Vojtech Olle (Hamamatsu) and Mike Poulter (SPI Lasers).

Finally, we extend our thanks to outgoing AILU committee members for their 3-year term of service (Simon Andrews, Fraunhofer Centre for Applied Photonics; Louise Geekie, Croft AM); Stuart McCulloch, SPI Lasers).

Shireen Khanum, GF Machining

Anke Lohmann, M Squared Lasers

Vojtech Olle, Hamamatsu

Mike Poulter, SPI Lasers

NATIONAL STRATEGY WORKSHOP - STEPS TOWARDS A SECTOR DEAL

This important meeting and workshop followed on directly from the AILU AGM on 18th May 2017. The goal of the meeting was to inform, review and build on the recommendations from the strategy report that AILU and the EPSRC CIM has jointly produced "Lasers for Productivity" which was issued in draft format in March 2017. There were 4 recommendations calling for implementation by the sector, as follows:

- **Skills & Training:** Significantly increasing vocational training, building laser processing into Further Education and funding more apprenticeships.
- **Access to Finance:** Easing the purchase of capital equipment, perhaps through Innovate UK loans or other flexible and innovative funding models.
- **Process Demonstration & Customisation for SMEs:** Demonstration of proof-of-concept and proof-of-process to help SMEs take sound return on investment decisions based on Laser Materials Processing implementation.
- **Laser & Laser Process Innovation:** Making sure the UK is at the leading edge of technology and process development to maintain a competitive edge.

The scene was set by two talks, one by John Lincoln, CEO of the Photonics Leadership Group, and the second by Duncan Hand, Director of the EPSRC Centre for Innovative Manufacturing. John's talk centred on the link between Laser Processing and Manufacturing and the National UK Industrial Strategy which was published as a Green Paper in January this year. John set out to explain why industry should care about this new UK strategy (steering Government investment, access to significant funding - some £2Bn through to 2020). He then explained how the work of AILU members fits with the 10 pillars identified by the green paper emphasising in particular investment in innovation, developing skills, creating world leading sectors and driving growth across the whole of the UK. John concluded with the opportunity for a "sector deal" for Laser Processing and Manufacturing. This requires industrial match to Government commitment and is a key mechanism for taking the sector forward, leveraging new funding and catalysing growth across the UK regions.

Duncan highlighted the key points from "Lasers for Productivity: A UK Strategy" pointing out the current state of the industry, particular strengths in the UK and then expressing a number of the identified barriers for future growth. He concluded with the action plan addressing skills and training, access to finance, process demonstration, process innovation and opportunities afforded by the industrial strategy.

Following the talks the delegates split into groups and were asked to answer a number of specific questions under the themes of the action plan presented by Duncan. The groups rotated such that everyone in the room was able to input to and comment on all of the questions. This lead to a very lively session and the input received from the delegates was excellent. The data received is currently being analysed and will form the basis for the Sector Deal document for submission to Government in the early autumn.

Delegates share their thoughts

Overall this was an excellent and highly productive half day with outputs that will go on to strengthen and enhance laser processing and manufacturing in the UK.

Ric Allott
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BUSINESS NEWS

OBITUARY: MARTIN COOK

We were greatly saddened to hear of the sudden death of Martin Cook, a director and co-founder of Cutting Technologies Ltd and highly respected member of AILU. Martin died at his home on 1 July 2017. The words of his friends and colleagues below allow us to reflect on Martin's enthusiasm, warmth, generosity and wit. He will be sadly missed.

"I first met Martin in 1995 as we were both head-hunted at the same time to work with NG Bailey Manufacturing Ltd in Bradford. We got on really well and it was Martin that introduced me to the "Frantic life of Job Shop Laser Cutting". In March 2003 we had set up our own laser cutting Job Shop, Cutting Technologies Ltd (it seems like yesterday). Martin had a knack of seeing different angles in the market place and it was through this sixth sense the company steadily started to grow.

He was deservedly well respected in the laser community and in particular the AILU Job Shop Special Interest Group. He had an incredible, intelligent and sharp sense of humour that kept us all smiling and giggling no matter what the day brought. He is a massive loss to Cut-Tec and the team here and will be really missed by everybody. However, his resolve lives on within the team and we will harness and move on with the things he taught us. See you on the other side Pal (but not too early)."

Barry Proctor, Cutting Technologies Ltd

"Martin was one of the warmest, friendliest open and most honest people one could ever wish to meet with a great sense of humour, and he didn't take himself too seriously. He was one of the main reasons I joined the AILU Job Shop committee all those years ago - he put forward such a strong case for joining the committee at one of the AILU meetings that it was hard not to be moved by his enthusiasm, his knowledge and his passion.

There is no doubt that Martin will be sadly missed, but for me it's a bit more personal. When my brother passed away from pancreatic cancer nearly 2 years ago, Martin was very supportive and even contributed a sizeable donation to a fund set up in my brother's memory, to buy equipment for our local hospital to help detect early signs of cancer. That to me sums up the type of guy he was. I cannot pay any finer tribute to the man other than to say that sadly the laser community is a far poorer place with Martin's passing and he will be missed beyond words."

Tom Mongan, Subcon Laser Cutting Ltd

"Martin was a good friend of mine – and I remember (and will miss) him most for his wit. So I'm sure he would be delighted to have one of his latest witticisms included amongst his obituaries.

A few months ago I organised a curry evening for some fellow job shop owners. I had given a lot of thought to the choice of curry house (as one should) but no thought at all to the choice of hotel – I just chose the one nearest to the restaurant. Which is why half a dozen posh cars ended up in the car park of an IBIS budget hotel. It was about £35 a night in central Birmingham, and the rooms had bunk beds, the place was full of foreign school groups and there was no proper bar. Needless to say there was a lot of laughter at my expense for being such a poor organiser.

Martins comment was by far the funniest; 'As soon as I saw my room I knew I needed to escape – so I started making a German uniform out of the blankets.' Martin – you will be missed – and many pints will be raised in your honour."

John Powell, Laser Expertise Ltd

"I have known Martin since he became involved in AILU and it was obvious to all that he was a man who would be difficult to dislike. Always personable, always smiling and always with some helpful advice, when needed. He will be sorely missed."

Dave Lindsey, Laser Process Ltd

"I have known Martin for quite some time, through various jobs and at Cut-Tec. I am sure that others will write about his enthusiasms and his love of 'the best'. For me, he was always lively, fun, a curry addict – like a lot of us – and very willing to share information or pass judgement. In fact the willingness to share and help between "competitors" was one of the reasons the Job Shop group succeeded. A recurrent theme in our discussions – usually over a curry – was on finding niches and other processes that would make us distinctive and able to find a different set of customers. Martin, with his co-directors Barry and Jane, certainly found a very distinctive niche that has been, and continues to be, very successful. Martin was a character. He will be missed."

Neil Main, Micrometric

Martin's partner has set up a Just Giving page in his memory for anyone who would like to contribute: www.justgiving.com/crowdfunding/judy-ayres

BUSINESS NEWS

ULO OPTICS WELCOMES NEW TEAM MEMBER

As part of ULO Optics' commitment to a program of growth through diversification it has recently welcomed Stuart McCulloch as their new Business Development Manager, overseeing the expansion of ULO products into the 1µm, fibre laser compatible arena.

Stuart joins ULO with over 9 years' experience in the fibre laser field, most recently having held positions at SPI Lasers working across both Product Management and Business Development units. Prior to this Stuart spent a number of years working for the laser integrator 'thinklaser'.

Contact: Stuart McCulloch
stuart.mcculloch@ulooptics.com
www.ulooptics.com

LASERMET CELEBRATES 30 YEARS IN LASER SAFETY

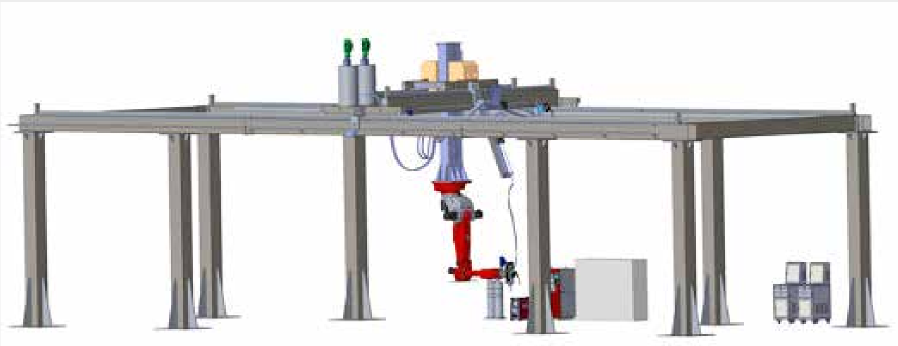
Lasermet is celebrating its 30th anniversary this year. The company, founded in 1987 by Bryan Tozer, (chairman of the BSI and European laser safety standards committees), has been manufacturing a full range of laser safety products, and providing laser safety services worldwide ever since. Lasermet has grown extensively and is managed by Director, Steve Geldard and MD, Paul Tozer, who oversee the UK manufacturing sites, Lasermet Inc. in the USA and the global distribution network.

L-R: Paul Tozer, Bryan Tozer, Steve Geldard

Contact: Paul Tozer
Paul@lasermet.com
www.lasermet.com

TWI AND VERO SOFTWARE IN EU KRAKEN PROJECT

AILU members TWI and Vero Software join European partners in a EUR 5.9 million Horizon 2020 project named Kraken. The project will develop a hybrid and automated multi-material machine which integrates additive and subtractive manufacturing technologies, able to work in a frame 20x6x3 m, with high accuracy and quality. The hybrid machine is reported as being "the world's largest 3D printer". For more information see www.krakenproject.eu



ANDRITZ TAKES STAKE IN POWERLASE PHOTONICS

ANDRITZ AG has taken a majority stake in Powerlase Photonics Ltd. “This agreement represents a major step forward for Powerlase,” said Dr Young Kwon, Managing Director of Powerlase, “and enables us to pursue our ambitious growth plans to be a key provider of high-power lasers for surface preparation, polishing, cleaning, ablating, and many other industrial applications.”

Contact: Alisha Mehmet
a.mehmet@powerlase-photonics.com
www.powerlase-photonics.com

M SQUARED EXPLORE INNOVATIVE RESEARCH

Innovative research using ultra-pure lasers, led by the University of St Andrews and M Squared, could benefit researchers looking for new ways to diagnose and treat dementia and cancer. Laser-based imaging techniques using light scattering will be applied in medical research for early diagnosis.

Contact: Anke Lohmann
Anke.Lohmann@m2lasers.com
www.m2lasers.com

TLM LASER IN PARTNERSHIP WITH IPG

TLM Laser have further enhanced their laser products and systems portfolio through a recent partnership agreement with IPG Photonics.

TLM Laser will be responsible for the sales, marketing, installation and servicing of IPG’s comprehensive range of laser cutting and welding systems throughout the United Kingdom and Ireland.

TLM Laser Director Andy Toms commented: “We are delighted to be representing IPG Photonics, and this additional and complementary range of laser cutting and welding systems will open up new opportunities for us within a number of sectors including Medical, Automotive and Aerospace”.

Contact: Andy Toms
andy@tlm-laser.com
www.tlm-laser.com

STEWART WILLIAMS WINS TWI WELDING AWARD

TWI has announced that Cranfield University’s Professor Stewart Williams, Chair in Welding Science and Engineering, and Director of the Welding Engineering and Laser Processing Centre (WELP), has been awarded their prestigious Larke-Lillicrap Award for 2017. The award recognises Stewart Williams’ work developing WELP’s reputation as a centre for excellence in the UK in welding and welding-related technologies.

The Larke-Lillicrap Award is given annually to the person or team who has had most influence or impact on the practical application of novel welding or joining knowledge or technology. Under Professor Williams' leadership, WELP has built up a strong, extensive laser processing (including welding) portfolio, making it a centre of expertise in processes such as laser welding science, laser hybrid welding for pipelines, laser-assisted MIG welding for hyperbaric applications, fundamentals of laser powder-based additive manufacturing and pulsed laser processing.

The Centre also has a major industrially-focused programme on additive manufacturing of large-scale engineering structures using wire + arc technology. This programme has more than 20 industry partners and recently produced the world’s largest 3D printed metal part in the form of a six-metre-long, 300 kg aluminium spar.

Contact: Stewart Williams
s.williams@cranfield.ac.uk
www.cranfield.ac.uk

BE AWARE - EMAIL HARVESTING SCAM

It has come to our attention that unknown and unauthorised sources have been harvesting emails from the AILU website, possibly to validate your email address. AILU's policy is never to share contact information with an unverified third party. You might be asked to respond answering certain questions, probably with the aim of verifying live email addresses for spam emails.

Things to look out for: the email 'from' address does not contain @ailu.org.uk, and the imposters do not give any contact details in a signature.

We have investigated ways to prevent this happening and have taken measures to further secure our website. If in doubt of the authenticity of any communication mentioning AILU please get in touch.

NEW EUROPEAN OFFICE FOR BOFA

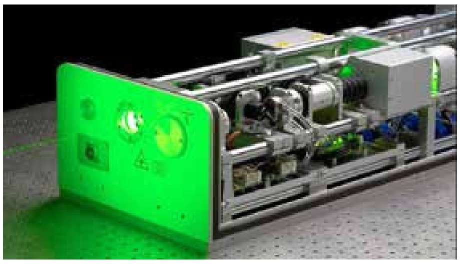
BOFA International is expanding its reach in Europe by opening new offices in Hamburg, Germany. The company has opened the new centre as part of its strategy to grow its business across central Europe.

Contact: John Horsey
John.horsey@bofa.co.uk
www.bofa.co.uk

SOURCES & SYSTEMS

LITRON LASERS' NEW PLASMA SERIES

The Plasma series comprises diode pumped, pulsed, Q-switched Nd:YAG lasers. Applications include; semiconductor annealing, semiconductor and display inspection, laser shock peening, laser lift-off and laser cleaning.



Contact: Hans Taylor
Htaylor@litron.co.uk
www.litronlasers.com

SPI INTRODUCES NEW G4 FIBRE LASER

The new redENERGY G4 EP-M & EP-Z pulsed fibre laser offers flexibility and speed for a number of applications including micro-machine drilling and precision cutting.

Contact: Jack Gabzdyl
Jack.gabzdyl@spilasers.com
www.spilasers.com

COMPACT HIGH PULSED LASERS FROM ELUXI

MatchBox laser modules from Eluxi deliver high-end performance from a miniaturised package. These lasers offer high pulse energy and single-frequency operation from the most compact self-contained units available today.

Contact: Riccardo Tomassoni
enquiries@eluxi.co.uk
www.eluxi.co.uk

COHERENT'S HIGHLIGHT AT MUNICH SHOW

A new 10 kW fibre laser from Coherent made its debut at Laser World of Photonics in Munich as a part of the HighLight™ product family. HighLight products are high-power fibre, direct diode and fibre-coupled diode lasers that combine innovation and reliability into solutions for industrial materials processing applications.

Contact: Roy Harris
Roy.harris@coherent.com
www.coherent.com

AMADA LAUNCHES NEW 3KW FIBRE LASER SYSTEM

AMADA has added a 3 kW version to the ENSIS fibre laser range. The machine includes improved cutting speeds and quality, and is also be fitted with an automatic nozzle changer and AMADA's original Water Assisted Cutting System for stable thick mild steel processing.

Contact: Gary Belfort
gary.belfort@amada.co.uk
www.amada.co.uk

MAZAK'S NEW MATERIALS HANDLING SOLUTION

Yamazaki Mazak has enhanced its laser automation offering for the UK market following the introduction of a new materials handling solution. Mazak's new QUICK CELL laser automation technology is ideal for volume production operations and is available in three different specifications, a 6-pallet, 10-pallet and 14-pallet variants. The new QUICK CELL technology is capable of significantly faster processing speeds compared to the original design.

Contact: Ian White
IWhite@mazak.co.uk
www.mazakeu.co.uk

TRUMPF UDI-COMPLIANT MEDICAL DEVICE MARKING

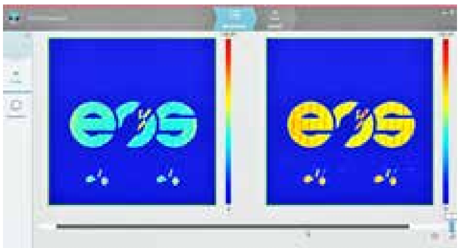
TRUMPF has developed a laser and software module for UDI marking, specially designed to create corrosion-resistant marks on highly reflective materials using ultra-short pulsed lasers. The new TruMicro Mark 2000 offers an ultra-short pulsed laser and high pulse energies of up to 20 microjoules. It produces completely corrosion-resistant marks that maintain their high contrast appearance even after repeated cleaning and sterilisation.

Contact: Gerry Jones
Gerry.jones@uk.trumpf.com
www.uk.trumpf.com

ANCILLARIES

EXPOSURE OPTICAL TOMOGRAPHY FROM EOS

EOS is expanding its EOSTATE monitoring suite to include an additional tool. EOSTATE Exposure OT now provides real-time, camera-based monitoring of the additive, metal-based build process, based on the EOS M 290 system. The solution fully maps each part throughout the build process, layer by layer, regardless of its geometry and size.



Contact: Garth Stevenson
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www.eos.info/en

LASER MECHANISMS' NEW SCANNING HEAD

Laser Mechanisms' new FiberScan™ HR is a scanning head for high-power laser sources including fibre, disk, CO_2 and diode lasers.

Available for collimated beams up to 48 mm diameter, FiberScan™ HR can deliver 20+ kW of laser power to any point within the system's field of view. FiberScan™ HR employs direct water-cooled copper optics for all wavelengths throughout its optical path to provide reliable, ultra high-power capability with minimum thermal focus shift.

Contact: Arvi Ramaswami
sales@lasermech.be
www.lasermech.com

PRODUCT NEWS

HAMAMATSU INFLUENCES LIGHTFAST PERFORMANCE

Hamamatsu Photonics K.K. has developed a LCOS-SLM (liquid-crystal-on-silicon spatial light modulator) with a heatsink that offers lightfast performance for applications such as laser marking with 100W class high-power lasers.

The new LCOS-SLM is optimised to minimise the influence of temperature changes, in which an optimised mirror design and a heatsink are introduced.

Contact: Victoria Hudson
vhudson@hamamatsu.co.uk
www.hamamatsu.com

SCANLAB'S OSCILLATING LASER BEAM

SCANLAB GmbH has developed a scan system for oscillating-laser-beam cutting and welding. The new welDYNA scan head unites the advantages of higher laser powers and maximum dynamics. Considerable process benefits are gained by welding and cutting with high-frequency beam oscillation, particularly in macro material processing of larger components. For example, thick metal sheets and fibre-reinforced plastics can be cut more quickly and cleanly. Diverse materials of poor weldability can be robustly bonded.

Contact: Erica Hornbogner
info@scanlab.de
www.scanlab.de

INTELLIGENT SOLUTIONS FROM RAYLASE

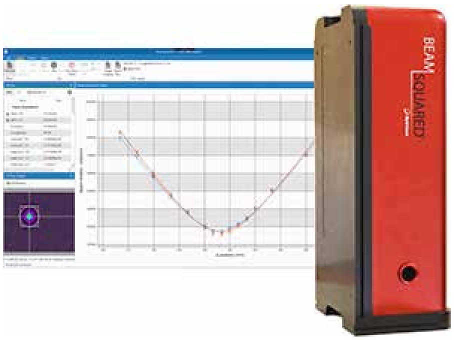
Machine Vision Control (MVC) from RAYLASE is the intelligent machine vision solution that optimises and monitors laser processes for a wide range of materials. Part of this system is the new CLICK&TEACH, intuitive machine vision software that enables a precise and easy setup of the production process and eliminates the need for trial-and-error iterations. Also unveiled is the AM-MODULE, specially developed to process powdered metal alloys using bed fusion.

Contact: Harnesh Singh
h.singh@raylase.de
www.raylase.de

OPHIR PHOTONICS LAUNCHES NEW SENSORS

Several new laser beam profiling and power/energy measurement systems were introduced at Laser World of Photonics. Among them were: A new version of BeamSquared™, the M2 laser beam propagation system that measures the quality of the beam to optimise performance;

a new line of high damage threshold laser power/energy sensors designed for CW lasers with high power densities; the new Pyrocam™ IV USB, a laser beam profiling camera that allows users to see their laser beam for dynamic alignment and proper operation.



Contact: Kenneth Ferree
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AEROTECH'S NEW NANOPOSITIONING STAGE

Aerotech's QFOCUS QF-50 piezo nanopositioning stage is designed for high-performance microscope objective and optics positioning. It accommodates optical instruments and next-generation laser micromachining applications. The QF-50 is ideal for optical positioning applications requiring high precision and throughput coupled with long travels.

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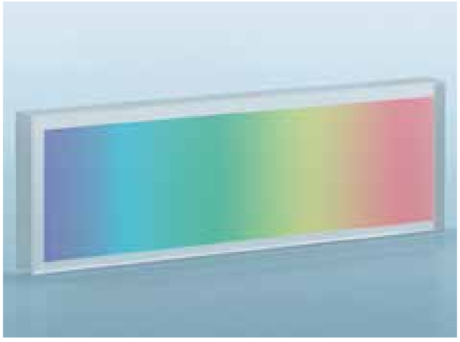
JENOPTIK REFINES PULSE COMPRESSION GRATINGS

Jenoptik's e² pulse compression gratings are encapsulated quartz glass transmission gratings with a diffraction efficiency of almost 100%. In addition to the high diffraction efficiency, the encapsulation of the grating nanostructures also permits easier handling. This encapsulation also protects against external contamination and damage, making it ideal for industrial applications.



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CUTTING COMPANY DIVERSIFIES WITH BLM

Family-owned business ML Fabcuts provides a sub-contract service for flat sheet laser and waterjet profiling. It boasts an extremely diverse customer base ranging from motorsport through the construction industry and sign making sector to processing one-off commissions for artists.

Over time, the company co-founder, Matt Levett, had identified the potential opportunities presented by tube laser cutting, but until recently remained cautious, not wanting to commit to a dedicated tube laser machine. However, during a visit to the recent EuroBLECH exhibition, both Matt and Production Manager James Waldron-Stevens, had what they describe as a ‘eureka moment’ after seeing the 5 kW fibre laser BLM LC5 with integrated tube cutting module.

“We had known about BLM and their reputation for tube processing, but when we saw that it was possible to combine tube cutting with flat sheet processing in a seamless package it was almost an instant decision to place an order.

"The combination of flat bed and tube gave us peace of mind as the machine could still be used as a flatbed machine if the tube business didn’t develop,” says James. As it is, with the machine only being installed in May 2017 it is already running at 50/50 tube/sheet capacity with the aim to increase its use of tube processing to 75%.

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RENISHAW ASSISTS IN AMERICA'S CUP BID

Renishaw is part of Land Rover BAR's Technical Innovation Group which brings together the best of British engineering in a bid to win the America's Cup. Land Rover BAR's America's Cup Class (ACC) race boat Rita (code name R1) is the culmination of 85,000 hours of design and build, on the water testing and rigorous construction. The 15 m racing catamaran has 130 m of hydraulic pipes and over 1200 m of electronic and electric cabling connecting 190 sensors. A hydraulic manifold directs the flow of fluid in a hydraulic system linking valves and actuators. It enables the design engineer to manage the operation of a hydraulic circuit whilst combining the components in a compact unit.

The design team at Land Rover BAR recognised the potential of AM to allow weight savings and improve efficiency on the R1 boat so they set out to thoroughly review the hydraulics system. Renishaw contributed by highlighting the manifold components which would most benefit from being manufactured using metal AM technology, by collaborating and advising on iterations, then producing the necessary parts.

Renishaw's Product Marketing Engineer, David Ewing explains "The design of the manifold is created in CAD software by Land Rover BAR. Renishaw produces its own build preparation software called QuantAM. We take the CAD file from Land Rover BAR, orient it, rotate it, support it and slice it up into multiple layers. Once we've done that we can send the machine file to the AM system which builds up the part using a high-powered laser and there's room to iterate and make design improvements."

Land Rover BAR demonstration metal AM manifolds in Renishaw's QuantAM software

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OUTPUT INCREASE WITH BYSTRONIC FIBRE

Former investment banker Troy Barratt gave up his career in Wall Street and then the City of London to buy a subcontract sheet metal fabricating business in Sittingbourne, Kent. Part of the money invested has been used to purchase a Bystronic BySprint Fiber laser cutting machine, capable of processing sheet up to 3 m x 1.5 m using a 2 kW fibre laser source. Purchased in January 2017, it replaced a 3 kW CO_2 laser cutter of the same sheet size capacity dating back to 2002.

Mr Barratt commented, “When we took over CEL, the CO_2 laser machine’s utilisation rate was under 50% over an 8-hour day shift plus nearly daily overtime. We quickly moved to a double shift, 16 hours a day, put a Bystronic service contract in place and were able to raise the time the machine was cutting to 60%". This is among the highest in the industry for subcontract manufacturers. Moreover, as the fibre laser source was at the low end of the power range, it has lower operating costs.

The available power is more than capable of achieving three times higher output when processing material of 1 to 2 mm thick, be it stainless steel, COR-TEN weathering steel, mild steel including galv and zintec or aluminium. Thicker material gauges up to 5 mm are routinely cut by CEL at least as fast as on the CO_2 machine, while mild steel up to 10 mm thick is regularly processed on the BySprint Fiber.

Everything is in place for CEL to become a significant force in sheet metal fabrication across the whole of the UK and especially in the south of England.

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SCHOOLS FAILING EXTRACTION EXAM

A lack of knowledge is not something commonly associated with education. However, ignorance is the root cause of a potentially serious health risk that lies within many school, college and university Design and Technology departments where lasers are being used for cutting or marking. Fume extraction, or rather the lack of it, is the reason.

Over the years, TLM has visited hundreds of educational establishments and, from what we've seen, we estimate that 95% of educational facilities using lasers are under-extracting. We've been inside school departments that are virtually fume-filled and where a toxic film can be seen around the laser area. In an even worse example, students were asking to leave the classroom due to headaches and eye irritation created by the laser fumes. In all of these cases there has been some form of extraction – but it has just not been sufficient enough to match the installed laser's specifications.

Toxic fumes in the classroom puts students' health at risk (toxic gases can cause inhalation injury, ranging from minor respiratory discomfort to acute lung and airway injury and, in extreme cases, fatality). It also counters COSHH regulations especially with regard to Local Exhaust Ventilation testing (LEV) and contravenes the educational establishment's Duty of Care leaving the school or college liable to costly legal action.

Away from the risk to health, under-extracting is uneconomic, with airborne contaminants reducing the life of the laser's lens and mirrors with resulting heavy replacement costs. The condensed films inside the laser also build up over time - we visited one school where the extraction system was so blocked, fumes were leaving the extractor before the laser was even switched on! This also creates a fire risk. The disturbing fact to emerge from our visits is that if schools worked to current industry standards, most would not be allowed to use their laser.

A school that learnt the lesson

Schools often buy a laser from a laser supplier and rely on the same supplier to provide a suitable and adequate extraction system. In a typical example, TLM visited a school recently where it was clear from the outset that corners had been cut with regard to extraction. Fume odour was obvious within the classroom and inside the laser casing, plus contamination was also damaging the laser optics. The school had relied on its laser supplier to provide an effective extraction system but what had been installed was simply not powerful enough. Having been informed of the problem by TLM, the school took action virtually immediately and a suitable BOFA system was installed – one that matched the specification of the laser.

The Design Technology department is now fume-free and the laser's optics have not been replaced since the new extractor's installation. Prior to the installation of the new extraction system these were being replaced twice a year at considerable expense. The new and effective extraction system means that the school is not only protecting its students' health, it is actually protecting its budget too!

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ARE HARDENABLE ALLOYS STILL HARDENABLE WITH ADDITIVE MANUFACTURING? INITIAL RESULTS FROM THE UNIVERSITY OF NOTTINGHAM

Heat treatments are procedures developed to tailor the mechanical performance of materials to fit specific applications. Precipitation hardening, a conventional strengthening heat treatment, is applied to alloys that have the potential for sites creation where precipitates can grow and act as barriers to dislocations (the more difficult it is for a dislocation to move, the harder the material is). In other words, the formation of precipitates enhances the material's hardness.

There is a threshold for the amount of precipitates that a material can accommodate to yield the optimum performance, a state referred to as 'peak hardened'. When the fraction of precipitates is below the threshold, the material is termed under-aged, meaning that the highest achievable hardness has not yet been realised. On the other hand, surpassing this critical limit yields an over-aged material where the hardness decreases.

One of the alloy families heavily used in the AM industry is aluminium. Traditionally, the alloy AlSi10Mg responds to precipitation hardening by gaining strength. However, when researchers at Nottingham University investigated the effect of this heat treatment on AlSi10Mg parts manufactured by selective laser melting, the material was surprisingly softened, a behaviour expected when annealing the material.

After testing a wide range of treatment durations, this outcome has not changed. This raises the question of whether the conventionally-developed heat treatment procedures apply to additively-manufactured parts that have completely different metallurgies from the traditionally-processed materials.

This result was not all bad news. Although precipitation hardening did not harden the additively-manufactured material, it was found to introduce a push of ductility to the material without significantly sacrificing on the strength – unlike annealing which improves ductility at the expense of strength. It has been reported by the same researchers that a well-designed heat treatment (in terms of selecting the temperature and duration of treatment) can yield a compromise between the material's strength and ductility which is very attractive for several applications.

Despite the positive aspect of this finding, it is important to understand whether hardenable alloys became non-hardenable after processing by AM, or whether they are being peak hardened during the fast heating and solidification rates associated with the process, so that any further treatment acts as an over-ageing treatment.

Research is currently underway to develop an understanding for this interesting finding[1].

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[1] Metallurgical and Materials Transactions A 46 (2015) 3337-3341; Materials Science & Engineering A 667 (2016) 139-146

ENERGY PROCUREMENT AND YOUR BUSINESS - WHERE WILL COSTS GO NEXT?

James Isaacs of BCR Associates gives his insights into the complex world of energy procurement.

"May you live in interesting times," is a well-worn phrase that has rarely been more apt. Global and local political and economic uncertainty are the circumstances in which all of us have to live and trade. Certainly, commodity and energy prices are experiencing all sorts of volatility, which in a narrow budgetary sense, can make it extremely difficult for a business owner or manager to make purchasing decisions.

What do we know that is likely to have an impact on the gas and electricity market over the next year or so?

- Inflation is predicted to continue to rise. The Bank of England expects core inflation to remain above its 2% target rate for the next 3 years. This means costs are likely to rise.
- Global economic growth is increasing. The IMF expects growth to be around 3.7% in 2017 and 3.6% in 2018. This increase in demand will most likely lead to commodity cost increases which will feed to through to increased material and energy costs.
- Political uncertainty in the UK. Clearly the current febrile environment in the UK could lead to pressure on Sterling and if that happens, costs are likely to rise further.
- "Non-unit rate" energy costs (e.g. transportation, distribution and government levy costs) are all set to rise and will, in some cases, represent more than 50% of the cost of the energy supply.

Negotiating your contract with energy suppliers

There are no certainties of course but longer-term contracts have become increasingly popular as businesses seek to find some cost certainty. Listed below are just some of the factors that are worth considering when negotiating your contract with energy suppliers:

Tariffs

There are a huge range of products available on the business energy market with a bewildering range of tariffs and deals. Extensive research and due diligence is the only way to secure the right contract for your company.

Obscure contract terms

Making sure that your contract includes the right terms and conditions is vital for the long-term security of your business. All energy suppliers have different terms and conditions and it is essential that you understand these as well as your agreed service levels before committing to a contract. Businesses can find themselves rolled into exorbitant new deals simply because they failed to understand the small print.

Transparency

The current lack of regulation in the advisory market means some energy 'advisory' services can be more reputable than others. Service levels spectrums can range from a broker trying to promote the most profitable deal, to a reputable consultancy operating as an extension of your business. A tip to distinguish the two; ethical consultancies will work hard to understand your business requirements after an enquiry or referral, whereas brokers tend to cold call and will focus on the product they are commissioned to sell.

Lessen the impact on your business

Although prices in the business energy market are ever rising, steps can be taken to lessen the impact on your business:

Co-terminus end dates

Ensure, where possible, that all supplies renew on the same date. This simplifies the purchasing process and gives you greater buying power when going to market, especially if you are a business with a larger portfolio of suppliers.

Timing

Try to manage supplies so they renew in a lower demand part of the buying cycle. Of course, there are no guarantees, but for historic reasons energy costs more in Autumn and Winter due to greater demand, colder weather and transportation issues. Therefore, it may be advantageous to renew your contract in the summer months.

Avoid pot holes you can see coming

If you know that you want to move suppliers, ensure contracts are terminated as early as possible in order to avoid expensive roll over deals.

Knowledge of the industry

Employ trusted advice to help you navigate the energy market. Commodity (the energy price) only forms 45-50% of your electricity price or 70% for gas prices. The rest is made up of costs for; distribution, transportation, transmissions, government levies and other non-commodity energy costs. These costs can vary depending on the supplier you choose, economic circumstance and your business status.

Technology

Use technology to provide accurate information and reduce waste. There are a number of systems and applications that can help you with energy management and reporting, ask your incumbent supplier or a trusted energy advisor.

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CHANGING THE PERCEPTION OF WOMEN IN STEM

To mark International Women's Day (23 June 2017) Louise Geekie, Project Director at Croft Additive Manufacturing discusses her experiences in the manufacturing sector and the importance of getting more women into STEM.

Although steps are being taken to ensure there is less stigma around women in STEM (Science, Technology, Engineering and Mathematics) roles, recent figures suggest we have some way to go if we are to completely rid ourselves of inequality in these fields.

A 2017 study, published by Accenture, found half of parents and teachers felt they subconsciously treated girls and boys differently when it came to STEM subjects. The same study also showed that women still only make up to 14 per cent of the STEM workforce in the UK.

This reminded me of my experiences when I started looking at STEM careers over 30 years ago. My father, a civil engineer, told me women weren't treated well in this industry and, worried that it would be a difficult career path for me, advised me to avoid the field altogether.

As Britain prepares for its future outside the European Union, manufacturing and the STEM roles that support it will become even more crucial to help drive the UK economy. Engineering UK's 'State of Engineering 2017' report found that there are simply not enough engineering graduates to meet demand; a shortfall of 20,000 individuals annually. With this shortage of skilled individuals in the industry becoming more of a real concern, it is vital that we encourage more young women to work in these types of roles.

Once in an STEM career, the benefits are clear; engineering students are second only to medics in securing full time jobs and good salaries. Further to that, The Women's Engineering Society also found that more than 80 per cent of female engineers in the UK are either happy or extremely happy with their career choices.

In the last year alone, jobs have grown in the UK manufacturing sector by more than a quarter. It seems that a key challenge in closing the skills gap is to make the subjects themselves more engaging to children at a younger age; Accenture's study found a dip in girls' enjoyment of traditional STEM subjects as they enter secondary school.

For this to occur, those in the industry must to take a leading role and collaborate with the education sector to change the perceptions amongst girls considering taking STEM subjects. It is also essential that we start seeing more women at all levels of the industry acting as positive role models and on an equal footing with their male counterparts.

Filter fabricator, Veronica Sharrock, works alongside the team at Croft Filters

Although greater awareness is needed, we are certainly beginning to see larger organisations address the issue of gender inequality in the workplace. However, we need to see work like this replicated by SMEs and local education providers, making sure every student in the UK understands the true value of a STEM career.

For women already working in the industry, we must recognise our own responsibility to inspire and support the next generation of workers. By sharing our success stories and by drawing more attention to high-flying females in the workplace, we can encourage more young people to embark on a rewarding career in STEM.

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This article first appeared on zenott.com

RENISHAW ENGINEER NAMED AS ONE OF UK'S TOP 50 FEMALE ENGINEERS

Lucy Ackland, Senior Development Engineer at Renishaw, has been selected as one of the UK's Top 50 Women in Engineering in 2017. The initiative is organised by The Daily Telegraph in partnership with the Women's Engineering Society (WES) and employers in the industry.

Results were announced on June 23, 2017, to coincide with International Women in Engineering Day. The 2017 list is made up of outstanding female engineers under the age of 35, who have all made a significant contribution to the field.

Lucy joined Renishaw aged 16 as an apprentice and went on to study Mechanical and Manufacturing Engineering at the University of South Wales, where she achieved a First Class Honours degree.

Lucy is actively involved in Renishaw's education outreach programme, where she has been a science, technology, engineering and maths (STEM) ambassador for nine years. She now runs weekly events to inspire young girls to consider engineering careers and show young people where an apprenticeship can take them.

"Historically, women's achievements in STEM have gone unnoticed, and this needs to change," explained Lucy, "The Top 50 Women in Engineering celebrates the great work done by women in the engineering sector.

"The awards showcase the amazing work that women are doing, highlighting how women are performing and achieving so much. Showcasing these achievements gives young women role models, challenges stereotypes and shows that engineering is an exciting career path."

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'STEM' AND 'STEAM' AT CUTTING TECHNOLOGIES

Staff at Cutting Technologies think working in STEM is pretty fantastic. Last year the company welcomed a very talented student from Bangor University on work experience. In June, Director, Jane Robinson, was invited to speak to young students at Bangor University's Design Conference and Degree Show. Jane jumped at the chance to be able to go and speak to the wider university about creativity in manufacturing.

At Cut Tec it's all about STEAM – incorporating arts with the wider STEM movement. Working in manufacturing is no longer all about greasy factories and heavy machinery – it's creating, it's inventing and it's making.

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The Laser Micro Manufacturing (LMM) Lab is part of the High Value Manufacturing group based in the School of Engineering at Cardiff University. The LMM Lab has been conducting research in this field since 1999.

Our facilities include short and ultra-short pulsed laser systems. Our early research efforts were focused on the applications of laser milling to support the development of micro machining applications. While still pursuing this particular line of work, in recent years, we also started investigating the application of lasers as a value-added post-processing technique for the selective functionalisation of various surface characteristics, which include topographic, mechanical and magnetic properties.

The LMM Lab has been supported by various funding sources including EU framework programmes, EPSRC, the Welsh government and industrial contracts.

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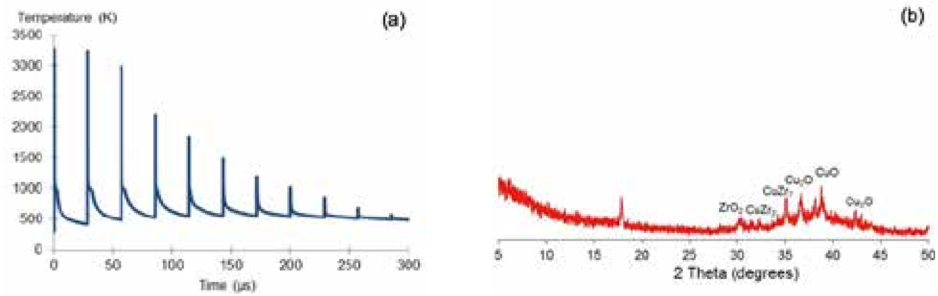
SELECTIVE POLISHING OF ALM COMPONENTS

Metal Additive Layer Manufacturing (ALM) is rapidly enabling the production of complex 3D shapes in a wide range of metals. However, one common issue with the obtained parts is the quality of the produced surfaces, which may hinder the intended functionality. These surfaces would generally require post-processing such as polishing. However, this can be difficult to control due to the complexity of the geometries produced by ALM. Theoretically, laser machining technologies have the capabilities to reach effectively external 3D structures produced by ALM, allowing post-processing of complex surfaces. However, the reliability of such process chains is limited due to various issues such as part alignment and the effect of ALM surface irregularities on the laser-material interaction. We are developing such process chains, focusing on the use of laser ablation technologies for the cost effective post-structuring, finishing and functionalisation of 3D surfaces produced by metal ALM.

PROCESSING OF BULK AMORPHOUS METALS

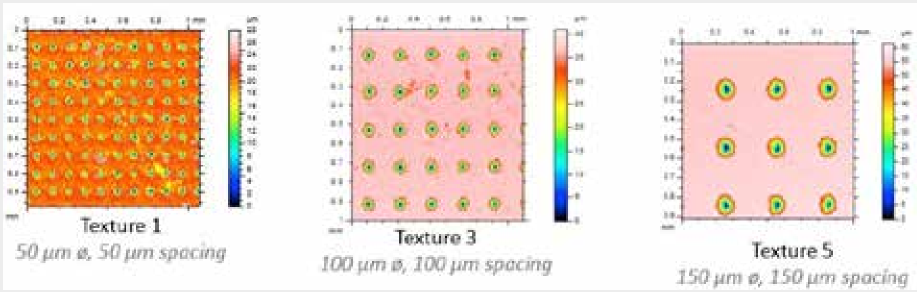
Complementary experimental and theoretical laser milling investigations are conducted on bulk amorphous alloys, also known as bulk metallic glasses (BMGs). These materials exhibit improved properties such as high-strength, high elastic strain limit and superior corrosion resistance. BMGs have received increased attention from the laser research community in recent years for applications such as laser welding, micro machining or surface treatment. We are focusing our research efforts in this area on understanding and predicting the occurrence of physical phenomena that favour the onset of crystallisation during laser processing. Depending on the intended end-user application for BMG components, the rationale is to reduce the current trial and error approach for the controlled generation, or avoidance, of crystalline precipitates in the otherwise amorphous matrix. To achieve this, thermal load profiles are simulated and studied in addition to analysing processed BMG specimens with a range of material characterisation techniques.



(a) Example of simulated temporal temperature evolution for moving irradiations using a pulse length of 220 ns at 70 J/cm^2 and (b) corresponding XRD pattern showing evidence of laser-induced crystallisation on a Zr-based BMG

SURFACE TEXTURING OF ORTHOPAEDIC IMPLANTS

Pulsed nanosecond laser irradiation is employed to engineer the surface topography of biomedical materials for novel orthopaedic implants. Our results from a recent scoping study demonstrated the promising potential of laser surface texturing for improving the tribological performance of carbon-fibre-reinforced polyether ether ketone (CFR PEEK) bearings. Extended testing showed that the coefficient of friction of CFR PEEK could be reduced compared to the plain material for a range of surface textures and thus, lead to better wear resistance of implants.



Examples of single craters generated on the surface of a CFR PEEK sample

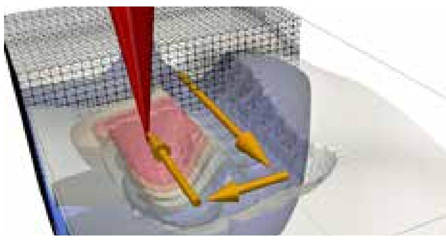
DOMAIN REFINEMENT FOR ELECTRICAL STEELS

We are investigating the fundamental mechanics governing the process of laser domain refinement (DR) of grain oriented electrical steels. These steels form the magnetic core of transformers and the DR process creates large gains in their operational efficiency.

The process works by generating regions of tensile stress between DR lines, produced by a CW laser, which acts to reduce the width of magnetic domains. The work investigates both the optimum laser parameters for different steel properties and the role of different distribution patterns of DR.

PROCESS SIMULATION

We are working on the development of CAM solutions using new computational modelling strategies for the efficient simulation and control of the laser ablation process. These computational tools are aimed at combining theoretical models representing the fundamental principles of the process with knowledge extracted from experimental data.



Laser ablation simulation

ANNUAL JOB SHOP BUSINESS MEETING 18 OCTOBER 2017

This year the Annual Job Shop Business Meeting takes place at BOC's Wolverhampton facility where there will be an excellent programme of presentations on topics relevant to business owners.

The presentations will be aimed at winning new business, entering new markets like the Nuclear Industry, opportunities in laser welding, understanding the latest technology in laser sources, saving money through wise negotiation, and avoiding the common pitfalls in internet marketing.

The results of the AILU Breakdown Response Satisfaction Survey will be presented and there will be a lively discussion forum on topics of relevance and interest to job shop owners and their supply chain.

As usual, there will be plenty of networking opportunities for new members, visitors and experienced AILU members.

After the event, BOC will give delegates the opportunity to visit their Manufacturing Technology Centre where the latest in digital technology, welding and cryogenic gases will be presented in an interactive way.

Alternatively, some BOC customers may prefer to take the tour of the Cylinder Test Shop where they can find out how cylinders which are returned from the field are tested, refilled, painted and finished.

To register for the JS Business Meeting please visit the link below or call the AILU office (01235 539595).

www.ailu.org.uk/events

APPRENTICESHIPS OFFERED BY GRATNELLS

Gratnells Engineering has been in the laser tube cutting business since 2015 and is happy to train up aspiring operations engineers. Recently a new apprentice has joined the laser cutting team. Sam has just completed his Engineering level two diploma at Harlow College and is looking forward to the start of his level three as an apprentice at Gratnells. He is keen to develop his skills and one day aspires to fully operate the machinery and be able to completely understand and talk about the processes involved.

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HUTCHINSON LAUNCHES TRAINING ACADEMY

Hutchinson Engineering has launched a Training Academy addressing the skills shortage in welding and fabrication in the manufacturing sector in Northern Ireland. The academy will operate from the company's 80,000 sq ft world class manufacturing facility, based in Kilrea.

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GF LASER EXPANDS AND INVESTS

As with any laser cutting business continual investment is vital to keep the company growing and to remain competitive as laser cutting machines become faster and faster.

With this in mind GF Laser purchased their fifth laser cutting machine in May which is now up and running and ready for business. The new model joining the GF Laser family is the TRUMPF 3030 Laser.

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YORKSHIRE LASER ON THE MOVE

Yorkshire Laser and Fabrication has moved to new, larger premises:

Unit 1 New Court
Mildred Sylvester Way
Normanton
Wakefield
West Yorkshire
WF6 1TA

01924 220236

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CHAIR'S REPORT

AN INSPECTOR CALLS!

Last week I arrived at work seconds after a visitor pulled up in the car park. I followed him into the building a few meters behind and saw, hanging from his waist, a hi-vis jacket. Immediately I had the pangs of fear, I knew immediately who this was. Sure enough when I finally caught up with him he introduced himself as the "HM Inspector for Health & Safety". My blood ran cold but I put a brave face on. Now this is not because I feel that we are doing anything wrong, in fact I work very hard to ensure the workplace is safe. Rather it is the knowledge that this person has the power to shut down my business if he finds something he doesn't like… and they can always find something they don't like if they look hard enough!

Following the recent awful tragedy of the Grenfell Tower fire I think Fire Safety and Health & Safety are currently in the forefront of peoples' minds, even more than usual. We always need to be thinking "what can we learn?", whenever something goes wrong. Although there are no doubt many important lessons to be learnt for the building and construction industry, for everyone else I think there is an important lesson in a common sense approach to Fire Safety and Health & Safety. Just ticking the boxes and following the basic rules is OK up to a point but without a bit of joined up thinking, stepping back and reflecting "is that actually how we should be doing this" you can miss an obvious issue.

Going back to the HSE Inspector, luckily all my paperwork such as risk assessments and electrical certificates etc. were all up to date and the inspector was very happy to see all of our machinery had either interlocks or light barriers which were all functioning correctly. Also, no sheets of metal are stored on their sides or left leaning against anything but instead they are all stored flat and on pallets. Before you go thinking I got off scot free, the inspector pulled us up on not having "Face Fitting Tests" for those to whom I provide face masks for grinding/deburring. So anyone wearing a face mask for these tasks needs to be tested to ensure they are provided with the correct shaped mask for their face. I did not know that was required so hopefully you now know too. I am still awaiting full instructions from HSE about what they want us to do and provide them with, but there is some useful info on the HSE website, just search for: "Fit testing basics"

So don't forget, put that Risk Assessment hat on regularly to try and spot any potential dangers before they become an issue.

Mark Millar

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ADDING VALUE TO METAL

AN INTERVIEW WITH JAMIE SHARP

MANAGING DIRECTOR, DNA METALWORK

Q. Can you give us an overview of DNA Metalwork ?

DNA Metalwork was founded in Rotherham during 2016, operating as a new business on the MTL site, and becoming the latest addition to the large and successful WEC Group. I joined the company as Managing Director, after 22 years at Sheffield company Outokumpu Stainless. Currently DNA employs 8 direct staff and utilises the production facilities at MTL and the whole of the WEC group, with a revenue around £3 million, there are open vacancies for 21 staff on the MTL site and ambitious plans to double the DNA turnover by the end of Year 3.

With 7 laser cutting machines, supplemented by plasma and flame cutting, press brakes, robot welding, fabrication, shot blasting and painting, DNA Metalwork seeks to offer more than just laser profiling if required with all the value-added services at its disposal. Addressing any and every market where metal fabrications are required, the opportunity to increase value and provide parts larger than the capacity of many UK job shops sets DNA apart from typical laser job shop. Supplying everything from architectural steels for the construction industry to high quality stainless steel assemblies in the catering, O&G, general process and nuclear industries, DNA Metalwork sees plenty of opportunities in the UK market, supplemented by a significant amount of potential export trade.

Q. Which suppliers do you use for laser cutting and how do you manage the production system?

We have laser systems from TRUMPF, Bystronic and Messer. Recognising the need for a fast turnaround in quotations, and a rapid response from order to delivery it is important to have an efficient internal management system. All our systems are integrated with SigmaTEK software, which allows us to respond in a timely manner in a highly competitive environment. Automation keeps us lean and competitive, allowing us to achieve a large company performance from a small but growing team. Using the network of machinery at other WEC Group factories allows us to offer the widest capability in terms of services and cope with capacity fluctuations with ease.

> "Automation keeps us lean and competitive, allowing us to respond in a timely manner in a highly competitive environment"

Q. What are the key markets for DNA?

We have the capability to supply large parts, over 20m in length, and by enhancing our laser cutting service with the addition of plasma, flame and waterjet, we can cope with extremely thick materials – allowing us to supply nuclear, transportation, construction and energy markets. However, a sizable proportion of our work is still in the thinner materials for catering and lighter process industries, and stainless steel makes up over half of our output. Combining profiling with bending, fabrication and painting or coating allows us to offer higher value parts and simplifies the supply chain for our clients.

Q. What are the benefits of AILU membership for you?

The obvious benefit that I have seen, during the period I have been representing the WEC Group within AILU, is the opportunity to network with like-minded individuals facing the same market conditions and challenges. Previously, I have had experience of the BSSA (British Stainless Steel Association), and now I would see AILU as a single point of contact to ask questions and challenge ideas in the applications of lasers for metal fabrications – calling on a wealth of experience and knowledge within the AILU membership.

Q. What do you find the biggest challenges?

Our biggest challenge currently is recruiting the staff we need to grow the business. The UK skills gap is very pronounced and I have observed a gap of at least 10-15 years in the training of engineering and manufacturing skilled or semi-skilled employees at the level the UK market now demands. Also, for many younger people, there doesn't seem to be the interest in taking responsibility and seeking career progression that was more common in my youth. This makes finding the right people a challenge, but we are addressing this by a focus on apprenticeships to build a home-grown team of shop floor and admin staff that are trained and experienced in the specific needs of our business. In this we work alongside local training providers like Rotherham College, Sheffield College and Sheffield Hallam University.

> "AILU gives me the opportunity to network with like-minded individuals facing the same market conditions and challenges"

Q. Has Brexit and the political situation in the UK created any difficulties for you?

We have not seen any significant evidence of business uncertainty to date in the year following the EU referendum, and the only significant risk we face is uncertainty over exchange rate which affects our material prices – in common with everyone else in the market. We source all of our stainless steels from the EU zone, to provide a reliable and consistent level of quality to our customers. Recently however, in certain markets, stainless steels from India, China and Korea appear to be gaining traction and respectability.

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IMPROVING METAL CUTTING OF HIGHLY REFLECTIVE MATERIALS

CHRISTIAN KELLER

Over time fibre lasers have become increasingly accepted for industrial laser applications. For many years, companies and universities have developed new generations of fibre lasers which compete with other laser types, such as CO_2 lasers. As the market for CO_2 lasers shrinks, the solid state market expands due to advantages such as higher efficiency, high beam quality and the ability to process highly reflective material such as copper and copper-alloys.

Processing such materials with CO_2 lasers is challenging due to the lower absorption characteristics of these metals at this wavelength, but opens a whole new range of laser applications for fibre lasers. Highly reflective material can be difficult to process for solid-state lasers including fibre lasers, since the typical emitted wavelength of commonly used industrial systems (1030 – 1080 nm) is mostly reflected by the work-piece rather than absorbed. However, some energy is absorbed, generating a local hot spot which increases absorption, allowing a greater proportion of the incident beam to be absorbed and a stable process to be established. During this initial period there are significant back-reflections from the work piece into the optical beam delivery system which has the potential of causing damage to process optics and to the laser source.

Fibre lasers are generally more sensitive to back reflections compared to other solid-state lasers, however the SPI Lasers redPOWER laser range has several different mechanisms and features to cope with this. Furthermore back reflections can be used to provide process feedback information, and this article describes how SPI fibre lasers use back-reflection data to provide pierce detection and cut quality information.

For simplification purposes, the main application which is being considered is 2D laser cutting in CW mode. The SPI redPOWER lasers are equipped with an internal sensor system which measures back reflection in real time. This information can be used to detect the end of a pierce, and it also contains detailed information about the cutting process itself. Trials have shown that the amount of back reflection is directly linked to the machine feed rate, on the basis that the amount of back reflection is linked to the angle of the cut front within the cut kerf. This means that the measured back reflection can not only be used to measure the speed and cut front angle, but also to detect a cut fail or collapse of the cut front.

A typical laser cutting process is structured in several different phases [2]. Piercing is logically the first phase of a laser cutting process which produces a near-vertical cut front through the sheet metal, forming the start point of every cut. Depending on material and sheet thickness, a complex pulse shape and power ramp may be necessary to achieve short pierce times and reduce spatter and bulging on the work piece surface. Depending on temperature, surface roughness and material quality of the work piece, pierce times can vary widely for the same pierce program. For industrial processes, a certain safety factor (typically up to 3x) is added to the average dwell time which is not necessary for most pierces, but vital to ensure a stable process for every pierce.

This is where a pierce detection system comes into play. Such a system detects the end of a pierce which is then fed back to the machine to stop the piercing cycle. Most existing systems are based within the cutting workstation (as opposed to the laser) but this can result in a more complex cutting head and optical system. SPI's redPOWER QUBE lasers come with a pierce-detection system integrated inside the laser itself which removes the need for any additional sensors within the cutting head. The laser internal system is based on back reflected light from the work piece and works on all typical metallic sheet materials. Simulations have shown that process time can be shortened by up to 15% on a typical 3m by 1.5m sheet with realistic part layout. Depending on the part complexity and size, actual time savings could be even higher.

Figure 1 shows a typical back reflection signal trace during piercing. In the first milliseconds, there is a peak visible, which can be explained by the laser beam hitting the blank surface of the metal. Once the laser couples into the material the absorption of the metal surface increases due to the temperature rise and mulitple reflections within the pierce hole. After approximately 280 ms the signal drops below a programmable threshold. This activates a programmable delay time, which is important to ensure the pierce detection signal does not rise above the threshold again. Once the detection signal is below the threshold during this dwell time, the pierce is detected as finished and the laser provides a feedback signal which can be integrated into the production machine. This procedure ensures high machine efficiency and reduced time loss during piercing. The thresholds and dwell times are programmable, so the customer can adjust the settings to ensure an optimised process, tailored as needed.

The next step is the cut-path of a part. The laser beam together with the gas jet form a dynamic cut front. The geometry of this cut front mainly depends on the following parameters: focus spot size, feed rate, focal position, gas pressure.

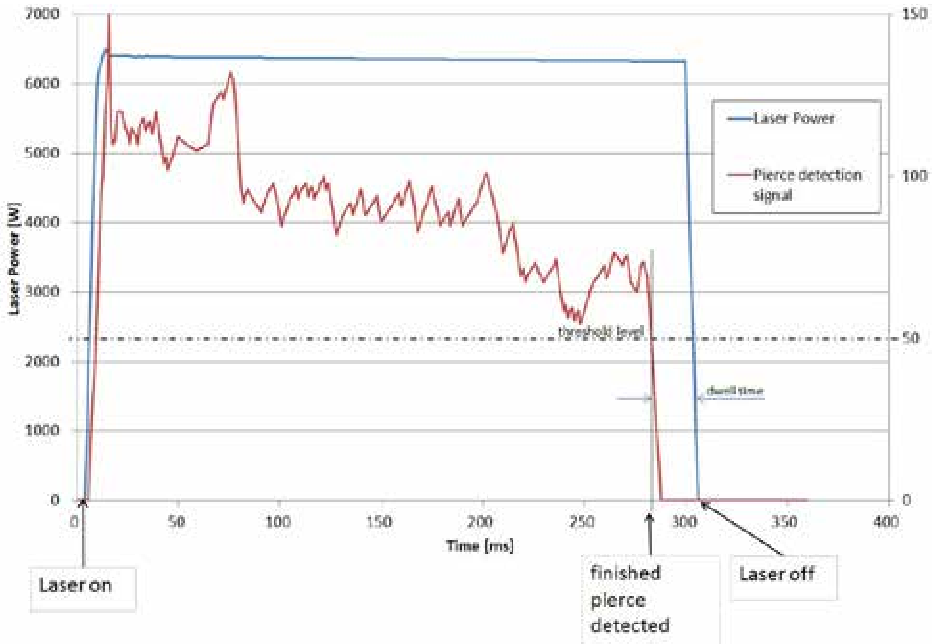

Figure 1: Example of power and back reflection signal while piercing.

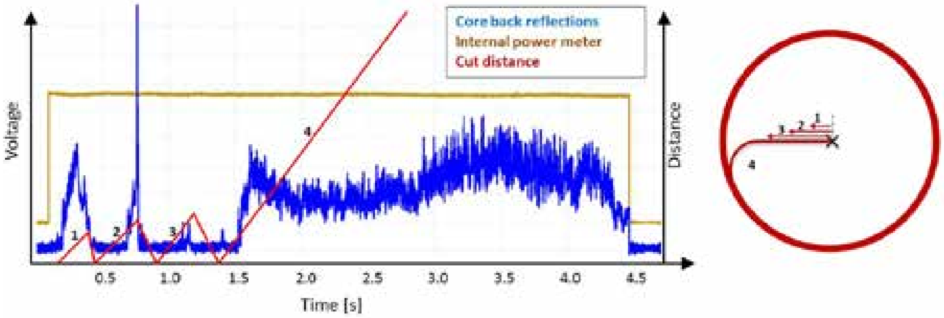

Figure 2: Signal trace of copper being cut with nitrogen as assist gas, overlayed with a distance/ time diagram (left) and a schematic top view of contour being cut (right). A special lead-in strategy is used to highlight the dependency of back reflection on feed rate.

Changing one of these will affect the cut front and therefore change the cut edge or cut quality. The main parameter under consideration is the feed rate. Cutting trials with copper using nitrogen as the assist gas show a clear link between the feed rate and the level of measured back reflection. As shown in Figure 2, a circular shape with a start point in the centre of the circle was cut. A special lead-in strategy was used to highlight the dependency of back reflection to feed rate. The pierce was at the centre of the circle, and a short cut was made along the lead-in path before returning (still cutting) to the centre point. The machine repeated this cycle 2 further times, each time with a slightly longer cut along the lead-in line. On the fourth repeat of the cycle the machine followed the full lead-in and continued to cut the complete circle.

For copper and brass, measurements have shown that the amount of back reflection is directly linked to the cut feed rate. The faster the cutting head feed-rate, the higher back reflection is measured. This can be explained in two ways.

The first possibility is that the cut front angle is larger at higher speeds than at lower speeds, resulting in higher levels of back reflection from the work piece at high cutting speeds. To melt the material and eject it downwards, a certain interaction time is needed. Faster feed rates would either not completely melt the full material thickness or not eject the melt properly. Figure 3 is a schematic drawing of how the cut front might affect back reflection [3].

The second possibility is to consider how much of the leading-edge of the beam is absorbed on the top surface. Disregarding heat conduction and considering that the laser beam only melts the material inside the beam propagation, the forward-facing boundary of the laser would always hit solid, blank metal. With a given time constant for the material, the area of blank metal would be smaller at slow cutting speeds than at high speeds. This theory is illustrated in Figure 4. Trials have shown that, particularly in the first microseconds of piercing, back reflection is high, as the laser hits solid, blank metal and is not immediately coupled into the material. This effect could also explain the high back reflections while cutting.

The larger area of overlap at high speeds would cause more back reflection than low speeds. To state whether one of the two possibilities cause the link between back reflection and cut speed needs further investigation. A superposition of both effects is likely.

Conclusion

The measured effects as well as cutting results are clear evidence of how useful back reflection sensors can be for industrial usage. Pierce detection systems nowadays are state-of-the-art to ensure high performance and efficiency. What makes this system unique is that all the sensors are integrated in the laser itself. The customer can therefore decide to use a more cost efficient cutting head, rather than a high end product.

Being able to monitor the amount of back reflection while cutting is a huge advantage especially while setting up the correct process parameters. With SPI's redPOWER QUBE lasers excessive back reflection can be avoided by measuring reflections and optimising the process.

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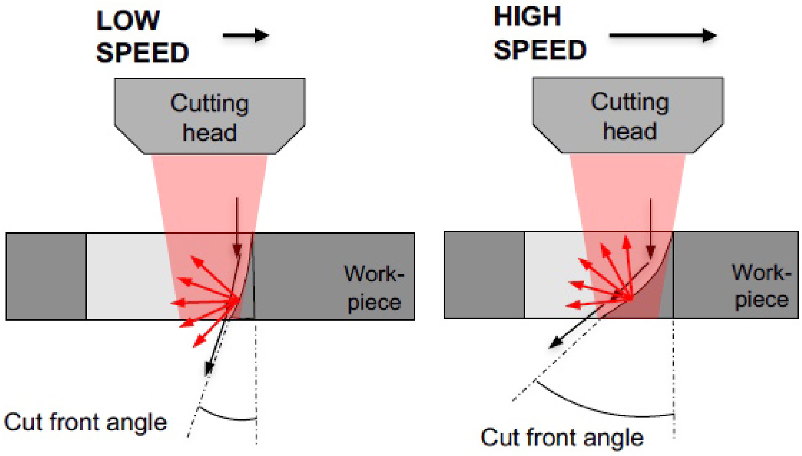

Figure 3: Non-scaled side view sketch of the cut front at two different speeds, red arrows illustrate back reflection.

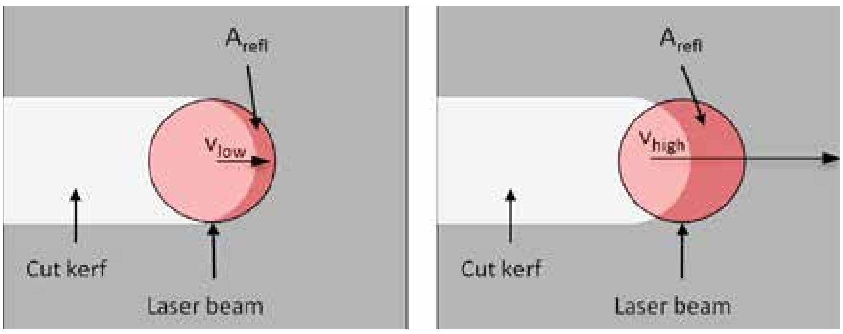

Figure 4: Top-view drawing of laser hitting workpiece at two different speeds.

Christian Keller joined SPI Lasers UK in 2016 where he is currently Applications Engineer in the New Product Introduction division.

SEE OBSERVATIONS P34

Q-SWITCH LASER SURFACE REFURBISHMENT OF SEA VESSELS

IOANNIS METSIOS

Laser cleaning and paint removal is becoming a hot subject in industry. As industrial grade ns pulsed lasers with an average power beyond 1kW have become available, the capability emerged to process most material and structures at commercially viable speeds. Such lasers typically feature pulse peak power beyond 100kW and typically beyond 1MW. The high peak power ensures interaction with nearly any material, leading to ablation, decomposition or detachment, based on the material properties and the beam size. Such industrial lasers are based in either q-switching or power amplification of diode signals, offering pulses of high peak power. Each pulse is a packet of energy capable of evaporating a set or volume of coating, or detach it from its substrate or melt and restructure its surface.

Several projects on laser paint and coating removal for commercial and defence aircrafts have already been conducted. Systems like the LADS I & LADS II and the ARBSS have been built and tested on aircraft and aircraft components. In 2017 a commercial laser paint removal system was commissioned by Singapore Airlines, using advanced scanners by EWI and a large 8 axes robot by NTS. The Marine industry offers a greater diversity of applications, with a potential annual market for commercial vessel paint removal only standing at around $300 million, exceeding that of aircraft estimated at $250 million globally. If other more localised processes such as selective rust and corrosion removal, shaft and propeller resurfacing, etc., are added to the market, the estimate rises to $2.3 billion annually. However, market accessibility is low as the sector suffers low commercial utilisation with only profitable areas remaining in the cruise, ferry transport, private boat and the LPG/LNG transport.

For marine applications coatings are much thicker, often ~1 mm. Coating thickness variations are much less controlled. Coating consistency has often changed during service. Deep substrate corrosion typically accompanies any degradation of the coating. Access to complicated structural geometries is nearly impossible. Moreover, the surface area of a commercial vessel is significant and dockyard delays need to be minimised.

Removal rates

Two key applications are examined, paint removal and rust removal. A Panamax being an average size commercial sea vessel features approximately 19000 m^2 of external surface area. Laser technologies like CW or QCW CO_2 emitting up to 30 kW, suggest good interaction with organic paint, but have demonstrated removal rates only approaching 22,500 mm^3/kW.min. Comparing to surface area and volume of paint of the Panamax, the operation would take 130 days with 1 kW of laser power. Ideally, process speeds of approximately 10 times that are required so that a commercial case of utilising 4 to 6 kW of total laser power can be distributed around the vessel in 3 to 4 workshops and address the task in less than 1 week. Alternatively, low energy ns pulses of 0.1 to 12 mJ may be used at high pulse repetition rates of 100 to 1000 kHz, achieving higher coverage range per raster while being focused into adequately small spots to maintain irradiance levels above the ablation threshold, resulting much lower removal rate, near 2,000 mm3/kW.min, as the increase in coverage rate by decrease of spot size and pulse energy mathematically results in slight increase of removal rate, in reverse proportion to pulse energy. However, the increase in removal rate is limited by the size of the smallest spot size practically and theoretically attainable. Finally, both these technologies can thermally impact the substrate as heat continuously diffuses into the material at CW or above 200 kHz.

Detachment

The above methodologies are based on an ablation removal method, being subject to thermal diffusion as the whole volume of the material removed needs to be vaporised. In a different industry, high energy pulses have been used since the late 80s in semiconductor processing to remove metal films with minimum damage to the substrate [1]. Subsequently the technology evolved to provide a tool for transparent coating detachment in the optics industry [2] and semi-transparent paint removal [3]. Detachment significantly increases coating removal efficiency. 1 μm near infrared radiation, is adequately transmitted by most polymer and organic based materials, like paints. They are semitransparent even when white scattering additives or other pigments are introduced in the polymer matrix of the paint. Polymers transmission in the NIR region is higher than the visible radiation, mainly due to the larger wavelength, and limited molecular vibration interaction. Consequently, by the simplified Beer-Lambert equation, the beam intensity transmitted reduces in negative exponential relationship to the coating depth, governed by the absorption coefficient at the laser wavelength. Absorption at the coating to substrate interface is typically boosted, due to the zero practical optical transmission of the metal, and due to surface roughness acting as absorbing discontinuities. Moreover, vaporised

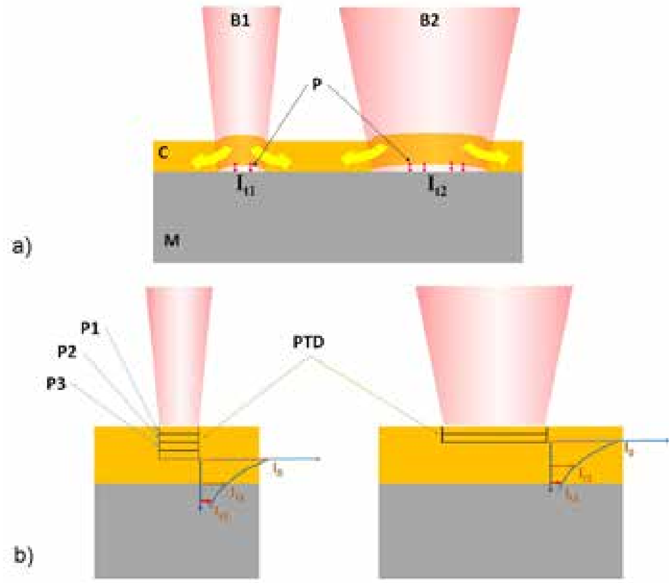

Figure 1: a) Interfacial pressure P and b) hybrid detachment with P1, P2, P3 … Pulses To Detachment (PTD), induced by small (B1) and large (B2) pulse energy beams delivering irradiance I_{t1} and I_{t2} respectively.

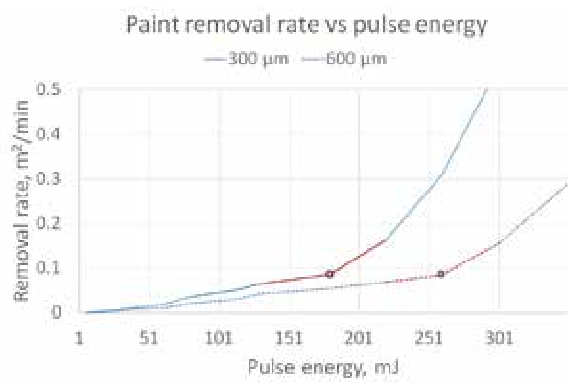

Figure 2 : Example paint removal efficiency thresholds for hybrid detachment of 300 µm and 600 µm thick semi-transparent paints.

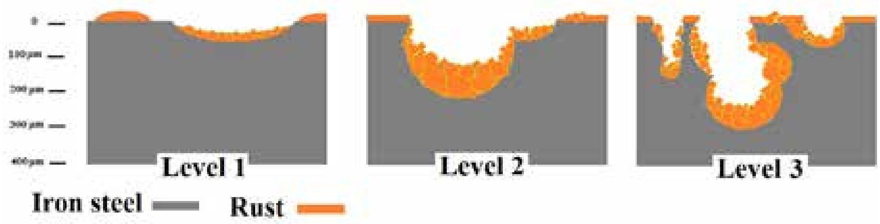

Figure 3 : Sketches of 3 modelled levels of rust development.

material is trapped by the two layers contributing to huge interfacial pressure. It is this pressure that powers coating removal via ejection. Consequently, it is only necessary to vaporise a very small volume of material in order to achieve detachment of material with thickness orders of magnitude greater than the vaporised layer. Additionally, laser beam intensity equal to the detachment threshold needs to reach the interface via the Beer-Lambert equation. This ablation threshold is typically lower than a smooth and clean semi-transparent coating surface. High pulse energy q-switched lasers inherently offer high enough intensity I_0, achieving single pulse detachment of most paints up to 100 µm thick. Process efficiency is hence improved in a non-linear fashion, when the detachment threshold is reached.

Increasing pulse energy further and distributing over larger surfaces to maintain irradiation just above the detachment threshold, only reduces further the detachment threshold. This phenomenon occurs due to the increase of evaporated species at the interface and increasing the area over which the detachment pressure is applied. Hence, less pressure is necessary to overcome the shear forces on the perimeter of the irradiated area that withholds the coating (Figure 1a). The coating removal rate and efficiency, consequently increase at a much steeper gradient than the volume ablation process.

Hybrid detachment

For the case of thick coatings as used in marine vessels, single pulse detachment is challenging. An ablation-detachment hybrid process however is used to achieve high removal efficiency. In the hybrid process, the first few overlapping pulses aim at reducing the coating thickness on a pulse to pulse basis (patent pending GB1710188.2). When enough radiation can be transmitted through the remaining thickness to kickstart detachment, the rest of the material is removed at high efficiency (Figure 1b). Again, higher energy pulses typically above 100 mJ at 50 to 100 ns, unlock the non-linear efficiency growth threshold demonstrating removal rates in excess of 40,000 mm³/kW.min. Figure 2 shows the increase in process speed for white paint on primer for a 300 µm thick coating and 600 µm thick coating. The onset for high efficiency removal is observed at 180 and 260 mJ respectively. Average power is maintained at 1.5 kW, and the process is optimised for spot size and overlap per datum. Pulse duration changes from 114 ns to 42 ns as the pulse energy increases. Pulse shortening only contributes to a linear increase in efficiency and has not been observed to achieve a non-linear efficiency boost without the accompanying increase in pulse energy. Results obtained using a Powerlase Rigel i1600 Q-switched DPSS Nd:YAG laser.

Rust removal

Rust removal is a completely different process than paint removal. Typical steel rust is a combination of iron oxides such as ferric oxide, Fe_2O_3, ferrous oxide, FeO and magnetite Fe_3O_4. These are partially transparent to NIR radiation, resembling semiconductors. However, rust is far from being a homogenous or continuous layer. A model describing the different levels of rust and relevant surface structuring is depicted in Figure 3. Level 1, the rust only exists as surface layers and occasionally creates shallow pits of maximum 50 µm depth with the edges of the pits in line of sight to a single reference point above the surface. Level 2 with eroded cavities as well as mutli-grain rust filled pits with parts of the pit walls not in line of sight to an elevated reference point. Level 3, with deep cavitation and multi-grain rust filled pits

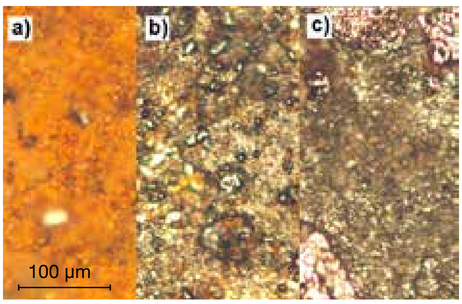

Figure 4: a) Level 3 steel rust. b) Rust removed with 5% pulse overlap. c) Rust removed with 60% pulse overlap.

that have progressed underneath the substrate surface thus generating concealed features from the line of sight of an elevated reference point. Erosion typically progresses in multiple stages, with new erosion seed locations being activated on successive stages. Rust filled pits may also contain suspensions of non-oxidised steel.

Tests using the Rigel i1600 laser were conducted on steel, featuring rust penetration depths between 40 and 230 µm. Figure 4a shows a typical example of a level 3 rusty plate. Pulses were released with 5% overlap to investigate process speed based on a detachment model. A maximum speed of 0.75 m²/min was demonstrated using 12kHz pulse repetition rate, 70 ns pulse duration, 1.62 MW/mm² irradiance and 1.5kW average power transmitted through a fibre. Figure 4b depicts the result of processing, showing signs of remaining pockets of rust. When overlapping the pulses by 65%, process speed increased to 1.35 m²/min at 12 kHz and 0.85 MW/mm² irradiance. Figure 4c depicts an area processed by overlapped pulses showing less pockets of rust and more surface melting. This indicates an ablation based process where the overlapping pulses melt or ablate a significant volume of un-oxidised metal until reaching concealed corrosion cavities.

To conclude, hybrid ablation-detachment approach can return commercially interesting paint removal rates around 40,000 mm³/kW.min. Rust removal at rates of 1 m²/min is demonstrated for moderately oxidised plates using 1.5kW Q-Switched Nd:YAG laser. The applications prove a competitive edge of laser for the marine industry.

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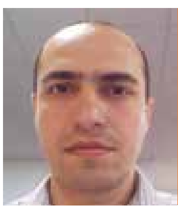

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SEE OBSERVATIONS P34

AM FOR MEDICAL PROTOTYPING – BREAKING NEW GROUND

ALEX BERRY

Prototyping intricate medical devices using Additive Manufacturing (AM) to reduce cost is on the verge of becoming common-place, and using more than one form of AM to form functional models capable of initial medical trials is an ultimate goal.

AM seems like an obvious solution for small companies or individuals who wish to develop medical devices that require multiple prototypes during the development phase of new designs. Units that traditionally take weeks or months to machine or mill can now be printed in the space of hours or days, with costs reduced by large factors, allowing for a greater range of test parts to develop a design to its maximum potential.

Additive Manufacturing at Sutrue Ltd

Sutrue Ltd, a small SME, has used AM to develop a range of functional devices with a series of intricate mechanisms. The technology has allowed the development of a new type of gear-train to rotate a medical grade needle with the required action and force to perform various types of sutures (medical stitches).

Our article in the Spring 2016 issue of *The Laser User* reported on how we combined AM and subtractive manufacturing (SM) by using selective laser melting (SLM) parts from a Concept Laser Mlabs with laser etched and selective laser sintering (SLS), Polyjet and stereolithography (SLA) plastics to prototype our design. Since then we have been refining our electronic module for the control of each type of device and refining the robotic version, preparing for trials, and applying for our European and Russian patent, with other territories (including the US) not far behind.

We are now on the verge of starting animal and robotic trials to show just how the devices might function in the medical world.

AM challenges in medical prototyping

There have been limitations and lessons along the way; AM reliability and design constraints have changed dramatically since we started using 3D printing as our main source of prototype parts. Five years ago SLA and SLS parts were hit and miss when it came to smaller intricate parts, but in the last few years this has improved dramatically and along with new materials seemingly arriving every week, the technique is now a major part of device design.

Integration of varying materials is also a learning curve for designers. Tolerances differ from SLM to SLS and SLA and when using them together in combination with laser-etched and SM parts (while minimising post-production finishing) there is definitely an ongoing design lesson.

Surface texture, support structure remnants (for SLA), excess surface material and even beam widths have a major role in the design considerations and material choice. The smallest Sutrue device (currently) uses internal gears that are Module 0.2, so the teeth are only 0.4 mm long (these have been sintered on a Concept Laser Mlab machine and are extremely accurate).

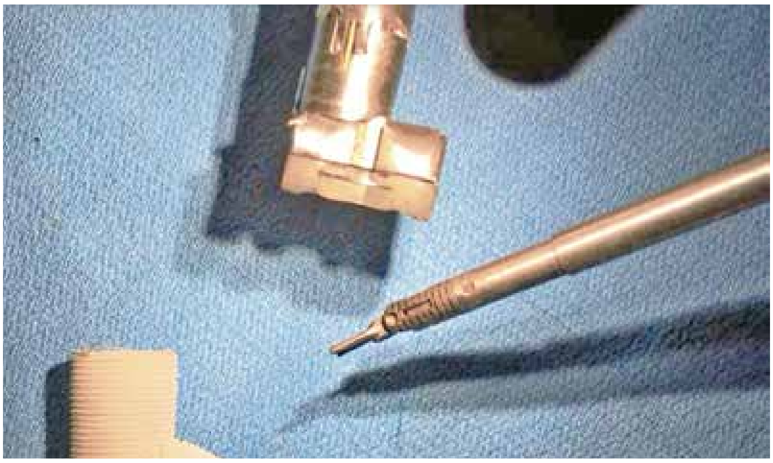
There is a mechanical lesson to be learnt when inserting 13 of the gears in a unit; they still needed “running in”, a few hours of turning the gears cause a surface effect similar to peening, the fine gear-teeth start with a textured surface (obviously) and eventually work between themselves to flatten each tooth surface through repetitive contact. This causes a much smoother running of the assembled gear-train which has a significant effect on the grip of the device needle.

These parts also have several other features on them that need to function with little or no post-production cleaning. The design of these features at that such a scale relies on the understanding of the machine capabilities, and in this case, some of these parts are designed around the laser beam width and particle size of the powder in use. Cutting away any support structures on parts of this size is very problematic so obviously overhang is an issue, all of the designs at this size have no overhang where the perpendicular difference between each layer is greater than half of the beam-width, preventing the need for support structures.

Although for initial prototypes material choice is not an issue, when moving further into trials and tests there needs to be a consideration of medical grade materials that have been approved for human contact both externally and internally, along with design considerations using AM that will allow for regulatory approval.

We know the SLM materials that we can use, there is ample evidence and AM implants are in common use. It is the SLA, Polyjet, Fused Deposition Modelling (FDM) or SLS materials that are of greater interest. There is still a very limited choice and also trepidation from regulators that understandably err on the side of caution. The development of the Sutrue range has so far allowed for the use of SLS parts, relying on their accuracy as opposed to their material properties, but fairly soon those parts will either

The small hand-held suturing device in planning (left) and ready for trials (right)



The assembled 7th robotic prototype (left) and in initial tests (right)

need to be constructed of approved materials that can print very accurately, reverting to SLM parts, or the more expensive option of molding parts in approved plastics. Medically-approved materials that can be used by standard FDM, Polyjet, SLM or SLA printers will move medical device development into a whole range of fields, allowing for limited patient trials under certain conditions and eventually into bespoke tools for complex surgery formed around individual patient scans.

Continued Development

In the meantime Sutrue will be moving into limited veterinary trials in the next couple of months, along with continued robotic tests that allow for final design tweaks before moving into more complex endoscopic and robotic trials. The ultimate aim is to prove efficacy over a range of needle and device sizes and prove that the AM components are more than good enough for continued trials and tests.

One of the advantages of using AM in creating a range of parts to test involves differing needle types. The drive rollers that sit within the gear mechanism of each device are also printed in a range of options and can be easily replaced or changed, allowing for different needle types of the same length to be tested for grip limits. This extends the number of devices, effectively, from 2 hand-held sizes, a robotic and an endoscopic to 5 hand-helds, 3 robotics and 3 endoscopics – all within a cost affordable to a small SME.

Our intention for longer term medical trials is to provide suitable professionals with a set of devices relating to their medical discipline. An initial 6-10 sets are planned and these will contain the relevant equipment tailored to each user. There are 6 main areas we hope to concentrate on: Endoscopy, Robotics, Veterinary, Dentistry, Surgery and General Medicine. We plan 2 fully functional units in the endoscopy and robotic sets and then a mix of small and large handheld devices along with a few handles and battery pods for the remaining packs. These sets need to be robust enough to get the knocks and forces not yet seen in our in-house, carefully monitored, trials to date, without our team standing by to fix issues that might arise (in other words as close to a finished product as possible).

This is another good example of the advantages of AM - limited or medium run manufacturing of detailed parts that function fully and can be used in a range of environments. Although the endo and robotic sets will have a limited run of a few, and we are only looking at 20 of each head and handle, the gears and rollers run to several hundred units as each head contains up to 25 parts. There are 3 different sizes of gears at the moment for the 3 sizes of heads (small hand-held, large hand-held and endoscopic/robotic) so we are looking at around 1,500 internal components - too large a number for machining, to small for mass manufacturing.

Material choice

One of the interesting results of using AM in a mechanical device is learning the extents that integrated materials can act upon each other before failure. The Sutrue device mechanism relies heavily on the accurate positioning of several gears within an active train each of which rotates both on the horizontal and vertical plane. These gears are SLM 316 steel but sit either within a part also SLM printed or in the case of the hand-held devices, within a plastic casing. Using SLS parts for the seating of these gears, combined with SLA for any parts not in contact with the gear train, means a reduction in cost from SLM to SLS, and another from SLS or Polyjet to SLA using an in-house machine (SLM are provided by Concept Laser and SLS parts are bureau printed). With new, SME-affordable SLS machines now coming onto the market Sutrue is likely to acquire one for both reduction in cost (eventually) and the increased speed of in-house development and print-to-assemble. An added bonus that some of the newer SLS materials look like they can achieve skin contact regulatory approval at the very least.

Finally we have to consider durability and reliability. The initial Sutrue devices were developed using accurate but delicate materials. Dropping the device, for example, would certainly result in shattered or broken SLA and SLS parts. As the intention is to begin with veterinary trials, it is anticipated that a few knocks and bangs are likely (suturing a horse in a field in the pouring rain, for example) and the hope is that trials have the least amount of interruption due to mechanical failures.

The final Sutrue trial devices are going to be produced using some different materials to the original prototypes: SLM for smaller casings, the internal components and the handles; SLS Nylon 12 for the hand-held casings; and SLA Durable (Formlabs) for the internal electronic carriages.

Training and regulation

Video footage taken during trials is going to be an essential tool for the regulatory process but also as a training tool (no-one knows the extent of the use of each device as yet) and those videos will be uploaded to the Sutrue website as often as possible. Of course (using AM) any new or more reliable materials or manufacturing techniques can be integrated into the device without compromising the trials plan, something that using SM would be much more difficult to do and Sutrue will continue to investigate the best combination of techniques to produce the most reliable devices.

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Alex Berry is Director of Sutrue. He has invented, developed and created the Sutrue device range. He has also completed the CAD work and design development.

SEE OBSERVATIONS P 34

LASER VS. ELECTRON BEAM WELDING IN SPACE APPLICATIONS

CHRIS ALLEN ET AL.*

Welded joints in satellites must be of consistently high quality, made with minimal distortion to meet tight dimensional requirements, and result in high performance structures up to the job of operating in the demanding environment of space.

Welded propellant flow control valves (FCVs), used to position satellites, are a prime example (Figure 1). In past years, quality anomalies in laser welded valves have occurred, jeopardising projects, qualifications and in some cases missions, resulting in substantial costs and delays.

Given these experiences, the European Space Agency (ESA) now favours electron beam (EB) welding in valves, over laser welding. Nevertheless, with the advent of new laser source options, ESA is currently re-evaluating laser welding, and has been working with TWI to develop and compare it to EB welding.

Work carried out

Comparative trials have been carried out on coupons, moving to representative demonstrators, comprising joints between 347 austenitic, 430 ferritic and/or 17-7 martensitic stainless steels. The welds required are commonly in thin sheet materials (t≤2 mm), to minimise weight, and only partially penetrating, to prevent thermal damage to sensitive components within the flow control valve structure.

The corresponding EB and laser weld qualities, microstructures and properties have then been analysed and compared, using inspections including radiography, metallography, hardness surveying, weld profile scanning, scanning acoustic microscopy (SAM), scanning electron microscopy (SEM), electron backscattered diffraction (EBSD) pattern analysis, and electron dispersive X-ray (EDX) analysis. Tensile strength tests have also been carried out on coupons and, at time of writing, work is in progress evaluating stress-corrosion cracking (SCC) tendency, fracture toughness (FT) and fatigue crack growth resistance (FCGR).

Results

Coupon work begun developing suitable laser and EB welding parameters for partial penetration joints with penetration depths ranging typically from s=0.2 mm (e.g. for attachment of membranes and diaphragm structures) to s=1.5 mm (e.g. for sealing of the valve body).

In the EB welding trials, these penetration depths were accomplished by adjusting the beam current of a 60 kV, 4 kW EB welding system, operating at a fixed welding speed. In the laser welding trials, a number of options were considered, including multi-kilowatt continuous wave (cw) fibre laser welding for the deeper welds (s≥0.7 mm), or sub-kilowatt and pulsed laser welding, as both available from a QCW fibre laser welding system, for the shallower welds (s≤0.7 mm). The multi-kilowatt cw laser welding was carried out over a range of different welding speeds, to alter the penetration depth achieved. In an approach more similar to EB welding, QCW laser welding was carried out at a fixed speed, but using different heat inputs. Beam probing indicated that the waist (diameter) of the electron beam was of the order of 100-200 µm, being slightly smaller than that of the multi-kilowatt cw laser beam (at d~275 µm), but larger than that of the sharply focused QCW beam (at d~60 µm).

Figure 2 shows example results from the EB system, as depths of penetration measured in melt run trials on stainless steel plate. Two of the penetration depths targeted (s=0.7 and s=1.5mm) could be met using beam currents of 6 and 12 mA, respectively, with the use of circular beam deflection to improve weld quality. At the welding speed used in the EB trials, these beams equated to available heat inputs of ~18 and ~37 J/mm, respectively. Welds could also be made without beam deflection, using ~2-4 mA less beam current for the same penetration depths.

Figure 3 shows example results from the multi-kilowatt cw laser welding system. The s=0.7 mm penetration depth could be achieved using a 1.5-2 kW beam, at 8.5-9.5 m/min, equating to an available heat input of ~9.5-14 J/mm. The s=1.5 mm penetration depth could be achieved using a 1.5 kW beam at a slower speed of 4.5-6 m/min (~15-20 J/mm). These heat input values were lower than that required by EB welding, as the laser beam was, although slightly defocused, not deflected circularly during welding. Nevertheless, this resulted in narrower welds with correspondingly stricter tolerances on beam:joint alignment.

Using the QCW laser system, the s=0.7 mm penetration depth could be achieved using a tightly focused cw beam, with an available heat input of only 5 J/mm. Using that same laser source but pulsed at 100 Hz, the s=0.7 mm penetration depth was achieved using overlapping 4 J pulses, with a higher available heat input of 25 J/mm.

Shallower penetration welds (down to s=0.2 mm) could be achieved using a lower power cw beam, or lower pulse energies, respectively, with that same system.

Using a pulsed laser welding approach for shallower (s≤0.7 mm) penetration welds was preferred to using a cw beam. Although of

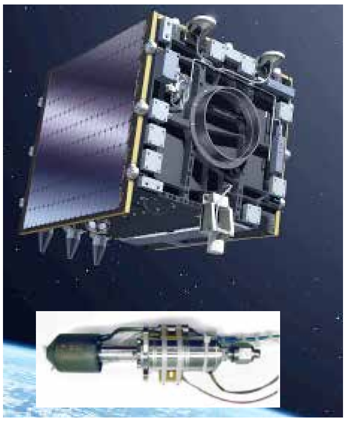

Figure 1: Artists impression of the Proba-V satellite (image courtesy of ESA), insert showing a Flow Control Valve (length ~100-150 mm).

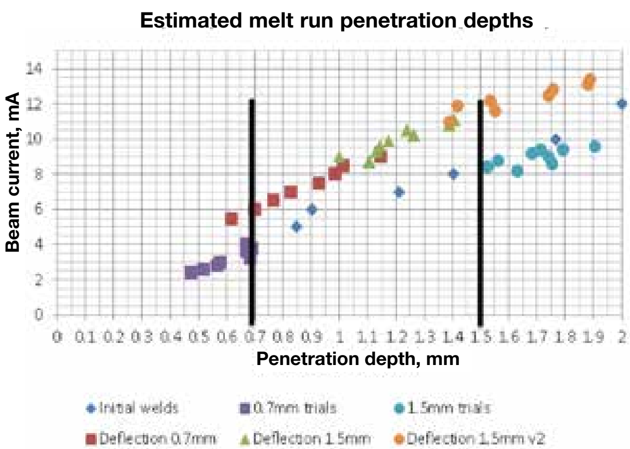

Figure 2: Example EB melt run penetration depths.

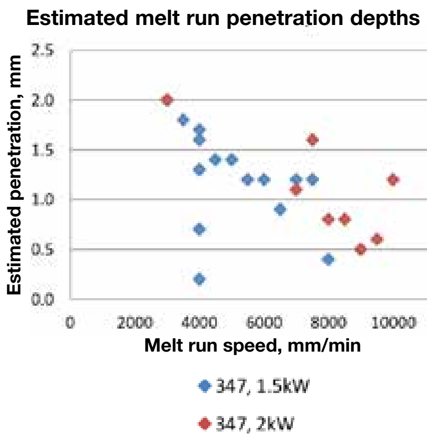

Figure 3: Example cw multi-kilowatt laser melt run penetration depths.

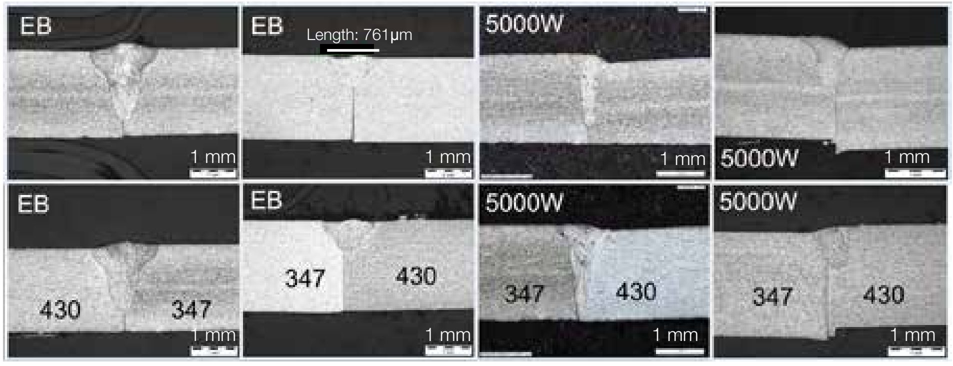

Figure 4: Example power beam butt welds in (top) 347-347 joints and (bottom) 430-347 joints, made using EB (left) or laser (right) systems, to penetration depths of either 0.7mm (EB or pulsed laser welding (QCW-p)) or 1.5mm (EB or multi-kilowatt cw laser welding).

higher heat input, slower speed pulsed welding resulted in a more practical, wider weld, with more beam:joint alignment tolerance and less risk of lack of fusion defects.

Figure 4 compares weld cross-sections from typical welds with penetration depths of 0.7 and 1.5 mm, made using the different power beam approaches.

In terms of the surface profile of these different welds, laser scanning indicated that both EB and laser welding resulted in weld caps with a small amount of undercut, but that this was <50 µm deep in all cases. Some isolated incidences of spatter were also detected with the laser welds.

In terms of internal weld qualities, only a few isolated pores ≤0.2 mm in diameter were detected in both the EB and laser welds, when nitrogen shielding the latter. These results were well within end-use requirements.

An extensive amount of SEM was carried out to characterise and compare the weld microstructures present, depending on the grades of stainless steel being welded together and the welding process used. For example, a columnar grain structure was observed in both EB and laser welds in 347-347 joints. EDX indicated that in these autogenous welds the bulk composition of the weld metal was the same at that of the parent 347, EBSD indicating that it remained austenitic. More interesting microstructures were observed in the mixed 347-430 weld metals. In both EB and laser welds the bulk weld metal composition appeared intermediate between that of the two parent materials. EBSD revealed this as being sufficient to render the weld metal ferritic (Figure 5), i.e. as the 430. In addition, unidentified Ni-enriched phases were observed to decorate selected grain boundaries, nearer to the 430 side of the joint. Figure 6 shows an example of such phases.

In terms of the mechanical properties of the welded coupons, cross-weld hardness surveying indicated some heat affected zone (HAZ) softening in 347-347 EB welds. This was absent in the corresponding laser welds, perhaps owing to the lower heat inputs used. Conversely, hardness surveying indicated some weld metal hardening across both EB and laser welds made between 347 and 430, perhaps in part related to the presence of the Ni-enriched grain boundary phases.

The cross-weld tensile strengths of the EB and laser welds were correspondingly similar. As an example, both sets of welds in 347-347 joints had yield stresses of ~300-350 MPa, and ultimate tensile stresses of ~600-700 MPa. At time of writing, further weld property tests are in progress, including SCC, FT and FCGR testing.

Given the similarity of results achieved to date with both EB and laser welding, comparative demonstrator FCV structures were then welded using both processes. As the joints involved in these demonstrators required penetration depths of typically 0.8 mm, either EB or pulsed QCW laser welding was used. Figure 7 shows examples of the demonstrators made. These demonstrators are also currently undergoing a comparative set of non-destructive and destructive inspections, as well as pressurised proof testing and burst testing to failure.

Conclusions

The work to date has demonstrated that, with correct development, modern laser systems are capable of producing shallow partial penetration welds suitable for satellite FCV manufacture, and with qualities and with strengths comparable with EB welds.

Further detailed testing of coupons and representative demonstrators will provide valuable information on the fitness for purpose of these laser welds, including information on their resistance to stress corrosion cracking, fracture, fatigue cracking and pressurisation. This suite of information should, going forwards, help the designers and manufacturers of satellite systems have a better understanding of where new laser technologies can once again be used in fabrications.

Acknowledgment

TWI would like to thank the European Space Agency for supporting this work, and Airbus Safran Launchers for its ongoing collaboration in this area.

*** Chris Allen (TWI), Tim Mitchell (TWI) & Andrew Norman (European Space Agency)**

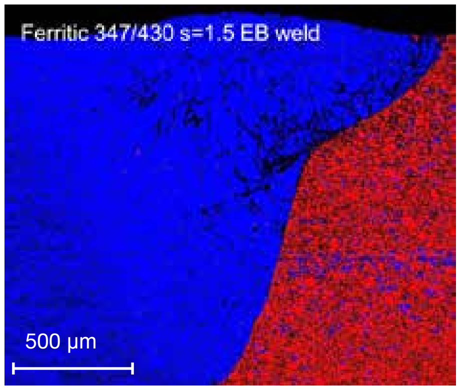

Figure 5: EBSD colour map of phases across an EB weld made between austenitic 347 (in red) and ferritic 430 (blue), resulting in a ferritic weld metal.

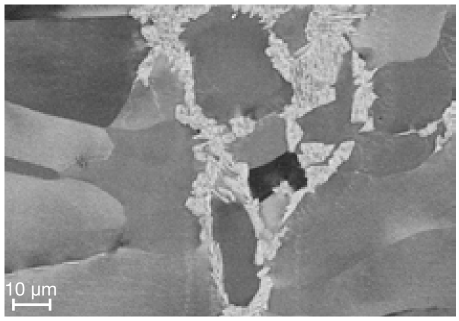

Figure 6: Scanning electron micrograph of grains decorated with unidentified Ni-rich phases in a mixed 347/430 power beam weld metal.

Figure 7: FCV demonstrators: top, EB welded, bottom, laser welded.

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SEE OBSERVATIONS P34

EXPERT LASER SYSTEM: PRACTICAL APPLICATION FOR KEYHOLE WELDING

SÓNIA MECO

Laser processing is currently highly dependent on user knowledge and experience to choose correct parameters to obtain a reliable and high quality joints. Alternatively for every new application or different laser system a new process development is required. This is the reason that laser processing is often called as 'black art' which limits the exploitation of laser based production process in industry. The development of the Expert Laser System (ELS) for keyhole CW laser welding greatly simplifies the selection of laser welding parameters.

The ELS contains the power factor model, which enables achievement of a particular penetration depth with variable beam diameter, and a Graphical User Interface (GUI) for easier utilisation of the model. The user only needs to set the quality requirements for the laser process and the joint (i.e. productivity, fit-up tolerance, penetration depth etc.) and the ELS specifies the optimum welding parameters from these requirements. This means that the process parameters are selected based on quality requirements, rather than on system requirements. Using the power factor and on-board database the ELS is capable of adjusting the welding parameters according to the current status of the optical system. The user requirements can be easily transferred from one laser system to any other with minimal process development. Furthermore for a new application the user just inputs the new requirements and the ELS will update the welding process without extensive process development To prove the viability of the ELS, the power factor concept was extended to a wider range of group of metals such as mild steel, aluminium and titanium for different material thicknesses, beam diameters and joint configurations. The ELS can potentially be integrated into the control system of a commercial laser system or into an online monitoring system to guarantee consistent welds.

What is the power factor model?

For a non-expert user or in the case of using a new optical set-up it is often difficult to select the right processing parameters to achieve a required weld depth and quality. The challenge is exacerbated in the cases where the optical set-up changes over time due to degradation of optics or with multiple systems working simultaneously. The traditional parametric approach to determine the correct welding parameters is costly, time consuming and wasteful and it is unique to a particular system. The power factor model was developed for CW keyhole laser welding to overcome all these issues. The power factor is a phenomenological model which enables achievement of a particular weld profile (depth and width) independent of the laser beam diameter [1].

The investigation of laser material interaction showed that the same weld depth and width can be produced with different combinations of laser power and travel speed. In addition, for a constant combination of laser power and travel speed, the weld depth will vary if the beam diameter varies. This means that there are a multitude of parameters to consider when developing a laser process

Unlike the system parameters (laser power and travel speed), which are specific to a particular system, the fundamental laser material interaction parameters (power density, interaction time and specific point energy) characterise the response of the material to the laser energy and because they take into account the beam diameter the process is specified more uniquely. The depth of penetration in keyhole regime is controlled by the power density and specific point energy and the interaction time controls the weld width. It was found that under certain conditions this can be simplified and the weld depth is proportional to the interaction time and ratio of the laser power to the beam diameter. It was shown that when the beam diameter was varied at constant interaction time and power factor the weld depth remained constant.

The empirical data for the power factor model are shown in Figure 1, which is based on several welding experiments. The graph shows the correlation between the power factor, interaction time and the penetration depth (PD). The model combines three system parameters into two and it is shown that there are infinite number of combinations of power factor and interaction time for any weld depth, but every combination results in different weld profile and quality, i.e longer interaction time usually results in wider welds and smoother beads.

To prove the robustness of the power factor model several tests were carried out under different welding conditions.

Application of the PF model to a wide range of beam diameters

One of the benefits of using the power factor model is the transferability of the results between laser systems with different optical set-ups. If a particular combination of power factor and interaction time is used to produce a weld using a Laser A then the same weld should be possible to achieve on a Laser B, just by calculating the required power and travel speed to achieve the same power factor and interaction time for a given beam diameter.

Several experiments were carried out to prove that the weld depth was independent of the laser beam diameter when the power factor and interaction time were both constant. In these experiments the power and travel speed were continuously adjusted as according to the beam diameter in order to keep the power factor and interaction time constant. Figure 2

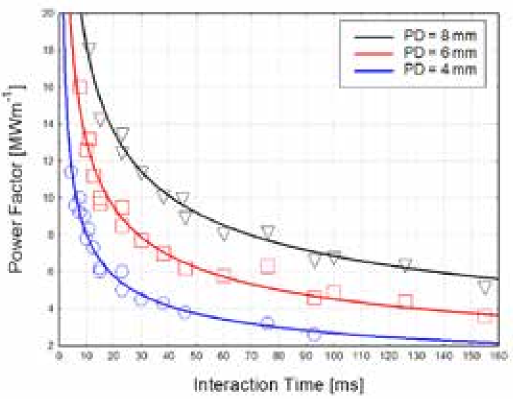

Figure 1: Power factor model for CW keyhole laser welding [2]

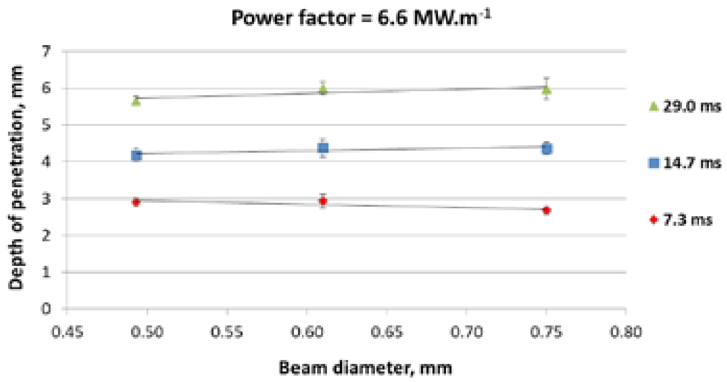

Figure 2: Effect of the laser beam diameter on the weld depth of penetration for constant power factor and different levels of interaction time

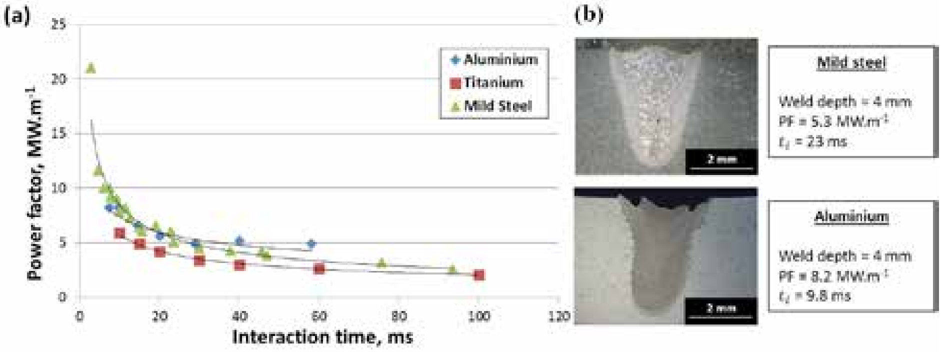

Figure 3: (a) Power factor model applied to different types of metal: Mild steel, aluminium and titanium. (b) Cross-sections of the 4 mm deep welds in mild steel and aluminium

shows that the weld depth remains constant when the beam diameter changes. As the power factor is constant (6.6 MW.m-1), the weld depth increases only when the interaction time increases.

The power factor model was tested and validated for a wide range of beam diameters between 180-780 µm. Within this range the weld depth remained constant.

Application of the PF model to different metals

The power factor model was tested for different group of metals. Keyhole welds were produced in mild steel, aluminium and titanium and compared (see Figure 3). Even though the physical properties of the three metals are very different the three curves follow similar trend and there is a small offset between the materials.

This is an important finding because it shows that a generic model can be used to determine the welding parameters for a particular material thickness. Figure 3b shows the cross-sections of the welds produced in mild steel and aluminium substrate and shows high similarity.

Application of the PF model to different joint configurations

The power factor model was developed for butt welding however, the majority of the welding applications require joining in other joint configurations, such as lap-joint or partially penetrated welds. In order to assess whether the power factor model could be used in other joint configurations, the same welding parameters were compared for bead-on-plate, butt and in lap-joint configuration. The material thickness in both joint configurations was equivalent, i.e. 4 mm thick steel used in bead on plate configuration and two steel sheets, 2 mm thick each in lap joint configuration. The cross-sections of the welds produced in bead-on-plate and lap-joint configurations are very similar.

The results suggest that within the experimental range the thermal distribution across the material in both joint configurations is similar despite of the interface between the sheets in the lap-joint configuration.

What is the Expert Laser System?

The Expert Laser System (ELS) is a graphical user interface with the power factor model integrated designed to help the laser user to choose the welding parameters for a required application (Figure 4). The laser user must follow the following steps:

1. Select material: The graphical user interface contains a selection of group of materials that the laser user can choose, including mild steel, aluminium and titanium.
2. Specify weld depth: The weld depth is usually the most important feature of the weld. Depending on the material thickness, deeper or shallower welds could be required. Moreover, depending on the application a partial or fully penetrating weld can be required.
3. Specify laser beam diameter: Different laser systems have different optical configurations and therefore, the laser beam diameter varies.
4. Specify the operating limit of the system (laser power, processing speed) or weld quality (interaction time): Depending on the processing restrictions (maximum output laser power or maximum speed of the motion system) the user will select laser power or travel speed and insert a corresponding value. Alternatively the user can fix the interaction time having in mind that a longer interaction time produces welds with higher quality and better fit-up tolerance whereas processing with shorter interaction time offers higher productivity and narrower welds due to higher processing speed.
5. Press calculate: The ELS will calculate the processing speed (if the user chose laser power) and laser power (if the user chose processing speed or interaction time) needed to achieve a particular weld beam for a particular beam diameter.
6. Observe the results: The ELS will display both the system parameters and the fundamental parameters.

What are the main benefits of the Expert Laser System?

- Determine the laser parameters based on the user requirements (productivity, fit-up tolerance, penetration depth etc.);
- Transferability of the results between laser systems with different laser beam diameters;
- Can be applied to multiple metals;
- Can be applied to bead on plate and lap joint configurations;
- Can potentially be integrated into the laser control system or into process monitoring.

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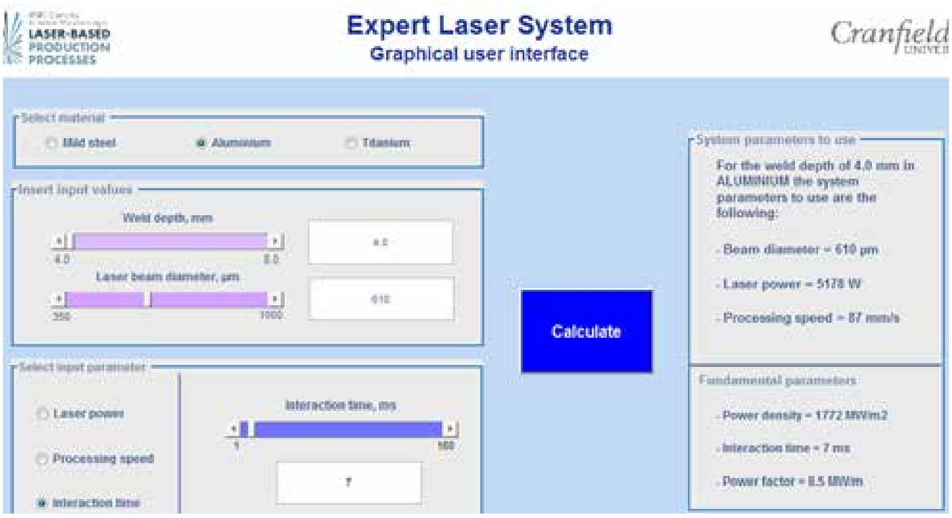

Figure 4: Expert Laser System

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SEE OBSERVATIONS P35

LASER PROCESSING AND TESTING OF AEROSPACE THERMOCOUPLES

NEAL CROXFORD

When a major manufacturer of aerospace-grade thermocouple assemblies first contacted us with a problem, they had little or no experience with the use of industrial lasers in manufacturing and were sceptical of lasers' practical application. Two years on we are introducing diverse laser applications into their production cycle and they are coming to us to solve what they thought were unresolvable bottlenecks and inefficiencies in their production processes.

The thermocouples consist of a number of thin delicate wires contained in an aerospace-metal sheath of around 1.5-2.0 mm external diameter. The wires are insulated from each other and from the sheath by a densified ceramic powder. The thermocouple assemblies are fitted in jet engines to monitor part and gas temperatures, and so are subjected to extreme temperatures for prolonged periods and must provide accurate data for their entire working life.

Problems with traditional testing methods

The production cycle involves hundreds of different processes and at several points in the cycle the thermocouples need to be tested or calibrated. To achieve this, connections have to be made to the wires which have to be exposed from inside the hard metal sheath. The traditional method of exposing the wires is to use a modified lathe to 'turn' about 10 mm away from the end of the metal sheath, exposing the ceramic insulator. The ceramic can then be broken up to expose the thermocouple wires. However this process is difficult and prone to failure for a number of reasons:-

- The thermocouples can be up to 2.5 m in length and only 1.5-2.0 mm in diameter, so rotating them is difficult and the process has to be done slowly and carefully. In the later stages of the production cycle the sheath can be formed into complex shapes and fitted with various mounting features which have to be supported securely to allow the assemble to be rotated by the lathe.
- The metal sheath is constructed of high-temperature aerospace alloy and consequently is tough so the cutting forces are high. Conversely the wall thickness of the tube is very thin and the application of high forces would distort the tube or bend it away from the cutting tool.
- Even when the cutting process has been successfully initiated, the alloys from which the sheaths are constructed typically do not self-chip during the turning process, resulting in the production of a continuous spiral of swarf from the cutting point. This swarf must be controlled to prevent it wrapping itself around the now exposed delicate wires which would cause them to break off.
- Being a contact process, the lathe tool also extrudes the metal away from the cutting tip creating an inward facing burr on the cut edge. As part of the qualification of the thermocouple assembly it has to pass a high voltage insulation test, showing that there is no conduction from the sheath to the wires. An inward facing burr acts as a corona initiation point allowing the high voltage to jump from the sheath onto the wire, resulting in the thermocouple being rejected. Any debris from the turning process will also create a conduction path between the wires and the sheath.

Laser processing provides solutions

We have developed a laser cutting process which resolves all of these failure issues, greatly reducing the rejection rate of the process.

Laser cutting is a contactless process so there are no forces on the sheath to distort it, reducing problems with setup and increasing the consistency of the process.

The densified ceramic strongly adheres to both the internal bore of the sheath and to the wires so it is not possible to simply make a circumferential cut and pull the sheath off like you would in wire stripping. Firstly a number of longitudinal cuts are made from the cut end of the sheath to the point where the circumferential cut will be made. These cuts must completely penetrate the metal sheath but must not cut into the ceramic insulator to a point where the wires are exposed. Also the risk of polluting the ceramic with metallic debris or re-condensed metal vapour must be minimised to ensure the later insulation tests are not compromised (Figure 1).

Figure 1: Longitudinal cut of sheath.

A nanosecond pulsed fibre laser with galvo beam delivery system was selected to remove the sheath using many thousands of small hits of the laser, each creating a high energy vapour ejection, minimising debris and re-solidification, localised heat build-up and thus producing a clean cut.

Following longitudinal cutting a circumferential cut is made (Figure 2). The circumferential cut must be carefully aligned with respect to the longitudinal ones to ensure it completely penetrates the sheath but there is no evidence of the longitudinal cuts in the final product because any 'castellations' on the cut end would again act as initiation points for corona in the high voltage insulation test.

The circumferential cut is carried out in multiple stages so the final cut edge is dross free and is radiused, removing any possibility of corona initiation sites, and finally a cleaning pass is made to remove any loose debris, ceramic or redeposited metal vapour (Figure 3).

Figure 2: Clean cuts through to ceramic.

Figure 3: Cleaned up cut edge showing exposed wire ends.

To simplify the customer's production process, instead of rotating the thermocouple we have developed a beam delivery system which precesses around the stationary thermocouple assembly. The galvo system creates the rapid motion required for the cutting, milling and cleaning processes, the beam delivery moves around the sheath to access each side for the longitudinal cuts and to create the circumferential cut. The customer simply inserts the sheath to be stripped into our Class 1 enclosure to a pre-set end-stop, selects the type of sheath to be stripped and presses the process start switch, the rest of the cycle is fully automated.

Our job was not yet finished. Even with the longitudinal cuts, the sections of cut sheath still adhere strongly to the wires because of the ceramic insulator. The cut parts can be removed by simply applying pressure with a pair of pliers or a vice but this has a risk of breaking the wires. So we developed an ultrasonic process to break-up the ceramic on the stripped section, freeing the wires from the cut sheath and the ceramic (Figure 4).

Figure 4: Ultrasonic breakup of ceramic

Leaving the sheath and ceramic in place after the cutting process is actually desirable as it protects the wires until just before they need to be exposed to be connected to the test equipment or be integrated into the final assembly. Therefore the ultrasonic stripper was provided as a separate machine to be placed at the point of use. Despite the fact that the stripping system was outside of our requirement as a 'laser machine' supplier, this final piece in the process acted as the enabler for our customer to be able to introduce the laser process into their production cycle.

Thermal calibration with a laser

One of the processes for which the wires have to be exposed is to find the exact point inside the metal sheath where the thermocouple wires are joined together.

The junction between the wires is the only point at which the thermocouple will measure temperature. However due to the complex manufacturing process of the thermocouple assembly, the exact point at which the wires are joined is lost, with a potential error of tens of mm. In the final thermocouple assembly the region in which the temperature needs to be monitored can often be only 2-3 mm wide and ideally the point of best response needs to be positioned in the assembly to better than 0.5 mm. The current process to find the best response position is to mark the sheath of the thermocouple every 2 mm with a pen and then manually apply a flame at the marked points for a fixed time, recording the response from the thermocouple, before cooling with compressed air and moving to the next mark. This process is prone to significant errors and inconsistencies however. The width of the flame is large compared with the required resolution of the test, the positioning of the flame is by eye of the operator, the heating time is inconsistent and the response is manually recorded, potentially introducing recording and transposition errors.

The customer asked if it was possible to improve the accuracy and consistency of the process as well as automate it to improve throughput and traceability.

After conducting trials we demonstrated that we could focus the output of a fibre delivered diode laser onto precise points on the thermocouple, heating that point to 200-500 ˚C in 1-2 seconds. The focusing assembly from at the output end of the fibre is translated along the length of the thermocouple with a linear slide and motor drive system. Using compressed air the thermocouple can be cooled within a few seconds and another reading taken. We demonstrated that the thermocouple's response characteristics could be measured and recorded with a resolution of better than 0.25 mm.

Accuracy and traceability

Once we had demonstrated that we could exceed the customer's requirements we developed and agreed a specification for a fully automated test system.

On the system, the part is loaded and the thermocouple wires connected. The system then checks the thermocouple is correctly in place, the wires have been connected and the workstation doors are properly closed. The type of thermocouple to be tested is then selected from a custom Windows program and the number of parts in the batch to be tested entered. The system them moves the focus of the laser in steps as small as 0.1 mm along the length of the thermocouple taking and recording temperature readings. Once the thermocouple has been scanned the software displays the results in the form of a graph of temperature

Figure 5: Junction position mark

Figure 6: Spoil cut through to ceramic

vs. position, selects the highest peaks in the data, displays these and indicates which it believes to be the best response point. It also checks that the best peak found falls within the acceptable temperature and position range for that type of thermocouple being tested. If the operator accepts the results, the system then changes the focusing optics on the diode laser to produce a smaller spot, moves the focus to the position of peak response and then uses the small laser spot to put a mark on the sheath at the position of best response (Figure 5).

If the software finds that the thermocouple has failed the test and the operator confirms this, the system then uses the small laser focus spot to drill a hole in the sheath, giving a visual indication that the thermocouple has failed and also exposing the ceramic inside the sheath so that the thermocouple will fail a later insulation test, so ensuring the defect device cannot get into the production cycle (Figure 6).

The software collects all of the test data and stores it in a SQL database providing calibration documentation for all the parts.

Satisfied customer

After exhaustive testing of the system the customer has since ordered a number of identical systems for use at its manufacturing plants around the world.

Contact: Neal Croxford
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Neal Croxford is a director of DeBe Lasers Ltd. who design and build standard and custom industrial laser systems and sub-assemblies, lasers and bespoke laser delivery solutions.

SEE OBSERVATIONS P35

OBSERVATIONS

IMPROVING METAL CUTTING OF HIGHLY REFLECTIVE MATERIALS

Christian Keller

Christian Keller's article provides a good description of the benefit of fibre lasers and the in-built sensors that most, if not all, fibre lasers have to protect the source from damaging back reflections. Using the output of the IR reflection detector as an input for a pierce detection module is a valid approach for reflective materials where the change in signal level at pierce is very pronounced.

Probably because pierce times are more of an issue on thick metals (typically not the highly reflective materials), laser cutting head manufacturers have frequently opted to use a visible-light detector, rather than IR detector, as a choice for giving better visibility into the plume. Cutting heads that are specifically optimised for fibre lasers, such as the IPG FCL-D30MP offer this visible light detection (even though the IR reflectance signal is available from the laser), because of the high-quality performance in both reflecting and non-reflecting applications, providing the cutting system versatility that many fabricators demand.

John Bickley, IPG Photonics Corp.

Q-SWITCH LASER SURFACE REFURBISHMENT OF SEA VESSELS

Ioannis Metsios

Laser cleaning is a very prominent application at the moment. It has also become very much an engineering application compared to the days when I was first introduced to it by Bill Steen and Ken Watkins in Liverpool, with an emphasis on conservation applications.

Ioannis presents an interesting insight in to the potential of using the much higher power DPSS lasers for the removal of paint and rust and with target applications in the maritime industry and recognising the scale of the problem in the size of ships, but also demonstrating that the use of lasers in this application can now be considered seriously.

I think the insight into the two different processes of paint and rust removal is very informative and the inclusion of some real removal rates is very helpful.

The development of large area coverage rate surface treatment applications is an important area of development in laser material processing. This article shows that the use of Powerlase's unique high power laser products is certainly one important approach that can lead to successful outcomes.

Martin Sharp, Liverpool John Moores University

AM FOR MEDICAL PROTOTYPING - BREAKING NEW GROUND

Alex Berry

The article by Alex Berry is not about lasers but about the use of machines that use lasers, from an end user perspective. As a more general article on using additive manufacturing (AM) in medical device development, rather than specific laser parameter development, it nonetheless raises some issues for further thought.

As I work a lot in medical devices I have seen an increase in the both the use of 3D printers and in questions about 3D printers. The issues that Alex discusses are certainly relevant around the usage of additive manufacturing in the medical sector. From my experience, the two problems associated with AM in medical device prototyping are accuracy and transferability to market.

In terms of accuracy, AM is normally not sufficiently accurate or repeatable for fine medical device manufacturing. Most medical devices have very tight tolerances, which is in part due to the highly regulated nature of the business and also because the devices tend to have lots of miniature component in close proximity. The tolerances need to be tight to prevent failure. AM, in my experience, has not yet reached this level of precision.

Transferability relates to the process of turning a prototype into a product, with associated technical file and CE approval. With AM the designer is forced down particular routes in terms of materials, which may not be the best materials for the end use. Therefore, the prototype only really demonstrates functionality, and that functionality is limited by processing accuracy. A kind of vicious circle in any product development, where engineering time is spent on overcoming problems associated with the production methods and not focused on the end product.

Medical device development is expensive because it needs to be done properly. 3D printing is a low cost method to build things, and although good for bench testing and making functional prototypes , I am not yet convinced if it is cost effective over the long term when moving into animal trials and onto CE marking.

David Gillen, Blueacre Technology

LASER VS. ELECTRON BEAM WELDING IN SPACE APPLICATIONS

Chris Allen et al.

This is a timely article on laser vs. electron beam welding because both space and aerospace industries are exploring alternatives to electron beam (EB) welding. Currently EB welding is the most widespread technique for welding a range of similar and dissimilar materials, however a new generation of laser sources (fibre & disk) with high powers coupled with an excellent beam quality can be a convenient alternative for welding complex shapes and a range of different types of materials. These laser sources with high power densities are capable of producing a deeply penetrating weld pool allowing a through thickness weld to be made rapidly and accurately in a single pass without the presence of vacuum, which meets the stringent quality requirements.

The work reported in this article shows that there was no difference in the weld quality in terms of crack or weld porosity, however the surface appearance of the resultant welds was slightly different, i.e. QCW fibre laser weld exhibited spatter. With pulsed laser welding, detailed laser parameter optimisation is necessary to produce welds with reduced spatter and undercut. For this work a low power CW laser would have been a better option. Both the weld quality and weld profile, as well as depth, can be tailored by modulated output. Maybe further welding work should include these tests.

Mohammed Naeem, Prima Power Laserdyne

Very interesting article, we can expect more space applications emerging in the future. Both laser welding and EB welding give enormous freedom due to their independent control of energy in spatial and temporal domains. As demonstrated by the authors the energy can be delivered to the workpiece by many different ways, i.e. in pulse or CW regime, with different spot diameters and energy profiles. In my view, it should be possible to achieve exactly the same weld profiles regardless of the heat source if we can provide the same conditions. In that sense, we should be able to use our understanding of laser-matter interaction to tailor the heat source in order to achieve the desired weld joints. Unavoidably, the EB welding is the preferred choice in many industry sectors over lasers because this technology is available with high power capability for longer, which led to development of standards and know-how. However, considering the complexity of EB welding and all the ancillary equipment required, the laser technology will hopefully catch up soon.

Wojciech Suder, Cranfield University

There is a lot of interesting information contained here and Chris's enthusiasm is apparent.

Parameter comparisons aside, the overview of the mechanical testing indicates a sound equivalency between EB and laser welding even if the micro sections are less conclusive. It is also positive to see that modern lasers are a capable tool for this job. However I'm left asking why this became an EB application in the first place? What was the issue for laser welding? I think this context is a vital part of the story.

In terms of the capability to manipulate the resultant weld bead, lamp-pumped pulsed YAG laser systems (naming no names) still offer far more control than the QCW systems as used for these experiments (but at a cost), and yet they were deemed incapable for what should have been a showcase application.

This suggests that either a) the application was improperly developed, or b) there is something else fundamental about the resultant weld that hasn't been uncovered/discussed yet; and I'd really like to find out which of these it is, and why.

I hope Chris and his team can publish further updates for as long as this programme of work continues because he has really piqued my interest.

Nicholas Blundell, MTC

EXPERT LASER SYSTEM: PRACTICAL APPLICATION FOR KEYHOLE WELDING

Sónia Meco

I found Sónia Meco's article very interesting – it is always satisfying to see a useful model that works. This sort of expert laser system should be useful for application engineers and students who want to examine the effects of varying the parameters on the finished weld. It would be very interesting to know the limitations of the model – for example at what beam diameter for a given power do the results stop being accurate? Keep up the good work.

John Powell, Laser Expertise

LASER PROCESSING AND TESTING OF AEROSPACE THERMOCOUPLES

Neal Croxford

This is an excellent example from Neal showing how a small company can make transformative changes to major companies' outdated manufacturing methods. The problems and solutions are succinctly outlined and it is clear that Neal's decades of laser experience has been brought to bear along with some innovative concepts such as the means of eliminating the need to rotate long, thin parts (this element will have broader application – more detail in another paper perhaps?) and use of non-laser technologies (gasp!) such as ultrasonics.

On a commercial level, Neal has found a way to fund basic R&D necessary for the solution which can be a challenge for a smaller company. Perhaps the end-user deserves credit for the way they commercially structured working with DeBe. From a laser perspective both the heating and the cutting solutions rely upon on laser characteristics totally, even though the laser components themselves may only represent perhaps 10-20% of the solution value. This is commonly the case and can mean that such projects are not attractive to companies specialising mainly in laser solutions. There is a shortage of capacity to take on this sort of work in the private sector in the UK but it is good to see such success stories being published; more please!

Andrew May, Coherent ROFIN

LASER PRECISION MICROFABRICATION (LPM 2018)

The 19th International Symposium on Laser Precision Microfabrication is to be held in June 2018 at Edinburgh Conference Centre. 2018 will be the first time that this global Symposium has visited the UK and AILU will be running the event alongside the Centre for Innovative Manufacturing in Laser-based production processes. Hosting this symposium will enhance the co-operation between AILU and the JLPS (Japan Laser Processing Society) and will attract around 300 visitors to the event.

During the four day event, there will be multiple sessions on topics from micro laser joining, through surface engineering and laser ablation, drilling, cutting and micro fabrication. The latest developments in ultra-short pulsed laser processing, systems, ancillaries and applications will be presented and there will be more than 130 speakers with a parallel two day exhibition and a poster session to expand the reach of the event to a wider audience and to improve networking opportunities.

Researchers, manufacturers, end users and suppliers are invited to attend – contact the AILU office to express interest in opportunities for presentation, sponsorship or exhibition stands. This is a one-off opportunity to experience this event in the UK, so make sure to reserve the dates in your diary now.

LPM 2018 gives delegates and exhibitors an excellent opportunity to visit Edinburgh and experience the local atmosphere, including golf, whisky, fine dining and breath-taking scenery. A sumptuous banquet will be held at the impressive Grand Gallery of the National Museum of Scotland in the heart of the city centre. During the next few weeks more information will become available on the event website.

LASER PRECISION MICROFABRICATION EDINBURGH 2018

www.lpm2018.org

TRADE ASSOCIATIONS... WHY JOIN?

Derrick Jepson, Sales Manager at Aerotech Ltd, highlights some of the benefits of belonging to a Trade Association.

I must admit, this was a question I used to ask myself all the time when constantly being bombarded about this or that trade association, and this was before social media really took off. Nowadays, there are even fewer places to hide from questions like this.

Searching these terms in any internet browser will return a veritable smorgasbord of information, so what I would like to do is share my experiences with trade associations, the benefits of joining and continuing to support them and what you should get back, remembering that old adage ‘you only get back what you put in’.

Firstly, like any sales pitch you have ever read, I will start with a list of reasons for joining:

1. **Tap into a knowledge base**. First and foremost, there could be someone somewhere in your trade association who can help you with market knowledge, answers to vexing technical problems or advice on export controls etc.
2. **Advocacy**. Your trade association represents your industry/market sector on a national and sometimes international level.
3. **Networking**. Sounds obvious, but, trade association events offer you an opportunity to connect and transact with others in your industry, as well as create alliances or partnerships.
4. **Market Research**. Trade associations conduct market research and analysis on their industry sector. Sharing information and resources benefits the whole association and membership.
5. **Enhance your reputation**. Trade associations, through self-regulation, help to stamp out bad practice and purveyors of bad or sub-standard practices.

Secondly, to illustrate a point, you can’t beat a good quote:

"*An investment in knowledge pays the best interest*" Benjamin Franklin.

Thirdly, how about some stats:

- How many trade associations are there in the UK? Albeit this data is a little old, but, at last count there were upwards of 3500 Trade Associations in the UK.
- Who won ‘Trade Association of the Year 2017’? That would be the BCF, the British Coatings Federation.

- What is the current membership of AILU? This currently sits at circa 275 members with the split being 38% manufacturers and suppliers of laser-related products and services, 22% end-users including laser Job Shops, and 30% research organisations.

The reality is that any industry group NEEDS a Trade Association and the Trade Association NEEDS its membership, rather like a symbiotic relationship, one cannot survive without the other.

AILU is a case in point. The organisation was founded in 1995 with a number of objectives. The first two, as listed in the Articles of Association, are to:

1. Foster co-operation and collaboration on non-competitive technical matters and provide a forum and mechanisms for sharing experience and expertise.
2. Represent and promote the interests of industrial laser users and particularly those practising in the United Kingdom.

I don’t need to continue, even the first two items in the Articles of Association match with the bulleted list above.

Another point to mention is the very active Job Shop Special Interest Group, designed to provide a forum for members with like interests.

I will leave you with this simple message: get involved and work with your Trade Association so that it, in turn, can get involved and work with, as well as for, you.

Contact: Derrick Jepson
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www.aerotech.com

WOULD YOU LIKE TO WRITE FOR ‘THE LASER USER’?

We are looking for new content to make The Laser User more interesting, relevant and entertaining to read.

If you would be interested in contributing to the magazine, we would love to have your input and we will do our best to use your words and high resolution images.

To submit content contact
cath@ailu.org.uk

We need:

- Press releases
- Personnel & business news
- Technical articles
- Observations
- Anecdotes
- Case studies
- Interviews
- Application guides
- Tips and tricks

AILU WORKSHOP

Presentations, Exhibition, Networking

LASER CLEANING

13 SEPTEMBER 2017

FANUC, Ansty Park, Coventry

Programme

08:45 Registration, refreshments, exhibition

09:30 Introduction

09:40 - 11:00 Session 1

Laser cleaning - from university laboratory to industry production floor	*Lin Li, University of Manchester*
High-speed paint stripping in the railway industry	*Eamonn Fearon, ALT Lasers*
Laser clean - the light way	*Stan Wilford, IPG Photonics*
Clean surfaces - a need for further production steps	*Peter Kallage, Coherent ROFIN, Germany*

11:00 - 11.30 Refreshments & exhibition

11:30 - 12:50 Session 2

Laser cleaning of aerospace components	*TBC, Rolls Royce Aerospace*
Laser cleaning of industrial components	*Leo Sexton, Laser Age*
Faster removal of corrosion and coatings	*DeChang Dai, Andritz Powerlase*
Laser cleaning with ns pulsed fibre lasers – the effect of beam mode and power	*Louise Partridge, SPI Lasers*

12:50 - 13:50 Lunch & exhibition

13:50 - 15:10 Session 3

Cleaning of composite made moulds in the aerospace industry	*Zheng Kuang, ALT Lasers*
Laser cleaning as an alternative to media blasting in building maintenance	*David Gillen, Blueacre Technology*
Safety implications of laser cleaning	*David Lawton, Lasermet*
Robotics and Automation for use in laser cleaning applications	*TBC, FANUC*

15:10 - 15:40 Refreshments

15:40 Tour

16:40 Departure

For more information go to www.ailu.org.uk/events

AILU WORKSHOP

Presentations, Exhibition, Networking

LASER MANUFACTURING OF LIGHTWEIGHT STRUCTURES

23 NOVEMBER 2017

Warwick University

For more information go to www.ailu.org.uk/events

A FUNNY THING...

HOT STUFF...

The issue of safety around lasers is a constant topic of conversation and discussion. Dealing with invisible radiation leads to some understandable issues about eye safety and skin safety, but there is sometimes an apparent disconnect between the risk from a laser and the other risks we face in everyday life. Even when dealing with lasers there are many other hazards than the laser beam itself (fumes, electric shock, mechanical injury). Perhaps the most dangerous aspect of a laser is the risk of it falling on you (serious damage or death can occur!) – once I heard of a colleague who put himself between a (heavy) laser and the ground – nearly resulting in serious injury or worse. No warning sticker or risk assessment was able to prevent that accident from happening.

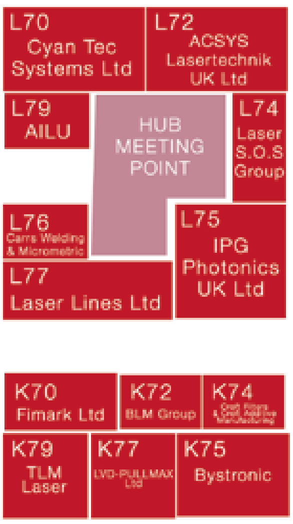
On one occasion I submitted a Risk Assessment before bringing a manual laser welder to an event at a large organisation (who shall remain nameless to avoid embarrassment), and this prompted an exchange of emails and phone calls since the plan was to allow delegates at the event to try laser welding “hands on”. Did we really intend to let people expose their hands inside a Class 4 laser? Did we know that this would result in a possible contact of skin with laser light capable of burning? Whilst it might be OK for me to operate the laser in this manner, it wouldn’t be safe to allow the “general public” to risk this activity as they would not be sufficiently trained to be safe. Someone might burn their fingers and goodness knows what might happen…

I was a little bit surprised and frustrated by the apparent lack of common sense displayed and I was prompted to ask this question: “Will you be serving tea and coffee at this event?” to which the answer was “Yes, of course!”. “Will it be hot?” I queried, and again the reply was “Yes, of course!” (can you see where this is going?). The fact that a group of people walking around and holding cups of hot liquid with the risk of dropping, slipping, tripping or by any means pouring this liquid onto their own hands, feet or even other people was a potential accident waiting to happen. Pointing out that a scald from hot liquid was a potential risk that was both more serious (perhaps requiring a trip to hospital) and much more likely, didn’t really seem to have the desired effect. Rather than suggesting that they desist from offering hot liquids, I wanted to convince them that the risk was really small by real-world standards and this point is often missed. Driving a car to the event or using a mobile phone while walking around are both significantly more dangerous than using a manual laser welder in my humble opinion.

In spite of this there are some flagrant disregarders of laser safety out there. Several years ago I spotted an exhibitor at the NEC during a trade fare, showing a live fibre laser marking system on their stand with no guarding. Shielding my eyes, I approached the user and asked him to switch it off – suggesting that it was very reckless to use a laser unguarded in public. Not until I pointed it out to one of the security staff did he actually stop using it, and I suspect he carried on. The moral of this is take whatever precautions you see fit when using a laser – but keep it in perspective. It seems ironic that Walmart in USA can sell guns, but selling a laser pointer of more than 5 mW could result in a prosecution…

Dave MacLellan
dave@ailu.org.uk

AILU LASER MANUFACTURING HUB AT ADVANCED ENGINEERING 2017



Exhibitors in the AILU-hosted Laser Manufacturing Hub are:

- Cyan Tec Systems
- ACSYS Lasertechnik UK
- Laser SOS
- Carrs Welding/Micrometric
- Laser Lines
- IPG Photonics
- Fimark
- BLM Group
- Croft Flters & Croft AM
- TLM Laser
- LVD Pullmax
- Bystronic

If you are walking the show come and see us - take a break in the Meeting Point, chat to members, meet clients.

Contact the AILU office if you are interested in joining the Hub in 2018 - it will be expanding to accommodate more stands.

Alongside the exhibition is the Open Conference – talk to me if you would like to offer a presentation in the Performance Metals Session, it would be great to have more laser case studies and applications presented. As in the past 2 years I will be giving an overview of what lasers can do.

Dave MacLellan
dave@ailu.org.uk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September 2017

17-22
EUROMAT 2017
Thessaloniki, Greece

13
AILU WORKSHOP
LASER CLEANING

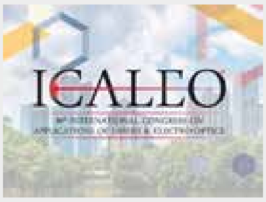
Image courtesy Blueacre Technology

October 2017

11
METAL POWDER-BASED ADDITIVE MANUFACTURING
Ricoh Arena, Coventry

18
ANNUAL JOB SHOP BUSINESS MEETING

22-26
ICALEO
Atlanta, USA



November 2017

1-2
ADVANCED ENGINEERING 2017
with AILU Laser Manufacturing Hub
NEC, Birmingham

23
AILU WORKSHOP
LASER MANUFACTURING OF LIGHTWEIGHT STRUCTURES

Image courtesy TRUMPF

JANUARY 2018

27 JANUARY - 1 FEBRUARY
SPIE PHOTONICS WEST
San Francisco

APRIL 2018

9-13
MACH 2018
NEC, Birmingham

JUNE 2018

5-7
LASYS
Stuttgart

25-29
LASER PRECISION MICROFABRICATION (LPM 2018)