BIGGER, BROADER, BETTER...

This year, the annual euspen Conference and Exhibition was held in Nottingham, UK. The event had more delegates, more paper submissions and more businesses in attendance than in the past few years, but did that make it any better? "The annual event gave me hope for the future. I had a number of conversations with younger researchers who taught me new things. I also found out a lot from my learned colleagues", one of the senior participants commented.

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EDITORIAL NOTE

This report was compiled from various contributions. The effort by all authors is acknowledged, for they did an excellent job under a tight time schedule.

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From 30 May to 3 June at the University of Nottingham, East Midlands Conference Centre in Nottingham, UK, euspen (European Society for Precision Engineering and Nanotechnology) hosted its 16th annual International Conference and Exhibition. Networking opportunities and scale are key to euspen's flagship event, and in this respect the Nottingham event was a big success.
The organisers received 299 abstracts from which 37 oral presentations were selected, with 232 poster presentations. The 429 attendees (representing 236 individual companies or institutions from 27 countries) also accessed three keynote addresses, three workshops, and three tutorials, covering everything from multifunctional additive manufacturing to positioning in six degrees of freedom.

Tutorials

A feature that has become popular at the euspen Conference (and other similar events) is the pre-conference tutorials and workshops. This time they covered a broad range of topics from fundamentals of precision design to biomedical fabrication and functionalisation. Despite the Monday being

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a public holiday in the UK, these tutorials and workshops were well attended and judging from the comments from delegates very well regarded.

Prof. Alex Slocum (MIT) and Piet van Rens (Settels Savenije) gave a very inspiring, high-paced overview of design principles for high accuracy. They both brought lots of hardware examples to share with the large audience of over 30 attendants. Audience and tutors discussed a lot of cases and their discussions carried on well into the conference. After several tutorials at the annual ASPE conference, are Prof. Slocum and Van Rens set to re-appear at the euspen Conference?

In the afternoon there were two tutorials, "Optical Measurement Technology" by Prof. Wolfgang Osten (University of Stuttgart) and "Introduction Design in Ultra High Vacuum" by Mark Meuwese and Sven Pekelder (Settels Savenije). In the last tutorial, about ten attendants were introduced to the world of vacuum technology and various specific topics were selected by the attendants to be discussed further. For several attendants the tutorial provided a good overview of the intricacies of the actual designing and building of a vacuum system, and the aspects to take into account, on top of "it needs to be in vacuum...".

Keynotes

The conference venue had a large steeply raked auditorium easily able to seat 520 delegates, hence although busy, it was never uncomfortably full. While European delegates as usual dominated the audience, there were significant numbers of attendees from Japan, China and North America present, illustrating how international the event has become.

The keynote presentations often set the tone for the conference and the opening keynote from Ben Hughes of NPL certainly set a standard for both metrology and precision, describing a 6-degrees-of-freedom micro-vibrational test facility developed for the European Space Agency (ESA). He showed the impressive performance of a 30+ kg testbed able to detect the impact of a feather landing on it.

The second keynote was on multifunctional additive manufacturing. Dr. Christopher Tuck, University of Nottingham, discussed the activities regarding the integration of different additive manufacturing techniques. He showed the different possibilities of additive manufacturing and the incorporation of different materials in a single manufacturing operation, e.g. touch sensors in prosthetic hands, where the structural parts, flexures and sensors are printed in a single process. In his opinion, the real value of additive manufacturing will be found when looking across multiple sectors, creating multifunctional parts using different materials and different additive manufacturing techniques.

Both in the keynotes and the following track, the picometer resolution was more or less taken for granted. It shouldn't be taken for granted, not even for something seemingly trivial as measuring the diameter of a small machined hole. After all, how do you measure, and how do you correlate the different measurement techniques, when they all provide a different outcome to the question: what is the diameter of the hole?

Metrology

Indeed, metrology was a key topic at the event, having a high number of European national measurement institutes present (NPL and PTB most noticeable) and several well-known metrology research groups (Nottingham and Huddersfield Universities again being prominent). The first and last sessions of oral presentations were on Metrology and Manufacturing Metrology, however, unlike in previous

1 *Venue for the euspen Conference was the East Midlands Conference Centre, University of Nottingham. (Photos: Martin O'Hara)*
2 *The pre-conference tutorials and workshops were well attended.*

events where a trend for say surface metrology was evident, the contributions were extremely mixed covering some of the 'usual suspects' of angular measurement and interferometry, but also robotic inspection and hybrid mixed-measurement systems.

The talks all touched on the reliability of measurement data and the necessity of integrating measurement systems into the 'production process' to put them to effective use. The problem then arises that the uncertainty of the measurement data needs to be known, without the need for offline (re)calibration, as this would mean downtime, additional tooling and another source of uncertainty. Combined with the possibilities of big-data analysis, the uncertainty of measurement data becomes even more important.

Ben Hughes (NPL), in his keynote speech, had called for a rethinking of sensor system design in order to create sensor systems that can be calibrated in-situ (when integrated into complex measurement applications with their own uncertainty). He also envisioned sensor systems that would include a self-assessment of the uncertainty of their measurement while in operation.

In the Mechatronics and Control session, there seemed to be a trend towards using various forms of adaptive control to improve machining performance, particularly for dynamic control, suggesting maybe a shift from the more traditional methods of increasing mass. This was also a feature of the first keynote paper. It was interesting to see how others independently have also been experimenting with such techniques.

Manufacturing technologies

The second day started with a keynote from Dr Sascha Migura of Zeiss on the challenges of EUV lithography for sub-8 nm resolution. This provided a very good explanation of the issues and solutions that ASML, with the help of Zeiss and other suppliers, has adopted to achieve resolutions for sub-8 nm feature sizes in silicon within their lithography systems. The detail was superb and made it relatively obvious why this node step wasn't a simple change and why the "end of Moore's Law" debate has been so hot in the past few years. However, they appear to have the solution and we should be able to get another potential node step out of the technologies developed for sub-8 nm, possibly down to 3 nm

Plasma and other energy beam manufacturing technologies was a major topic of day 2. The energy beams were all being used for specific applications: plasma on glasses for figuring and on diamond for planarisation, droplet-assisted laser for hole cutting in tungsten carbide and ion beam figuring on aluminium. Removal rates were small, except for the droplet-assisted laser; but not all the control parameters were well explained for this. These technologies are close to commercialisation, but it appears some aspects of their processes are not fully understood enough to be deployed.

By contrast to energy beam manufacturing, precision cutting might be seen as a mature and well understood process, but the session on this topic illustrated that a lot of work is still ongoing in this area. One of the best presentations, suited for direct application, was from Dr Chris Evans of University of North Carolina, Charlotte (UNCC), whose paper on single-crystal diamond tool wear could be useful for anyone and everyone operating single-point diamond turning and milling processes.

3 *A large attendance was easily handled by the venue with everyone getting a good view.*

Precision engineering in biomedical sciences is without doubt one of the hottest application areas in the precision field. There was a late-afternoon but well-attended session on this subject that showed a large range of potential applications from precision bio-cell printing, laser- and plasma-treated stent manufacture, in-vivo force measurement of medical instruments and micro-fluidics for blood-plasma separation.

Diverse mix

The Precision Machining, Replication and Additive Processes session on day 3 mostly focused on the processes themselves and little information on the achieved precision was provided, other than a couple of papers which focussed more on the analysis side. This is undoubtedly another area that will feature in future events, but it demonstrated not yet the maturity where the process precision itself starts to be a determining factor for the technology or its deployment.

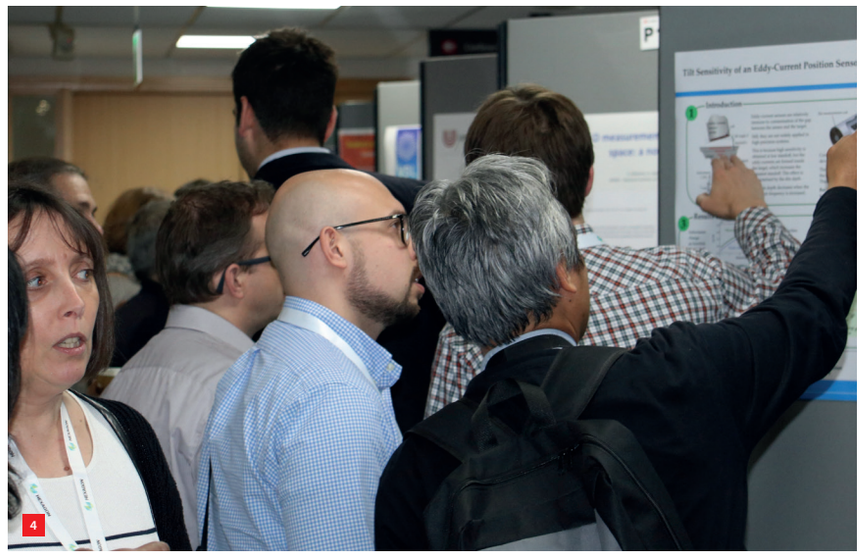
The penultimate session on Advances in Precision Engineering and Nanotechnologies was possibly one of the best due to its diverse mix, although the two papers on focussed ion beam processing could both have been in the plasma/energy beam session. The presentation on the pellicle architecture for high-power EUV lithography from ASML was a great accompaniment to the third keynote. This session inadvertently showed how well the different technologies being presented fit together under the generic banner of precision, and sometimes how broad that definition really is.

Poster sessions

Undoubtedly the poster sessions were not only numerous, but the delegate attendance at them was also one of the highest for the past few years. Possibly because the layout of the venue meant the posters, main conference auditorium and exhibition hall were all very close and on the same level, it was easier for delegates to get around all areas both easily and quickly.

Overall it was a very impressive display of poster and in particular a good number from both industry and some non-academic groups that added a bit of a different flavour to this section of the event. Academia, however, did win out in the votes for best posters with Jason Ten, a doctoral student at the Institute for Manufacturing (IfM), Cambridge University, winning first prize.

A series of scholarships were awarded by Heidenhaim to students to help them cover the costs of attending such events and expand their horizons on where their future careers in precision may lead.



4 *Poster sessions were very busy and well attended.*

Exhibition

The exhibition running alongside the conference was an interesting assembly of UK, Dutch and international companies and institutions that focus on precision engineering. There was a significant presence from NPL in addition to a number of new exhibitors. In total, there were 39 exhibiting and 11 sponsoring companies presenting attendees with an array of cutting-edge technologies and solutions for precision engineering projects. Measurement technologies in the picometer range, 3D printing with integrated functionality, accurate machining – it was all there.

It felt very familiar to anyone who has exhibited before at a euspen event. The introduction of exhibitor drinks at the end of day 1 gave delegates and exhibitors the opportunity to interact in an informal setting.

There were also four company tours at this year's event to either the Advanced Manufacturing Research Centre in Sheffield; to leaders in precision optics measurement Taylor Hobson; to metrology specialists GE Measurement & Control; and to the University of Nottingham.

Social networking events

The social side and opportunities for networking are often overlooked, but can be one of the biggest benefits of such an intensive conference programme. On the first day of arrival, ASML hosted the welcome reception at the conference venue itself, allowing old friends to re-connect and new connections to be quickly made before the main programme started.

On the second evening, Professional Instruments hosted a drinks reception in the exhibition area, while Contact Singapore held a Student's Dinner in the main hotel. There was a lot more focus, it felt, for students at this euspen event, both in the poster sessions expansion to give more opportunities to display research, and in the dinner, plus the great support of

5 *ASML sponsored and hosted the welcome reception. Here, Jelm Franse, Senior Director Mechanical Development at ASML, brings out a toast.*

businesses like Heidenhain in awarding scholarships. These contributions are undoubtedly to be applauded and great examples of how to encourage more young talent to train and remain in the precision field of engineering.

The conference dinner on day 2 was very well attended and held at the former home of English poet Lord Byron, Colwick Hall.

Comments

David Billington, Executive Director at euspen, summed up the 2016 event: "It was extremely gratifying to see how well the event in Nottingham worked this year. We are acutely aware as organisers that people have to be very careful how much time they commit away from their offices these days, and as such we need to produce an event that has enough activity and potential in terms of networking to merit the trip. Feedback this year has been extremely positive from exhibitors and delegates alike and the event is becoming a fixture on people's calendars year-to-year, so we are confident that it will grow still more as we move forward."

Prof. Richard Leach from the Advanced Technology Research Group in Nottingham University worked closely with euspen to host this year's event. Leach said of the event: "The exhibition was packed, and all the exhibitors expressed their appreciation of the way the conference was planned and executed. The Manufacturing Metrology Team (of which I am a member) were well represented with four papers, including a session keynote from Dr Christopher Tuck looking at multifunctional additive manufacturing."

Prof. Stuart Smith from UNCC stated: "The annual event gave me hope for the future. I had a number of conversations with younger researchers who taught me new things. I also found out a lot from my learned colleagues, made plans for interesting research, and picked up loads of condensed wisdom. It was an awesome experience, I will go back home with renewed vigour".

Dirk Smits from regular sponsoring exhibitor IBS Precision Engineering was eager to congratulate the organisers of the event, and also noted that once again euspen has raised the bar in terms of the quality of the conference presentations. Smits said: "The number of concrete quotations we had to make at the exhibition was the largest of all euspen events to date. What cannot be underestimated is the enormous network of academia and industry we meet with every year. It is interesting business-wise, but also a lot of fun to talk to similarly-minded peers and find out what they are working on."

Derrick Jepson from exhibitor Aerotech also praised the quality of the event. He said: "As I have come to expect from euspen, this was a very professionally organised event. The choice of venue also ensured that delegates had equal and easy access to the exhibitors for those all-important networking discussions in the scheduled breaks between conference sessions. I was attending with my sales engineer for this sector, and he reported that he was able to progress current opportunities with the attendees, which was an added benefit."

Joost van Rens from The High Tech Institute, Eindhoven, the Netherlands, mentioned that he found that "everybody who is anybody in precision engineering" was at the event in Nottingham. The organisers are aware of the fact that it is important to continue to bring together such a comprehensive and high-quality community of academics and industrialists. However, the key is not to simply provide a forum for the same people year on year, but to continually ensure that new professionals are invited and can come to experience the unique quality and depth of information concerning micro- and nanotechnology.

Dishi Phillips, Business Development Manager at euspen, reinforced this point: "As organisers, we were delighted to extend the reach of the Nottingham event, and the fact that we saw global representation from over 230 different companies is testament to the fact that we are providing an international networking event for what is a truly international set of disciplines."

And this is ultimately what sets the euspen annual event apart, not just gathering academics and industrialists involved in the area of precision engineering together, but stimulating the exchange of views and ideas, and thereby stimulating innovation. The last word should perhaps be left to Alison Raby from nanopositioning experts Queensgate Instruments. "I have attended euspen's annual event for the last three years and every year it has been a better event for Queensgate. The networking component sets euspen ahead of other events. We will certainly attend next year."

Conclusion

While the venue was not as stunning as in previous years (re. Dubrovnik), euspen 2016 managed to organise a much larger conference, engaging a significantly increased number of delegates from around the world, not just Europe. The increased number of students is to be welcomed as were the excellent expanded poster sessions.

The next euspen International Conference & Exhibition will be held 29 May-2 June 2017 in Hannover, Germany. ■

INFORMATION
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