Front Cover Image – Impact Crater

At the time of going to press details of this front cover image weren’t available, but needless to say is that a brittle surface layer has reacted badly to either a mechanical or thermal shock.

My suspicion is a shock caused by a laser pulse, were the surface layer has been vaporised. Around the edge of the impact location appears to be a region of solidified melt residue. The thermal strains induced appear to have caused the surface layer to fracture and delaminate in a brittle manner. The highest strained regions near the impact site have a finer crack crazing than regions radiating out from the impact site.

I you can give an alternative to the above, I’m more than happy to receive it and will include an update in the next issue.

Editor: pete.barnard@btinternet.com
EMG newsletter lead

Editorial

Welcome to the latest edition of the EMG newsletter, and yes we have been off publication for few months, my apologies for that but we have seen some interesting events over the last few months, so I thought I’d give an overview of the energy market driven by the Covid-19 pandemic, based upon the IEA Global Energy Review 2020.

Let’s start with the size of the issue, namely was this a global issue and how did this effect the energy demand, well the below graphs give the scale of the issue. The left-hand graphic shows essentially 100% of the world population has been affected with energy demand globally down by circa 50% for a significant period of time.

![Share of global population under containment measures](image1)

How unusual is this reduction in energy demand from an historical perspective? as we can see in the next graphic it’s not such a big deal compared to the early 1900’s. It’s surprising the difference between the 1900-1960 and 1960 – 2020 halves of the statistics. Since the 1960’s we have seen fairly benign conditions so the current crisis is a bit of a shock to the system. Yes the current crisis hasn’t ended yet so the peak decline has still to be recorded.

![Share of global primary energy demand affected by mandatory lockdowns](image2)

![Rate of change in global primary energy demand, 1900-2020](image3)
I’m sure it will come as no surprise to anyone that the reduction in demand has affected the fossil fuelled plant disproportionally as shown in the next graphic, where it can been seen that surprisingly the renewable have increased whilst other sources have seen significant declines.

Inevitably this has had a large effect of CO2 emissions as the below right graphic summarises. The decrease resulting from the Covid-19 lockdowns have reduced the emissions but can this be maintained or have a real significant effect on emissions going forward. From a personal point of view, I hope so, but am not very optimistic as I fear the search for GDP growth will take precedence.

The final graphic I’d like to share is the bottom on showing the oil demand for 2020 relative to 2019. What interests me here is that demand is predicted to rebuild over the coming months back to a level below that of 2019 but not as far below as one might have expected. Oil demand decline is largely driven by the reduced demand for transport fuels, both land and air-based transport.

The prediction seems to be that as soon as lockdown is over transportation will recover fairly swiftly. Within the IEA report there is lots of data relating to all the energy source types, I’ve chosen oil as it gives a fascinating insight into the global response to the pandemic. The graphic for coal appears not to recover so well as that for oil, but not really a surprise.

Should the reader wish to review the full IEA report this can be downloaded from the IEA website, https://www.iea.org/reports/global-energy-review-2020

Dr Peter Barnard
EMG Newsletter Editor
The Energy Materials Group is an interdisciplinary special interest group of the Institute of Materials, Minerals and Mining.

Energy Materials Information Streams

The EMG microsite is a mine of information relating to Energy Materials with links to various sources of information, including funding sources for collaborative research/development. The EMG microsite is actively managed and regularly updated; the link to the appropriate location on the microsite is given below.


Materials at High Temperatures, Vol. 37, Issue 1 & 2, 2020

- Oxidation behaviour of alloy S16 in superheated steam and supercritical water
- Smokeless flare tips failure investigation: case study
- Creep lifetime prediction of virgin and service-exposed Super304H austenitic stainless steel boiler tubes based on hierarchical multiscale analysis and creep cavitation model
- The effect of threshold stress on the high-temperature fracture parameter
- Internal oxide thickness measurement by ultrasonic method
- Effect of holding duration at maximum and minimum stress on creep fatigue interaction of P92 steel
- Microstructure evolution and oxidation behaviour of shot-peened S30432 stainless steel during exposure in double reheat USC power plant steam environment
- Recovery and recrystallisation during creep exposure of cold worked Ti-modified 14Cr–15Ni austenitic stainless steel
- Hydrogen transport during steam oxidation of iron and nickel alloys
- Determination of creep cavity nucleation rates
- Damage assessment of topping furnaces radiant tubes and creep behaviour of ASTM A335 P5 steel
- Oxidation and electrical behaviour of direct and pulse current electroplated cobalt coatings on Crofer22APU stainless steel interconnect
- Probabilistic structural integrity: methodology and case-study in the creep regime
- Comparative evaluation of tensile properties of simulated heat affected zones of P91 steel weld joint
- The development of creep damage constitutive equations for high Cr steel
- Creep damage of a high Mo single crystal nickel-based superalloy
- Modification of the high-temperature performance of thin chromium coatings deposited on valve steels
Organisation Profile

Institute of Physics

The Institute of Physics, IOP, is the professional body and learned society for physics in the UK and Ireland. The Institute of Physics as we now know it was once two bodies, the Physical Society of London and the Institute of Physics. The Physical Society of London was established in 1874, with the Institute of Physics emerging from the Physical Society of London in 1920 as a separate body. The Institute and Society merged in 1960 with the new organisation called The Institute of Physics and the Physical Society. With the acquisition of the Royal Charter in 1970 the Institute was retitled to ‘Institute of Physics’ with Sir John Cockcroft the first President of the combined Society and Institute.

Members come from across the physics community whether in industry, academia, the classroom, technician roles or in training programmes as an apprentice or a student. The IOP undertakes its main technical activities through its “subject groups” and administrative activities via its national and regional branches which operating on a geographical basis, and through outreach programmes to the general public.

Of interest to members of the Energy Materials Group are the IOP’s Energy Group and The Materials and Characterisation Group. The Energy Group focuses on 6 themes, namely

- power generation technologies: conventional, renewable, and nuclear
- the efficient use of energy
- the exploitation of resources for energy use
- security of supply
- materials for energy applications
- energy use in the built environment

The Materials and Characterisation Group focuses on 4 main themes, namely

- The properties and application of materials, old and new
- The manufacture, modification and extraction of materials
- All types of material characterisation including physical, electrical, optical and elemental
- Development of materials characterisation techniques and applications

The IOP also includes many groups dedicated to specific topics which may be of interest to some EMG members, e.g. Environmental Physics Group, Nuclear Industry Group, Semiconductor Physics Group and Superconductivity Group and many more special interest groups. Like the IOM3 group each group is responsible for organising conferences/workshops and lectures e.g. “Materials for the Energy Transition Roadmap Webinar” and “High Efficiency Materials for Photovoltaics”

Like IOM3 the IOP has relocated to new premises in the recent past, namely to 37 Caledonian Road, London on 29th Oct 2019.

For more information on the activities of IOP please visit [http://www.iop.org/](http://www.iop.org/)
Editor's Titbits Section

**UK's power emissions hit all-time low and wholesale prices head south**

The UK's power system emissions recently hit an all-time low according to new statistics published by Drax Electric Insights, which show carbon dioxide levels fell to an all-time low as the amount of renewable power being sent to the grid soared, replacing the need for coal power.

Bright skies across the country saw solar panels begin generating power alongside wind farms, helping to push the carbon intensity of grid electricity down to its lowest ever level of 33g of carbon dioxide per kWh. On 23rd May, carbon intensity levels averaged just 61g of carbon dioxide per kWh, beating the previous record low of 76g set on 17th August 2019.

Due to high levels of wind and solar combined with reduced demand during the coronavirus lockdown, day-ahead wholesale power prices fell to a new low on 22nd May – across the whole 24-hour period, the average day-ahead wholesale price was minus £9.92/MWh.

This is more than twice as low as the previous record, set on 8th December 2019, when prices fell to minus £4.62/MWh. In the early hours of Friday morning, the day-ahead price was as low as minus £52.03MWh as supply massively outstripped demand across the grid.

**Serbia's new €370m waste-to-energy project**

A new €370 million (£329m) waste-to-energy project located 15 kilometres from the centre of Belgrade has secured financing to proceed. The new facility will provide the 1.7 million citizens of Belgrade with a modern waste management system which will replace Europe’s largest unmanaged landfill, which holds more than ten million tonnes of waste after more than four decades of operation. The site will host a new sanitary landfill, a waste to-energy plant and a modern facility to process construction and demolition waste.

The 103MW waste-to-energy facility will help reduce the dependence of Belgrade on fossil fuels. It will have the capacity to process approximately 340,000 tonnes of household waste every year and treat 200,000 tonnes of construction and demolition waste. The new sanitary landfill, with a capacity of 170,000 tonnes every year, will be finalised by the end of 2020, while project completion and full commercial operations are expected in 2022.

**What’s driving the recent fall in UK power prices?**

The wholesale energy power price saw a spike in late 2018, trading as high as £61/MWh, whilst recent fundamentals have driven it down to a low of £38/MWh early this summer. The drivers for this are 3 main reasons:

- Liquefied Natural Gas (LNG) liquefaction capacity has ramped up over the past couple of years, with new projects opening in the U.S., Russia and Australia. This has flooded the global market with gas, with demand not able to keep pace. In the UK, LNG imports have been continually breaking records month-on-month, whilst further supply growth is expected over 2020.
• Mild temperatures this winter and last winter has kept demand subdued and allowed European gas storage stocks to remain high, with levels 20% fuller than normal at this time of year.
• More recently the coronavirus pandemic has sent shockwaves through the industry, significantly disrupting supply / demand balances and causing market volatility. Severe demand destruction caused by nationwide lockdowns has heavily weighed on global gas markets, and caused crashes in other commodities.

All the above has played a big role in driving the UK power market. The chronic oversupply in the gas market, exacerbated by the coronavirus pandemic, has significantly pressured near-term contracts, with negative prices.

**Siemens Gamesa reveals ‘world’s biggest wind turbine’**

Siemens Gamesa has revealed what it claims is the world’s biggest wind turbine, a 14MW offshore Direct Drive turbine boasting a 222-metre rotor featuring 108-meter long blades and a 39,000 square meter swept area.

The 14MW capacity means one SG 14-222 DD machine is able to provide enough energy to power approximately 18,000 average European households every year and approximately 30 SG 14-222 DD offshore wind turbines could furthermore cover the annual electricity consumption of Bilbao, Spain.

**UK’s first large-scale battery factory to be built by two British startups**

The UK’s first large-scale battery cell manufacturing factory is to be built by two British startups.

The London-based battery cell maker, AMTE Power, has signed a Memorandum of Understanding (MoU) with Britishvolt to develop the 30GWh GigaPlant.

The facility will manufacture lithium-ion batteries to service the automotive and energy storage markets and is expected to generate up to 4,000 jobs. The GigaPlant will support the UK to achieve its net zero targets by generating an onshore manufacturing supply chain, in addition to reducing the transportation costs and the emissions related to importing batteries.

**UK’s ‘first’ commercial waste-to-jet-fuel plant receives green light**

The ‘UK’s first’ waste-to-jet-fuel plant has been granted the green light by the North East Lincolnshire Council (NELC)’s Planning Committee. The Immingham plant would convert hundreds of thousands of tonnes of non-recyclable everyday household and commercial waste, otherwise destined for landfill or incineration, into cleaner burning sustainable aviation fuel (SAF) every year.

The project which is expected to produce fuel from 2025, is a collaboration between Velocys, British Airways PLC and Shell International Petroleum Company. The fuel, based on Velocys’s technology, would offer net greenhouse gas (GHG) savings of around 70% for each tonne of conventional jet fuel it displaces, with up to a 90% reduction in particulate matter from aircraft engine exhausts and almost a 100% reduction in sulphur oxides.

Editor’s Note: Unless mentioned the source of many of these titbits is Energy Live News.
Mini Feature

Paper Making

On reviewing the U.S. Energy Information Administration’s International Energy Outlook 2016, I was struck by paper making being identified as one of the top energy intensive industries. It would appear that between food, pulp and paper, basic chemicals, refining, iron and steel, nonferrous metals (primarily aluminium), and non-metallic minerals (primarily cement) the energy consumption comes to over 50% total industrial sector energy consumption across both OECD and Non-OECD countries. Pulp and paper come 4th in the list just behind chemicals, number 1, Iron and Steel making, number 2, and oil & gas refining, number 3. This was a bit of a surprise so decided to look into why the pulp and paper making process is so energy intensive.

Paper is essentially dried and compressed wood pulp. The source wood comes from debarked logs that are chipped or wood chips from industrial saw mills. The main types of wood used are deciduous, birch, poplar, beech and eucalyptus and/or conifer, spruce, fir and pine, with the conifer with its longer fibre yielding a stronger paper. After chipping the wood moves into a digester where the chips are cooked in an acid solution to dissolve the lignin leaving the cellulose fibres. (Wood is mainly a composite of cellulose fibres in a lignin matrix).

After washing and bleaching and with the addition of water we have the pulp solution ready to move from the pulp mill to the paper mill. The paper mill starts with refining, i.e. chopping the fibres, to produce a consistent fibre length with defribulated fibre ends to aid cross linking. Fillers, e.g. calcium carbonate and clay, are added to both increase density and uniformity of density followed by additives, dyes, brighteners and sizes. Sizes are added to improve the wear resistance of the fibres. The pulp solution is now ready for the paper making process.

The pulp is injected at high pressure, from a header box onto wire screens which pass through a gap former, i.e. rollers to drain the excess water, producing “green” paper which is now in solid form. This process from injection to first pressing takes milliseconds at production rates. Further presses remove further water before winding through a series of heated rollers to dry the paper. The speed of travel is circa 1Km per minute through the dryers, so a large number of heated rollers are used to ensure a dry product before entering the sizing rollers, then the coating rollers where starch and dyes are film pressed onto the surface of the paper. This coating is to allow the ink to dry on the surface rather than be absorbed into the paper, to give strength and water resistance. Coatings are usually dried using infrared heating panels. This virgin paper is then reeled, usually up to 8.5m wide with each reel circa 120 tons, representing an hour’s production; at a running speed 1km per minute that 60km per hour.

Finishing of this paper usually involves multiple coats to provide a smooth finish often calcium carbonate, clay and talcum powder using starch or latex as the binder. Between each coating cycle is a drying cycle often involving infrared heaters. The final operation, high temperature
rollers and high pressure to give the paper a gloss finish. All that is now needed is slitting and cutting to size before packaging and shipping. The process above will have used circa 100 litres of fresh water for each kilogram of paper, of which 90% is recycled, and between 25 and 50 MJ of energy. This energy consumption reduces to circa 18-35MJ is all recycled paper is used. This energy consumption is for the most modern plant which have reduced the energy consumption by some 60% over the last 50 years. As such further reductions in energy consumption are likely to be limited.

As the first graphic shows the use of paper products globally is increasing. Whilst paper consumption in Europe and North America is trending downwards the rapid increases in Asia and Africa outstrip the reductions. The current global production is just over 400 million metric tonnes and as the second graphic shows the majority of the usage of paper products is in packaging and for printing/writing.

Unfortunately, it is not only the energy consumption that has the pulp and paper industry exercised, the disposal of the chemicals used in manufacture and the source of the original feed stock are subject to international concern.

Great strides have been made in reducing toxic materials e.g. use of peroxide rather than chlorine in bleaching. Waste management is subject to international regulation. Use of recycled/recovered fibre can reduce the need for virgin fibre. Deforestation and illegal logging have been a feature of pulp and paper production historically. The bottom graphic shows that the use of recycled fibre had reached over 50% by end of 2015, this coupled with better tracking of wood products from legal timber mills will continue to reduce the need for illegal wood sources.

Should the reader wish more details you are directed to the 2 main sources of information for this feature, namely

2) Environmental Paper Network - The State of the Global Paper Industry 2018
NEXT COMMITTEE MEETINGS
11:00 July 2020, location TBA

EMG SPONSORED WORKSHOPS/CONFERENCES
ECCC2021, 13–15 Sept, 2021, Edinburgh, UK (New Date)

OTHER WORKSHOPS/CONFERENCES/COURSES OF INTEREST
CREEP2020 15th International Conference on Creep and Fracture of Engineering Materials and Structures, 14-18 June, 2020, Bad Staffelstein, DE (Postponed, date TBA)
36th World Congress on Materials Science and Nanotechnology, 27-28 July, 2020, Amsterdam, NL (New date and venue)
21st European Annual Conference on Advanced and Energy Materials, 28 - 29 Sept, 2020, Amsterdam, NL
CF-8 8th International Conference on Creep, Fatigue & Creep-Fatigue Interaction, 9 – 12 Feb, 2021, Mamallapuram, IN.
ALTA 2021 Nickel-Cobalt-Copper, Uranium-REE, Gold-PM, in Situ Recovery, Lithium & Battery Technology Conference & Exhibition, 22 - 30 May, 2021, Perth, AU

Editor’s Note: Date for the above events were correct at the time of going to print. Revisions to the events are likely to occur in the coming weeks, so please refer to the events web site.