The Contract Heat Treatment Association Newsletter

HOTLINE

Issue No. 135
March 2014

Inside . . .

A date for your diary...

CHTA AGM, 8 May 2014

Members will again be able to update and network at this year's Annual General Meeting, to be staged at SEA's Birmingham headquarters. Full details will be circulated in April.

Chairman Simon Blantern will present the CHTA progress report.

CEO Dave Elliott will update on SEA activities including CCAs.

Guest speaker will be Dr Chris Dungey of the Manufacturing Technology Centre

CHTA Secretariat

Items for inclusion in *Hotline* and enquiries about CHTA activities should be addressed to:

Contract Heat Treatment Association
c/o SEA / BATF,
Federation House, 10 Vyse Street,
Birmingham B18 6LT
Tel: 0121 329 2970 (or 0121 237 1123)
Fax: 0121 237 1124
E-mail: mail@chta.co.uk
Website: **www.chta.co.uk**

CHTA Secretary and *Hotline* Editor:
Alan J. Hick B.Sc., C. Eng., FIMMM

CHTA is affiliated to the Surface Engineering Association

CHTA Non-disclosure Agreement released

See page 3

CHTA members invest heavily in more vacuum furnaces

See news, page 8

CONFIDENTIALITY AGREEMENT

CHTA non-disclosure agreement released

In December 2012's *Hotline* 130, Simon Blantern, now CHTA Chairman, addressed "The burden of non-disclosure agreements".

He asked if members would value CHTA compiling a standard NDA upon which they might base their own, as in the case of the *CHTA Guidelines for Conditions of Business.*

Support for the proposal encouraged Simon, in conjunction with fellow Management Committee member Richard Burslem and CHTA's solicitor, to undertake the project, which is now complete.

As anticipated in *Hotline* 134, the mutual NDA (Confidentiality Agreement) document has now been posted in the Members Area at *www.chta.co.uk.*

CHTA's solicitor ***John Chadaway****, of Brindley Twist Tafft & James LLP, comments...*


MUTUAL NON-DISCLOSURE AGREEMENT

Nowadays, confidential information is often a very important "asset" for most businesses, with companies spending a lot of money and time to develop/compile the same. Accordingly, it is becoming increasingly common for businesses to look to protect such confidential information both practically (e.g. by putting in place systems to safeguard information) and legally (e.g. confidentiality agreements).

A confidentiality agreement "works" by placing obligations on the recipients of information to keep the relevant information secret, and also to control the use of such information.

The draft standard confidentiality agreement that has been produced for CHTA members is one of a mutual nature, under which both the heat treatment company and its customer will be under mutual obligations of confidentiality.

It is also intended that the agreement will be signed and dated before any information is divulged to either party as part of the process of evaluating the feasibility of a possible business relationship between the parties.

It is important to note that, although the document has been drafted to be a "standard" document, not all of the provisions/obligations may be applicable or suit the needs of each individual heat treatment company and/or their circumstances. Accordingly, proposed users of the draft confidentiality agreement MUST read the document carefully and in full before deciding whether to use it.

Furthermore, of course, we must advise each proposed user to obtain independent specific legal advice on the document before using it as we cannot provide any guarantee or comfort that the document is suitable for each specific user and/or their circumstances.

As a final point, it is also important to note that if, following the completion of a confidentiality agreement, you become aware of a breach of its terms, you MUST act and seek legal advice quickly. Any delay will prejudice your ability to enforce the agreement and/or will affect the scope of remedies available to you as a result of any such breach.

If you require any specific legal advice in respect of the above, or generally in respect of issues of confidentiality, please do not hesitate to contact either myself, John Chadaway, or my colleague Samantha Wright at Brindley Twist Tafft & James LLP Solicitors on 02476 531532.

TRAINING

Metallurgy Certificate re-cast

The AMRC Training Centre is now welcoming candidates for METTECH – the Metals Technology Certificate.

METTECH is a successor to the Certificate in Metallurgy that was developed by the AMRC early in 2013 with support from the CHTA. Says AMRC's Graham Small: "Feedback from the 30+ employees who embarked on the Certificate in April 2013 has indicated that the time needed to sit the examinations and complete assignments was prohibitive in many cases".

METTECH, by contrast, requires just one on-line multiple choice examination per training course. Candidates must select six topics from a portfolio of thirteen (to be expanded in the coming months).

As before, each course is delivered in one day at locations in Sheffield and the West Midlands. Dates and venues are listed on the AMRC Training Centre's website at *http://www.amrctraining.co.uk/en/64/prof-dev-technical-course-calendar.*

The structure of the original Certificate will be re-examined over the next 12 months with a view to re-launching it early in 2015. For further information on METTECH, contact Graham Small on 07545 429434 or *g.small@amrc.co.uk.*

AGM

CHTA AGM guest speaker

Our guest speaker at CHTA's May 8th AGM will be Dr Chris Dungey PhD, MEng, SenMWeldI, High Integrity Fabrication Technology Manager at the Manufacturing Technology Centre (MTC). His topic will be "Catapult Centres and the Role of the MTC as a High-value Manufacturing Catapult".

A Catapult is a technology and innovation centre where the very best of the UK's businesses, scientists and engineers can work side by side on research and development, transforming ideas into new products and services to generate economic growth.

One of seven High-value Manufacturing Catapults, the MTC represents one of the largest public sector investments in manufacturing for many years and is housed in a 12000m² purpose-built facility at Ansty Park, Coventry. Opened in 2011, the centre was founded by the University of Birmingham, Loughborough University, the University of Nottingham and TWI Ltd. Industrial members include some of the UK's major global manufacturers.

Chris Dungey joined the MTC in 2010, bringing with him a wealth of expertise in the field of high-integrity fabrication and, in particular, solid-state welding and metallurgy. In his role at MTC, Chris is responsible for managing the High Integrity Fabrication Theme and leading the development of innovative manufacturing technology solutions for MTC's academic partners and industrial members.

Prior to joining MTC, Chris was responsible for new-part introduction utilising the inertia welding technology at Rolls-Royce in Derby. There he successfully managed a range of major engineering develop-ments and assumed technical authority and responsibility for the inception and development of novel inertia welding applications.

In addition to his professional success, Chris achieved his PhD in Metallurgy and Materials at the University of Birmingham in association with Rolls-Royce. Whilst undertaking his Masters degree at that university, Chris was awarded the Hanson Memorial Prize for outstanding academic achievement and contribution to the School of Metallurgy and Materials.

Industrieverband Härtetechnik

Germany's Contract Heat Treatment Association

CEO Dirk Hölscheid outlines the aims and activities of CHTA's German counterpart.

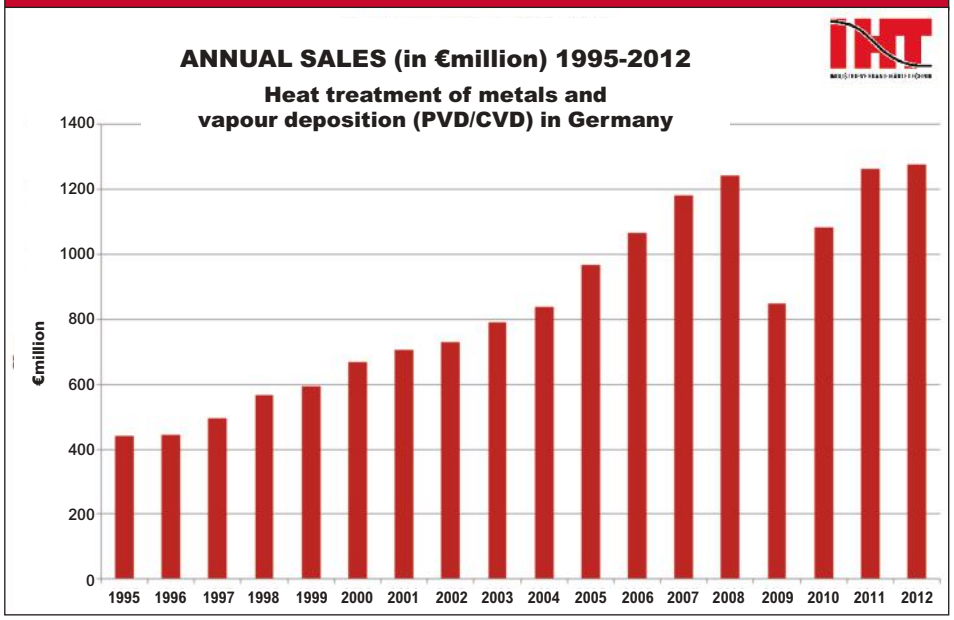
The association of German commercial heat treaters, Industrieverband Härtetechnik eV (IHT), was established in 1977 in Hagen, Germany.

Its members belong to the metalworking and metal processing industry sector. As specialised companies, they are active in the areas of heat treatment and material technology.

The contract heat treaters in Germany are typically medium-sized companies (SMEs) with approximately 175 plants. In 2012, they generated a turnover of €1.3billion with nearly 6,800 employees.

As specialised companies within the supply chain, the heat treaters contribute to the reputation of manufacturing in the German metal industry. In recent years, the trend towards lightweight construction and increased competition has led to the substitution of alternative materials with more demanding requirements for material processing.

Fig.1: Development of sales (IHT)



The target has been to optimise specific material properties through sophisticated heat treatment technologies. This has been achieved via the introduction of modern testing and laboratory facilities, investing in more efficient heat treatment equipment, intensive and ongoing training of the employees and the introduction and implementation of modern quality management systems.

Some market data

The German contract heat treaters were able to increase their sales after the economic crisis in 2009 in a very short time (*Fig.1*). They benefit from the ongoing trend of closure of in-house processing facilities, in favour of the commercial heat treaters, and their flexible heat treatment services combined with a fair cost-benefit ratio.

CHTA hosting sister organisation Industrieverband Härtetechnik in 1987. Seen here during Wolfson Heat Treatment Centre's "Quality Assurance in Heat Treatment" conference, co-sponsored by CHTA, are then officers (l. to r.): IHT Secretary Heinrich Benneker, IHT Vice-President Willi Wingens Jr, IHT President Heinz Handle, CHTA Vice-Chairman Nick Storer, CHTA Chairman Phil Griffiths and IHT board members Friedhelm Rentrop and Werner Keller.

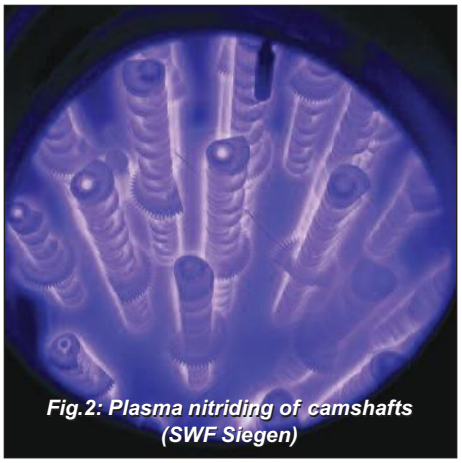
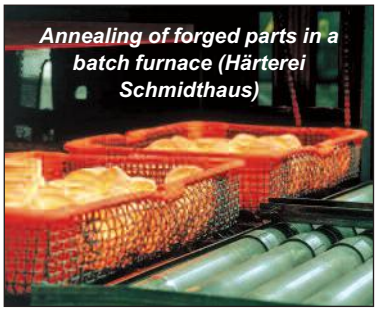
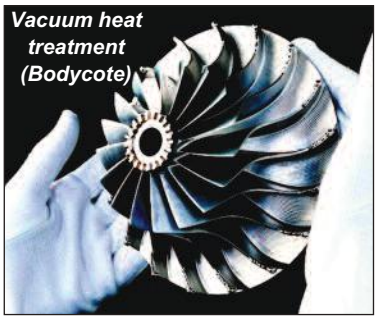


Fig.2: Plasma nitriding of camshafts (SWF Siegen)

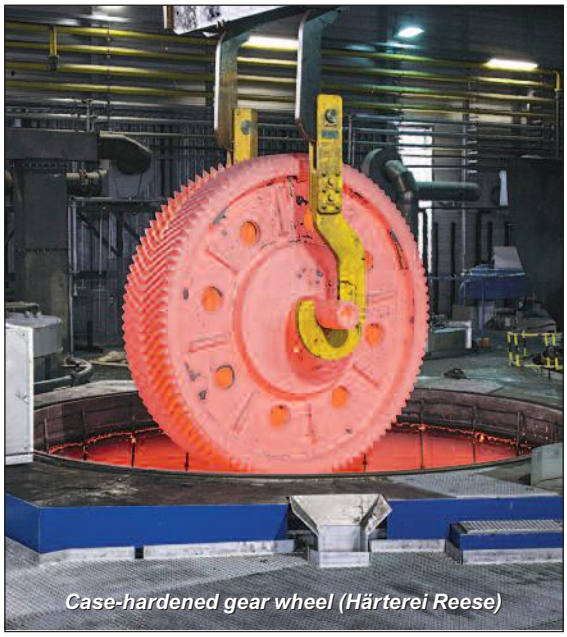
Some IHT member services



Annealing of forged parts in a batch furnace (Härterei Schmidthaus)



Vacuum heat treatment (Bodycote)



Case-hardened gear wheel (Härterei Reese)

An internal IHT study of sales by heat treatment facilities shows that vacuum technology was able to increase its market share at the expense of traditional heat treatment processes such as the salt-bath technology. Around 49.4% of sales are generated with thermal processes; i.e. annealing and hardening. Thermochemical, diffusion and coating processes contribute about 41.9% to the sales (*Fig.2*).
Major customers (85%) of the German contract heat treaters are in the automotive industry, mechanical engineering and aerospace.

Members of a strong association

The aim of the Industrieverband Härtetechnik (*www.haertetechnik.org*) is to protect the common professional interests of its members and to promote them to the authorities, economic and ecological associations (NGOs) as well as to the customers. With the founding of the IHT in 1977, conditions were created to ensure that the commercial heat treaters could establish a legally-independent group, in the industrial economy of Germany, to promote their legitimate interests.
The IHT offers a wide range of exchange and joint activities:

Fig.3: IHT booth at the Härtereikongress.

- visiting companies or suppliers of heat treatment equipment in Germany and elsewhere in Europe;
- legal advice on terms and conditions of the customers and their quality contracts;
- collection and preparation of market and structural data in Germany and Europe;
- lobbying in German energy and corporate policies;
- environmental protection;
- and last, but not least, advice on occupational safety in the heat treatment plants.

The field of public relations as well as the presentation of member companies and their range of services, at trade fairs and in publications, are also core areas of the IHT agenda.
The many activities of the association are supported by the active volunteer work of many of its members.
The Industrieverband Härtetechnik is also part of an industrial network beyond the heat treatment industry, through its membership of the WSM (Wirtschaftsverband Stahl- und Metallverarbeitung eV). The umbrella association of the German steel and metal processing industry, WSM represents 25 industrial sectors with over 5,000 companies, a total of 435,000 employees and an annual turnover of around €78.6billion. It enables the IHT to bring its interests into political discussion in Germany and Brussels.
For many years, the IHT has been in close contact with the Bremen-based AWT (Arbeitsgemeinschaft Wärmebehandlungstechnik) and represents its members at an information booth within AWT's annual *Härtereikongress*, hitherto held in Wiesbaden, Germany (*Fig 3*).

Don't miss out on benchmarking benefits

…says Wallwork's ***Richard Burslem****.*

The biannual CHTA Benchmarking Club has been running successfully for almost 12 years and, about 18 months ago, was enhanced with the addition of price information for some of the major commodities used by CHTA members.
The pricing value used is the total cost of supply divided by the total quantity supplied and so reflects the actual cost to the business and not the "unit cost" as is so often quoted by the supplier. It is very easy to calculate as a result.
As well as the relative costs, such as sales per employee, the commodity prices make the Benchmarking Club information a most useful tool to be able to compare the performance of your business, over time, with that of other CHTA members and to use the information to negotiate with suppliers.
The Benchmarking Club is only available to CHTA members and there is only one drawback: the summary of resulting information, which is anonymous, is only released to members who complete and return the questionnaire. Quite rightly, you cannot get the benefit of this useful data without contributing to it in the first place.
Another useful facet of the information is that we are able to present to Government the actual cost of a commodity to the user. When electricity prices are quoted, for example, it is usually the price per kWh and it is often pointed out that industrial electricity costs much less than domestic, which is exactly correct. However, few people realise that industrial electricity carries 'green' taxes adding an extra 17% to the bill, additional supplier charges of 25% and, as a consequence, the VAT charged on the whole bill is actually 28% of the electricity price. Although for most members it can be reclaimed, this VAT element does seriously affect cash flow.
The Benchmarking Club is only meaningful if a significant number of members complete the survey, and this has always been the case. If you are one of the members who do not participate, why not give it a try? You may be surprised at the quality of information you receive. Hopefully, you could also be pleasantly surprised by your figures in comparison with your anonymous competitors; if not, you have the ammunition for action.
The next CHTA Benchmarking Club survey takes place in May 2014.

Member news

NEW INSTALLATION AT TAMWORTH HEAT TREATMENT

Tamworth Heat Treatment have installed a new high-temperature high-vacuum furnace at their site in Tamworth, Staffordshire.

The investment of some £350K is part of the continuous improvement activities and demonstrates the company's commitment to keeping pace with the changing demands of industry.

The new equipment complements the existing eight vacuum furnaces. With the high-vacuum capability, along with the availability of nitrogen and argon as process gases, it provides a facility for the treatment of stainless steels, super alloys and titanium, along with the potential to develop high-temperature brazing.

Use of PC supervisory and SCADA-based control systems ensures a high degree of temperature uniformity satisfying the AMS 2750 specification requirements for thermal processing equipment.

The new vacuum furnace at Tamworth Heat Treatment.

The equipment was made in the Midlands by Vacuum Furnace Engineering. It shows the commitment of Tamworth Heat Treatment to Midlands engineering and the provision of a modern up-to-date processing facility for their customers throughout the UK and Ireland.

NEW LPCN FURNACE AND WASH SYSTEM FOR TTI

Further investment has been made by TTI Group Ltd at its Luton site.

A new low-pressure carbonitriding (LPCN) furnace has been commissioned following the continued growth in low-pressure carburising (LPC). Much work has been done in preparation for the furnace, including installation of a new cooling tower, upgrading the electrical system and work on the technical gas bunker.

One of the biggest vacuum furnaces in the Group, with a working envelope of 600mm diameter and 1000mm height, the new furnace will give TTI much-needed extra capacity for low-pressure carburising and vacuum hardening and tempering. It is

The new LPCN vacuum furnace at TTI Luton.

fitted with the latest cutting-edge technology, with *PreNit* (nitriding prior to high-temperature carburising to prevent grain growth) and *SimVac* software for simulation of the case-hardening processes.

Apart from LPC, the Luton site will be able to offer vacuum nitriding, nitrocarburising and carbonitriding, as ammonia will be one of the four process gases available.

With increased capacity in the vacuum department, it was also appropriate to upgrade the washing facility at Luton's Motorsport division.

After running several trials on existing and future materials, a MecWash system was selected to meet all requirements for washing motorsport components from aluminium and titanium to medium-carbon and highly-alloyed steel.

The system is an aqueous wash with two tanks (wash and rinse) and an option to rotate the components during washing, which will guarantee the cleanliness in blind holes and very-complex-shaped components. The chamber size is suitable to wash most of the engine and transmission components for F1 customers. MecWash also supply the chemicals suitable for cleaning the wide range of materials TTI will treat.

BODYCOTE INSTALLS NEW HIGH-TEMPERATURE PRECISION VACUUM FURNACE AT DERBY

Bodycote's heat treatment facility at Derby recently took delivery of a new state-of-the-art vacuum furnace. The plant is located next to Rolls-Royce's Precision Casting Facility (PCF), serving Rolls-Royce and their first-tier supply chain. The new equipment was installed to meet demand and more stringent controls on the processing and pyrometry for new single-crystal alloys.

These alloys, used on engines for the Airbus A350 and Boeing Dreamliner, need to be processed at significantly higher temperatures than earlier generations of single-crystal alloys. Processing is typically carried out above 1360°C.

The furnace design benefits from Bodycote's 30 years of experience in the processing of single-crystal alloys and

The MecWash equipment.

incorporates a number of custom modifications to enable it to meet the stringent performance requirements including AMS2750E. Rated a class-one furnace, it can achieve a maximum working temperature of 1450°C and a temperature tolerance that is better than ±3°C. These features, along with unique gas-quench and vacuum capabilities, position Bodycote to serve the full spectrum of aerospace heat treatment needs.

The new furnace complements the existing capacity at the Derby facility, which includes five vacuum furnaces and a hot isostatic press.

Simon Blantern, Vice-President of Sales Europe for Bodycote's Aerospace, Defence & Energy heat treatment division, says: "This investment demonstrates Bodycote's continuing commitment to support our key aerospace customers who are pushing the envelope on processing temperatures with advanced materials that will drive engine efficiencies, enabling them to gain greater market share."

Vacuum furnaces at Bodycote Derby.

ALLOY HEAT TREATMENT FILL THE GAP IN DORSET

Following the recent closure of a major aviation firm offering heat treatment services in Bournemouth, many of the region's manufacturing businesses have been left struggling to find suitable alternatives.

With the company having been the main provider of heat treatment in central South England, its decision to move operations to Spain has left a significant demand for the service, as many companies have failed to identify other local providers to fill the gap.

Midlands-based Alloy Heat Treatment (AHT) have now stepped in to tackle the growing demand. Already working with a couple of firms in the South, the company would like to think there is a strong demand to warrant additional premises in the Dorset region.

Having been awarded the prestigious Nadcap Merit Status in 2012, overall, AHT has nearly thirty years of experience in heat treating aerospace components. One of the companies AHT is currently helping out with its expertise is Christchurch-based NFF Precision Ltd.

Tony Rogers, Director at NFF Precision, says: "The support from AHT to NFF has been excellent and their team has worked very hard to help us. We are very pleased to be working together with a business of this calibre which is extremely important to NFF. With both companies being Nadcap-approved in the aerospace and defence sector, the future looks good for us and we are looking forward to a successful working relationship."

Alloy Heat Treatment's Sales Director, Ian Perks, adds, "The only challenge we are currently facing is the transport from our Midlands base in Dudley down to Bournemouth and vice versa. Due to the distance, transport times and costs are higher than usual. However, if the demand in the South of England turns out to be high enough, we would consider opening up additional premises in the area in order to provide local businesses with the same service we currently offer to our clients in the Midlands."

FELLOWSHIP AND CHARTERED STATUS FOR WALLWORK DIRECTOR

Peter Carpenter, technical director at aerospace and motorsport thermal processing specialist Wallwork Heat Treatment, is marking his 30th year with the business. At the same time, he is celebrating election to Fellow of the Institute of Directors (IoD) and individual qualification as a Chartered Director.

"I joined the IoD in 2008 to take advantage of the training offered and have taken both the certificate and diploma courses delivered through Salford University. There are just over 1000 Chartered Directors worldwide," Peter noted.

Peter Carpenter

Peter joined the Bury-based company in 1983 as a metallurgist. He became a director of the Bury and Birmingham businesses in 1992 and was involved in the selection and acquisition of Cambridge-based technical coating specialist Tecvac in the late 1990s.

"There have been significant changes in the business over 30 years," Peter explained. "We still have core customers in general engineering but, with more customers in advanced sectors such as aerospace, motorsport and nuclear, there are new technical challenges, requiring the research and development of more sophisticated thermal treatment and coating processes."

Peter initiated substantial investment in Tecvac, including relocation to a new purpose-built factory, new equipment and the establishment of world-class research, development and metallurgical laboratories.

Supplier news

An optimistic press release?…

WHERE WILL HEAT TREATMENT BE IN FIVE YEARS' TIME?

The need to develop high-quality cost-effective products is driving the worldwide heat treating market to grow over 7%, according to a new report on the *Global Heat Treating Market 2012-2016**, but where will heat treatment be in five years' time?

Kevin Robinson, Business Development Manager at Invensys Eurotherm, a company that has been providing control solutions for the heat treatment industry for more than 40 years, offers his predictions for an industry undergoing a range of challenges as well as opportunities.

Kevin explains, "There was a slowdown in innovation in heat treatment processing during the last recession, as volumes dropped and the focus shifted to immediate costs and cash flow, but in recent years, with new model introductions, the industry is increasingly looking to the future."

Here, Eurotherm offers its predictions for heat treatment over the next five years:

1. India, China and Singapore will continue to grow; the quality of their parts will be a key driver for greater penetration of heat-treated high-value engineering products.
2. There will be a slow drift of aerospace manufacturing away from the traditional strongholds such as the US and UK.
3. Globally, the deskilling process in manufacturing will continue, with companies relying more and more on automation and 'expert' systems for process control.
4. Usage of new materials, that don't require heat treatment, and low-distortion processes will continue to grow.
5. Smaller lighter components will lead to smaller batch sizes and an increased requirement for smaller energy-efficient furnaces and controls.
6. An increase in the use of energy-efficient heating and furnace techno-logies combined with improved control systems.

Invensys Eurotherm provides furnace control solutions that enable customers to optimise the heat treatment furnace control process. This reduces waste through increased accuracy of furnace control and specialist control algorithms, optimising energy and power usage, curtailing rework and reducing scrap by improving consistency and repeatability.

Details of the* Global Heat Treating Market 2012-2016 *report can be found at:* **www.researchandmarkets.com/research/f5h7zf/global_heat.

Another similar report, "Global Vacuum Heat Treatment Market 2014-2018", *is outlined at:* **www.researchandmarkets.com/reports/2726290/global_vacuum_heat_treatment_market_20142018.**

Low-temperature surface hardening of stainless steel

Thomas L. Christiansen *and* ***Marcel A. J. Somers*** *of the Technical University of Denmark, Lyngby,* *update on how low-temperature surface hardening of stainless steel provides the required performance properties without affecting corrosion resistance.*

Stainless steels rely on the presence of chromium in solid solution, which allows the development and maintenance of a passive layer at the surface. Nitriding, carburising and nitrocarburising are generally not considered good practice, because processing in the conventional temperature range between 490 and 950°C leads to chromium nitride and chromium carbide precipitation. While this provides a hardening effect, it is highly detrimental to corrosion properties.

Since the mid-1980s, several processes have been developed that enable low-temperature surface hardening of stainless steel at temperatures below 440°C.

The first deliberate surface hardening of stainless steel was achieved by a process known today as *Kolsterizing*[1], a method ostensibly inspired by corrosion phenomena observed in liquid-metal fast breeder reactors[2,3]. About the same time, seminal work by Zhang and Bell[4] on plasma nitriding of stainless steel was published. Throughout the 80s and 90s, the development of low-temperature surface hardening of stainless steel relied largely on plasma-based techniques, while in the past ten years in particular, gaseous processing has been developed and commercialised.

Reproduced here with kind permission, this article was first published as: "Low-temperature surface hardening of stainless steel" Thomas L. Christiansen and Marcel A. J. Somers
HTPro, December 2013, Volume 1, Issue 2
ASM International Heat Treating Society
www.asminternational.org

HTPRO
BUSINESS AND TECHNOLOGY FOR THE HEAT TREATING PROFESSIONAL

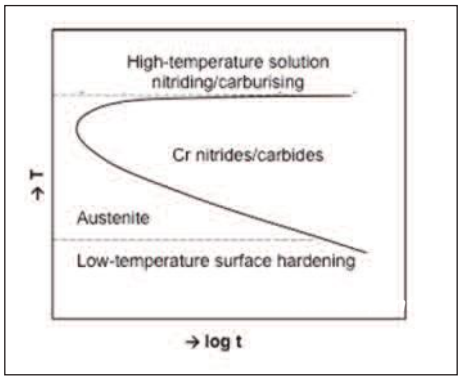


Fig.1. *TTT diagram of austenite with a high nitrogen or carbon content. A low-temperature treatment of long duration or a high-temperature treatment (>1050°C) combined with fast cooling can be applied to prevent development of chromium nitrides/carbides.*

This article describes fundamental and technological aspects of low-temperature surface hardening (LTSH) of stainless steel. The results shown are taken from the authors' research during the past 15 years.

LTSH principles

The TTT diagram in *Fig.1* demonstrates the combination of allowable treatment time at low temperature before precipitation of Cr-based nitrides or carbides occurs. In this temperature range, interstitially-dissolved nitrogen and carbon can diffuse over a relatively long distance, while substitutional dissolved metallic elements can be considered stationary. Consequently, nitride or carbide development proceeds so slowly that a nitrogen- or carbon-rich case free of chromium nitrides/carbides develops.

In the early days of LTSH, the case produced was considered a new phase, dubbed the S phase[4]. Recent research shows that no new phase develops, but rather LTSH of austenitic stainless steels produces a case that is essentially a solid solution of high amounts of nitrogen and/or carbon in austenite, where interstitial atoms group around chromium atoms[5–7]. Therefore, it is incorrect to refer to the case produced as S phase; "expanded austenite" is preferred.

The hardening effect that occurs by dissolving nitrogen and carbon at low temperature in stainless steel is not due to nitride or carbide formation. Rather, solution of high amounts of interstitial atoms in the austenite lattice provides effective hardening.

Process technology and applications

Plasma processes, apart from the proprietary *Kolsterizing* process, have a unique advantage over gaseous processing, because surface activation (removal of the passive film through sputtering) is an inherent step of such treatments. The (temporary) removal of the passive layer is necessary to allow surface penetration of nitrogen and carbon from the nitriding/carburising atmosphere.

Gaseous processing enables the highest flexibility, as well as straightforward monitoring and control. For a long time, it appeared that gaseous processing of stainless steel was possible only by in-situ removal of the passive layer in aggressive halogenides[8,9], or after ex-situ deposition of a metal layer promoting dissociation of the gas components and protecting the surface against (re)passivation during storage and treatment[10,11].

Later, robust gaseous treatments were developed based on gas mixtures that can both remove the passive layer and provide the nitrogen/carbon to the stainless steel surface[12–14]. Expanite, a company co-founded by the authors and Thomas Strabo Hummelshøj, works exclusively with gas mixtures that have this dual ability. *Fig.2a* shows the case produced during gaseous nitriding of austenitic stainless steel. The corresponding nitrogen content profile, hardness, and residual stress level are shown in *Fig.3.* Dissolution of a huge amount of nitrogen leads to an appreciable increase in surface hardness and high compressive residual stresses, which arise due to austenite lattice expansion in the nitrided case. High surface hardness contributes to improved wear and galling performance, while residual stress enhances fatigue performance.

During nitriding of austenitic stainless steel, an almost featureless case develops at the surface (*Fig.2a*), indicating that the zone is more difficult to dissolve by the etching reagent than the unaffected austenite.

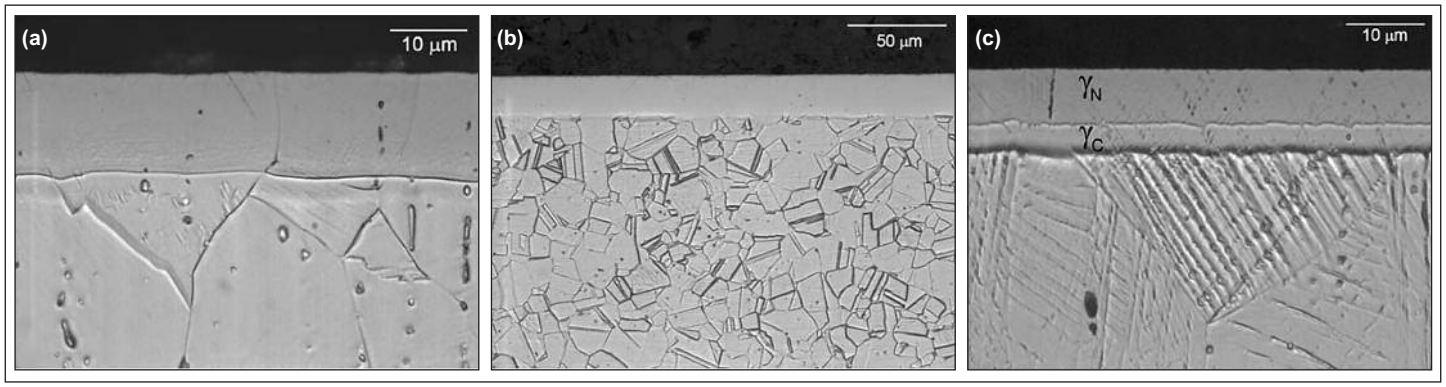


Fig.2. *Cross-sections of (a) AISI 316 after nitriding at 445°C for 22h in a gas mixture containing 60% NH_3 and 40% H_2, (b) AISI 316 carburised in acetylene at 520°C for 3h (the transition from core to hardened case is more diffuse than for nitriding), and (c) cold-worked AISI 304 nitrocarburised at 420°C for 19h (the nitrocarburised case is subdivided into a zone of nitrogen-expanded austenite and a zone of carbon-expanded austenite below).*

Similar results are obtained with carburising (*Fig.2b*), although less carbon can be dissolved, resulting in lower increase in hardness and residual stress. The choice of nitriding or carburising depends on the application, as both processes have advantages. For example, dissolved nitrogen has a positive effect on corrosion resistance (e.g. pitting). Carburising produces an advantageous shallow case-core transition because the affinity of chromium for carbon is not as high as for nitrogen. By comparison, nitriding yields a relatively sharp case-core transition. A gradual transition in hardness/ composition can be tailored by adopting gaseous nitrocarburising or the two-stage process of carburising followed by nitriding[15]. These processes produce a hardened case consisting of a hard zone of nitrogen-expanded austenite and a zone of carbon-expanded austenite underneath (*Fig.2c*).

For the case of heavy surface loading, austenite load-bearing capacity should be enhanced further. The simplest solution is to prolong the duration of the nitriding/ nitrocarburising treatment. However, this increases the risk for precipitation of chromium nitrides and associated loss of corrosion resistance.

In such demanding applications, the low-temperature surface hardening treatment can be preceded by a high-temperature solution nitriding treatment[16], which dissolves a relatively low amount of nitrogen into austenite up to a depth of several millimetres. Cooling from the solution nitriding temperature should be done carefully to prevent development of chromium nitride (Cr_2N or CrN) precipitation (*see Fig.1*).

Alloy grades other than austenitic stainless steels can be treated. Most stainless steel types, including austenitic, ferritic, duplex, martensitic and precipitation-hardening (PH) grades, can develop a surface case of nitrogen and/or carbon-expanded austenite by undergoing gaseous nitriding, carburising, and nitrocarburising treatments. Expanded austenite can also be formed in other types of (similar) alloy systems, such as many Ni-base alloys. For example, Ni-base superalloys such as the Nimonic series can be nitrided, but low temperatures (360–400°C) are required to suppress formation of unwanted CrN[17]. Also, martensitic and austentic PH steels can be nitrided and simultaneously bulk hardened[18,19].

Summary and outlook

Surface hardening of stainless steel can be achieved by low-temperature nitriding, carburising and nitrocarburising by transformation of the surface into nitrogen and/or carbon-expanded austenite. Gaseous processing provides a high degree of tailorability of the hard surface case, enabling tailoring of materials properties and, therefore, performance. Most stainless steels and similar alloy systems can be surface hardened by means of gaseous processing.

Today's stainless steel alloys treated using LTSH are designed for purposes other than surface hardening. New stainless steel alloys with compositions tailored for optimal LTSH will further expand the applicability of low-temperature surface hardening.

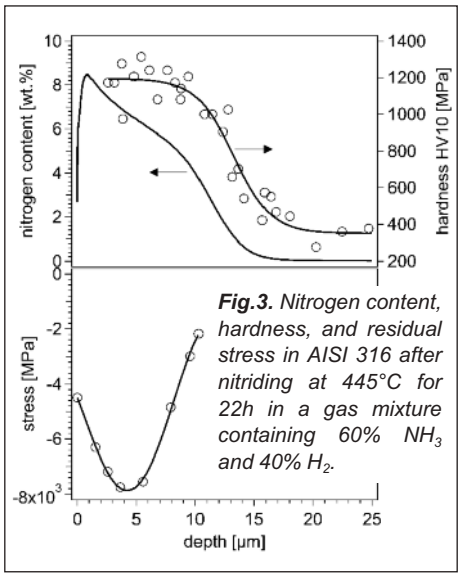


Fig.3. *Nitrogen content, hardness, and residual stress in AISI 316 after nitriding at 445°C for 22h in a gas mixture containing 60% NH_3 and 40% H_2.*

References

1. B.H. Kolster, *VDI-Berichte*, 506, p107–113, 1983.
2. B.H. Kolster and A.J. Rogers, Corrosion and Mass Transfer, AIME, p 252–264, 1973.
3. F.B. Litton and A. E Morris, *J. Less-Common Metals*, 22, p71–82, 1970.
4. Z.L. Zhang and T. Bell, *Surf. Engrg.*, 1(2), p131–136, 1985.
5. T. Christiansen and M.A.J. Somers, *Scripta Materialia*, 50, p35–37, 2004.
6. J. Oddershede, et al., *Scripta Materialia*, 62, p290–293, 2010.
7. J. Oddershede, et al., *Steel Research Intl.*,82(10), p1248–1254, 2011.
8. M. Tahara, et al., European patents EP 0588 458 B1 and EP 0 787 817 A2.
9. S. Collins and P. Williams, *Adv. Matls. & Proc.*, 164, p32–33, 2006.
10. S.V. Marx and P.C. Williams, European patent EP 1 095 170 B1.
11. M. A. J. Somers, T. Christiansen, and P. Møller, European patent EP 1 521 861 B1.
12. M. A. J. Somers, T.L. Christiansen, European patent EP 1 910 584 A1, 2005.
13. T.L. Christiansen, T.S. Hummelshøj, and M.A.J. Somers, *Surf. Engrg.*,27, p602–608, 2011.
14. T.L. Christiansen, T.S. Hummelshøj, and M.A.J. Somers, WO 2011 009463 A1.
15. T. Christiansen and M.A.J. Somers, *Surf. Engrg.*, 27, p445–455, 2005.
16. T.L. Christiansen, T.S. Hummelshøj, and M.A.J. Somers: PCT application PCT/DK2012/050139, 2011.
17. K.M. Eliasen, T.L. Christiansen, and M.A.J. Somers, *Surf. Engrg.*, 26, Vol.4, p248–255, 2010.
18. R.B. Frandsen, T. Christiansen, and M.A.J. Somers, *Surf. & Coat. Tech.*, 200 (16/17), p5160–5169, 2006.
19. F.A.P. Fernandes, T. L. Christiansen, and M. A. J. Somers, Heat Treat & Surf. Engrg. Conf. & Expo, Chennai Trade Centre, Chennai, India, May 2013.

For more information: Marcel A. J. Somers, Professor and Section Head - DTU Mechanical Engineering, Technical University of Denmark, Produktionstorvet Bldg. 425, 2800 Kgs. Lyngby, Denmark; somers@mek.dtu.dk; *www.mek.dtu.dk*.

Photograph courtesy of Renown Gears.

Technical Executive ***Andy Harry*** *outlines the activities of a fellow organisation with which CHTA has recently re-established links.*

The current British Gear Association (BGA) has its roots in the British Gear Manufacturers Association (BGMA) formed in Sheffield in 1945. Following a study on the competitiveness of the British mechanical engineering industry, commissioned by IMechE, the remit of the Association was widened in 1986 to include the whole supply chain, academic bodies, end-users, etc. The BGA moved to its current premises in Burton on Trent in 1993, when it became a Company Limited by Guarantee.

The Association exists to maintain and improve the competitive position of the mechanical power transmission industry associated with the UK and, therefore, the membership does include a significant proportion of UK-based members who have their main manufacturing activity located in a number of EU countries. Today the Association has a very diverse membership of some 70 companies ranging from "blue-chip" organisations down to small design consultancies.

The principal activities of the BGA today are centered around:

- collaborative research and development projects;
- education and training;
- BS and ISO Standards work;
- Special Interest Groups (SIGS);
- The annual Technical Awareness Seminar (*GEARS 2014*).

Research

The BGA has been involved in gear research for many years and brief summaries of these projects can be found on the website *www.bga.org.uk*. Since the early 2000s, the research has been entirely funded by the consortium members themselves. However, in earlier days projects were match-funded by the Department for Trade & Industry (DTI).

There are two current projects – one concerning the surface contact fatigue failure mode known as micropitting and the other on the bending fatigue performance of carburised gear steels. The research is mainly carried out by the Design Unit, Newcastle University, with some work also being conducted at Cardiff University and Intertek (formerly QinetiQ).

The BGA also enters selected research calls from the UK's Technology Strategy Board and the EU. The Association was part of a 22-member-strong EC Framework-6-funded consortium for Project X-GEAR, which was concerned with the production and testing of demonstrator gears for automotive and wind-power applications using novel materials, coatings and tooth microgeometries to optimise efficiency.

Education

The main roles of the BGA in the X-Gear project were the dissemination of information and education and training. The latter forms a significant part of the Association's activity via its Knowledge Transfer seminar programme which embraces the whole range of gear-design and manufacturing topics including heat and surface treatment.

The BGA also runs a four-day practical gear-cutting and measurement course which, we believe, is now unique in the UK although, at one time, almost every Technical College in the country would have run something similar.

Additionally, the Association sponsors the week-long gear-design courses, held at Cranfield University, which form a module in their MSc on Rotating Machines. Details of all current courses can be found on the website.

Standards

The BGA is the lead body for gear and spline standards work in the UK through BS Committee MCE/5 Gears, which shadows the work of TC60 Gears at the ISO level. The BGA itself is subcontracted by BSI to act as the secretariat for TC60 Subcommittee 1 "Nomenclature & worm gearing".

The BGA believes very strongly in the importance of having input to the key standards for the industry. A major benefit for committee members and their organisations is the opportunity to work with the foremost world experts in the field.

Special Interest Groups

Standards also form part of the work of the Special Interest Groups (SIGs), of which there are three currently running: Gear Measurement, Splines and In-Service Load Measurement.

Two further SIGs will be launched shortly: one will concentrate on the steel gear failure mode known as Tooth Flank Breakage (aka TIFF) by the ISO committee on Gear Calculation, and another on the very "hot topic" of Additive Manufacturing. It is unlikely that gears for power transmission applications will be made by this technique in the short term, but the process is ideal for producing complex shapes in many materials. It is already finding application for covers in the aerospace industry, for example, and gear casings are the logical "next step".

In the future, the BGA aims to further develop its activity in all of the aforementioned strands. A major initiative is the forging of closer links with universities to engage the engineers of the future. Part of this initiative is reflected in the award of the annual BGA/IMechE prize for the best final-year project (HND/BEng/MEng/MSc) on any topic relevant to mechanical power transmissions. Many of the winners have gone on to reach very senior positions in the industry.

Finally, the Association's annual Technical Awareness Seminar is held in November each year at locations such as AMRC Sheffield, The Defence Academy (Shrivenham) or AgustaWestland. This event allows members and non-members alike the opportunity to learn about the current developments in the power-transmissions industry. The *GEARS 2014* seminar will be held at Newcastle University on Thursday 20 November.

Putting a test case for integrity management

Widely-publicised catastrophic failures of forged materials in deepwater applications have called into question the structural integrity of such products and focused industry attention on the need for carefully-managed 'integrity management' of key components.

Errors in material selection at the design stage, the use of incorrect heat treatment techniques and inconsistent mechanical-testing regimes, often involving test pieces not taken from the actual components, can lead to product failures during operation, typically resulting in significant environmental, safety and financial costs.

With suppliers to the oil, gas and marine industries particularly appreciating the need for integrity management of deep-sea components to prevent expensive failures or prolonged shutdowns, Yorkshire-based independent heat treatment and metallurgical testing specialist Keighley Laboratories is experiencing an upturn in demand for first article inspection of pre-production components, to ensure meeting operators' engineering specifications. It is a preventative measure that the company believes could be adopted more widely, especially with the life-expectancy of products extending from ten years to 25 years or more, often in extremely harsh and corrosive environments.

"Product failures bring problems that engineering companies simply don't need, wasting time, money and damaging their commercial reputations, when customers are inconvenienced," says Leonard Stott, Customer Support Manager for Keighley Labs' Technical Services division. "More than ever there is a definite requirement for proven product reliability and fitness-for-purpose, as well as a need for consistent mechanical and corrosion properties that can only be achieved by applying the correct processing and heat treatment techniques. Also, product testing procedures need to be accurate, not least the correct positioning and orientation of test sample pieces, to ensure optimum and consistent test values.

"It would be costly for suppliers to set up the necessary in-house procedures to ensure critical mistakes don't happen, so it is worthwhile subcontracting the metallurgical testing of components to independent experts like ourselves," he adds. "We are specialists in the analysis, testing and heat treatment of metals, holding many leading quality accreditations relevant to various industry sectors, and we have the in-depth metallurgical knowledge and experience for the assessment of potential failures and the development of risk-mitigation strategies."

It was the catastrophic failure of a mooring shackle in the Gulf of Mexico and a second incident involving two sockets in another mooring system, which highlighted faults in the original heat treatment process as a likely cause. A subsequent report, by the US Department of the Interior's Minerals Management Service (MMS), concluded that defective heat treatment during component processing resulted in a metal unable to meet Charpy impact test requirements for material toughness and that testing parameters were either not followed or not adequate to ensure specifications were met.

Test laboratory

The MMS recommended that operators should revise their specifications to make sure that testing and manufacturing produces a satisfactory product, which will meet future usage demands. It also commented that operators should review their requirements for both destructive and non-destructive testing of critical elements, as well as ensuring that test coupons, or pieces, are properly representative.

Indeed, it was later found that the test pieces were not samples taken from the actual product and subsequent research indicated the importance of sample positioning in achieving representative and consistent toughness values. Thus, while energy absorption in a longitudinal orientation achieved a satisfactory 70-80 joules, the same test in the transverse direction recorded a disastrously-low four joules. It was also easier for a smaller test piece of 2" cross-section to pass the impact test, rather than a larger more-representative section.

Through a wealth of metal testing and heat treatment experience, developed over a market history dating back more than 90 years, Keighley Laboratories is perfectly placed to offer independent metallurgical testing, on a subcontract basis. Its long-established Test House boasts a full array of physical and mechanical testing resources, including room and sub-zero temperature assessment down to -196°C, Charpy impact test and sample preparation provisions, all the main hardness and micro-hardness testing methods, and specialist equipment for tensile and compression loading and determining other key mechanical properties. Accelerated salt-spray techniques, humidity chambers, solvent/chemical resistance and other corrosion-related testing are also among its specialised facilities.

A spacious new optical suite houses advanced metallurgical microscopes complete with image-capture software, a fully-equipped CNC machine shop, a highly-respected chemical analysis department and a dedicated team of NDT inspectors qualified to PCN Level 2/3, further extending Keighley Labs' in-house technical resources, establishing it as one of the best-resourced independent metallurgical testing services in the country. Added to which is its undoubted expertise in the heat treatment of metals, including expert consultancy on thermal and quenching processes and the selection of suitable materials at the design stage.

The fact that all of these interrelated metallurgical capabilities are available to customers on a single site only strengthens Keighley Labs' credentials for metallurgical testing of critical components and advising on product-quality issues.

AFC-Holcroft Europe

Hotline's *new advertiser has a central hub for all of Europe…*

AFC-Holcroft, one of the world's largest suppliers of heat treating equipment, offers a variety of thermal processing solutions to meet the increasing demand for flexible scalable heat treatment systems with consistent repeatable metallurgical results. A branch office in Boncourt, Switzerland serves as a central hub for all of Europe.

The branch in Europe allows AFC-Holcroft to expand their existing international presence, including sales, service, manufacturing and support, as well as to increase their corporate footprint across the globe.

Mr Marc Ruetsch, Managing Director of European Operations, is responsible for all European activity. With degrees in both Metallurgy and Engineering, he has held several management positions for other large European heat treat equipment suppliers throughout his 30 years in the heat treating industry.


Marc Ruetsch

Since its opening, AFC-Holcroft Europe has finalised numerous orders in several European countries, including:

- New sealed-quench furnace equipment for multi-national companies Bodycote and AAM.
- Austempering equipment for ADI in Birmingham, England and an automobile subcontractor in Italy.
- Pusher furnace equipment for eastern Europe for the bearing industry.
- Large roller-hearth equipment delivered to Spain.
- A complete batch integral-quench (IQ) furnace line for a leading commercial heat treater with multiple production sites across Europe.
- Pusher furnaces for the Russian truck and auto market.

As part of their global corporate strategy, AFC-Holcroft's UBQ (universal batch quench) family of sealed/integral-quench products and accessories were re-engineered with the specific goal of minimising international shipping expense and maximising global flexibility. This has proved highly successful to both new and existing customers who have also expanded into a global playing field, and continues to attract many multi-national manufacturing companies seeking to simplify their global supplier relationships.

The AFC-Holcroft product line encompasses equipment for both ferrous and non-ferrous metals. The company is well recognised for its continuous pusher furnaces, roller-hearth, rotary-hearth, sealed/integral-quench batch furnaces and accessories. Companion units, such as AFC-Holcroft's E-Z Series endothermic gas generators, continue to grow in popularity due to their efficient design, ease of maintenance, and fast payback time.

Many of the top manufacturing companies in the world utilise AFC-Holcroft equipment in their manufacturing process and continue to invest in the value that quality equipment can bring.

As an original equipment manufacturer, AFC-Holcroft also provides parts, service, maintenance, upgrades/retrofits and equipment replacement, with an emphasis on providing maximum value for the initial investment.

AFC-Holcroft manufactures heat treating systems for applications including commercial heat treating, automotive, heavy equipment, aerospace, tool and die, gear and fastener manufacturing, railroad industry and many more. The company continues to expand its global reach, with another branch office in China serving all of Asia and partners in the United States, Australia, Brazil, Mexico, Poland, Russia and Spain - many which have manufacturing facilities.

With many solutions to fit your unique business, and offices on three continents and partners worldwide, ISO 9001:2008-certified AFC-Holcroft stands ready to help you meet your specific heat treatment needs.

AFC-Holcroft Europe can be reached at +41 32 475 56 16, or via email at *Europe@afc-holcroft.com.* The company website is *www.afc-holcroft.com.*

FORTHCOMING EVENTS

Diary

March 27-28 2014
SOUTHWEST SUMMIT: NEW TRENDS IN HEAT TREATMENT
San Antonio, Texas, USA
www.secowarwick.com/en/infocenter/events/

April 9-10 2014
HEAT TREATMENT FORUM
Wroclaw, Poland
The first international conference and exhibition of the heat treatment industry in Poland.
www.heat-treatment-forum.pl/homepage/

April 14-15 2014
INTRODUCTION TO PYROMETRY
Birmingham, England
www.equalearn.com/learncenter.asp?id=178409

April 16 2014
HIP PROCESSING OF MATERIALS FOR OFFSHORE ENERGY APPLICATIONS
Aberdeen, Scotland *www.iom3.org/events/hip2014*

April 24 2014
CHTA PUBLICITY SUBCOMMITTEE*
Birmingham, England

April 28 – May 2 2014
41ST INTERNATIONAL CONFERENCE ON METALLURGICAL COATINGS AND THIN FILMS
San Diego, CA, USA
www2.avs.org/conferences/icmctf/

May 6-7 2014
8TH VACUUM CARBURISING SYMPOSIUM
Dearborn, Michigan, USA
http://www.ald-holcroft.com/Symposium2014.aspx

May 8 2014
CHTA MANAGEMENT COMMITTEE/ AGM*
Birmingham, England

May 12-15 2014
21ST IFHTSE CONGRESS / EUROPEAN CONFERENCE ON HEAT TREATMENT & SURFACE ENGINEERING
Munich, Germany
www.awt-online.org/ awt_seminare_und_ veranstaltungen/muenchen_2014.html

May 15 2014
BIFCA course: FURNACE & BURNER CONTROLS
West Bromwich, England *www.bifca.org.uk*

May 27-28 2014
INTRODUCTION TO PYROMETRY
Derby, England
www.equalearn.com/learncenter.asp?id=178409

June 3-5 2014
SUBCON 2014
Birmingham, England *www.subconshow.co.uk*

June 11-12 2014
A3TS 2014
Reims, France
41st congress on heat treatment and surface engineering. *www.a3ts.org/*

June 16-18 2014
5TH INTERNATIONAL CONFERENCE ON THERMAL PROCESS MODELING AND COMPUTER SIMULATION
Orlando, Florida, USA
www.asminternational.org/content/Events/modeling/index.jsp

June 16-18 2014
FURNACES & ATMOSPHERES FOR TODAY'S TECHNOLOGY
Meadville, PA, USA
www.secowarwick.com/en/infocenter/events/

June 18 2014
2ND HEAT TREATMENT CONGRESS
Querétaro, Mexico
www.metalspain.com/mexico-2014-english.htm

Members wishing issues to be raised at CHTA meetings should notify CHTA's Secretary, well beforehand, at mail@chta.co.uk

Market Movements

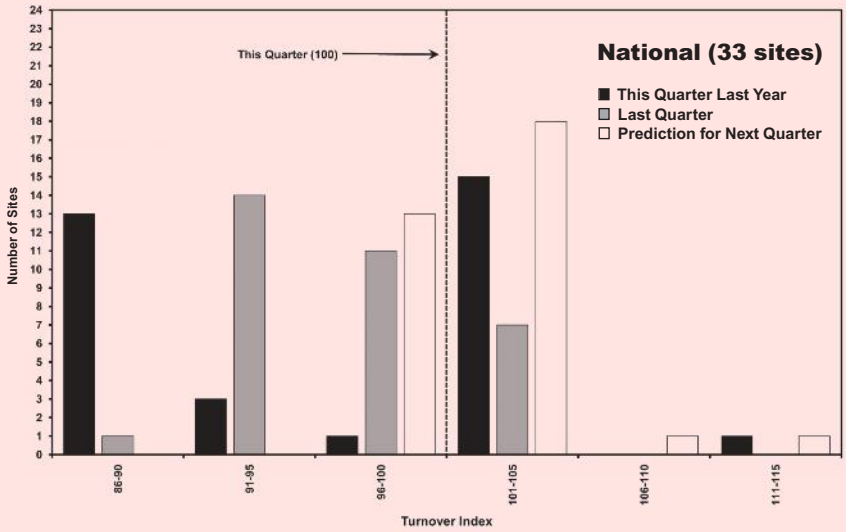
ANALYSIS OF QUESTIONNAIRE REPLIES RELATING TO 33 CHTA MEMBER SITES

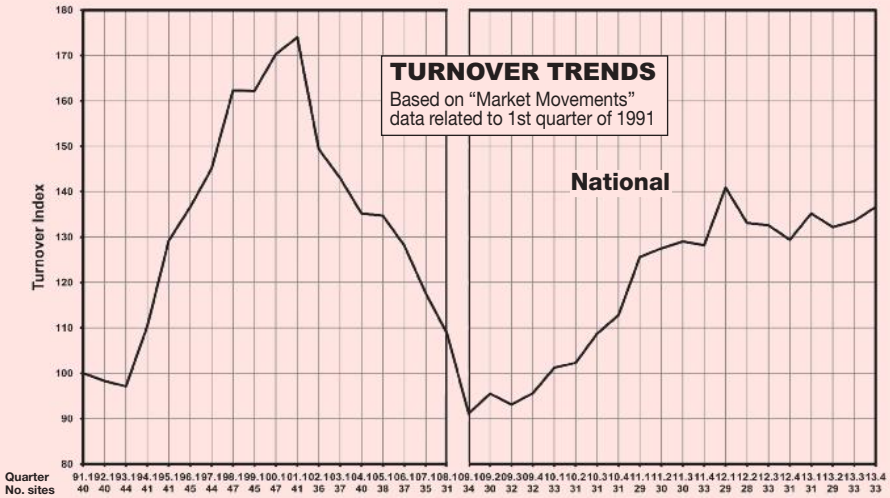
"THIS QUARTER" =

1 OCTOBER – 31 DECEMBER 2013

= TURNOVER INDEX 100

OVERALL ANALYSIS (33 SITES)	Mean index
This quarter last year	96.3
Last quarter	97.7
Predicted next quarter	100.7





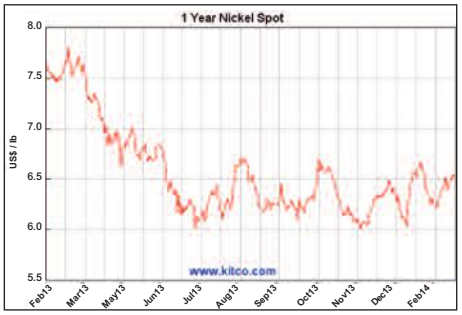
STATESIDE STATS

NORTH AMERICAN 2013 HEAT TREATMENT SALES DOWN BY 2% ON PREVIOUS YEAR

CHTA counterparts participating in the Metal Treating Institute's Monthly Sales Statistics Program reported total heat-treating sales of $877.0million in 2013, a drop of 2.0% from the $894.5million posted for January-December 2012.

With seven out of the nine MTI districts (New England; Middle Atlantic(!); South Central; Michigan; North Central; Pacific Coast; South West) reporting recent sales recovering, latest December billings amounted to $66.8million, an increase of 7.6% over December 2012's $62.1million.

NICKEL PRICE (US$/lb)



Please send comment and news items for June's *Hotline* 136 to: *mail@chta.co.uk*
Deadline: May 21st