The Contract Heat Treatment Association Newsletter

# HOTLINE

Issue No. 134
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## Inside . . .



# Sixty of the best...


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## 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



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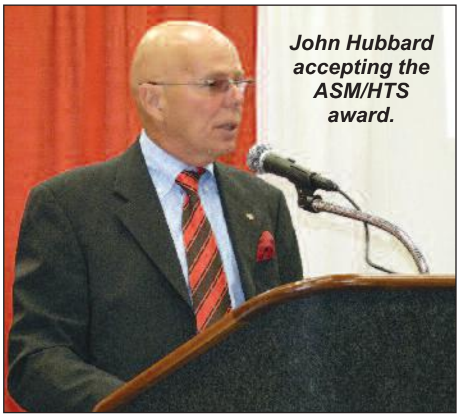
# Member news

### MAJOR AWARD FOR FORMER BODYCOTE CEO

Now retired, John D. Hubbard, former CEO of Bodycote plc, headquartered in Macclesfield, Cheshire, is the recipient of the prestigious 2013 George H Bodeen Heat Treating Achievement Award.



*John Hubbard accepting the ASM/HTS award.*

Established in 1996, this ASM International Heat Treating Society (HTS) award recognises distinguished and significant contributions to the field of heat treating through leadership, management, or engineering development of substantial commercial impact. Previous winners include the late Professor Tom Bell and John Chesworth.

John Hubbard is recognised "for a lifetime of devotion to and advancement of heat treating by transforming numerous small localised commercial heat treat providers into a network of knowledgeable and technologically-strong heat treating facilities to meet the needs of the worldwide manufacturing community."

*John Hubbard receiving his award from HTS President Thomas E. Clements of Caterpillar (left) and HTS Past President Terrence Brown (right), another recent retiree from Bodycote.*

## Season's Greetings
### to all our readers

John worked nights at Warner & Swasey while earning a B.Sc degree in metallurgical engineering at Cleveland State University. After graduating in 1970, he was appointed metallurgical engineer and promoted to manager of heat treating departments for six facilities. He received his MBA from Cleveland State in 1973 and was a part-time adjunct professor for Business Ethics and Statistics at the university.

John and a partner founded Furnace Services & Furnace Controls in Cleveland in 1973 and sold the companies in 1976. He joined Hinderliter Heat Treating Inc., North American Heat Treating Group, in 1976 as general manager and became president in 1983. Bodycote plc acquired the company in 1996 and John became president of Bodycote's North American Thermal Processing Division.

In 2002, John became CEO of Bodycote plc, growing the company from £479m and 5700 employees to £730m and 11000 employees in more than 300 facilities in 32 countries before retirement in 2009.

John Hubbard was on the Board of Trustees of the CHTA-counterpart Metal Treating Institute (1983–1986 and 1994–2002) and was MTI president in 2000–2001. He was also on the Heat Treating Society Board of Directors (1994–2000), HTS president (2000–2001) and received the ASM Distinguished Life Member Award in 2005.

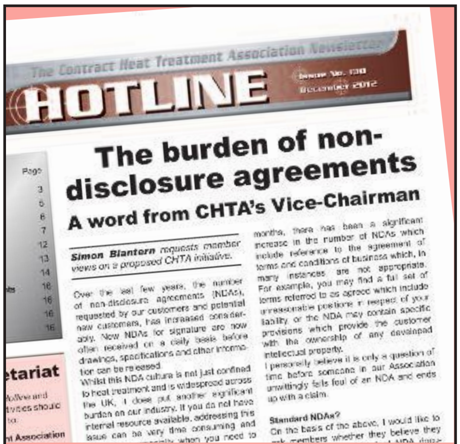
The George H Bodeen Heat Treating Achievement Award was presented to John at September 17th's HTS General Membership Meeting at the ASM HTS Conference and Exposition in Indianapolis.

### TTI INVESTMENT CONTINUES

Following on from the expansion of their PVD coating facility in Birmingham in December 2012, TTI Group has recently invested in two additional furnaces.

A new TAV vacuum furnace was installed at the site in Letchworth in August, adding to a Nadcap-accredited vacuum facility. Having a capacity of 1000kg, usable envelope of 800 x 800 x 1200mm and 10bar quench, with both nitrogen and argon capability, this furnace will provide capacity to expand the aerospace market. The furnace meets the requirements of the AMS 2750E pyrometry standard and AMS 2769 aerospace standard for vacuum furnaces.

At Telford, a new Rübig plasma nitriding furnace was installed in October, strengthening the existing capability for the process. This, the fifth plasma furnace at Telford and the eighth within the group, places TTI firmly as the number-one




## Coming soon...

### CHTA STANDARD NDA

Readers will recall that, in last December'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, completion of which is now imminent.

The NDA document will be posted shortly in the Members Area at *www.chta.co.uk.* Members will be alerted of its availability by e-mail.

*The new plasma nitrider at TTI Telford.*

supplier of plasma nitriding in the UK.
The facility at Telford is the only Nadcap-accredited plasma nitriding site within the UK. The new aerospace-approved furnace has a capability of four tonne, with a usable envelope of 1m diameter x 1.6m high, and has bespoke features to meet the AMS 2750E standard. Four load thermocouples, additional specific data logger, a twin-base arrangement and post-oxidation feature make this furnace unique in plasma nitriding.

## ENLARGED PIT FURNACE FOR TODAY'S LARGER COMPONENTS

Developments in renewable energy, mining and quarrying, oil exploration, marine and other applications have led to significant increases in the size of power-transmission components to handle greater productivity demands. As these are exposed to severe-duty cycles, there is renewed emphasis on the heat treating methods needed to enhance their wear resistance and strength properties.
Anticipating growing customer demand for processing larger gears, shafts and other components, subcontract heat treatment specialist Keighley Laboratories of West Yorkshire has enlarged the size of one of its largest pit furnaces. Increasing dimensions, to 1110mm working diameter and almost 1800mm maximum length, has yielded a gain of 30% in overall capacity.
At the same time, the company has upgraded the lifting capacity of its overhead crane, which services all seven pit furnaces, a salt bath and tempering equipment, to three tonne maximum lift.
Enlarging the No.1 pit furnace involved fabricating a custom-made inner retort, made from duplex stainless steel. This considerable investment has already been offset by orders for heat treating 1108mm-diameter gear wheels for an off-shore application and 1755mm-long 1-tonne shafts for a renewable energy project. Indeed, the company is already considering upgrading other in-house pit furnaces.
Says Keighley's Divisional Commercial Director, Michael Emmott: "With our new heat treatment department, modern furnaces and advanced low-temperature low-distortion thermochemical processes coming on stream later this year, we wanted to renew the focus on our pit-furnace capability, where we rank amongst the leaders in the contract heat treat industry.
When it comes to minimising distortion in heat-treated components, pit furnaces still have a lot to offer and with gears, shafts and other parts increasing in size, the distortion challenge is becoming even greater. It's an area where we can usefully contribute, drawing upon our many years' experience"

*Some of the CHTA members at the CHTA-sponsored NAMTEC event reported on page 6. (L to r): Tom Bell and John Jervis (Bodycote Heat Treatments), Debbie Mellor (Keighley Laboratories), CHTA Chairman Simon Blantern (Bodycote), Peter Fletcher (Holt Brothers) and Richard Burslem (Wallwork Heat Treatment).*

## BEST TECHNICIAN

Wallwork Heat Treatment Ltd (WHT) employee Catherine Holt was honoured by ICME (Institute of Cast Metal Engineers) at their annual awards in Birmingham in October where she was judged as "Best Technician" and received an engraved bronze medal.

Catherine was a first-year English undergraduate when she applied for an administration job at WHT's head office. Sadly, perhaps happily, she did not get the appointment but was offered a role as a junior technician in the company's quality control laboratory. Seven years and a lot of hard work later, Catherine has just completed a Btec course in Engineering and Materials at Bradford College.

### CHTA MEMBERSHIP FEES

In line with inflation, the annual CHTA membership fee for a single-site company is raised to £600+VAT for 2014. For multi-site companies, the additional fee will be £152+VAT per extra division.
The 2014 fees will shortly be invoiced on behalf of CHTA by SEA/BATF.

### AIR PRODUCTS SPONSORSHIP

CHTA is delighted to announce that Air Products plc will again be kindly sponsoring both the Association's website and *Hotline* in 2014.
Their much-valued support now extends to an unbroken period of fifteen years.

# REACH threat to refractory ceramic fibres (RCFs)

*SEA's **Dave Elliott** reports…*

Earlier this year, the European Chemicals Agency (ECHA) published its fifth recommendation of substances to be placed on the REACH authorisation list (Annex XIV). This recommendation included both Alumina-Silica RCF and Zirconia-Alumina-Silica RCF.

This means that, if confirmed by the European Commission later in the year, the future use of RCF within the European Union will be subject to the authorisation process. This is a very costly and time-consuming procedure with no guarantee of success. If an authorisation is not granted, then the use of these substances within the EU will be prohibited.

Refractory ceramic fibres (RCFs) belong to a class of fibres called man-made vitreous fibres (MMVFs), which are valued primarily for their insulating qualities. Because of their high thermal resistance, refractory ceramic fibres are used in high-temperature applications such as furnace linings and doors, kilns, catalytic converters, brake pads and heat shields.

The key concerns for CHTA members are:

- Is there a replacement for RCFs? You will need to check with your supplier and see what action they are taking.
- Make sure that you have proper control measures in place to cover any potential exposure to RCFs, which could occur during maintenance procedures or if a furnace lining was damaged.

The Health & Safety Executive have published a lot of information on the safe use of RCFs and a simple search of their website will provide documents such as: *http://www.hse.gov.uk/foi/internalops/ocs/200-299/267_3v2.htm*



# CHTA-sponsored NAMTEC event examines some latest heat treatment techniques

The NAMTEC workshop *Heat Treatment: the Latest Techniques*, sponsored by CHTA, attracted over thirty delegates to the Nuclear AMRC in Rotherham on October 23rd.

Chaired by NAMTEC CEO Dr Alan McLelland, the half-day event featured four presentations:

- In *Corr-I-Dur®: Corrosion and Abrasion Resistant Coating*, Tom Bell described the principles, practice and typical applications of Bodycote's gaseous ferritic nitrocarburising process with pre- and post-oxidation.
- In *Temperature Profiling System*, Dave Plester explained the operation of PhoenixTM's in-situ high-temperature profiling systems, with emphasis on the utilisation of the thermal-barrier-encased data-logger in sealed-quench furnaces.
- In *Furnace Control and Atmosphere Measurement Technologies*, James Cross (Super Systems Europe) concentrated on automated control of gas nitriding and ferritic nitrocarburising (see pages 12-13 here) and introduced *CAT-100* a new SSi approach to in-furnace checking of carbon potential during carburising.
- *Infrared Heating of Metals* was outlined by Jon Wood of Heraeus Electro-Nite (UK) Ltd.

The event also provided an opportunity for useful networking and a chance to view the impressive facilities at the Nuclear AMRC.

# Another successful *Understanding Heat Treatment*

The enduring value to our industry of Wolfson Heat Treatment Centre's well-established three-day *Understanding Heat Treatment* course was again illustrated by an excellent turnout, of thirty-one delegates, at the latest October event.

Over 1850 have now attended the 78 such courses staged since the series was inaugurated, 36 years ago, to convey a general appreciation of the metallurgical/technological background to industrial heat treatment processing.

As ever, there was strong support for the Birmingham-based course from CHTA members, who this time provided half of the delegates (seen in our photograph).

The success of the course is down to Wolfson Manager Derek Close, who not only organises and co-ordinates the course but has a major input as the main lecturer. He tells *Hotline* that the next *Understanding Heat Treatment* event is scheduled for **14-16 October 2014**. For full details, e-mail *derek.close@sea.org.uk.*

*Delegates from CHTA member companies at the 15-17 October* Understanding Heat Treatment *course. (L to r): Gavin Wood (Heat Treatment 2000), Les Hickens (Beta Heat Treatment), Chris Hayward and Mariusz Kostkiewicz (both TTI Group), Brett Nicholson (Tecvac/Wallwork), Peter Greenslade (TTI Group / Nitriding Services), Colin Wardle and Steve Garner (both Wallwork Heat Treatment), course organiser/chairman/speaker Derek Close (Wolfson Heat Treatment Centre), Mark Dyer (Tecvac/ Wallwork), James Beck, Richard Turner, Craig Mazurkiewicz and Bradley O'Toole (all Wallwork Heat Treatment, Birmingham), Robert Betts and Karle Tyler (both ADI Treatments).*

The Contract Heat Treatment Association

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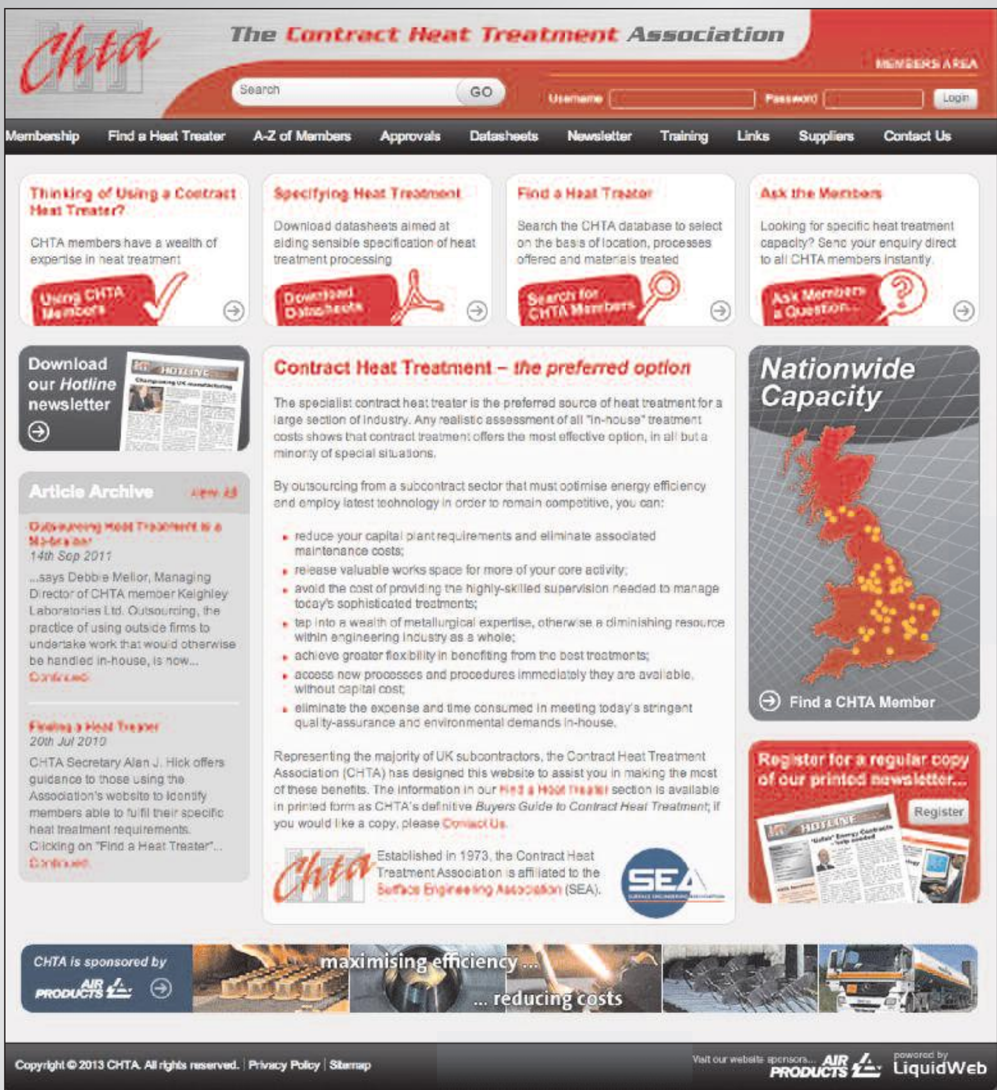


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Website: www.techniques-surfaces.uk.com

**TECVAC LTD**
Buckingway Business Park, Swavesey,
Cambridge CB24 4UG
Tel: 01954 233700 Fax: 01954 233733
E-mail: sales@tecvac.com
Website: www.tecvac.com

**THERMAL HIRE LTD**
Unit 12, Pagefield Industrial Estate,
Miry Lane, Wigan, Lancashire WN6 7LA
Tel: 01942 620062 Fax: 01942 620156
E-mail: sales@thermalhire.com
Website: www.thermalhire.com

**THERMAL HIRE LTD**
Tees Bay Business Park, Brenda Road,
Hartlepool, Cleveland TS25 2BU
Tel: 01429 868202 Fax: 01429 861063
E-mail: sales@thermalhire.com
Website: www.thermalhire.com

**TTI GROUP LTD**
Lower Philips Road, Whitebirk Industrial Estate,
Blackburn, Lancashire BB1 5RE
Tel: 01254 264901 Fax: 01254 662552
E-mail: Blackburn@ttigroup.co.uk
Website: www.ttigroup.co.uk

**TTI GROUP LTD**
PVD Coating Centre,
Unit 4, Witton Park Industrial Estate,
Bickford Road, Birmingham B6 7EE
Tel: 0121 327 2020 Fax: 0121 327 6461
E-mail: Birmingham@ttigroup.co.uk
Website: www.ttigroup.co.uk

**TTI GROUP LTD**
Bamfurlong Industrial Park, Bamfurlong Lane,
Staverton, Cheltenham,
Gloucestershire GL51 6SX
Tel: 01452 712023 Fax: 01452 714418
E-mail: Cheltenham@ttigroup.co.uk
Website: www.ttigroup.co.uk

**TTI GROUP LTD**
Blackhorse Road, Letchworth,
Hertfordshire SG6 1HD
Tel: 01462 472100 Fax: 01462 480643
E-mail: Letchworth@ttigroup.co.uk
Website: www.ttigroup.co.uk

**TTI GROUP LTD**
39-43 Bilton Way, Luton,
Bedfordshire LU1 1UU
Tel: 01582 486644 Fax: 01582 481148
E-mail: Luton@ttigroup.co.uk
Website: www.ttigroup.co.uk

**WALLWORK HEAT TREATMENT LTD**
Lord Street, Bury, Lancashire BL9 0RE
Tel: 0161 797 9111 Fax: 0161 763 1861
E-mail: sales@wallworkht.com
Website: www.wallworkht.com

**WALLWORK HEAT TREATMENT (BIRMINGHAM) LTD**
Sydenham Road, Small Heath,
Birmingham, West Midlands B11 1DQ
Tel: 0121 628 2552 Fax: 0121 628 1555
E-mail: sales@wallworkht.com
Website: www.wallworkht.com

**ZOTIC LTD**
26-30 Highgate Square, Highgate,
Birmingham, West Midlands B12 0DU
Tel: 0121 440 3130 Fax: 0121 440 6646
E-mail: enquiries@zotic.co.uk
Website: www.zotic.co.uk

# Selecting a heat treater at *www.chta.co.uk*

***The foregoing pages update the listing of CHTA members previously found in the CHTA Member Directory 2013 published in Hotline 130, December 2012. It also supplements the more detailed information that can be found at www.chta.co.uk, the website that facilitates easy identification of those able to meet specific heat treatment requirements.***

## Find a Heat Treater

Clicking on "Find a Heat Treater" at *www.chta.co.uk* takes the visitor to a constantly-updated searchable database that enables easy identification of CHTA members providing various subcontract heat treatment services in the North, Midlands and South geographical areas of the UK.

Selection, based on processes offered, materials treated and location, results in a list of names of appropriate companies; clicking on a name yields full details of the company, with direct access to its own website. Enquiries can be submitted to one or more of the chosen companies with a single click.

## Processes

The "Find a Heat Treater" database covers over forty heat treatment and ancillary processes from which the visitor can select.

Where appropriate, the search can be refined in order to specify the preferred medium in which a heat treatment is conducted, the choice being: air or products of combustion; controlled/ protective gas atmosphere; fluidised bed; pack; plasma; salt; or vacuum/low-pressure processing.

## Approvals

All companies featured in the database are members of the CHTA and, as such, are pledged to maintain the highest standards of quality and service. ISO 9001 is currently the universally-accepted quality accreditation, but many members hold additional quality approvals from major organisations, which are especially relevant in particular market sectors.

National and international accreditations/ certifications held by CHTA members (such as ISO 9001, ISO 14001, AS 9100, CQI-9, ISO/TS 16949 and Nadcap) are listed on the "Approvals" page of the website.

## Ask all the members *instantly*

Where a job is proving difficult to source (say, because of size or other special requirements), the "**Ask the Members**" page on CHTA's website allows the visitor to ask all CHTA members if they can offer appropriate specific capacity. Once submitted, such an enquiry is e-forwarded to members instantly; any able to help reply directly.

## Using a Contract Heat Treater

In order to benefit fully from the services of a company featured here and in "Find a Heat Treater", the website recommends that buyers of contract heat treatment should involve the intended supplier at the earliest moment.

CHTA member companies have a wealth of experience in heat treatment which can:

- make a positive contribution in the selection of the most appropriate treatment;
- warn of possible pitfalls;
- help avoid costly mistakes.

But, as the website observes, all of this can only happen if the visitor chooses to draw upon this expertise and specialist knowledge.

## Specifying Heat Treatment

Clicking on "Specifying Heat Treatment" or "Datasheets" at *www.chta.co.uk* accesses CHTA's series of *Datasheets for Non-heat-treaters*, guides aimed at aiding sensible specification of subcontract heat treatment processing and avoidance of common problems. Couched in layman's terms, they answer the questions: What are the treatments? What are the benefits? What materials can be treated? What are the limitations? What problems could arise? How do I specify? Where do I go?

In response to the last question, the datasheets recommend contact with appropriate CHTA member companies from those listed in this directory and at *www.chta.co.uk*.

# Advertising in *Hotline*

***Hotline*** **welcomes advertising (other than recruitment) from CHTA members and suppliers to the trade.**

## 2014 RATES

**Single-insertion charges for black-and-white ads:**

| Size | Dimensions | Charge |
|---|---|---|
| **Quarter page** | 121mm high x 86mm wide | **£190**+VAT |
| **Half page** | 121mm high x 178mm wide or 254mm high x 86mm wide | **£335**+VAT |
| **Full page** | 254mm high x 178mm wide | **£600**+VAT |

For **full-colour** ads, add an extra **£253**+VAT

**Advertisers in four consecutive quarterly editions of *Hotline* are entitled to a series rate where all of the above prices are discounted by 20% per insertion.**

**Series advertisers also feature on the new Suppliers page of CHTA's website at no extra charge.**

Booking deadline for March's *Hotline* 135: **February 12th**

For further details, contact *Hotline* Editor Alan J. Hick

Tel: 0121 329 2970; e-mail: *mail@chta.co.uk*

# A practical approach to controlling gas nitriding and ferritic nitrocarburising

***Stephen Thompson**, President of Super Systems Inc, reviews developments in process control*.*

For most of its history, heat treating has been controlled manually. Operators would observe readings from gauges connected to sensors and, if changes were needed, manually adjust heat, atmosphere or other outputs.

Over the last 30 years, technology has allowed heat treaters to automate those processes by using relay controls and intelligent process loop controllers that constantly monitor atmospheres and adjust outputs as needed. This kind of automation results in repeatability, traceability and higher quality at lower costs.

In this paper, I discuss different technologies employed in the past and the application of new technologies used today, particularly in nitriding and ferritic nitrocarburising.

Before considering these technologies, it is important to establish definitions for nitriding and ferritic nitrocarburising and related terms.

## DEFINITIONS

Nitriding and ferritic nitrocarburising are processes that respectively use nitrogen and nitrogen/carbon to create a case on steel that enhances wear resistance, corrosion resistance and anti-scuffing properties, all without distortion due to lower temperatures or the absence of rapid quenching.

**Gas nitriding** is a thermochemical treatment in which ammonia ($NH_3$) reacts at the surface of steel at temperatures needed to diffuse nitrogen into iron. Temperature is controlled between 500-565˚C. The reaction of $NH_3$ with steel causes nascent nitrogen to diffuse into iron and create a case.

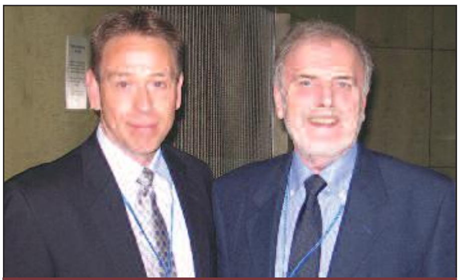
**Ferritic nitrocarburising (FNC)** involves two sets of reactions, nitriding and carburising, that occur simultaneously. A thermochemical treatment similar to nitriding, nitrocarburising (at 570˚C) also involves the addition of carbon to produce a thin surface layer of iron carbonitride and nitrides, commonly referred to as the "compound layer." The source of carbon in atmosphere FNC can be natural gas, propane, endothermic gas or carbon dioxide ($CO_2$).

**Dissociated ammonia** (DA) is the result of cracking ammonia into its constituent nitrogen and hydrogen.

**Nitriding potential** ($K_N$) is a derived measurement of an atmosphere's potential to allow for the diffusion of nitrogen into a material – specifically, in this case, iron:

$K_N = pNH_3 / (pH_2)^{3/2}$

where $p$ denotes partial pressure.



*Author Steve Thompson (left) with Hotline Editor Alan J Hick*

## TRADITIONAL CONTROL

Traditionally – and often still today – nitriding and FNC are controlled by temperature, time and flow. A metallurgical lab verifies the treatment and process variables can be adjusted based on the results of the lab's analysis. Pressure in the furnace is controlled with a manual valve or oil bubbler where the gas passes through oil to create 2.5-10mbar of back pressure.

A water burette (pipette) is used to test the percentage of dissociated ammonia, %DA. With $NH_3$ 100% soluble in water, this serves as a reliable way to measure the %DA, the remaining gas being composed of nitrogen and hydrogen. In this method, the furnace exhaust gas is passed through a vertical burette chamber and then sealed at the inlet and outlet. A valve is then opened at the top, where distilled water flows down and absorbs any unreacted $NH_3$. The water will stop flowing once the $NH_3$ is consumed.

The dissociation of the gas in the furnace can be determined based on the scale shown on the burette. Because of variations in the water source, gas purging of the burette and operator interpretation of the water level, the measured %DA may vary from the actual %DA. Gas flows are controlled manually and adjusted based on metallurgical results and the burette reading. Purging of the vessel to eliminate oxygen is strictly based on time, which is determined by flow and furnace volume. All of these factors increase the chance of variability in results and reduce process repeatability.

## AUTOMATED CONTROL

Automated control for both nitriding and FNC processes is based on temperature, time and flow as well as measurement of hydrogen, oxygen, carbon monoxide (CO) and $CO_2$.

### Nitriding

In nitriding, hydrogen is the only variable that must be measured as a result of the reaction of $NH_3$ during dissociation. The reason for this is that there will be three corresponding hydrogen atoms for each nitrogen atom, both before and after this dissociation:

$NH_3 \leftrightarrow N+3H$

*Table 1* shows the relationship between specific values for %DA and $K_N$. When measuring hydrogen, the amount of nitrogen present is known. When an atmosphere contains 75% hydrogen and 25% nitrogen, full dissociation is achieved. A hydrogen concentration lower than 75% will result in unreacted $NH_3$. For example, an atmosphere with 50%DA ($K_N$ of 2.18) and 37.5% hydrogen will yield a residual $NH_3$ of 50%.

Controlling a single- or dual-stage nitriding process is generally straightforward when $NH_3$ or dissociated $NH_3$ gas is utilised. These processes are regulated on the basis of temperature, time, flow control and the measurement of hydrogen.

This process becomes more complicated when a diluent, such as nitrogen, is introduced. The purpose of using nitrogen is to modify the %DA and the nitriding potential. When nitrogen is provided from a source other than the $NH_3$ reaction, more of it will be present in the atmosphere. Therefore, the $N_2$ (along with the $NH_3$) must be metered for the calculation

**This is an edited version of a paper presented at the 27th ASM Heat Treating Society Conference, Indianapolis, 16-18 September 2013.*

**Table 1. Relationship between percentage dissociated ammonia (%DA) and nitriding potential ($K_N$)**

| %DA | 1.33 | 2.67 | 6.67 | 13.33 | 20.00 | 26.67 | 33.33 | 40.00 | 46.67 | 50.00 | 53.33 | 60.00 | 66.67 | 73.33 | 80.00 | 86.67 | 93.00 | 100.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $K_N$ | 986.67 | 344.13 | 83.48 | 27.41 | 13.77 | 8.20 | 5.33 | 3.65 | 2.58 | 2.18 | 1.84 | 1.33 | 0.94 | 0.65 | 0.43 | 0.25 | 0.11 | 0.00 |

to compensate for the presence of additional $N_2$ that is not a result of the dissociation of $NH_3$.

Why not measure $NH_3$ instead of hydrogen for the nitriding process? The answer is simple: $NH_3$ must be measured with infra-red technology and the reading cannot be used reliably in the calculation due to the non-dispersive infrared (NDIR) frequency range and zero drift associated with it. Gases such as $CH_4$, $CO_2$ and CO have a more measurable frequency range that provides accurate and repeatable results when using NDIR.

However, hydrogen is highly conductive and easily measured using thermal-conductivity technology. Monitoring of thermal conductivity – the measure of the ability of the gas to conduct heat – is cost-effective and extremely stable. Re-calibration, though not frequently needed, can be performed easily.

Hydrogen is seven times more conductive than air and will transfer more heat when present, meaning that a heated sensor will require more energy to maintain a specific temperature. The thermal-conductivity cell measures the energy needed by its sensor and accurately calculates hydrogen. It is important to note that the temperature at which the thermal-conductivity cell operates must be below that of the temperature of dissociation of $NH_3$. Many hydrogen cells operate at temperatures above 775˚C.

Oxygen sensors are used to verify purging of the vessel. This shortens purge time and reduces the amount of nitrogen used in the process.

Electronic flow meters, with feedback, allow for automatic adjustment of $NH_3$, %DA and $N_2$ gases based on the $K_N$ calculated as a result of the measured hydrogen.

**Nitrocarburising**

FNC is similar to nitriding but with the addition of a carbon-bearing gas. When controlling FNC, hydrogen is one of a number of variables that must be considered.

With the use of $CO_2$ (common in pit-type furnaces), reaction with hydrogen produces CO to create a carbon potential, $K_C$ (see footnote to *Table 2*). Also commonly used, in batch-type furnaces, is endothermic gas having 40% $H_2$, 20% CO and small amounts of $CO_2$. With the addition of these gases, $K_C$ (dependent on the content of CO, $CO_2$, $H_2$ and $H_2O$) must be controlled, in addition to $K_N$, in order to provide the required metallurgical reactions of nitriding and nitrocarburising.

CO and $CO_2$ are both measured reliably with infrared technology. It must be noted that the infrared cell technology must be compatible with $NH_3$ and water for the FNC process. Oxygen is measured using zirconia or lambda-probe technology.

**Table 2. Ferritic nitrocarburising process parameters ensuring the formation of an epsilon-type compound layer with two ranges of porosity level. (From AMS 2759/12A)**

| Material | Process temperature | | Process time (hours) | Class 1: Porosity not exceeding 15% of thickness of compound layer | | | | Class 2: Porosity above 10% but not exceeding 50% of thickness of compound layer | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $K_N$ | | $K_C$ | | $K_N$ | | $K_C$ | |
| | ºF | ºC | | min | max | min | max | min | max | min | max |
| Group 1* | 1040<br>1075 | 560<br>579 | 3-6<br>2-5 | 2.13<br>1.50 | 2.41<br>1.60 | 0.57<br>1.10 | 0.69<br>1.22 | 2.48<br>1.68 | 2.68<br>1.78 | 0.49<br>0.86 | 0.54<br>0.94 |
| Group 2** | 980 | 527 | 6-30 | 4.51 | 5.55 | 0.16 | 0.24 | 6.03 | 7.10 | 0.09 | 0.13 |
| Group 3*** | 1060 | 571 | 3-10 | 1.82 | 2.10 | 0.76 | 0.99 | 2.22 | 2.64 | 0.48 | 0.68 |

Temperatures shown are not firm requirements. Once temperature is selected, however, both potential values shall be within specified limits for the given temperatures.

*Group 1: HSLA, carbon steels **Group 2: 4140, 4340, Nitralloy 135M ***Group 3: Cast iron

***According to AMS 2759/12A, the carburising potential can be defined based on one or another of two reactions:***

***1. The Boudouard reaction:*** $2CO = CO_2 + C$ *for which* $K_C = p^2CO/pCO_2$

***2. The water gas shift reaction:*** $CO + H_2O = CO_2 + H_2$ *for which* $K_C = pCO \times pH_2/pH_2O$

As with nitriding, it is important to meter the gas flows when using nitrogen and any other diluents. When using endothermic gas with 40% hydrogen present, it is important to measure and compensate for the gas flow and hydrogen content. With these variables being considered, $K_N$ and $K_C$ are calculated to allow for more precise control of the nitrogen and carbon in the compound layer.

Nitriding and FNC processes are often based on an Aerospace Material Specification (AMS) requirement. Taking FNC as an example, AMS 2759/12A is commonly used. It is possible to define the material, group and class. *Table 2* allows for the determination of the desired $K_N$ and $K_C$ based on the required epsilon compound layer and allowable porosity.

## CHALLENGES OF AUTOMATED CONTROL

Automating the nitriding and FNC processes brings new challenges that require specific technical expertise. In many industries, there is often a misconception that automation removes the need for any manual intervention. This is not the case with most automation technologies.

In fact, automation typically requires a more educated intervention. For example, sample lines and filters to the $H_2$ analyser and oxygen cell must be maintained on a regular basis. Calibration of the instrumentation and analysers must be completed at manufacturer-required intervals. Instrument certifications must be current and on record.

In addition, the mechanical assembly of the system must take into account the need for filtration and ease of maintenance. For example, sample systems must be supplied with drip legs in order to remove any moisture that might be generated during a pre-oxidation process. When nitriding stainless steel and using a pre-activation process, filtration and heat tracing must be included in the exhaust piping. Lines and filters must be cleaned for each run. Filtration systems should be designed with pressure indication and automatic by-pass modes. FNC processes are more challenging due to the formation of ammonium carbonate in the exhaust.

## BENEFITS OF AUTOMATION

Automating a nitriding or FNC process brings with it many distinct advantages. With the automated control of temperature, gas flows, $K_N$, $K_C$, supply pressure and back pressure comes the ability to generate alarms and, more recently, notify operators and others of alarm conditions electronically.

Automation allows for alarms on such events as temperature deviation, $K_N$ deviation, flow deviation, low or high back-pressure, and bypass mode. Today, electronic notification is available in the form of computer-automated e-mail and text messaging.

Just as important, the process requires no human intervention once started unless an alarm condition arises. Secure remote access to the process from anywhere in the world is now available.

Process automation allows heat treaters to generate and maintain historical records, reduce the consumption of gas and make decisions that ultimately provide a more repeatable process with higher-quality results.

# Hardening – where are the UK laser job shops? (Continued)

***Based on articles from the Spring 2013 edition of AILU's** The Laser User (TLU), **Hotline 133 featured opinions on the above question from CHTA members Chris Kenward (Ajax Tocco International) and Roger Haw (Flame Hardeners). In response, Autumn's** TLU **contains invited comments (submitted individually but combined here for clarity under key headings by Editor Mike Green) from AILU members Tony Bransden (Ionbond Lasertechnik), Roland Dierken (ERLAS Erlanger Lasertechnik) and Martin Sharp (Liverpool John Moores University).***

### The demand for laser hardening is much weaker than would be expected

For Tony Bransden, the big question is: why is UK demand for laser hardening so weak compared to that in Germany? He suspects it emanates from a lack in the education of young UK engineers who seem not to be aware of the possibilities that laser hardening offers.

Martin Sharp also thinks it all comes down to what is taught in engineering degrees and promoted through industry by experience and networking. The question is: does the modern graduate manufacturing engineer hit the shop floor knowing that laser hardening exists; and does the modern design engineer understand that a relatively small case depth can deliver the necessary solution? He suggests a survey of recent graduate engineers, asking how much teaching they received about laser processing in their degree, and had they been introduced to laser hardening.

Martin also suggests that, at least in part, the reason the UK contract heat treatment industry is not seeing enough enquiries for its members is simply because a search for a laser hardening subcontractor in the UK will not revel any. It is a vicious circle; but until someone makes the capital investment to establish a laser hardening job shop in the UK, the enquiries that arise will immediately go overseas; and overseas they do go. For example, Tony has a customer from the UK who ships them €100k each year – parts that cannot be hardened by induction.

Roland Dierken points out that, as long as nobody has a machine, there will be no chance to prove the competitiveness of laser hardening. For example, the temperature control that lasers offer means you can successfully avoid melting the workpiece surface; but we need somebody in the UK with a laser hardening installation to show this to potential UK clients.

As to where the UK business might come from, Roland agrees with Roger Haw (Flame Hardeners Ltd) that the best profit is made on big press tools but points out that ERLAS, one of the estimated 28 laser job shops in Germany, runs two profitable laser hardening job shop machines, and that as well as press tools they run small to medium lot sizes of "serial" parts such as truck brakes (in lot sizes of 1000 per month), extruder screws (5-10 per month) and big machine beds (5-10 per year), giving them altogether almost two-shift-per-day work over the year.

### Laser hardening would not compete significantly with traditional processes

Tony sees the laser as a *complementary tool* to induction. Its strengths are precision and flexibility and it is highly suited to smaller precision parts where case depths of 1mm are perfectly acceptable (parts for which wear of a few tenths makes them scrap so why harden deeper). The laser comes into its own where smaller areas of difficult geometry need to be hardened (although Ionbond do harden some parts with hardened widths of 30mm and case depths of 5mm). Induction and flame are more about large-area coverage or high case depths, especially on rotationally-symmetric parts where no overlap is allowed.

Roland adds that the high degree of temperature control provided by the laser process is a massive attraction when the process is compared with flame hardening.

### The need for a high grade of steel in laser hardening is misleading

Laser hardening requires a higher grade steel but Tony points out that most high-precision parts that need only the minimum of hardening (i.e. the situations ideally suited to laser hardening) are made of the higher-quality steel anyway.

Ionbond harden a wide variety of parts made of Q/T steels, cold- and hot-work tool steels and martensitic stainless steels. The attraction of these steels is that they have a high hardenability and do not need a large mass-to-depth ratio.

### Robotic control does not present a significant challenge

Tony points out that the "head" for laser hardening may weigh anything from a couple of kg up to 20kg and he thinks there should be no problem finding a robot capable of manipulating this load and that the use of robots is standard practice. He also points out that his laser hardening equipment is not too highly automated. Running a job shop enterprise, he has to maintain flexibility: typically he will have up to five jobs a day, where the quantity may range from one to 1000 parts, part weight from 10gm up to 5 tonnes, hardened widths from 2 to 30mm, part size from 10mm up to 3 metres – all on the same machine. These medium-size jobs are his bread and butter since, in these batch sizes, it is uneconomical for the customer to invest himself. He strives to offer a 24-hour turnaround on most parts.

Martin admits to being surprised that robot programming could be considered as being a bit difficult and requiring a high labour cost (i.e. to employ a CNC technician). He points out that the induction sector has its own requirements for process development and programming, and that the design of an induction coil is surely a highly specialised and skilled engineering requirement.

### Skill is required for laser hardening but no more than in other sectors

Roland claims that using temperature control and a little training on robot programming, together with a little experience of hardening essentials, one can run a job shop with people having only a basic technical understanding.

Tony points out that skilled people are needed, as in any high-tech branch, and that he runs his job shop with only one technician and three unskilled employees. Commenting further on this, Tony points out that laser hardening as a subcontract enterprise requires a mix of skills: a knowledge of laser radiation, physics, electronics, metallurgy, robotics, mechanical engineering and some economics are all beneficial. This should not hamper the education of young engineers and the awareness of designers in this field: which is where Tony thinks the UK problems reside.

FORTHCOMING EVENTS

# Diary

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

**January 30 2014**
**CHTA PUBLICITY SUBCOMMITTEE***
**Birmingham, England**

**February 11 2014**
**BIFCA course:**
**INTRODUCTION TO INDUCTION HARDENING**
**West Bromwich, England** *www.bifca.org.uk*

**February 12-13 2014**
**EUROPEAN OXIDE SCALE CONFERENCE 2014**
**London, England** *http://www.iom3.org/events/oxi2014*

**February 13 2014**
**CHTA MANAGEMENT COMMITTEE***
**Birmingham, England**

**March 11 2014**
**BIFCA course: BURNER TECHNOLOGY**
**West Bromwich, England** *www.bifca.org.uk*

**March 11-12 2014**
**NADCAP AUDIT PREPARATION – HEAT TREATING**
**Bristol, England**
*www.equalearn.com/learncenter.asp?id=17849*

**March 13-14 2014**
**INTRODUCTION TO PYROMETRY**
**Bristol, England**
*www.equalearn.com/learncenter.asp?id=178409*

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

**April 24 2014**
**CHTA PUBLICITY SUBCOMMITTEE***
**Birmingham, England**

**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**
*http://www.awtonline.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 heat treatment congress: *http://www.a3ts.org/*

**July 14-20 2014**
**FARNBOROUGH INTERNATIONAL AIRSHOW**
**Farnborough, England** *www.farnborough.com*

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

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

# Market Movements

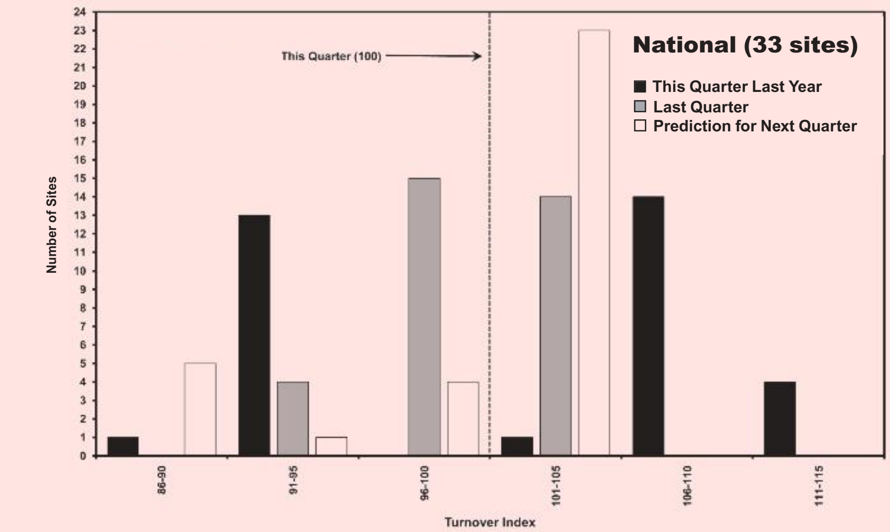
**ANALYSIS OF QUESTIONNAIRE REPLIES RELATING TO 33 CHTA MEMBER SITES**

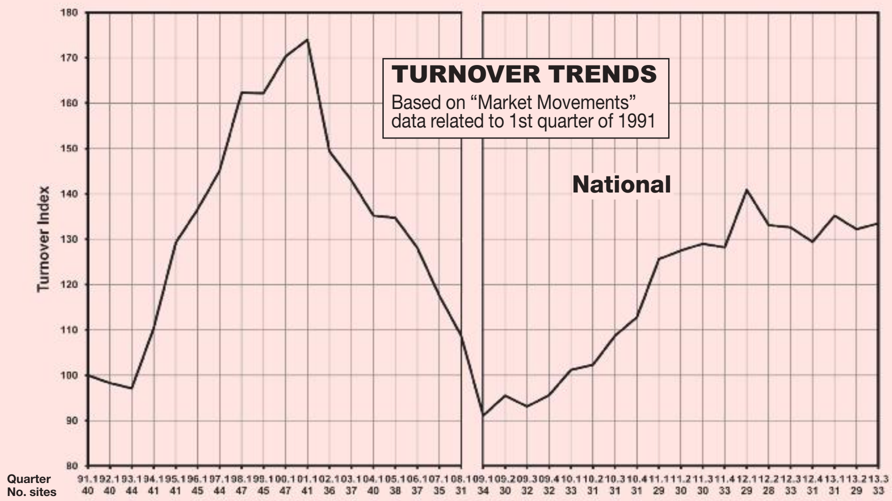
**"THIS QUARTER" =**

**1 JULY – 30 SEPTEMBER 2013**

**= TURNOVER INDEX 100**

| OVERALL ANALYSIS (33 SITES) | Mean index |
|---|---|
| This quarter last year | **102.6** |
| Last quarter | **99.0** |
| Predicted next quarter | **99.8** |



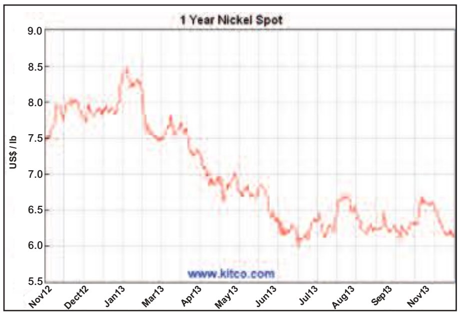

STATESIDE STATS

**NORTH AMERICAN 2013 SALES DOWN 4.6% IN FIRST NINE MONTHS**

CHTA counterparts participating in the Metal Treating Institute's Monthly Sales Statistics Program reported heat-treating sales of $659.8million for the first nine months of 2013, a drop of 4.6% from the $691.5million posted for the same period in 2012. However this September's billings amounted to $72.7million, an increase of 3.5% compared with September 2012's $70.2million.

The latest returns indicate October sales of $78.6million, an increase of 6.7% over October last year when billings amounted to $73.7million.

NICKEL PRICE (US$/lb)




**Please send comment and news items for March's *Hotline* 135 to: *mail@chta.co.uk* Deadline: February 19th**