Heat Treatment & Surface Engineering Summit

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Report by Christophe Stocky, IFHTSE Executive Committee member

Speakers:

- Janusz Kowalewski, IPSEN Japan
- Prof. Rainer Fechte-Heinen, Leibniz-Institut für Werkstofforientierte Technologien IWT, Germany
- Seiji Kaga, Dowa Thermotech Co. Ltd., Japan
- Toshiki Hara, Japan Metal Heat Treatment Industry Association, Vice Chairman, and METAL HEAT Co., Ltd., Representative Director, Japan
- Dr. Yoichi Watanabe, Japan Society for Heat Treatment, Vice President, and Nihon Parkerizing Co. Ltd., Fellow, Japan

The situation and trends of the heat treatment (and surface treatment) but mainly HT were presented for 4 big industrial regions in the world, namely USA, Europe, Asia (w/o Japan) and Japan. Some preoccupations are common and worldwide whereas according to the typologies of the market and current HT installations but also due to the local regulations (China net zero for 2060, India net zero for 2070), there are also differences in the development priorities from one region to another.

The common points are digitalization of the heat treatment and skilled manpower. For **Digitalization** following points are under consideration:

- Need of material data (Numerical methodology on data science, boundary conditions)
- Standardization of data, policies on data security
- Metallurgical modelling. Many physical models exist but a lot remains to do for new processes.
- Internet connectivity or continuous monitoring of the furnaces, predictive maintenance

Regarding the **human resources** (or human assets), The US industry in HT needs to find ways to attract younger workers. In Europe, there is a lack of skilled workers but we don't know if higher qualified personal is better or if press button personal helped with AI is sufficient. In Asia, n*o skilled person is necessarily needed* if the furnace is highly digitalized. In Japan they are convinced that without HT the society could not exist, so that they are trying to develop the pride to work in HT starting from the high school with demonstrations and experimental works.
With the carbone neutrality, there are lots of scientific subjects and this should be a big chance for young people.

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Trend in the US Heat Treatment Industry (IPSEN)

The American HT market represents 125 Billion $ with 15% hold by commercial HT 15%, whereas 85% is captive. MTI (Metal treatment Institute) prognose recession for 2025 (-11%) then recover for the turnover. Globally speaking, with EV total tonnage will reduce. General HT represents 35%, Brazing 20%, Carburising (25% - 65% Gas, LP 25%)) nitriding (10%).

5 megatrends were identified:

- consolidation in commercial HT shops because now there are 605 HT companies. (21.000 people).
- Digitalization, simplification, and automation of HT operation. Digitalization in HT is besides to predict what will happen to get prescriptive data (which action should I take to avoid problems)
- Transfer of HT process and maintenance K-H from end user to furnace manufacturer driven by proprietary software
- replacement of high CO2 generating furnaces with more efficient furnaces and lower temperature Processes.
- Increases in nano and thermo/chemical surface modification processes for near-net-shape Technologies – MIM and AM

The trends in process are ferritic nitro-carburizing FNC and nitrocarburizing, use of Vacuum HT (single Process flow), nitriding, LPC with gas or oil quenching.

The CO2 reduction is obviously one of the drivers but reducing costs is for now more important. And low temperature processes are a good solution to reduce cost. To reduce costs, SQ Quench is replaced by LPC, low-cost steels are preferred with surface treatment with nano-surface engineering. The sizes of the furnaces are increased. The technology of furnaces is changed to have convection heating in vacuum furnaces /SQ hybrid energy source.

Additional solutions to reduce CO2 emissions are for example heat recuperation from oil quench bath, solar panels used for nitrogen generation, green hydrogen/ammonia as a source of energy.

Additionally, H2 vehicle era is coming but need to reduce the cost of production. The US hydrogen shot seeks to reduce the cost of clean hydrogen by 80% to **$1** per **1 kilogram** in **1 decade** ("**1 1 1**").

Heat Treatment Situation in Europe (IWT)

The main trends for Europe are linked to the rise in energy costs, the efforts to carbon neutrality and digitalization in HT. Fechte-Heine presented for example the extract of the French survey made recently by A3TS to identify the key treatments for the future as well to identify the R&D topics (whole survey is at disposal). The main HT (LPC, CN, nitrocarburizing, IH, Vacuum HT) are equally represented. The R&D efforts are still mainly on LPC (50% of the interviewed) whereas nitriding and IH are promoted by 30% of the interviewed.

To reduce the energy costs, besides short-terms actions (shut down of companies, renegotiation of energy contracts), Europe is mainly working on conversion of heating systems, to develop hybrid (gas/ electricity) hydrogen ready furnaces. Instead of carburizing, the manufacturers try also to develop surface hardening, electron beam hardening, nitriding and nitrocarburizing to reduce the energy of high temperature HT (but also CO2 footprint).

With the electrification of the vehicles (less components) there are new needs for HT and SE but also higher alloyed steel grades for lightweight. Hydrogen transportation is also a topic in focus. The processes in the scope of development and research are for example carbonitriding, Bainitizing, interrupted quenching and nitriding specifically for hydrogen transportation.

ASIA w/o Japan (DOWA)

DOWA used the evolution of the populations in Asia with the 3 types of pyramids, in order to explain also the expected evolution of the needs. Evolution GDP and car ownership per person will expand especially in India and Southeast Asia. If they expect for China an increase of 2 times till 2050, India should increase 10 times. So, needs for HT in India will explode whereas today there are only 20~30 commercial heat treaters.

Focus was made on India and China which will be the major countries in the next years. In India LPC is very rare, the majority of HT are for 90% gas carburizing and hardening. Automotive represents 60% of the market of HT with new sites and concentration of some applications start also to export, Industry represents 20% (rail, bearings, wind), construction represents 10%, Other 10%. The market will also be faced with an increase of charging facilities also for EV the two wheelers.

In China, 13000 commercial HT facilities are present (1500 members). 150 million tons are treated each year. In 2002 it represented 91.000 million dollars and the volume should rise 115.700 million dollars in 2028 (+2.4%/y).

From a process point of view, the main trends are regenerative burners, vacuum carburizing, digitalization and remote monitoring. Lighter weight components are also needed.

Heat Treatment in Japan and Trends for Japanese Heat treatment

The development of the market and needs were presented on one part by JHTIA (the association regrouping 187 companies and 138 supporting companies) and on the other hand by JSHT (Japanese Society for Heat Treatment in charge of the research)

In 2019 505 factories (commercial heat treaters not including captive) were active. In 2019, HT Market represented 3.086 billion yen (~20 billion €). The applications are mainly transportation (61%), then metal machinery (18%), general machinery (12%), electric machines (4%). The main processes are carburizing, quenching and tempering (33%), quenching & tempering (20%), IH (13%) and nitriding (~10%). The impact of EV represents a loss of 10.000 types of parts (30.000 to 20.000 parts). Moreover Japan will see a shrinkage of production because of the shrinkage of population.

The evolution in Japan is mainly driven by carbon neutrality (hydrogen burners, IOT; reuse of waste heat). For the scientific aspects, JSHT took the 83 papers published in 2022, to get an of the main topics: HT theory and microstructure 15, strength toughness corrosion 17, IOT 10, and 51 concerned surface modifications and hardening (CH distortion 41%, nitriding 32%, induction 5%, coating 10%, others 12%)

Japan is focused on mild carburising or combined treatments, nitriding & modelling. Mild carburizing is combining different processes: Carburizing at 1000°C, induction reheating, and low alloy Mo free steel without REM use. This allows 52% reduction of CO_2 vs conventional but also an increase of 18% in fatigue resistance, reduction of distortion (-40%) and a reduction in production time (-60%).

Alternatively, to avoid the addition of Nb but to have the possibility to use high temperature (diffusion), the following process was presented: 1050°C vacuum carburizing with multi step quenching. After carburizing there is an intermediate cooling, then reheating to 870°C for final quenching