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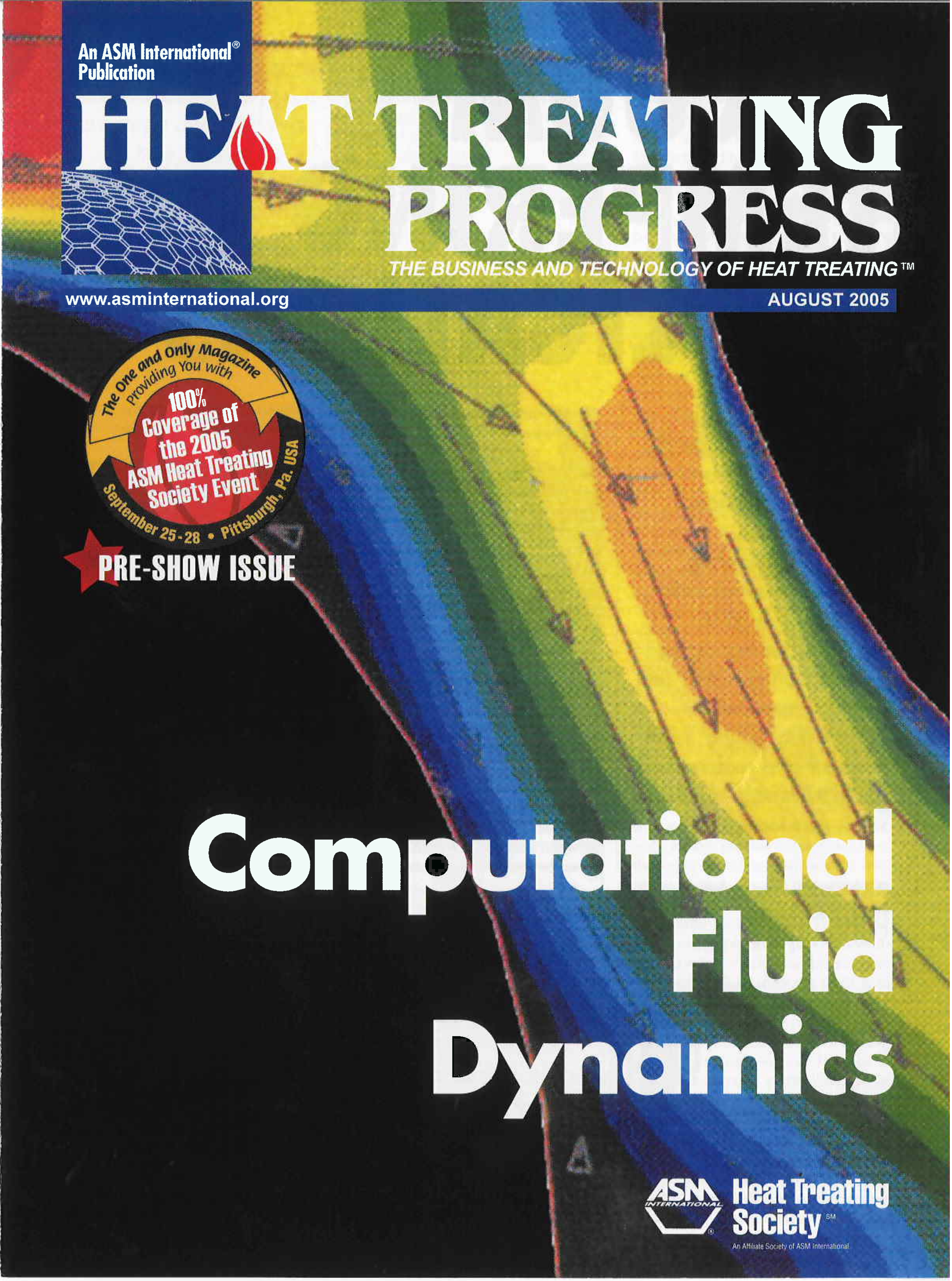

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PRE-SHOW ISSUE

Computational Fluid Dynamics

ASM INTERNATIONAL Heat Treating Society[SM]
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VACUUM TEMPERING APPLICATIONS

Vacuum tempering is being used for tempering high-speed steels and alloy steels to produce scale-free finish.
A vacuum tempering furnace is very versatile and can be used for bright tempering, aging and annealing. Other less common applications include degreasing, resin bake-off and preferential oxide treatment of carbon steels and tool steels.

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Vacuum tempering is being used for tempering high-speed steels and alloy steels to produce a scale-free finish. Additionally, there are several other applications, which make this style furnace very versatile. A vacuum tempering furnace can be used for bright tempering, aging, and annealing. Other less common applications include degreasing, resin bake-off and drying of parts.

A new vacuum temper furnace application is preferential oxide treatment. This application removes oily films on surfaces of low carbon steel parts, while creating an atmospheric corrosion-resistant oxide layer. This preferential oxide, which is quite resistant to corrosion, leaves a uniform color on the parts. Low carbon steel parts can be transported between work cells within a company or between different companies without requiring that the parts be preserved in rust inhibitors.

Background

Vacuum temper furnaces are designed to minimize oxide formation on surfaces when tempering or aging parts. They operate generally as follows:

- The furnace is loaded and the door closed. A vacuum, typically below .3 Torr (3.99x 10^{-2} kPa) is established in the furnace by means of a mechanical pump. If a blower pump is used with the mechanical pump, much lower pressures can be achieved.
- After evacuating the furnace, the furnace is backfilled with an inert gas such as nitrogen or argon to about 500 Torr (66.5 kPa). The parts are heated in this inert atmosphere to the required temperature and held for the required time.
- The furnace constantly purges in nitrogen gas during the heating and soaking of the parts at a rate of 10 cfh (.28 cubic meters

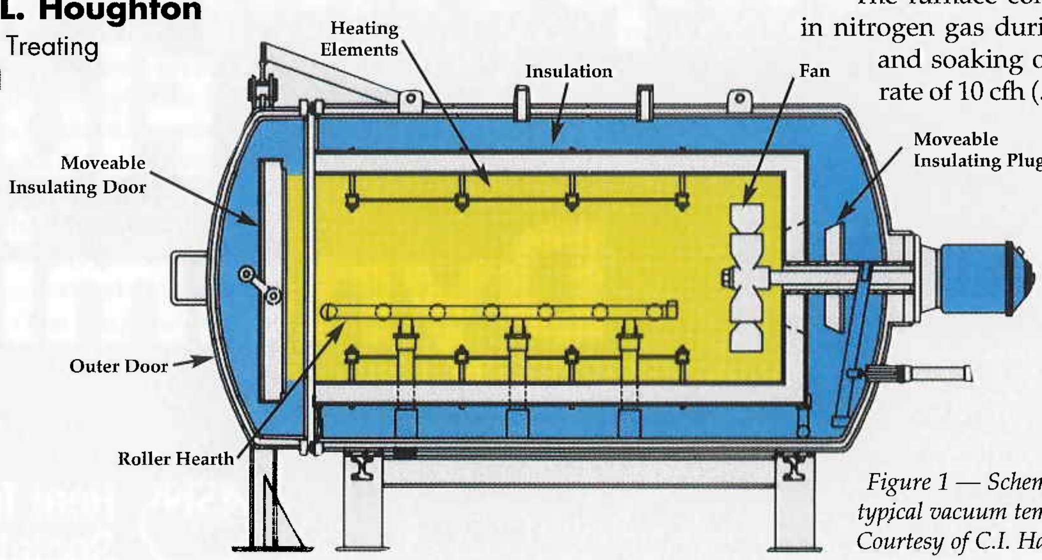

Figure 1 — Schematic diagram of typical vacuum tempering furnace. Courtesy of C.I. Hayes Corp.

A vacuum temper furnace can reduce atmosphere gas usage and total cycle time, as compared to a bell-type controlled atmosphere furnace.

per hour). This helps to purge impurities that may come off the parts at elevated temperatures. A vacuum-tight fan is used to circulate the atmosphere throughout the workload during heating.

- After soaking, the parts are cooled by circulation of the atmosphere.
- A rear "bung" and a front insulating panel open to force the atmosphere out of the heat chamber and along the cold walls of the vessel. The workload is removed from the furnace when the parts are below 300°F (150°C).

Applications

Bright Aging and Tempering — The most common application for a vacuum temper would be for bright aging precipitation hardening materials such as stainless steels, beryllium copper, bright tempering alloy steels, and tool steels (see Figure 2). In practice, it has been found that for tempering carbon and stainless steels, a vacuum temper can produce similar surface brightness as a hydrogen furnace up to 1000°F (538°C). Above this temperature, a hydrogen atmosphere yields a slightly better result.

A vacuum temper furnace can reduce atmosphere gas usage and total cycle time, as compared to a bell-type controlled atmosphere furnace. It takes far less time to pump down the furnace before ramping to temperature than to purge out the air in a bell furnace. Also, it takes much less time after the parts are cool to remove them from the furnace. With an atmosphere bell furnace, the hydrogen has to be purged at the end of cycle. Table 1 shows the productivity improvement possible using a vacuum temper furnace instead on a hydrogen bell furnace.

Degreasing/Drying — Vacuum tempers have been used for degreasing oily parts or drying parts that have been cleaned in a hydrocarbon solvent. To degrease, the cycle requires the oily parts to be heated under the partial pressure of nitrogen with a constant purge of gas. The parts are heated to the required temperature to vaporize the oil on the parts. Some of the vapors are removed from the furnace by the vacuum pump. During cooling, some of the vapors condense on the cold wall of the furnace leaving the parts relatively clean and dry. This cleaning application is somewhat crude and may only apply to in-process cleaning between machining operations. Furthermore, the furnace itself gets contaminated with the oil and may not be suitable for other "bright" work before the oil is baked out of it.

If the vacuum temper furnace is used for drying parts dipped in hydrocarbon solvent, the cleaning results are far better. Dipping the parts into a pre-cleaning solvent to dilute the oil will improve the parts' cleanliness. A vacuum temper can also be used for drying parts cleaned and rinsed in water-based cleaners.

Figure 2 – Tool steel bearing components, as vacuum tempered to a bright finish.

	Bell-Type Retort	**Vacuum Temper**
Furnace work zone	36" diameter x 36" high	24x24x36"
Max Load Size	1000 lbs.	1000 lbs.
Gas Usage	175 cfh	10 cfh
Gas Type	Dissociated Ammonia	Nitrogen
Cycle	Load furnace Purge with nitrogen Introduce Atmosphere Ramp to 600°F Hold for 2-2.5 hours Cool to below 200°F Purge out with nitrogen Unload	Load Furnace Establish vacuum Ramp to 600°F Hold for 2-2.5 hours Cool to below 200°F Backfill Unload
Total Floor to Floor Time	7 hours	4.5 Hours

Table 1 — Bright aging beryllium copper 172 alloy: The process requirement is to ramp to 600°F (315°C) and hold for 2-2.5 hours at temperature. Cool to below 200°F (93°C). The load consists of 160,000 pieces of an electrical contact. There are 80 lots, 2,000 pieces per lot. Each lot has to be kept separate and put into an individual basket. Therefore, the load consists of 80 small baskets loaded into larger framed baskets for support.