FIFTEENTH INTERNATIONAL COLLOQUIUM ON HEAT TREATMENT

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The fifteenth international scientific-technical colloquium was held May 29 and 30th, 1974, in Caen, France. The colloquium was organized by the International Society on Heat Treatment of Materials (MOTOM) and three French organizations: the Association on Heat Treatment (ATTT), the Society of Metallurgists (IRSID), and the Technical Center on Machine Construction (CETIM).

The International Society on Heat Treatment of Materials (the Russian initials of which are MOTOM) was organized in 1971. As of May, 1974, the members were England, Italy, Spain, Bulgaria, the Netherlands, Poland, France, West Germany, Switzerland, Sweden, and Japan.

MOTOM is an organization in which participation is voluntary. The society is headed by a board of delegates (Assembly). Each national delegation consists of three members. They may represent any number of national organizations.

The board of delegates meets several times a year. Day-to-day affairs are handled by a bureau consisting of three presiding officers (president, vice-president, and former president) and a secretary and treasurer.

Only one of the presiding officers is selected each year, which ensures continuity. The secretary and treasurer serve for two years. The headquarters of the society is in Zurich, Switzerland.

The purpose of MOTOM is to assist in the establishment and development of international exchanges of scientific and technical data and information in the area of heat treatment.

The activities of MOTOM consist of:

organizing international scientific-technical conferences (congresses);

exchanging information on national conferences or seminars;

setting up technical committees for collaboration on selected problems, etc.

At the present time the president of the society is Dr. H. U. Meier (Switzerland), the vice-president is Prof. Dr. O. Shaaber (West Germany), and the secretary is U. Wiss (Switzerland). Prof. Shaaber will be president until January 1, 1975. Candidate of technical sciences E. Shpunar (Poland) has been selected as the new vice-president.

MOTOM has set up technical committees on special terminology and consolidation of types and technical requirements for the operations of thermal hardening recommended for introduction in technical documents (U. Wiss); safety in heat treatment shops (G. Marti, France); coordination of national conferences and MOTOM congresses (H. U. Meier).

Preparations are being made for several new technical committees.

The fifteenth international colloquium was attended by specialists from the following twenty countries: France, West Germany, Austria, Belgium, Denmark, Spain, Finland, England, USSR, Bulgaria, Poland, Czechoslovakia, Hungary, Rumania, Holland, Japan, Lichtenstein, Sweden, Switzerland, and Italy — around 280 delegates.

The papers presented at the colloquium concerned two principal themes:

1. Deformation during heat treatment and residual stresses in machine parts.

Translated from Metallovedenie i Termicheskaya Obrabotka Metallov, No. 11, pp. 76-80, November, 1974.

2. Heat treatment with local high-speed heating. Brief reviews were also presented on several other matters in progress in various countries.

The Soviet representatives reviewed research in the area of nitriding (Yu. M. Lakhtin) and the problem of reducing self-deformation of machine parts during heat treatment (V. G. Vorob'ev).

Other reports concerned the following problems:

effect of steel composition, conditions of the quenching medium, and conditions of tempering and cold working on residual stresses;

distribution of residual stresses in machine parts after induction hardening;

warping of machine parts and residual stresses with high-speed local heating;

effect of the distribution of residual stresses and distortion of the crystal lattice on the fatigue limit of carburized and carbonitrided steels;

thermal stresses in hardened alloys based on aluminum;

microstructure of the surface layer after induction hardening;

the first data on hardening of unalloyed steels with use of pulse heating;

effect of metallurgical factors on warping and the properties of toothed wheels;

effect of the temperature of hot oil quenching baths on warping of machine parts with a surface layer differing in chemical composition.

The scientific-technical data presented at the colloquium were of considerable interest. Many of these data can be used in scientific research or recommended for trial in production.

Let us mention some data from the principal papers. *

V. Shampen, L. Serafen, and R. Triko (France) investigated the metallurgical factors affecting the deformation of toothed wheels during heat treatment – the source of noise in gear trains, local overloads, and rapid wear of the parts in operation.

A special method was used to investigate the effect of the following factors: 1) the composition of the steel on the hardenability; 2) special additions – boron to increase the hardenability, aluminum for grain refining, and sulfur to improve the machinability; 3) structural inheritance associated with specific forging and rolling conditions and also with normalization on annealing (structural banding); 4) characteristics of the technological processes in heat treatment.

The interactions of these factors were studied and also their role in creating residual stresses. The tests made it possible to determine the effect of these metallurgical factors on the strength characteristics of gears.

It can be concluded from this work that, in accordance with data from other Soviet and foreign studies, it is necessary to pay particular attention to the quality of the metal in parts that are machined – the optimal composition and structure, high purity, and the inheritance due to the technological factors.

Only on the basis of general improvement of the metal is it possible to determine the full and lasting effect of various special methods of reducing self-deformation of parts during heat treatment.

R. Priestner and D. Kazan (England) reported that the widely used marquenching does not always, as is usually thought, reduce warping with elevated temperatures of the oil bath.

Studies of four different steels quenched in two kinds of oil at temperatures from 20 to 270°C (with final cooling in iced brine) led to the following conclusions:

1. The statistical value of the deformation of rod-shaped samples homogeneous in composition and structure decreases with increasing temperatures of the oil bath down to a value of zero.
2. The same relationship is observed in quenching homogeneous samples with a notch on one side, although in this case raising the temperature of the oil bath cannot always completely prevent warping.

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*The texts of all reports can be acquired at the central office of NTO Mashprom (Scientific-Technical Society of the Machine Construction Industry).

3. Nonhomogeneous samples (carburized on one side to a depth of 1.2 mm or decarburized to a depth of 0.75 mm on one side) are warped to a greater extent with increasing temperatures of the oil bath. This is due to the difference in the time of the transformations in various zones of the sample and the overall distribution of residual stresses.

4. With lesser degrees of chemical heterogeneity there is an optimal temperature of the oil bath at which warping is minimal. Higher temperatures of the oil bath again produce inferior results.

The authors report that marquenching cannot be recommended to reduce the deformation of parts made of chemically nonhomogeneous materials.

Many reports concerned a relatively new heat treatment technique – high-speed local heating of the surface.

Data on phase transformations during rapid heating of steel were presented by Yu. Orlich (Technical University, West Berlin).

Rapid heating can be divided into three areas: 1) ordinary rates in which the heating time is measured in minutes (furnace heating); 2) rapid heating in the range of seconds (induction or flame heating); 3) pulse or brief heating in the range of milliseconds (electron beam, laser, or inductive heating).

The transformations during ordinary heating are characterized by C – C – T or T – T – T diagrams. The change to rapid heating does not alter the general pattern, but phase transformations shift, especially toward higher temperatures.

These relationships were well presented in a series of diagrams for the individual factors under consideration – grain size, solution temperature of carbides, hardness, M_S, etc.

Pulse heating has thus far been studied only in separate experiments accompanied by new phenomena.

Diffusionless formation of austenite can be achieved at least partially. With electrical methods of heating, carbides can reach a higher temperature and dissolve very rapidly. The austenite grain size is commonly smaller than grade 10 on the standard scale. An exception is an original martensitic structure which during reheating (requenching) undergoes the reverse M → A transformation, and the original grain size is reestablished. This can be avoided by preliminary tempering of martensite – tempering eliminates the reverse transformation and permits grain refining.

H. Reichelt and B. Koktanchik (West Berlin) investigated ultrarapid quenching of band steel (with 0.08 and 1.25% C) ~ 0.2 mm thick in water.

Heating pulses lasting 15-50 μsec were produced by discharge of a 40 μF capacitor. Temperatures in the range of 700-1100°C were recorded by means of a special circuit.

Measurements of the microhardness, examination of the microstructure, and determination of the amount of retained austenite revealed no essential differences as compared with the results of quenching with heating at the standard rate.

A detailed review of the theory of rapid heating and rapid cooling was presented by H. Shlicht (West Germany).

The conditions of phase transformation and structural characteristics were examined with local surface heating by means of electrical energy, lasers, and electron beams, and the resulting local plastic deformation. In all these cases rapid cooling occurs with heat removal to the bulk of the metal.

Considerable attention was given to an analysis of the mechanism of the formation and the nature of so-called WEA (white etching areas) – the white zones observed in areas subject to high contact pressures and shearing stresses.

High hydrostatic pressures and elastic and plastic deformation of the crystal lattice occurring under various conditions substantially affect the kinetics of transformations along with the strictly thermal effects.

Under conditions of hydrostatic pressure of the order of tens of kbar the phase equilibrium curves on the Fe – C diagram shift to the left and downward (for example, the eutectoid point lies at 645°C and 0.29% C at a pressure of 34 kbar).

With a high concentration of thermal energy purely allotropic transformations occur without diffusion processes. The solidus is reached without preceding solution of carbides. Considerable heterogeneity of the hardened zone (especially when rehardened) is noted, although the habitus of martensite is generally retained. The hardness of these zones is not unusual.

E. Schreiber (West Germany) described the commercial use of new methods of high-speed heating of the surface of steel parts that change the properties considerably; special equipment is manufactured for this purpose.

The structure, distribution of hardness, and residual stresses after local surface hardening of carbon and chromium steels were investigated with electron beam and pulse high-frequency heating (inductive).

The results depend greatly on the original condition of the material – tempered or previously quenched.

With pulses of the same power the depth of the hardened zone is larger in the latter case, but the hardened area is of course separated from the matrix by a tempered border. A comparative analysis was presented of the parameters after various treatments (changing the power and duration of the pulses).

Also of interest was a report by M. D. Wirr (England) on the rate of heat treatment in fluidized bed.

Reviews were presented of the theory and technological characteristics of heating in fluidized bed (in particular, the work of Soviet investigators A. P. Baskakov, V. Ya. Zubov, and others).

Furnaces with a fluidized bed are used for solutioning, particularly for oxidation-free heating, gas carburizing, and tempering, and also for cooling during austempering.

We should also mention similar equipment to replace the liquid cyaniding process involving the use of toxic salts.

The following comparative data were presented (in pence per English pound of finished steel):

Heat treatment in salt bath..........................	–1.15;
Same, in fluidized bed..............................	–0.847;
Liquid carburizing in fused salts	–2.16;
Carburizing in fluidized bed	–1.1

The principal advantages of this method of heating are due to the high coefficient of heat transfer – it is five to ten times higher for a fluidized bed than in a standard gas furnace.

The carburizing rate can be characterized by the increase in the thickness of the diffusion coating – of order 25 μ per minute:

Schematic diagrams and photographs of the equipment used in continuous processing were presented.

In the present stage of development the process and the equipment used are suitable for small parts. The productivity is characterized by the following data:

Furnace for gas cyaniding with dimensions of 450 × 300 × 300 mm (300 mm high)	200 English pounds per hour
Small conveyor quenching furnace	800-1000 English pounds per hour
Apparatus for patenting wire (diameter 0.8-1.6 mm)	1.5 English tons per hour
Annealing furnace for wire (operating in Belgium)	2.5 English tons per hour

We should also mention a report somewhat outside the theme of the colloquium by a group of investigators from the Renault Research Laboratories (France) – A. Diame, R. El Haik, R. Lafon, and R. Wiss.

They investigated pitting of carburized and carbonitrided couples in rolling friction without slippage.

These processes depend greatly on the interaction between the residual stresses after heat treatment and high local operating stresses – with some quantity of retained austenite in the structure.

When the amount of retained austenite is no higher than average the thermal stresses are compressive; with large amounts of retained austenite they change to tensile stresses almost immediately below the surface.

The stress and hardness in the carbonitrided case are inversely proportional to the amount of retained austenite. The amount of retained austenite is an important factor in the development of fatigue in the rolling friction surface.

After cooling of carburized and carbonitrided samples in liquid nitrogen the number of loading cycles to failure decreases notably. Carbonitrided samples not cooled in liquid nitrogen "adapt structurally" to the stress field from external loads. Atoms of carbon and nitrogen escape from the martensite lattice. The stresses decrease in a zone at a depth of 0.05-0.15 mm, i.e., where the Hertz shear component reaches its highest value. The stress gradient near the surface increases.

After cooling to −196°C and transformation of a considerable part of the retained austenite the "adaptation" of the material is strongly inhibited in the zone affected by the ruling forces.

Thus, in selecting the optima conditions for chemicothermal hardening of parts subject to rolling friction one must take into account the factors that affect the fatigue limit.

No review of the theoretical and technological fundamentals of heat treatment in vacuum was given.

The program of the colloquium did not include consideration of the problems involved in the use of vacuum, although they were touched on in discussions. Attention should again be drawn to this trend in modern machine and instrument construction, since it has become of considerable importance.

This is due to the advantage of vacuum technique and the development of branches of industry producing various vacuum equipment. *

These questions occupied almost the entire December issue (1973) of the West German journal Härterei-Technische Mitteilungen. The journal contains reviews of the designs and characteristics of vacuum furnaces and special instruments, the technical characteristics of using vacuum for heat treatment of various metallic materials, etc. Data on vacuum heat treatment were also presented at the 28th colloquium on heat treatment in Wiesbaden (West Germany).

Many of the furnace manufacturers in England, West Germany, the United States, and Austria produce various apparatus for vacuum heat treatment of machine parts (including chemicothermal treatment and quenching without the heated parts coming in contact with air as they are transferred to the quenching bath).

Furnace units are manufactured with interchangeable components to suit individual needs.

After the scientific reports were presented and discussions, the directors of the international society on heat treatment met on May 31 – the board of delegates. The Soviet delegates submitted documents to confirm membership of the Soviet Scientific-Technical Society (NTO Mashprom) in MOTOM.

In conformity with the preliminary arrangements, the Russian language became the fourth official language of the society (in addition to French, English, German) when the Soviet organization assumed membership. All publications of MOTOM will be printed in these four languages.

The next meeting of MOTOM on metal science and heat treatment will be held in 1976. The board of delegates accepted the suggestion of the English Society of Metals to hold a congress in London, May 4-6, 1976.

We should note the friendly reception of the Soviet delegates in Caen.

Our engineering-technical societies should be aware of the new opportunities for international exchange of scientific data and practical experience that are available due to Soviet membership in MOTOM.

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*These branches of industry have undergone rapid development in connection with the needs of atomic energy.