QUENCHANTS FOR SURFACE INDUCTION HARDENING OF PARTS

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In surface induction hardening all forms of quenchants and quenching methods used with furnace heating are used. Such intense quenchants as a water spray (sprayer) and a rapidly moving flow of water are widely used in surface hardening with induction heating.

The basic advantages of these quenching methods in comparison with the classic method of immersion of parts in a bath are:

a) a higher coefficient of heat transfer \[\alpha = 125-419 \text{ MJ/(m}^2\cdot\text{h} \cdot \text{K)}\] as compared with \[4.19-83.8 \text{ MJ/(m}^2\cdot\text{h} \cdot \text{K)}\] and, consequently, higher quenching rates in the range of least stability of austenite \[\nu_{\text{cay}} = 10,000-30,000 \text{ K/sec as compared with 70-2000 K/sec}\] and in the martensitic range \[500-2500 \text{ K/sec as compared with 5-500 K/sec}\];

b) elimination of appearance in the surface layers of structures of nonmartensitic character (troostite spots and other products of incomplete decomposition of austenite);

c) suppression of the processes of partial tempering of martensite during hardening [1], which makes it possible to obtain the highest hardnesses for carbon and alloy steels;

d) elimination of formation of cracks in hardening as the result of the shortness and uniformity of the quenching process [1, 2] and after hardening with a long hold of the parts before tempering as the result of appearance in the surface layer of residual compressive stresses;

a) a reduction in distortion of parts in hardening in some cases [1, 3, 4];

b) the possibility of stable occurrence of the operation of self-tempering of steel by controlling the quenching time and by use of quick-acting valves opening and shutting off the flow of quenching water.

Therefore the modern understanding of "quenchants" includes the following:

a) the quenchant itself;

b) the method of supplying it to the surface being quenched;

c) the design of the quenching equipment.

Methods of improving the design of quenching equipment and quenching methods directed toward increasing quenching intensity [1, 5, 6] must be considered modern and progressive. The use for surface induction hardening in spray quenching of carbon and alloy steels in place of water of various less intense quenchants such as oils, emulsions, and water-soluble polymers [7, 8] used in through hardening is unjustified for the following reasons:

increasing the cost of the heat treat operation as the result of introduction of relatively expensive components;

TABLE I

<table>
<thead>
<tr>
<th>Type of engine</th>
<th>Steel for crankshaft</th>
<th>Quenchant</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-240</td>
<td>45K</td>
<td>Jet quenching with water under a layer of water</td>
</tr>
<tr>
<td>A-41 A-91 SMD-60</td>
<td>45 45 45</td>
<td>Water spray</td>
</tr>
<tr>
<td>SMD-60</td>
<td>45K</td>
<td>Aqueous solution of urotropin (spray)</td>
</tr>
<tr>
<td>8DBT 12DBT SMD-19-20</td>
<td>38K 45</td>
<td>Water spray</td>
</tr>
<tr>
<td>B37E</td>
<td>45K</td>
<td>Aqueous solution of emulsion (spray)</td>
</tr>
<tr>
<td>ZIL130 ZIL130</td>
<td>45 45KMF</td>
<td>Water spray</td>
</tr>
<tr>
<td>KAMAZ</td>
<td>42KMF</td>
<td>Aqueous solution of osmanil (spray)</td>
</tr>
</tbody>
</table>

the increase in the number of operating personnel;

the increase in production area for equipment for preparation of the quenchant (measuring out of the added component, mixing, etc.);

the absence of advantages in heat treat quality obtained (structure, hardness, tendency toward crack formation, deformation).

However, at present in surface induction hardening of parts produced from alloy steels the above quenchants frequently continue to be used in place of water.

The reason for such an approach is the fact that in hardening of alloy steels in intense quenchants more significant internal stresses must occur than in hardening of normal carbon steels with the same carbon content. In connection with this to eliminate crack formation and distortion it is necessary to moderate the quenchant to reduce internal stresses. Unfortunately this erroneous point of view of engineers and designers frequently leads to unjustified use of alloy steels.

Actually in hardening of alloy steels in comparison with carbon steels there does not occur an increase in first order stresses, the basic source of which is the change in macro-volume during hardening caused by structural transformations. As is known, the carbon content and not the alloy element content has the greatest significance in increasing these stresses. In contrast to carbon alloy elements form substitutional solid solutions and are located at the nodes of the crystalline lattice, not causing large changes in volume in hardening.

However, many years of experience in induction surface hardening of such critical machine parts as rings for railroad rolling bearings (ShKh4RP), cold rolling rolls (9Kh, 9Kh3, 9Kh2SVF) [11], and a whole series of other parts has shown that the use as the quenchant of water in quenching with an intense flow and a spray does not lead to the formation of cracks.

The refinement of the austenitic grain size obtained in induction heating to No. 11-13 (No. 7-8 in furnace heating) significantly increases the brittle strength and plasticity of steel [11], which is a significant reserve for increasing the resistance of the steel toward crack formation.

Using as an example induction surface hardening of the necks of crankshafts of tractor and certain truck engines [12] the possibility of use of water as the quenchant in place of various polymer solutions in spray quenching was evaluated.

Table 1 shows the forms of quenchants used at present in induction hardening of crankshaft journals with rotation of the part. It may be seen that in hardening of 45 carbon