METHOD OF QUENCHING


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ABSTRACT OF THE DISCLOSURE

A metal quenching process in which a metal, such as steel, is heated above its critical temperature and then contacted with a liquid quenching medium formed of water, a normally liquid, water-soluble oxalkylene polymer having oxethylene and higher oxalkylene groups, and a water-soluble alcohol. The proportions of constituents of the quenching medium are such that all compositions lie within the area bounded by the lines AB, BC and CA in FIG. 1.

This invention relates to an improved metal quenching method and, more particularly, to a novel method of quenching heat-treated metal to provide clean, bright metal parts of improved physical properties.

The physical properties of structural metals, such as steel, can be modified by various heat treatments. Generally the heat treated metal is cooled rapidly by a process known as “quenching,” whereby the hot metal is immersed in a bath of water or oil.

Water produces very rapid cooling, and is not suitable for quenching many types of steel, for it produces excessive strains which warp and crack the steel. Hydrocarbon oils provide a relatively slow rate of cooling, which is required to produce certain desired physical properties, such as ductility, in steel. However, the slower cooling rate afforded by oil quenching, although it prevents excessive strains, often prevents development of the desired hardness.

It, therefore, is desirable to provide quench liquids which cool metal at rates intermediate between those obtainable with water or oil, whereby the quenched metal can be provided with the desired physical properties. To this end various aqueous solutions and dispersions of organic compounds have from time to time been proposed as steel quenching fluids, but for the most part these have not proved to be successful substitutes for oil.

Recently aqueous solutions of certain water-soluble, high molecular weight polyalkylene glycols have been suggested as quenching media for steel. These polyalkylene glycols have the ability to slow the quenching speed of water, and by varying the concentration of glycol, quenching media having different rates of cooling can be obtained.

The mechanism by which the cooling rate of water is decreased by the presence of polyalkylene glycol is believed to be related to that property called inverse solubility, whereby solubility decreases with increasing temperature. As the hot metal piece is introduced to the quenching medium, the polyalkylene glycol solute precipitates out on the hot surface of the metal, thermally insulating the quenched piece and thus decreasing its rate of cooling. As the temperature of the metal piece decreases, the solute redissolves.

Although solutions of such water-soluble, high molecular weight polyalkylene glycols slow the cooling rate of water, they, like oil, have the disadvantage of producing stained or darkened metal parts. They also have the further disadvantage of evidencing “bumping,” which is caused by water coming in direct contact with portions of the surface of the hot metal, resulting in a rapid evolution of vapor. This contact of areas of the surface of the hot metal with water can result in quenched metal pieces of non-uniform physical properties.

One of the objects of the present invention is to provide a metal quenching medium whose composition can be varied to provide a broad range of quenching rates between the quenching rates of water and oil, as well as rates slower than oil.

Another object of this invention is to provide a novel method for quenching heated metal to obtain quenched metal parts having the desired physical properties and an improved appearance.

A further object of the present invention is the provision of an improved quenching method which produces metal parts more uniform in physical properties and having a clean, bright metallic surface.

These and other objects of the invention will be apparent from the drawing and description thereof and the appended claims.

Referring to the drawing, FIG. 1 is a triangular coordinate graph showing compositions for use in the method of this invention, and FIG. 2 shows cooling curves for different quenching media, including a quenching medium according to this invention.

While this invention is applicable to the heat treating of various metals and their alloys, the use thereof is explained hereinafter with particular reference to carbon-containing ferrous metals, such as steel.

Generally, the objects of this invention are attained by contacting a metal, such as steel, which has been heated above its critical temperature, with a liquid quenching medium consisting principally of water having dissolved therein as essential organic quenching constituents (1) a normally liquid, water-soluble oxalkylene polymer having oxethylene and higher oxalkylene groups, and a water-soluble alcohol selected from the group consisting of glycerol, glycols containing from 2 to 7 carbon atoms, and mono- to lower alkyl ethers of said glycols in which the alkyl group contains from 1 to 4 carbon atoms.

A preferred oxalkylene polymer is one comprising about 75%, by weight, of oxethylene, and about 25% of oxopropylene, and having a viscosity of about 150,000 Saybolt seconds at 100° F. A preferred alcohol is ethylene glycol.

It was discovered that the novel method of this invention produces results not heretofore attainable with the prior known quenching methods. More particularly, the quenching medium employed in the present method can be varied in composition to provide cooling rates between the cooling rates of water and oil, as well as cooling rates which are slower than that of oil. In addition, the quenched metal pieces have a clean, bright surface. Furthermore, the quenched metal is more uniform in physical properties.

Apparently, these advantageous results are due to synergism between the two essential organic quenching constituents, namely, the oxalkylene polymer and the alcohol, for when either is used alone, similar results are not attainable. As noted above, when the oxalkylene polymer is used alone, discolored metal parts of non-uniform physical properties are obtained. The alcohols when used alone, have little effect on quenching rate at commercially feasible concentrations. Also, their relatively low boiling points mitigate against their being used as an additive in an aqueous quenching medium.

The presence of the alcohol produces at least two beneficial results. First, discoloring of the quenched metal by the oxalkylene polymer is prevented. Second, the quenched metal is more uniform in its physical properties.

Apparently, the alcohol constituent enables the oxalkylene polymer to form a more complete, continuous heat-
insulating film over the entire surface of the metal, thereby preventing direct contact between the hot surface and water, which is believed to be a cause of non-uniformity of physical properties in the quenched workpiece.

Water-soluble oxyalkylene polymers suitable for the practice of this invention are well known, commercially available compounds, and are viscous liquids even in the high molecular weight range up to those represented by a viscosity of 150,000 Saybolt seconds at 100°F and higher, which corresponds to an average molecular weight of about 20,000. These polymers contain both oxyalkylene and oxypropylene groups in the molecule and have an average molecular weight from 600 to 40,000, and higher. The amount of oxyethylene groups in the molecule is such that the polymers are soluble in water at ordinary temperatures, and the amount of oxypropylene or higher oxyalkylene groups is such that the polymers remain liquid at ordinary temperatures. The weight ratio of oxyethylene groups to higher oxyalkylene groups may vary from about 1:1 to about 9:1. Preferred oxyalkylene polymers are those composed of oxyethylene and oxypropylene groups having a viscosity in the range between about 50,000 and 150,000 Saybolt seconds at 100°F. A preferred polymer is one containing approximately 75% by weight of oxyethylene groups and about 25% of oxypropylene groups, and having a viscosity of 150,000 Saybolt seconds at 100°F.

Since the oxyalkylene polymers are completely miscible with water at temperatures below about 175°F, and during the quenching operation this component remains stable and does not decompose at interface temperatures as high as 500°F, the process of this invention can be utilized in a wide variety of heat-treating operations.

The second essential organic quenching agent employed in the method of this invention is a low molecular weight, water-soluble alcohol selected from the group consisting of glycerol, glycols containing from 2 to 7 carbon atoms, and mono- and lower alkyl ethers of said glycols in which the alkyl group contains from 1 to 4 carbon atoms. Typical alcohols, in addition to glycerol, are ethylene glycol, propylene glycol, diethylene glycol, and the monobutyl ether of ethylene glycol. A preferred alcohol is ethylene glycol.

The exact proportions of oxyalkylene polymer, alcohol and water employed in the method of this invention will depend upon the particular quenching operation, and advantageously can be varied to obtain optimum results. Satisfactory quenching can be obtained with a quenching medium comprising a composition lying within the area bounded by the lines AB, BC and CA on FIG. 1. Preferred compositions fall within the area defined by the lines DE, EF, FG and GD on FIG. 1. Slower quenching rates are obtainable with higher concentrations of oxyalkylene polymer.

The following examples further illustrate the advantages of this invention, but are not intended to limit the scope thereof.

Example I

The quenching bath employed consisted of 5 gallons of an aqueous solution comprising 8%, by weight of an oxyalkylene polymer consisting of about 75% by weight of oxyethylene groups and about 25% of oxypropylene groups and having a viscosity of 150,000 Saybolt seconds at 100°F, 8% by weight of ethylene glycol, and 84% of water. The specimen, a 2.5% sphere of 52100 steel, was heated to 1600°F in molten aluminum and then immersed in the quenching bath. The time required to cool the specimen to 400°F was 120 seconds. The specimen after quenching was bright and clean. No bumping was observed during quenching.

Example II

The procedure of Example I was repeated using a quenching bath containing 11% by weight of the same oxyalkylene polymer, but no alcohol. The specimen after quenching bath containing 11% by weight of the same Bumping was evident during quenching.

Example III

Example I was repeated using a quenching bath comprising 12% by weight of an oxyalkylene polymer consisting of about 75% by weight of oxyethylene groups and about 25% of oxypropylene groups and having a viscosity of 90,000 Saybolt seconds at 100°F, and 88% water. The quenched specimen was badly discolored, and bumping was observed during quenching. The time required to cool the specimen from 1600°F to 400°F was 118 seconds.

Example IV

Example I was repeated using water as the quenching medium. The time required to cool the specimen from 1600°F to 400°F was 80 seconds. Considerable bumping took place during quenching, and the quenched specimen was badly discolored.

The above examples highlight a number of the advantages of the process of this invention which is set forth in Example I. First the presence of the low molecular weight alcohol, in this case ethylene glycol, prevents bumping and the quenched specimen is clean and bright. The absence of bumping indicates that the physical properties of the quenched specimen should be quite uniform. On the other hand when the same type of quenching bath is employed in the absence of low molecular weight alcohol, undesirable bumping takes place, and the quenched specimen is badly discolored (see Examples II and III).

Referring to Example IV, where water was the quenching medium, and Example I where the method of this invention was used, it can be seen that the present method provides a much slower quench rate than water.

Example V

A "French Ring" having a gap of 0.242" and formed of 52100 steel was heated to 1600°F and quenched in the quenching medium of Example I. After quenching, the gap measured 0.243", a change of only +0.001". The quenched ring was clean and bright in appearance. The hardness survey of the ring is set forth in Table I, below.

Example VI

Example V was repeated with a quenching medium containing 4% by weight of the oxyalkylene polymer of Example I, 4% of ethylene glycol and 92% water. The "French Ring" measured 0.245" before quenching and 0.247" after, a change of only +0.002". The quenched ring was clean and bright. The hardness survey of the ring is also set forth in Table I, below.

Example VII

The procedure of Example V to VII show that when a "French Ring" is quenched according to the method of the present invention there is substantially no distortion of the ring (see Examples V and VI), whereas water causes considerable distortion (see Example VII). In addition the method of this invention provides the desired hardness, see Table I.

<table>
<thead>
<tr>
<th>Example</th>
<th>Measurement Point (Rockwell hardness)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>61 64 66 63 63 65 64</td>
</tr>
<tr>
<td>VI</td>
<td>63 60 61 62 63</td>
</tr>
<tr>
<td>VII</td>
<td>63 65 65 66 64</td>
</tr>
</tbody>
</table>

The data of Example V to VII show that when a "French Ring" is quenched according to the method of the present invention there is substantially no distortion of the ring (see Examples V and VI), whereas water causes considerable distortion (see Example VII). In addition the method of this invention provides the desired hardness, see Table I.
Example VIII

The cooling curves in FIG. 2 of the attached drawing were obtained by heating a 2½" sphere of 52100 steel to 1600° F. in molten aluminum followed by quenching the sphere in water, oil, and the quenching medium of Example I, respectively. The data on which the graph of the drawing is based show not only that according to the method of this invention, the quenching rate can be significantly decreased as compared to that of water, but that until the temperature of 640° F. is reached, the rate of quench according to the present invention is slower than that of oil. The various benefits of this invention, such as providing clean, bright parts having substantially uniform physical properties, have been enumerated above. In addition, it should be pointed out, that the method of this invention provides the benefits of oil quenching without the disadvantages thereof, such as discoloration of the quenched part of the hazard of fire which is inherent in the use of oil. Also tanks containing the quenching medium employed in the method of this invention can be cleaned with much less difficulty than tanks which contained oil.

What is claimed is:

1. A method for quenching heated metal to provide quenched metal parts having the desired physical properties and improved brightness which comprises contacting said heated metal with a liquid quenching medium consisting principally of water having dissolved therein as essential organic quenching constituents (1) a normally liquid, water-soluble oxyalkylene polymer having oxyethylene and higher oxyalkylene groups, and a water-soluble alcohol selected from the group consisting of glycerol, glycols containing from 2 to 7 carbon atoms, and mono-lower alkyl ethers of said glycols in which the alkyl group contains from 1 to 4 carbon atoms, said quenching medium having a composition lying within the area bounded by the lines AB, BC, CA on FIG. 1.

2. The method of claim 1 in which said quenching medium comprises a composition lying within the area bounded by the lines DE, EF, FG, and GD on FIG. 1.

3. The method of claim 2 in which said oxyalkylene polymer contains approximately 75% oxyethylene groups and 25% oxypropylene groups by weight and has a viscosity of about 150,000 Saybolt seconds at 100° F., and said alcohol is ethylene glycol.

References Cited

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CHARLES N. LOVELL, Primary Examiner

U.S. Cl. X.R.

148—20.6, 28
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Inventor(s) Marvin Lewis and Paul J. Welsh

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 8, "ot" should read --to--; line 11, "oxyalkylene" should read --oxyethylene--. Column 4, line 1, after "quenching" insert --was badly stained with a greenish-black color.--; delete "bath containing 11c by weight of the same"; line 66, "52" should read --51--. Column 5, line 19, "of" should read --and--.

SIGNED AND SEALED
MAY 19, 1970

(Seal)
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