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INDUCTION HARDENING SLACK QUENCH ISSUES

R E S E A R C H   J O U R N A L

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Precautions that are necessary to avoid quenching issues.

1. The quench ring must be designed and validated before using it in production.
2. The quench ring ought to be hard wire brush cleaned during each shift.
3. The quench ring must be aligned correctly to obtain the optimum quench angle and flow.
4. Place proper shielding to avoid overheating and burning the quench ring.
5. Implement filtration before the quench ring to prevent clogging of the quench holes.
6. Replace filters in a timely fashion to avoid interrupting the quench flow.
7. Clean quench tanks to meet the CQI-9 requirements.
8. As scheduled preventive maintenance, replace the induction quench ring after specified cycles before failure occurs.

Induction hardening is a selective heat treatment method that hardens the surface and sub-surface area of the part to the desired depth and keeps the metal core soft for toughness. Steel shafts and components made of medium carbon and alloy steel are mostly hardened using a semi or fully-automated induction hardening machine. It is a non-contact heating process that uses high-frequency electricity to heat parts, followed by immediate quenching, see Figure 1. Since being non-contact, the heating process does not contaminate the parts, and deformation and wrapping are usually minimized. There is also no surface scale formation, which often eliminates cleanup costs.

An induction hardening system typically includes a power supply, an impedance-matching circuit, and a tank circuit, Figure 2. When the parallel set of capacitors and inductors are used in a tank circuit,the capacitor and inductor become reservoirs of electrostatic and electromagnetic energy, respectively. The high current through the coil helps to have a good energy transfer from the induction coil to the workpiece (1).

Figure 1. Showing noncontact induction hardening of shafts.

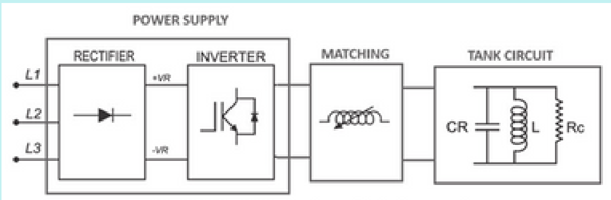

Figure 2. Simplified block diagram of induction heating unit

During induction hardening, the coil and quench ring are designed explicitly per the requirements to heat and quench the parts. Parts are generally loaded between the upper and lower centers in a machine setup. A hydraulically operated carriage advances the pieces to be heat treated to the start position; when alternate current is passed through an induction coil, it generates an electromagnetic field within the coil, and as a result, the current is induced into the work-piece, which due to resistance, produces heat. The quench ring positioned around the work-piece provides immediate quenching on the heated area and quenches the work-piece surface layer to the hard martensite structure. See Figure. 3 and 4.

Work-pieces that require induction hardening may have complicated designs; therefore, the quenching is as significant as the proper heating of the work-piece. The polymers that are soluble in water are used as quenching media. The temperature and concentration determine the quenching rate (2). Ineducable or improper quenching of the heated part results in low and spotty hardness and may also cause quench cracking. Quench flow is an essential factor. The high pressure causes the stream to impinge on the part's surface and, therefore, does not effectively remove BTUs from the surface. Therefore, A high flow rate at minimal pressure is more effective (3). Any debris accumulated in the quench ring may cause the plugging of the quench holes; reducing flow will result in slack quenching. See Figure 5, 6, 7, 8, 9 and 10.

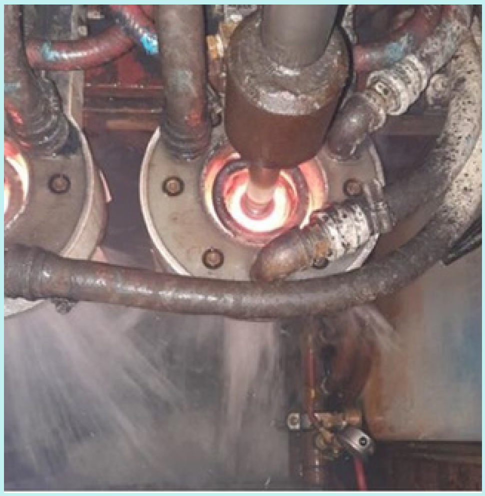

Figure 3. The induction-hardened shaft was heated and quenched properly with martensite microstructure.

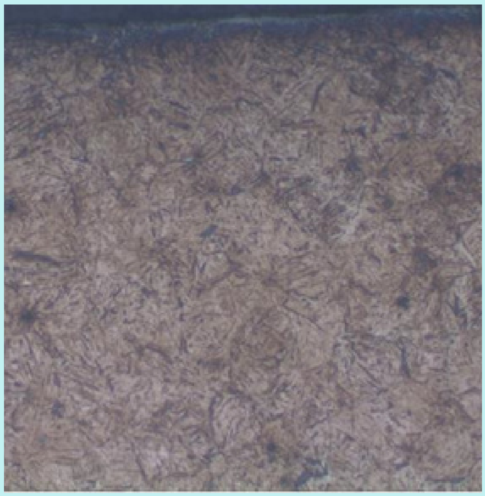

Figure 4. The induction-hardened shaft was heated and quenched properly with martensite microstructure

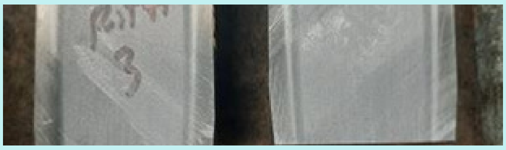

Figure 5. Soft induction pattern due to slack quenching issues. Quench ring holes were plugged.

Figure 6. Acceptable Induction hardening pattern.

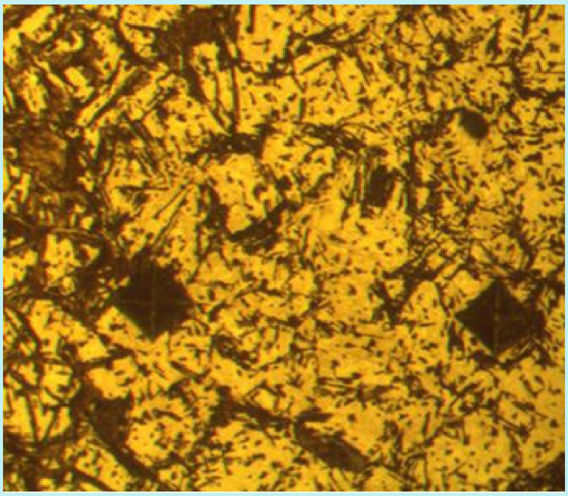

Figure 7. Induction hardening surface microstructure showing evidence of slack quenching. Microstructures consist of martensite and patches of bainite.

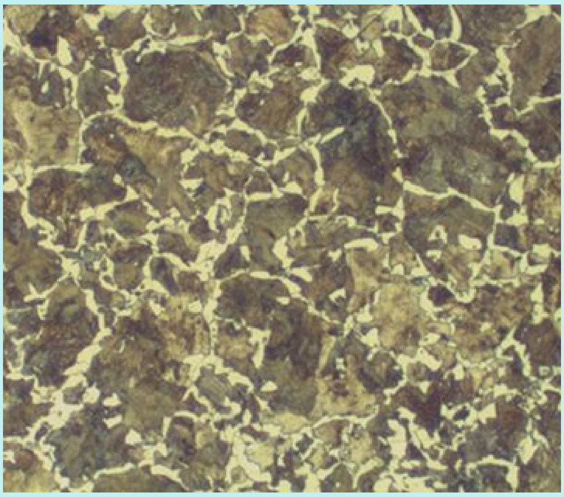

Figure 8. Metal shaft core microstructure not affected by induction hardening.

Figure 9. Induction quench ring and coil. Debris plugging quench holes will result in low hardness and undesirable microstructure.

Figure 10. As scheduled preventive maintenance, replaced the induction quench ring and coil, and a new set was installed to maintain desirable hardness and microstructure.

SUMMARY

The below precautions are necessary to avoid quenching issues.

1. The quench ring must be designed and validated before using it in production.
2. The quench ring ought to be hardwire brush cleaned during each shift.
3. The quench ring must be aligned correctly to obtainthe optimum quench angle and flow.
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8. As scheduled preventive maintenance, replace the induction quench ring after specified cycles before failure occurs.

References:

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