ABSTRACT

Boriding is an effective surface modification technique to improve the surface hardness, wear resistance and corrosion resistance of steels. During boriding of low and medium carbon steels at high temperature, boron atoms diffuse into the steel surface and needles of FeB and Fe_2B are formed on the surface. The presence of FeB on the surface is undesirable, because it cause high brittleness of the material. This brittleness prevents the effective use of borided parts when subjected to impact loads during the operation.

The literature review of boride surface modifications of steels focuses the problems associated with the boride layer developed using thermo chemical boriding processes, influence of alloying elements on the structure and properties of boride layer and different methods recommended by various researchers to lessen the brittleness of boride layer.

The objective of the present research work is to develop tougher borided and induction modified surface layer as compared to conventional borided layer whose hardness is above 1500 HV. Also, it should have adequate fatigue life. So, surface modification of borided layer was achieved with a new idea of induction surface heating. The structures and properties of borided, borided and induction modified samples are compared.

AISI 4340 (medium carbon low alloy) steel selected as the base material. The surface was coated with a boriding paste (1mm thick) containing $SiC+B_4C+KBF_4$ and TiO_2 at suitable composition and dried. To avoid possible oxidation (if cracks occur) of the samples a boron containing powder was kept around the samples at 950^{o}C for 3 hours. After boriding the

pack was cooled and samples were removed and again a thin paste was applied and dried. Then these samples were subjected to induction surface modification. The induction heating was done at optimum conditions. The borided, borided and induction surface modified samples were tested in reversible bending fatigue testing machine. Experiments were conducted at different bending moments and cycles to fail were recorded, and S-N curves were plotted. Borided and induction modified samples showed an improvement in endurance limit.

Borided medium carbon steels show needles of FeB and Fe_2B out of which FeB is very hard and brittle and also needle like microstructure leads to brittleness. Induction surface modification eliminates hard and brittle FeB layer and also reduces the sharpness of the Fe_2B needles. Hence, this improvement in the microstructure reduces the brittleness as a whole.

An attempt was made to evaluate the improvement in toughness through shear punch test. Sheet specimens were cut with 18 mm diameter and 0.6 mm thickness and some samples were paste borided and some samples were paste borided and induction modified. These samples were kept in a die and shear punch tested. Load vs displacement of pinch was studied. It is observed that borided and induction modified samples absorbed more energy before shearing.

The conclusions of the research work and are summarized.

1. Paste boriding generally results in the formation of FeB and/or Fe_2B needle-like microstructure at the case. The microhardness was found to be in the range of 1450 HV to 1975 HV at 100g load.

2. Induction modification resulted in improved toughness and homogeneity of boride layer. The hardness of the borided and induction modified AISI 4340 specimens were in the range of 1025 HV – 1075 HV at 100g load.
3. Brittle fracture is seen in borided samples and a relatively more ductile fracture is observed in borided and induction modified samples.
4. From the S-N curve it is understood that fatigue limit of borided and induction modified samples are approximately 14% more than the borided samples.
5. From the shear punch test, the area under the load vs displacement curves show 38% improvement in the toughness of borided and induction modified AISI 4340 steel as compared to conventionally borided AISI 4340 steel.
6. FeB is present in conventionally paste borided samples. After induction surface modification FeB is converted into Fe_2B which reduces brittleness.
7. The wear loss of paste borided specimens was low as compared to base material AISI 4340 specimen. This is due to the presence of FeB and Fe_2B in the borided layer.
8. The corrosion rate of induction modified specimen was 5 to 8 times lower than AISI 4340 steel. Borided and induction modified samples show better results than borided specimens.
9. Borided specimen showed marginal improvement in corrosion resistance as compared to induction modified specimens.