CHAPTER 6

DISCUSSION AND CONCLUSION

6.1 Discussion

The objective of this research was to study the factors of the induction hardening process, which were current of coil and traverse speed, in order to improve mechanical properties being surface hardness and hardness in depth.

Firstly, the specimen was tested by chemical composition and end-quench hardenability in order to prove that the material brought to manufacture was 1045 carbon-steel, and could be hardened to the desired hardness. From the composition test by ASTM E 415-95, the result demonstrated that the specimen had the same composition as identified in the AISI standard. And the end-quench hardenability illustrated that this grade of steel could be hardened to the hardness required.

After the specimen was hardened by induction hardening machine, all specimen were tested by the Rockwell hardness tester and Vicker hardness tester to measure the surface hardness and the hardness distribution of the specimen. When the current was changed, while the down speed was fixed. The result showed that increasing the coil current intensity, the surface hardness would be apparently increased while the case depth would be gradually increased. While the current in the coil increases, the raising surface temperature will result in faster diffusion in austenitizing region and the more homogeneous martensite formation after quenching. The case depth as well as the surface hardness will be increased. When the down speed was varied, while the current was fixed. The results showed that increasing the down speed, the surface hardness would be gradually increase, while the depth of hardening would be apparently increased.

The results from analysis of variance showed that the factors that influence on the mechanical properties, surface hardness and case hardness, of oil pump shaft were the coil current, the down speed, and the interaction between the coil current and the down speed. The coil current, the down speed and the interaction between them have the influence from maximum to minimum on the surface hardness and the hardness in depth respectively.

From the results of the experiments, the suitable condition to gain the surface hardness between 55-60 HRC and the hardness 450 HV in depth between 0.8-1.2 mm was down speed at 1.7 mm/sec. and coil current at 110 Amp.

When compared with the specimen before improvement, the experimental results of induction hardening treatment on AISI 1045-carbon steel after improvement indicated that after improvement result had lower down speed than before improvement because the decrease of traverse speed of specimen will result in the increase of case depth. By decreasing the traverse speed, there will be enough time for atom to diffuse in austenitizing and the amount of martensite obtained after quenching will be increased. The result was an increase in case depth.

6.2 Conclusion

- Increasing of surface hardness was due to the increase of current intensity, which generated much abundant resistance heat for austenitizing, therefore much homogeneous austenite formed on heating and hence fuli through martensitic structure formed after quenching. Besides, the formation of the compressive residual stress on surface caused by phase transformation was believed to make a further contribution to the hardness.
- By increasing the time of heating, heat will diffuse from surface into the inner core of the specimen. For higher frequency, the heating depth became shallower due to the skin effect. For heat generator with constant frequency, diffusion was the most effective mechanism that can be controlled to increase the depth of heating.
- From the microstructure figure, the sequential change of microstructure from outer surface to the inner core began with martensite formation in hardened surface layer and then turned out gradually to be pearlite or, may be fine pearlite, called pearlite ghost, in a little inside area. By further deeper inside, the existance of remained unchanged ferrite appeared as white area in the microstructure caused hardness to decline. The structure of pearlite ghost disappeared gradually and then a mixture of pearlite with ferrite was observed.

- Decreasing the down speed, there was enough time for atom to diffuse in austenitizing and the amount of martensite attained after quenching would be increased. The results were an increase in depth of hardening and the hardness in depth.
- The suitable condition for the case company to achieve the maximum surface hardness of 60 HRC and the minimum hardness in depth at 0.8-1.2 mm. of 450 HV was the current of 105 Amp and down speed of 1.7 mm/sec.

6.3 Recommendation

However, in this experiments the gap distance between coil and specimen were kept constant. It should be varied in order to demonstrate whether it had the influence on the surface hardness and the case hardness or not. If the gap distance had an effect on the surface hardness and case depth, the suitable condition may change to the better productivity.

From the results in Table 5.9 at the current of 110 Amp and down speed of 1.7 mm/sec. they had some variation of the surface hardness and hardness distribution between each experiment. For the further study they should study in causes of this variation and then find the way to keep the process constant.