CHAPTER 3
PROBLEM IDENTIFICATION AND ANALYSIS

3.1 Problem identification

The case factory studied was an automotive part manufacture which produce an oil pump shaft. The oil pump shafts were produced throughout many processes. In each process quality control staffs have inspected it before go to the next process.

In producing oil pump shafts, the induction hardening process used in the factory were as followings:

1. Oil pump shaft that was sew, faced, centered and chamfered into the right size, was taken to grasping stand by operator and locked.
2. Turned on the switch to move the oil pump shaft down, passed the coil. At the same time cooling water was spray.
3. When it, all, moved down pass the coil for quenching process, switch turn off automatically and spray the quenching media immediately.
4. Next, the oil pump shaft moved up and then down again for tempering process and the quenching media was spray again.
5. Then the oil pump shaft moved up and stop, and then the operator took it out by hand.

At first, when received the raw material, it was inspected in diameter and length, as well the staff will check that the raw material sent from supplier was precise (S 45 C) by checking the certificate of raw material. Next after sawing, facing and centering process, it was inspected in its length by vernier. Then after chamfering, it was checked in length of chamfer and angle of chamfer by profile projector. After induction hardening process, it was inspected for black color at surface by visual inspection as well as it is tested in crack at chamfer area by magnetic flux machine. In the next process, rough grinding and fine grinding, it was checked for its diameter by dial indicator and jig. After these the product was tested for hardness at surface and depth, also check it microstructure by microscope. Then go to the buffing, in this process the product checked for deburr at edge of chamfer. Finally, in the final inspection, the product was inspected in diameter, straight, roughness, length of chamfer, parallelity, and burr or flash.

The main production problem of the company being the oil pump shafts defects was the lower hardness than customer specification. The specification was that the hardness at any point in the range of 0.8-1.2 mm. must be more than 450 HV.

From the information in figure 1.2, the problem of the low hardness in depth exactly occurred from induction hardening process, which its process will be described in the next paragraph.

3.2 Problem analysis

According to the literature survey, Low hardness of the oil pump shaft might occur from:

1. Raw material
2. Process (Induction hardening process)

These two aspects were the main assumptions concerned with low hardness of the products. In raw material topic, it was meant that the material purchased from supplier might not be similar to the standard of 1045 carbon steel. Therefore material delivered to the company should be inspected and then study about the hardenability of this material. In process topic, it was meant that low hardness of the oil pump shaft might occur from some factors in induction hardening process such as quenching medium, quenching temperature, tempering temperature, so forth.

First, the material brought to produce the oil pump shaft must be proven that it was the same as the standard of 1045-carbon steel or has the same carbon content as the standard specified. This material, tested by ASTM E 415-95, composes of the following.

C	Mn	P	S	Cr	Mo
0.46	0.82	0.013	0.009	0.169	0.011

From the information of the table above, it indicates that this material brought to produce the oil pump shaft is the 1045 carbon steel, according to the ASM standard. Secondly, the hardenability of this material needs to be considered, however the hardenability of this steel is shown in table 5A in appendix. From the information in appendix, it confirms that this grade of the carbon steel can be hardened to the desired hardness, which are surface hardness and the hardness in depth between 0.8-1.2 mm.

Consequently, the low hardness in depth of the oil pump shaft certainly caused from the induction hardening process. According to Davies and Simpson (1979), they mentioned that "the grade of steel, the rapidity of cooling, the coil design, and the heating time all affect the depth of hardness". However, the grade of steel was already considered. The coil design was not considered here because previously, the oil pump shaft could be hardened to the required hardness in depth.

So there had only two factors concerned, which were:

1. The rapidity of cooling
2. The heating time.

The rapidity of cooling concerned about cooling rate of quenching medium. However, it was difficult in examining quenching medium because the company and supplier had not enough data, and mixture of the quenching medium was confidential. Also because of purchasing aspect, it was hard to change from present quenching medium to another medium. Therefore the suitable way to find out this problem was consideration in the heating time.

In heating there was a relationship between power density, heating time, and frequency. The power density and frequency were the specifications of induction hardening machine. Accordingly, in this research, the heating time was studied because the problem certainly occurred from unsuitable heating time. From Lee and Hwang (1979), they mentioned that the heating time was the factors which affected the hardened depth required. The factors involved in heating the product were electrical current and traverse speed of specimen (down speed).

3.3 Quenching and tempering stages

The induction process was consists of two minor processes which were first the product was heated and then quenched, it was called quenching stage. Second after quenching, the product was heated up for tempering, it was called tempering stage. In this topic, it could be divided into two considerations: quenching stage, and tempering stage.

From the assumptions above, it showed that firstly, there should concentrate in quenching stage and then detecting the tempering stage in that the tempering stage or the quenching stage had an affect on the surface hardness and hardness in depth. After reviewing the quenching stage by operating only the quenching stage, it illustrated that the results of hardness at each point were similar to figure 1.2. So it could be induced that the low hardness in depth occurred from quenching stage. This tempering stage only increased ductility and toughness, and did not effect to the hardness of the oil pump shaft.