CHAPTER 4

EXPERIMENTAL PROCEDURE

From the problem analysis, the main cause of this problem occurred from the quenching stage, therefore the experiment was concentrated on the factors involved in the quenching stage of the induction hardening process only. However, tempering process was operated continuously after the quenching process was finished and at the same time all parameters in tempering process were fixed at the same value.

4.1 Material

As-received material used in this experiment was AISI 1045 carbon steel. It was sew, faced, centered, and then chamfered to a smooth-surface round bar with length of about 72 mm. and diameter of 13.2 mm.

4.2 Experimental method

The experiment of this study was mainly concerned with the induction hardening process in terms of the heating temperature. The experiments were carried out on High Frequency Induction Heating System with model TG2-200-100 II. The equipment was specified with a frequency of 200 kHz, maximum output power of 100 kW, maximum output voltage of 460 V, and maximum output current of 240 Amp.

The experiments were made under different testing conditions that were varying the factors in quenching stage, while the factors concerned in tempering stage were fixed. Two famous factors strongly effecting on the mechanical properties, especially in surface hardness and hardness in depth are heating current on the coil and heating time (traverse speed or down speed) of the work-piece.

Heating current on the coil were varied from 95-125 Amp and down speed were varied from 1.5-2.1 mm/sec (3.6 mm/sec. maximum). Other parameters, which were water quenching temperature and cooling water pressure at inlet, were kept constant at 29^{o}C and 0.3 Mpa. respectively. Moreover, quenching medium used in all experiments

came from the same lot After heating, quenching medium was sprayed directly and then the specimen was tempered at current of 35 Amp and down speed at 1.7 mm/sec. After the heat treatment was finished, the specimen was measured hardness at the surface by Rockwell hardness testing, and hardness distribution in each depth was measured by Vickers hardness testing.

4.3 Material characterization

In this research, as-received and hardened specimens were characterized as composition test and hardness test respectively.

4.3.1 Material compositions test

The composition of the as-received materials was tested in order to consider that the raw material brought to produce the oil pump shaft had the same compositions as specified in the standard of AISI 1045 steel. According to Heat Treater's Guide from American Society from Metals, the material, 1045 steel, has the chemical composition as following:

C	Mn	P	S
0.43 to 0.50	0.60 to 0.90	0.040 max	0.050 max

The composition test method used in this study was followed by the standard of ASTM E 415-95 using the equipment of SPECTROLAB M7

4.3.2 Hardness testing and Microstructure

The hardness testers used in this research were Rockwell Hardness tester and Vickers Hardness tester. The Rockwell hardness test was used for measuring the surface hardness of specimen before hardening, and the Vickers hardness test was

used for measuring the hardness distributed in each point from surface to inner core of specimen. Material used for penetrator is a diamond-tipped penetrator with a 120° conical point and a spherical tip of 0.200-millimeter radius. The diamond penetrator is known as a brale. Load used was 150 kilograms. So, the Rockwell hardness scale used in this study was scale C. In Vickers hardness tester, it used a diamond penetrator shaped as a four-sided pyramid.

For metallographic microstructural observation, G.M. machine was used for magnify the specimen in order to see the changes of microstructure before and after hardening.

4.4 Statistical analysis

Analysis of variance used in this research was two factors ANOVA with replication. The analysis of variance will indicate that the current or the down speed, which one, has the influence on the surface hardness and the hardness in depth.

The assessment of regression also used in this research in order to test the significance of the relationship. The correlation coefficient (or r-test) was used and then the linear regression was used for forecasting the equation. From that equation, the trend of the relation, such as depth of hardening and current, and depth of hardening and down speed, and the unknown value could be predicted.