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DETERMINATION OF THE SINTERING DWELL TIME OF GEARING IRON BASED COMPOSITION BY USING 900 KHZ INDUCTION SYSTEM

ABSTRACT

In this study, iron based powder metal (PM) compacts are sintered by two different sintering methods. One of the sintering methods is conventional sintering, 2kW atmosphere controlled oven is used in the sintering application. TM compacts are sintered at 1120°C for 30 minutes. In the study other used sintering method is induction which is a novel and fast. PM compacts are sintered at a temperature of 1120°C for 1 to 10 minutes using a 900 kHz ultra-high frequency induction system (UHFIS) with a power of 2.8kW. Hardness, density and microstructure images of PM compacts are examined and compared each other. When the obtained results are evaluated, 30 minutes conventional sintered PM compacts test results' are reached in 5 minutes using by UHFIS. Thus, iron-based PM compacts are sintered in 6 times less dwell time while using the induction system.

Keywords: Iron, PM, Induction, UHFIS, Sintering

1. INTRODUCTION

Production of the materials by the powder metallurgy (PM) method consists of homogenous mixing of various metallic or ceramic powders at micro-scale, shaping by pressing and lastly sintering by heating. PM Production is known as a fast and practical method. Although powder metallurgy method is generally used in the production of metallic materials, it is possible to produce many non-metal parts by using PM method nowadays. It is a very useful and less problematic method because the PM parts are in desired sizes after sintering process. The iron PM parts takes the first place, within the metallic PM parts. They can be produce fast and inexpensive. Iron-based PM parts are mostly produced in industrial applications by using conventional sintering methods. In the conventional sintering process very long batch type furnaces are used. For the sintering of these furnaces, heating to the needed temperatures and fixing them at the sintering temperatures provides significant energy consumption and energy cost. Different sintering processes are being used in order to provide the same sintering process. Among these are SPS (Spark Plasma Sintering), microwave sintering, hot pressing and induction sintering. Induction sintering has a very different place among other comparative sintering processes. During induction sintering process, induction current is passed through to the magnetic materials. At this point, PM compacts temperature is reaches to sintering temperature in 10-15 seconds. Iron and iron-based PM compacts can be successfully sintered with medium [1, 2 and 3] or ultra-high frequency induction systems [4 and 5]. Induction system is generally using in forging [6], heat treatment [7], welding [8, 9, 10 and 11] and casting [12 and 13] operations.

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2. RESEARCH SIGNIFICANCE

In this study, iron PM samples were sintered by using conventional or induction system. The obtained results are compared each other. The optimum ultra-high frequency induction sintering dwell time is found for iron PM compacts.

3. EXPERIMENTAL METHOD-PROCESS

In the study, pure Al PM samples were separated into 2 different groups, some sintered in batch type furnace and the other part in induction system. The image of the induction system used in the sintering process is given in Figure 1. The dimensions of the powders used in the study range from 45 to 106 µm and the composition of the powder used is given in Table 1. This iron based composition is generally using in the production of gear wheels.

Table 1. Chemical composition of the iron powder

Composition	Fe	Ni	Cu	Mo	MnS	C	Zn-St
Wt. %	Rest	1.58-1.93	1.35-1.65	0.45-0.55	0.45-0.55	0.15-0.25	0.8-0.99

Figure 1. Image of induction system

In order to obtain a homogeneous mixture, Al powders were mixed with a V-type mixer at 25rpm for 30 minutes and then produced by single-axis single-acting hydropar press with 300MPa cold pressing method. The resulting PM compacts have a diameter of 18mm and a height of 3mm. The first group of samples was sintered using an ultra-high frequency induction system with a 900kHz and a power of 2.8kW. The induction temperature is measured and fixed with the infrared thermometer in the system. Iron based PM compacts were sintered with UHFIHS (Ultra-high frequency induction heating system) at 1120°C in 10^{-1} thoor vacuum environment for 6 different dell times between 1 to 10 minutes. Iron based compacts are cooled naturally after sintering processes. The image of the sample for the induction sintering is given in Figure 2. İnduction sintered images of the sample is given in Figure 3-a. The second group of samples was sintered in an argon atmosphere at 1120°C for 60 minutes using Proterm Chamber Furnace at 2 kW power. Conventional sintered PM compacts are cooled naturally too like induction sintered compacts. The conventional sintered iron based PM compact image is given in Figure 3-b. All the sintering operations of the presented work are given in Figure 4.

Figure 2. Induction sintering process of the iron based PM compact

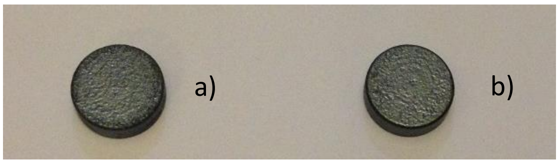

Figure 3. a) Induction sintered, b) Conventional sintered iron based PM compacts images

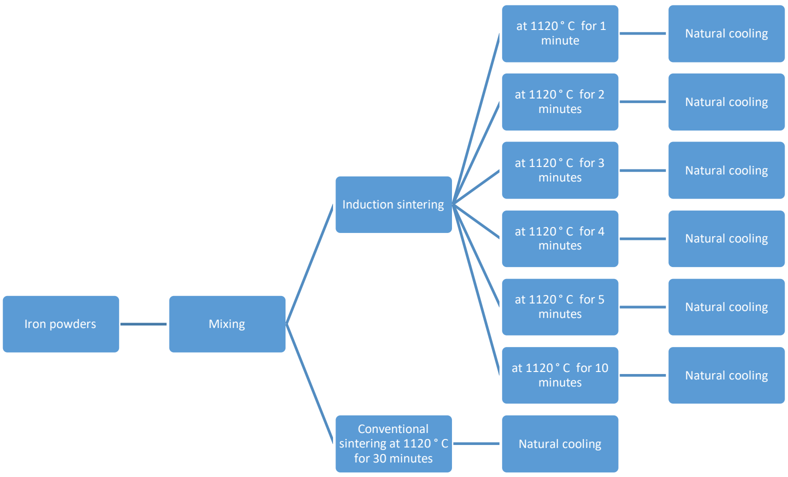

Figure 4. Flow chart of the sintering process

The HRB hardness measurements of the all sintered compacts were made with the MMS 200 RB Macro Brinell Hardness tester under the load of 100kgf. The hardness values were taken from 5 different points of each sample and the results were found by calculating the average hardness values. The densities of the compacts were calculated by using the Archimedes principle method. Microstructure images were taken by using JEOL JSM-6060 Scanning Electron Microscope.

4. FINDINGS AND DISCUSSIONS

The hardness and density values of the iron based PM compacts after sintering operations are given in Table 2. The error ranges of the all results obtained is ± 5%.

Table 2. HRB hardness and density results of the iron based PM compacts

Iron Based PM Compacts	Induction Sintering (at 1120°C)						Conventional Sintering
	1 min.	2 min.	3 min.	4 min.	5 min.	10 min.	At 1120°C (For 30 min.)
Hardness (HRB)	42	46	50	52	57	60	55
Density (g/cm^3)	6.3	6.5	6.8	7.0	7.2	7.4	7.1

The conventional sintered PM compacts were found to have a hardness of 55 HRB hardness and a density of $7.1 g/cm^3$ in a furnace at 1120°C for 300 minutes in an argon atmosphere. The approximately same hardness and density results were achieved in 5 minutes Ultra-high frequency induction sintering operation under vacuum. After the literature review was examined, it was found that iron based compacts could be sintered with induction in 5 minutes [2 and 8] successfully. When the hardness values obtained in the previous studies are compared, it is seen that the hardness value for the iron-based TM samples is about 50 HRB [3 and 14] under an open atmosphere and 55 HRB [5] in an argon atmosphere. It has been determined by this study that the vacuum environment increases the hardness value. In addition, it was found that the PM compacts harnesses were increased of 3% occurred near the induction coil. The reason for this hardness increase is due to the magnetic currents are passing over the compacts directly. Thanks to the magnetic current generated, the surface of the compacts near to the induction coil were hardened. It is seen that the hardness and density values increase with the increase of the induction sintering dwell time. When the values are examined, it can be seen that for the induction sintering dwell times from 1 to 3 minutes, the compacts are not sintered enough and cannot form bonds. Although hardness and dense values for 10 minutes dwell time are the best results, it is seen that the eruptions occur in the compacts. It has therefore been determined that dwell time above 10 minutes are too high for induction sintering application for iron based PM compacts. When the test results obtained were evaluated, it was decided that the optimum induction sintering dwell time should be chosen 5 minutes for iron based PM compacts. The microstructure images of the 5 minutes induction sintered iron based PM compact which is taken from near to the external surface is given in Figure 5-a and from center is given in Figure 5-b.

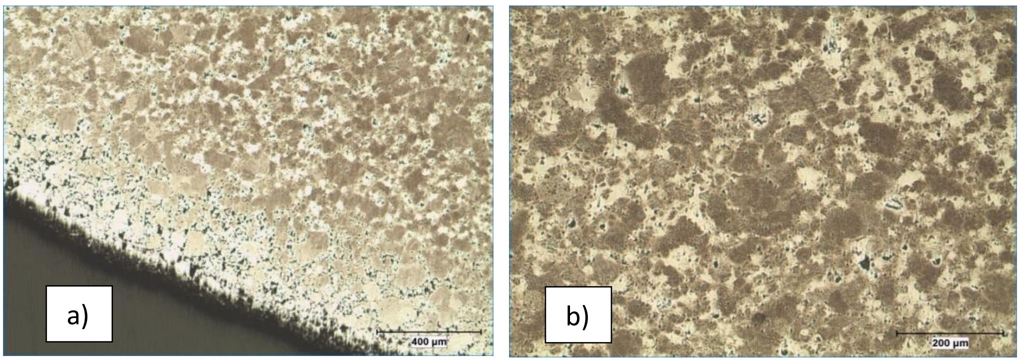

Figure 5. Micro structure images of the induction sintered iron based PM compacts a) from near to the external surface (50x), b) from the centre (100x)

Nearly 400µm change which is near to the external surface is clearly seen in Figure 5-a. This change is also seen in the hardness values. Thus, while induction sintering is carried out, surface hardening operation is also occurs to the PM compacts. This changing is also seen all induction sintering processes. This difference occurs because the magnetic current passes directly over the compact.

5. CONCLUSION AND RECOMMENDATIONS

In this study, iron based PM compacts were sintered UFIHS or conventionally. The results obtained are given below.

- It has been determined that the optimum sintering dwell time of iron based PM compacts by induction is 5 minutes.
- Compared with the conventional sintering and induction sintering processes, iron based PM samples were found to be sintered in 6 times faster by using induction. When the hardness and density values are compared for both sintering process, the test values are nearly the same.
- It has been found that some part of induction sintered compacts are changed at a depth of about 400µm in near to the induction coil. This changes reason is magnetic current of induction. Approximately 5% hardness increase has been experienced in this area. Thus, when the PM compacts are sintered by induction, surface hardening is also occurs at the same time.

In the future studies, sintering temperature and heat treatments of the iron based gear powder metal compacts will investigate by using 900 kHz ultra-high frequency induction system.

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NOTICE

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