Design and Manufacturing of a Powder Compacting Press

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Abstract
A powder compacting press was designed and manufactured. The press consisted of a fixed die plate, a fixed core-rod plate and two hydraulic cylinders attached to movable upper and lower punches. The design allowed the press to be worked as a “single-action” or “double-action” pressing. The maximum load of the upper punch was 100 metric ton. Travelling of upper and lower punches was controlled by a programmable logic control (PLC) circuit. Experimental compaction performed with commercial metal powders showed that green density distribution in cylindrical test pieces could be improved by the double action pressing. The press showed its potential to be used in a ‘press and sinter’ processing.

Keywords: Powder compacting press, design, manufacturing

1. Introduction
Powder metallurgy (P/M) process offers greater flexibility in part design with superior properties and dimensional accuracy. The P/M process has been becoming more attractive among the various metal forming processes. It offers lower production cost when number of P/M parts (higher than the economy-scale quantity) are produced. The attraction of P/M is mainly resulted from the ability to produce various parts such as porous, fully dense, precise (close tolerance), and high performance components in an economical manner [1, 2].

There are three P/M compacting presses, classified due to pressure or force sources. They include mechanical, hydraulic and hybrid presses [3]. The press can work in several ways, depending on tooling systems such as single-action, double-action, floating die, floating die withdrawal double action and anvil single-action.

Most of the P/M compacting presses used in Thai P/M industry were imported. This costed the industry high investment value and less competitiveness. Development of the P/M parts may be one of the solutions for investment cost reduction and competitiveness improvement. In this article, design and manufacturing of a hydraulic press for metal powder compaction at MTEC are presented. The aims of the press development include (i) to construct a 100 ton hydraulic press, which can work by using either single-action and double-action tooling systems and (ii) density distribution of the green parts is improved.

2. Design of the Compacting Press
(2.1) The press structure

The press structure is shown in Fig. 1. The press was designed to have two hydraulic cylinders at top and bottom, in order that pressures could act from top and bottom. The upper hydraulic cylinder was attached to the upper punch support plate, which was guided by two main columns. The lower hydraulic cylinder was attached to the lower punch support plate, which was not used for lower punch installation directly. The lower punch plate was sitting on two columns extended to the lower punch support plate. The two columns could move up and down through the holes in the core rod support plate, which was fixed on the two main columns. The die plate was also designed to be fixed above the core rod support plate. This type of design allowed the press to work in flexible ways, both by single action tooling and double action tooling. Dimensions of the press were 1,135 mm (width) x 1,635 mm (length) x 3,118 mm (height). The total weight was 5,500 kilograms.
(2.2) Hydraulic pump
The hydraulic pump was designed to sit on top of the press. The pump was responsible for pumping hydraulic oil into or out from the hydraulic cylinders. It was capable to give a maximum pressure of 240 kg/cm² by using a 20 horse-power motor with a speed of 1450 rpm.

(2.3) Hydraulic cylinders
The upper hydraulic cylinder was attached to the upper punch support plate. The upper cylinder had a moving distance of 250 mm. The lower hydraulic cylinder, attached to the lower punch support plate, could move within a distance of 173 mm.

(2.4) Cooling system
The cooling system was behind the press. The system was responsible for heat removal from the hydraulic oil. Temperature control of the oil was important as the hydraulic pressure was sensitive to temperature variation.

(2.5) Programmable logic control (PLC)
The press was designed to work under control of PLC and displacement sensors for both upper and lower punches. The hydraulic pressure information was determined by a pressure sensor. Displacement of the punch and pressure variation was able to be adjusted by a press operator.

(3.1) Single-action pressing
Metal powder compaction using a single-action tooling includes the following steps. First the powder is filled in the die. Filling height of any metal powders for any P/M parts should be known. After filling the upper punch is moved down, touched and pressed on the powder particles. Displacement of the upper punch is stopped by the input order via the PLC. After pressing, the upper punch is moved up to its original position. Ejection of a pressed (green) part is functioned by the lower punch moving up. Precise displacement stop of the lower punch is important in the case that this press is working automatically. Schematic working cycle of the single-action powder compaction is shown in Fig. 3.

(3.2) Double-action pressing
Double-action pressing can help improving green density distribution and green parts height. To modify the working cycle of the press, the control circuit (shown in Fig. 2) was redesigned as shown in Fig. 4. By this modification the press could work according to the working cycle for the double-action powder compaction (Fig. 5). The double-action pressing is similar to the single-action one. The difference can be found only at the pressing stage, in which the lower punch is also in a pressing action. The encounter pressure help improving density distribution of the green parts.
Figure 2. A sketch of the control circuit for the single-action pressing.

Figure 3. Working cycle of the single-action powder compaction.
4. Performance Test

Water-atomised 303L stainless steel powders was chosen for performance tests of the hydraulic press. The powder was pressed into cylinder test pieces with a diameter of 20 mm. and height of 14 mm. Pressing action was carried out by two tooling systems, single-action and double-action. In order to test the press performance, the target was set as follows;

(i) green density difference between the upper and lower parts of the test pieces should be improved,

(ii) reproductivity of green density distribution should be produced in 100 test pieces.

In addition to the compaction target, other sintered materials properties such as sintered density and hardness were also examined.

(4.1) Green density
Green density differences resulted from single-action and double-action are shown in Fig. 6. The figure clearly indicates that double-action pressing minimizes green density difference. The error bars, indicating data scattering, are shorter for the double-action pressing. This may suggest that the hydraulic press performance can be improved.

(4.2) Sintered density
Fig. 7 shows sintered density differences between top and bottom parts of the sintered test pieces. The figure also indicates that both density differences and data scattering are minimized.

(4.3) Hardness of the sintered test pieces
Fig. 8 shows hardness of the sintered test pieces at both top and bottom sides. The hardness differences was higher for the double-action pressed test pieces. This abnormal results were not understood yet. Because of abnormal results, performance tests will be further carried out on the 303L stainless steel powder and other powdered materials in the future.

Conclusions
The hydraulic press, developed by MTEC, was able to work as by either “single-action” or “double-action” pressing. The maximum load of the upper punch was 100 metric ton. Travelling of upper and lower punches was controlled by a programmable logic control (PLC) circuit. Experimental compaction performed with the water atomized 316L stainless steel powders showed that green density distribution in cylindrical test pieces could be improved by the double-action pressing. The press showed its potential to be used in a 'press and sinter' processing.

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References