Possibilities of New Products After Installation of 70MN Press

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SUMMARY

A 70MN open die forging press installed at the Daido Steel Co., Ltd., Shibukawa Plant alongside the existing 35MN open die forging press began operating commercially in April 2008. Providing a maximum press power of 70MN and equipped with the programmed pass scheduling system, automatic record collection system, and other state-of-the-art functions and technologies, the press was designed with an eye toward environmental aspects. This new press will meet the needs for higher product quality and higher performance.

1. INTRODUCTION

The Shibukawa Plant of Daido Steel Co., Ltd. manufactures high-grade steel open die forged products, including products for aircraft and generators, forged tool steel products, and billets for rolling in an integrated manner from melting, forging, heat treatment, machining, to inspection. Of these processes, the forging process is currently performed with a total of four machines: three hydraulic type open die forging presses and one mechanical type four-sided high-speed forging machine, with the monthly forged volume of 7600 tons.

In recent years, due to market demand increased for higher quality and capabilities in processing materials with limited formability and due to client requirements for even higher product quality, the number of items whose quality is hard to achieve with a press power of maximum 35MN has increased. Meanwhile, the 35MN press installed in 1976 and used for the past 30 years has become obsolete. The 70MN press recently introduced replaces the old press and embraces the risk management for its equipment.

This paper introduces the 70MN Open Die Forging Press which entered into practical operation in April 2008.

2. EQUIPMENT OVERVIEW

2.1 BASIC CONCEPT

The purpose of introducing the new press at our plant was to replace the existing 35MN press and to meet the demand for higher product quality and to handle materials with limited formability. However, the product weight needed to remain the same, meaning the maximum steel ingot to be handled was limited up to 21 tons as before. If the operating speed equal to or higher than that of the existing 35MN press could not be secured, the effect of increased press power would be cut in half. And, its massive press power requires increasing the rigidity of the press main body, resulting in heavier machine members. This also brings up larger cylinder diameters, which requires the control in large quantities of hydraulic fluid, all factors generally leading to lower operating rates.

With the above in mind, Daido selected the push-down open die forging type which moving parts are lightweight and adopted the large-capacity servo system to permit switching of multiple valves at the appropriate timing. This allows the high-speed operations, free of switching shocks and degraded dimensional precision.

2.2 STRUCTURE OF PRESS MAIN BODY AND FEATURES

Photo 1 gives an external view of the 70MN press, while Table 1 shows the equipment specifications. The main body of the press is composed of upper and lower cross-heads, two hollow columns, a moving cross-head, three main pressing cylinders, and two return cylinders. The new press drastically improved workability, increasing working space over the existing 35MN press (extending daylight from 3,700 mm to 4,100 mm and internal-surface distances between columns from 2,600 mm to 3,800 mm).

The new press provides press capacity at three different stages: 60MN for normal use, the maximum of 70MN, and 30MN for high-speed forging. And operators can select the forging stage best suited to the required product quality.

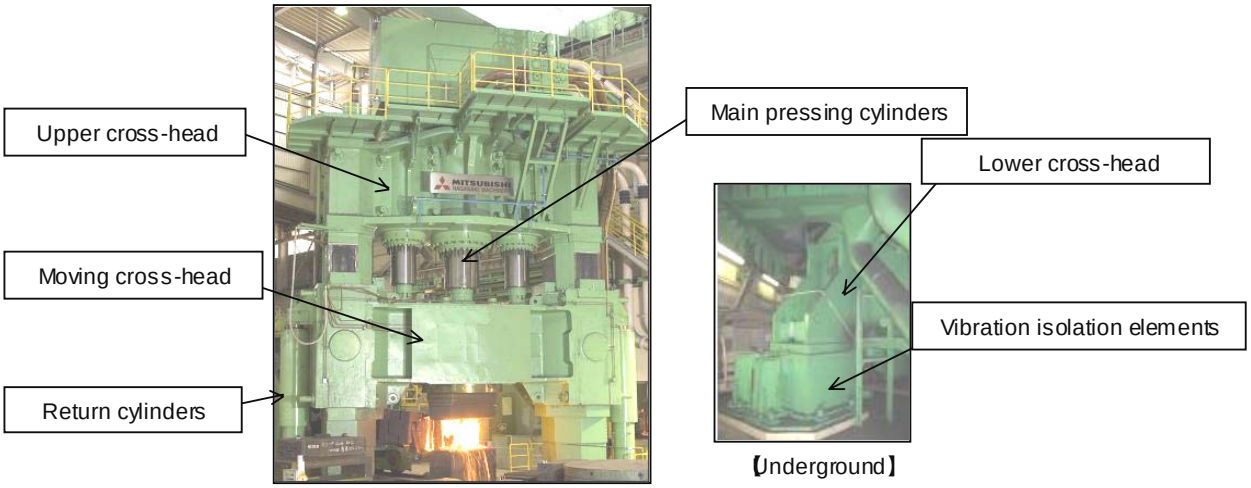


Photo 1. External view of new press main body

Table 1. Comparison of specifications between new and old presses

	New 7000t Press	Existing 3500t Press
Structure	2 columns Push down type	2 columns Pull down type
Capacity	High speed: 30MN Nomal use: 60MN Maximum: 70MN	Nomal use: 30MN Maximum: 35MN
Daylight	4100mm	3700mm
Stroke	2500mm	2000mm
Distance between columns inside	3800mm x 1600mm	2500mm x 1600mm

2.3 FEATURES OF PERIPHERAL EQUIPMENT

When some surrounding equipments installed near the new press to enhance the effectiveness, such as a high-performance heating furnace and a die-exchanger allowing its smooth setup alteration, it became possible to forge materials with limited formability that previously could not be processed in the plant. Table 2 shows specifications for the surrounding equipments related.

The steel ingot is fed from the heating furnace to the press line by the overhead traveling crane or transport manipulator. After the ingot is subjected to forging through the interlocked motions of the press, the rail type manipulator and disc turner, it is carried out from the press line by the ingot car and transported to the next process by the overhead traveling crane.

The table shifting device, die-cross shifting device, and die magazines can automatically be set to the programmed positions (forging position) by selecting buttons on the operation desk. Since a larger quantity of die magazines than for the 35MN press was adopted, the time required to exchange the lower anvil has been reduced.

The moving-table shifting device can stop with a precision of up to ± l mm. And this allows us to expect higher finished dimensional accuracies in the die forging and other operations.

Besides, the upper anvil can be exchanged within 20 seconds using the hydraulically-driven clamp built into the moving cross-head and its rotating mechanism.

Table 2. Specifications for ancillary equipment

	New 7000t Press	Existing 3500t Press
Table stroke	9000mm	7000mm
Die-cross shifting device	3 units	2 units
Die magazine	5 positions	4 positions
Turntable	Cart-mounted type	Underground retracting type
Manipulator	40t (80 tm) diverted	40t (80 tm)
Transport manipulator	7.5t	5t
Large heating furnace	3 units diverted	3 units
Small heating furnace	2 units	2 units

2.4 ENVIRONMENTAL PROTECTION MEASURES

Due to the presence of private residences near the plant, four sets of vibration isolating elements consisting of disc springs were placed underneath the press to reduce vibrations, successfully reducing vibrations from the foundation by 15 dB during forging operations. A vibration isolation ditch (10 m deep) was also provided, allowing environmental standard values to be met under worst-case conditions.

As noise countermeasures, the internal walls of the press site were lined with glass wool noise-absorbing material, reducing noise levels by 5 dB. The addition of sound-insulating walls (6 m high) makes it possible to meet environmental standard values.

The increased power of the new press over the former 35MN press has resulted in higher productivity, reduced heating operations (frequency of heating), and lower CO_2 emissions.

3. NEW FUNCTIONS AND NEW TECHNOLOGIES

Functions that could not be provided in the former press and technologies that could not be implemented due to lack of power are now incorporated into the 70MN press, enabling us to develop the highly reproducible product quality.

3.1 AUTOMATIC PROGRAMME OF PASS SCHEDULES

The new press is equipped with epochal pass scheduling systems based on theory and experience.

3.1.1 DIVERSE PRODUCT SHAPES NOW PROCESSABLE

In tandem with the introduction of the new press reported herein, the two following pass scheduling systems were developed into practical uses :

(1) Programmed pass scheduling for flat steel bars

(2) Pass scheduling for discs

Although certain examples of pattern-programmed scheduling systems capable of handling only bars into square or circular section shapes (Oblateness = 1) can so far be found in existing technologies, the new scheduling system is revolutionary in what it is capable of handling section shapes of any oblateness. Furthermore, the introduction of the new pass scheduling system makes it possible to reduce dispersion in the internal composition of discs, which normally requires complex quality control.

3.1.2 VERIFICATION THROUGH SIMULATIONS

The calculation parameters of the new pass scheduling system, such as extension coefficient according to the steel type, constitute significant factors in product quality. Formerly based on our skilled operators' experience, as verified by the expertises, these

calculation parameters, including the distribution of equivalent plastic strain, deformation behaviors of corner sections, can be determined by FEM analysed simulations to improve system quality reproducibility. The results of the verification are reflected in the actual pass schedules.

3.2. AUTOMATIC COLLECTION OF FORGING RECORDS

The collection of records in the open die forging is critical for the technical improvements, skills transfer, and quality assurance.

3.2.1 STORAGE OF RECORDS ON NUMERIC DATA

Major quantitative data, including forging times, actual records of pass scheduling, press powers, and current press positions are automatically collected from various instruments through the sequencer and the process computer. And these data are then stored in databases.

3.2.2 COLLECTING RECORDS ON IMAGE DATA

In open die forging, it is also important to collect and analyse the image-based information that cannot be quantified. For such data, the moving images of a series of operations continually recorded onto VTR are stored as visual data, and any desired operation can be reproduced with the product number for analysis. Moreover, a system was developed and introduced to accumulate the distributions of material temperature in the form of thermographic heat image data at the end of forging. This makes it possible to exert quantitative control over forging-end temperatures, which are generally hard to measure and control. (Figure 1)

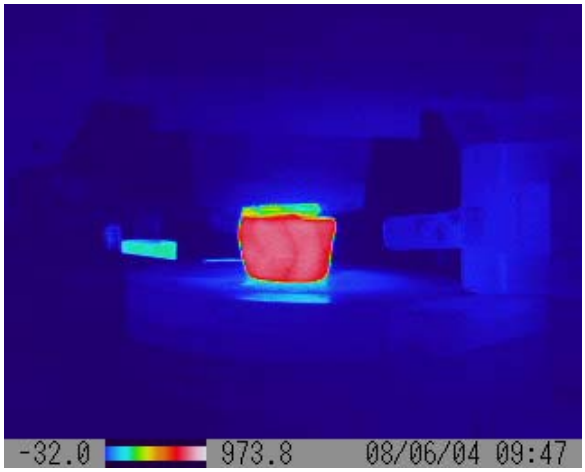


Figure 1. Heat image data for collecting records

3.3 NEW FORGING PROCESS THAT DRAWS ON THE HIGH PRESS POWER

The high press power of the new press changes the way in which conventional forged materials are formed and adds new value. The development of internal quality based on large reduction forging and low-temperature forging and the development of appearance quality based on near-net shape forging using die forging are currently under testing.

3.3.1 DEVELOPMENT OF QUALITIES BASED ON LARGE REDUCTION LOW - TEMPERATURE FORGING

The introduction of the new press enabled the reduction amount and feed per stroke to be augmented and made it possible the design of pass schedulings with maximized quality and productivity. At the same time, forging at lower temperatures improved internal quality.

Table 3 shows some examples of the quality for SUS304N2 discs resulting from the large reduction forging. The increased press power brought about finer grain sizes, which results in improved mechanical characteristics, and reduced frequency of heating, which results in improved productivity.

Table 3. Forging process for SUS304N2 discs

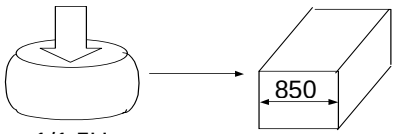
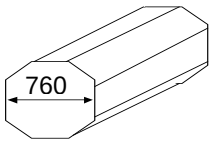
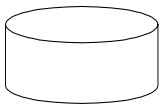
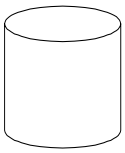
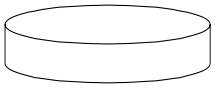
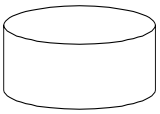
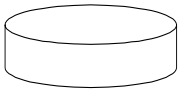
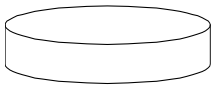
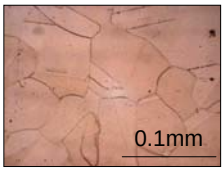
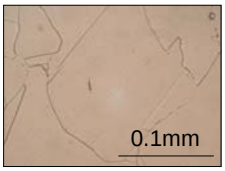
Process	Process of new 70MN press	Process of old 35MN press
Heating	<1250℃	<1250℃
1st upsetting Conversion	 1/1.5U	
Heating	<1250℃	<1250℃
Another conversion		
Heating	<1250℃	<1250℃
2nd upsetting	 ϕ1720 x H390	 ϕ1200 x H800 ⇒ Grinding
Heating	<1150℃	<1250℃
3rd upsetting	 **ϕ2100 x H260 (Finish)**	 ϕ1250 x H750 ⇒ Griding
Heating	—	<1250℃
4th upsetting		 ϕ 1380 x H600
Heating	—	<1250℃
Final upsetting		 **ϕ2200 x H240 (Finish)**
Frequency of heating	4	6
Heat treatment	Solution Treatment	
Grain size rating	 Grain size number #4.6	 Grain size number #2.2

Photo 2. SUS304N2 disc under forging

4. CONCLUSION

A 70MN press equipped with various new functions and technologies was introduced at the Shibukawa Plant of Daido Steel Co., Ltd. to replace a superannuated 35MN press and to achieve higher product quality and provide the capacity to handle materials with limited formability.

This new press constitutes the core of the plant's equipment set for facilitating the new businesses to be developed in the future. The authors intend to work together to further improve its productivity and extend technical capabilities.