Development of a Small-scale CVJ Forging Line

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We have improved the global standard forging line for the CVJ outer race by transforming it into a smaller line that is simple and versatile. This line achieves a lower manufacturing cost with cost down technologies such as press downsizing and integration of transfer equipment. Furthermore, to maintain forging quality, this line has a high precision sizing method and new lubrication system.

With this line regarded as the Global Standard Line, we are expanding the same concept line overseas.

Key Words: *CVJ, forging, downsizing, transfer, global standard line*

1. Introduction

The environment surrounding the automobile industry over the past few years, while remaining sluggish regarding demands in Japan, has seen a gradual shift in production to overseas locations as demands within Asia have risen. Furthermore, forging processes have until now focused mainly on large-lot production on large size equipment, requiring a large amount of WIPs (work in process) due to the length of production lead time. The global development of JTEKT, however, requires the construction of a small-scale production line with low investment which incorporates downsizing, simplicity, versatility, and easy changeover of work number. We have therefore focused our efforts towards the "development of a small-scale CVJ forging line" for the outer race, a CVJ component.

2. About the CVJ

2. 1 CVJ installation position and components

The CVJ, which transmits drive force to the tire, is installed inside the vehicle in the positions shown in **Fig. 1**. Within each vehicle, there are two CVJs in the front of FF vehicles, two CVJs in the rear of FR vehicles, and four CVJs within AWD vehicles. The CVJ is comprised of four components, including the outer race (inboard, outboard), inner race, and tripod (**Fig. 2**).

* CVJ: Constant Velocity Joint

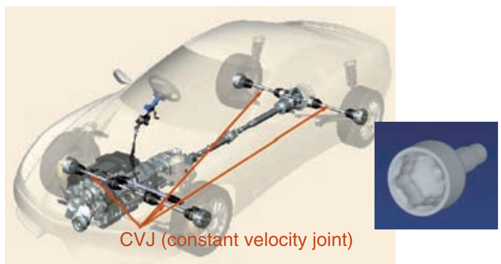


Fig. 1 CVJ installation position

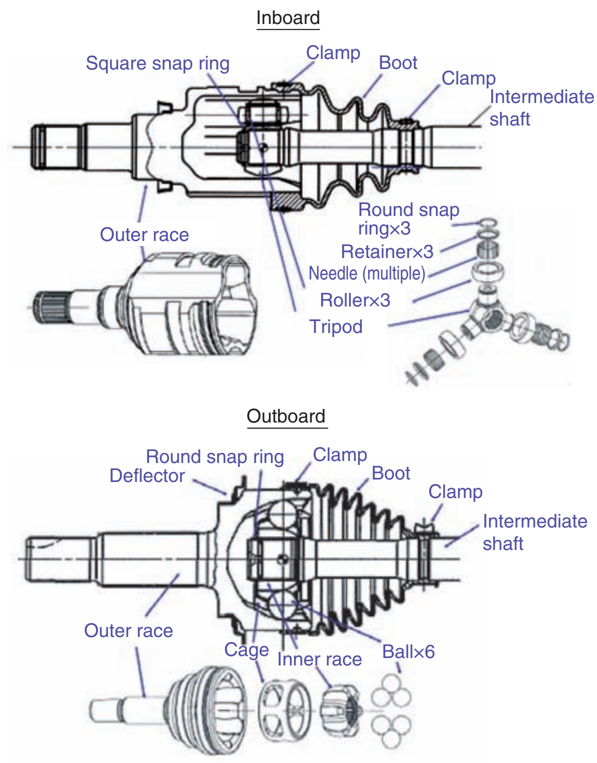


Fig. 2 CVJ components

2. 2 CVJ forging process

As shown in **Fig. 3**, the outer race is warm forged from steel and completed within the cold sizing process. Production conditions, which are specified for each process, are maintained and operated using the appropriate measuring devices.

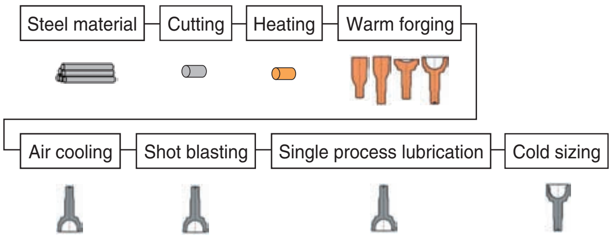


Fig. 3 Process flow chart for outer race forging

3. Construction of a small-scale forging line

3. 1 Line concepts

As stated previously, the conventional forging process used for the outer race consisted of a long production line which included a large size forging press, required a large amount of WIPs due to large-lot production, and had a long production lead time. To resolve these issues within the Global Standard Line (GSL) for the CVJ, we have conducted an investigation based on the following concepts:

(1) Forging line that enables added value at one half the production scale
(2) Small-scale line suitable for small-lot production (Simplification and downsizing, no changeover)
(3) Utilization as mother line and global application

3. 2 Goal setting and results

To promote global application of the line, we have set the following goals (**Table 1**) which include improvement of operational availability and shorter production lead time (reduction in WIPs) through line scale downsizing. We also plan to establish the developed line as the GSL and refer to our ideal state to pinpoint issues which shall be resolved before implementing global application. By doing so, we shall create a versatile line that can be operated without experience, intuition or know-how.

The results in **Fig. 4** show that for the GSL for CVJs, we have halved the total length of the conventional line and reduced space by 58% from 304 m^2 to 127 m^2. This has been achieved by directly connecting processes from the heater up until cold sizing, and decreasing the size of equipment. This has consequently achieved a 10% increase in space productivity, from the conventional 585 products per month per m^2 to 636 products per month per m^2. In particular, the elimination of WIPs has greatly reduced production lead time from the conventional two days, to 0.03 days.

Table 1 Setting goals

Item		Conventional line	GSL	Aim/Target
①Investment amount	%	100	50	–
②Production capacity	%	100	50	Reduce production scale by half
③Reduce production lead time	%	100	25	Reduce WIPs
④Operational availability	%	70	85	Improve productivity

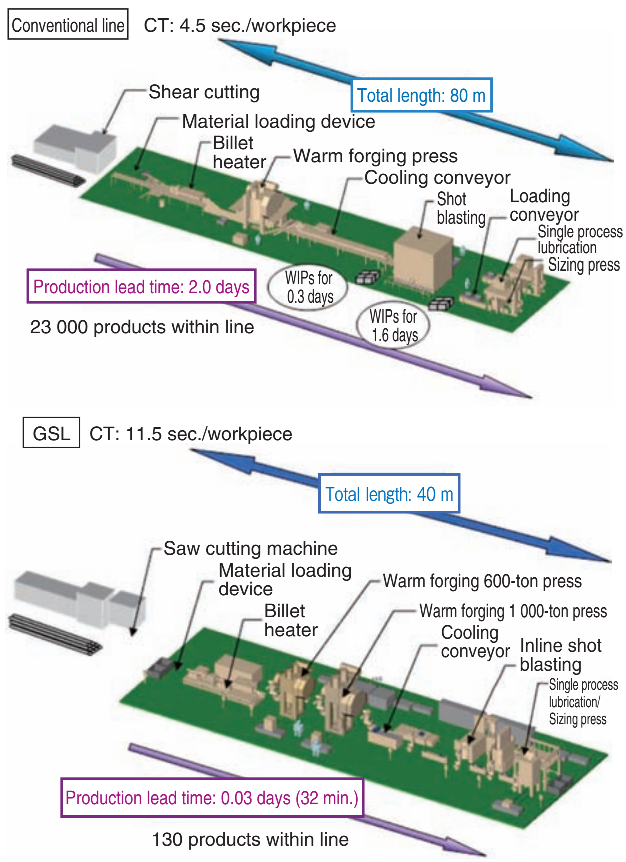


Fig. 4 Comparison of conventional line and global standard line

3. 3 Simplification and downsizing of forging press

To create a simpler and more compact warm forging press, we have optimized the internal mechanism of the press, thereby achieving a more compact structure and reduction in number of parts, and contributing to lower investment.

Furthermore, while the conventional line required a 2 000-ton press, we have achieved downsizing suitable for small lots by a tandem press combining a 600-ton and a 1 000-ton press. We have also increased the speed of strokes from 40 spm (strokes per minute) to 60 spm, and abolished the deceleration mechanism by employing a servo motor. **Table 2** shows the effects of investment and the items optimized within the internal mechanism. In addition, **Fig. 5** shows the parts of the forging press which have been optimized.

Table 2 Effects of investment and optimization of internal structure

Item	Conventional line	GSL
Pressing capacity	2 000 tons	600 tons+1 000 tons
Deceleration mechanism	Two-stage reduction gear shaft	None
No. of strokes	40 spm	60 spm
Main motor	Inverter motor	Servo motor
Transfer	Transfer unit	Robot
Investment amount	100%	60% (two units)

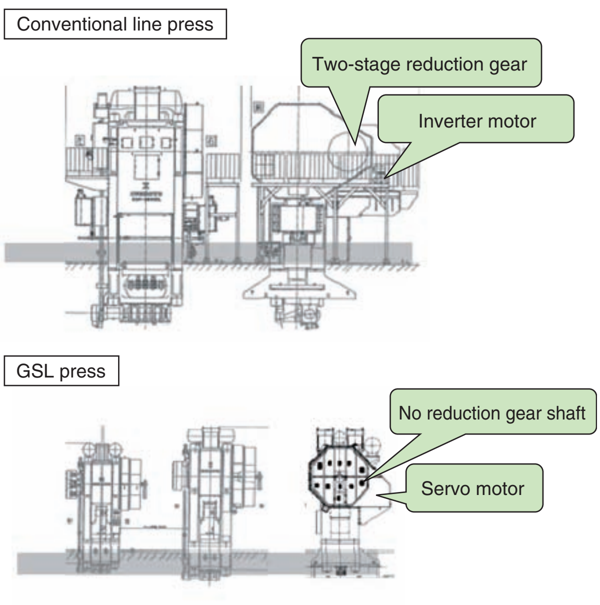


Fig. 5 Optimized portions of forging press

3. 4 Robotization of transfer between processes

In contrast to conventional transfer between forging processes, which mainly used a transfer unit, the developed small-scale forging line utilized a robot transfer system. A transfer unit requires transfer chuck changeover and adjustment between each product number and process, lengthening the time between changeover and causing errors when adjustment is insufficient. These factors cause reductions in line operational availability. We therefore investigated transfer methods able to transfer products using the same chuck, regardless of differences in forged shape or size. Through this study, we were able to standardize a chuck for all product numbers, shown in **Fig. 6**, thus eliminating the need for adjustment and changeover. Furthermore, we have established the optimum equipment layout, die design, process design and timing of lubricant coating by using robot simulation analysis (**Fig. 7**) to optimize cycle time and conduct preliminary verification of the interference between the robot transfer unit and the peripheral equipment. In particular, we have efficiently utilized the space created by transfer robotization for lubricant coating by optimizing the coating position of the moving nozzle, which has greatly contributed to improving die life (**Fig. 8**).

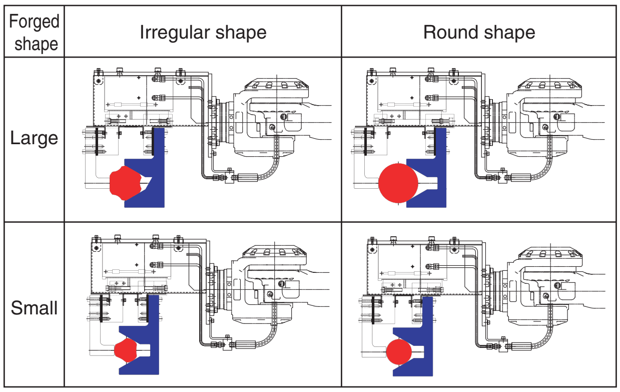


Fig. 6 Robotized transfer between processes

Fig. 7 Robot simulation analysis

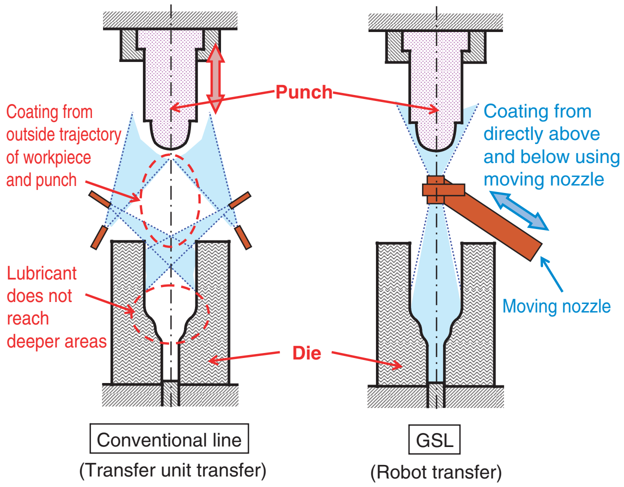
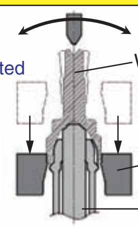
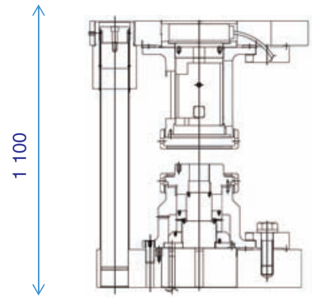


Fig. 8 Review of die lubrication method

3. 6 Development of high precision sizing method

The conventional cold sizing method conducted pressing with the cup facing downwards, in which case the stem area of the workpiece cannot be restricted. This caused instability of the workpiece posture during pressing. As a result, a large amount of variation occurred in stem runout. As a countermeasure, we have changed the sizing method so that pressing is conducted with the cup facing upwards. This restricts the stem area and maintains stable workpiece posture, which suppresses stem runout and successfully reduces stock removal. Stem runout has been reduced from the conventional standard of 2.0mm in diameter to 0.8mm in diameter, and stock removal has been reduced from 1.3mm on one side to 0.8mm on one side. This has enabled a reduction in material weight by 20 g.

This sizing method has also reduced the weight of the die set by 30% in comparison with the conventional die set, contributing the ease of mold replacement and maintenance (**Fig. 9**).

<table>
<tr><th></th><th>Runout tolerance and stem stock removal</th><th>Weight of die set</th></tr>
<tr><td>Conventional line</td><td>Runout tolerance standard: 2.0
Stem stock removal: 1.3mm/side

</td><td>
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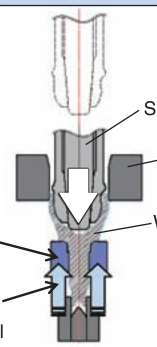
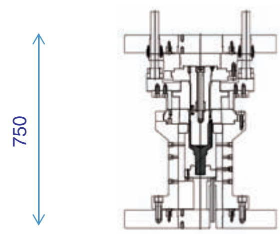
<tr><td>GSL</td><td>Runout tolerance standard: 0.8
Stem stock removal: 0.8mm/side

</td><td>
</td></tr>
<tr><td>Effect (Compared with conventional)</td><td>–20 g</td><td>–30%</td></tr>
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Fig. 9 High precision sizing method

4. Results of implementation

The GSL was installed at the Tadomisaki Plant in January 2013, achieving the pursued goal values (**Table 3**).

Table 3 Results

Item		Conventional line	GSL	Aim/Target	Result	Evaluation
①Investment amount	%	100	50	–	60	×
②Production capacity	%	100	50	Reduce production scale by half	50	○
③Reduce production lead time	%	100	25	Reduce WIPs	0	○
④Operational availability	%	70	85	Improve productivity	87	○

○ : Goal achieved × : Goal not achieved

5. Conclusion

We have achieved the development of a small-scale forging line with high versatility through the creation of new engineering methods, including a review of specifications of each unit of equipment. The developed line achieves 0.95 (CIM) compared to the 1 (CIM) of the conventional line, through accomplishments such as halved production capacity and 40% reduction in investment amount. We will continue to downsize production processes and further reduce investments in order to lower costs.

*CIM: Cost Index of Manufacturing

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