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# Development of a Co-Use Welding Jig for Shock-absorber Parts

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**Abstract**

In order to enhance customer satisfaction and competitiveness, companies should be able to respond effectively to changes in the external environment, and the most important properties to partners in supply chain manufacturing according to orders is to cope with fluctuations in the volume of production. This study is about the co-use welding jig which has flexible size adjustment function according to parts' size to improve the inefficiency of the existing process that welding after fixing parts manually during the machining of various types of vehicle shock absorber parts. The co-use welding jig, handled in this study, is a flexible manufacturing system (FMS) which can be freely applicable regardless the type of vehicles and provides a fast process and delivery system of parts when receiving orders based on an easy and flexible process of parts according to the desired size. For this, an upper jig, lower jig, and spring device that can be co-used in the variety of types of products and automatically control the median value as well as run-out defect are developed.Technology development resulted in shortening the machine set-up time by around 3/5 and cycle time by around 1/3. Defect rate was also reduced from 13% to below 1%.In addition, the developed technology could flexibly cope with numerous model changes by order of the variety of products. Furthermore, it could help shortening the product delivery time.

***Keywords:*** *Shock absorber base assembly, FMS, Co-use, Welding, Jig.*

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## 1. Introduction

In order to enhance customer satisfaction and competitiveness, companies must respond effectively to changes in the market and have the capability to manufacture products promptly after receiving orders. The ability to cut down delivery time, which is continuously able to shorten the set-up time of the machine and adapt to model changes as well, should be developed [1,2,3]. At the same time, the process

November-December 2019
ISSN: 0193-4120 Page No. 566 - 574

quality of parts processing must be developed to an infinite level. GE, a world leading top ranking company in management innovation, has developed a policy to reduce the defect rate by 90 percent every two years and has set up bold figures in customer satisfaction and is satisfying it [3].

Automobile manufacturing technology is developing with eco-friendly technology using electricity and hydrogen energy, intelligent technology in which AI and satellite are used, high-performance collision and braking safety, parts' high tensile strength, light weight and modularization technology. As the market for product sales expands and the block in the competitive market collapses, the world is fiercely competing among companies to seize market advantage while forming one market. To survive in such a market scenario, it is necessary to build low-cost, high-efficiency production and manufacturing capacity. The flexible manufacturing system (FMS) is a production system for automation having a flexibility of system in the production of the variety of products. Many researches are being conducted to establish knowledge base in relation with the production [4,5,6,7]. This study deals with the co-use Welding Jig technology which can flexibly and efficiently cope with various demands of customers in the manufacturing process of automobile shock absorber base assembly. It aims to induce improvement of production by applying automation in the manual assembly through process improvement rather than complete automation which has a high technical and economic burden. To this end, by developing co-use Welding Jig technology for the part which is processed some parts by hand in the welding in the base assembly manufacturing process, we can flexibly respond to demand, and also execute studies to establish a production system that is able to manufacture uniformed-quality products such as maintaining high-performance tensile strength.

## 2. Process status analysis

### 2.1. *Process status*

The shock-absorber base assembly is one of the major components of a shock-absorber, which protects the valve and manages the up and down straightness during valve operation. It contributes to the function of a shock absorber that controls the behavior of the vehicle and absorbs shock and vibration energy to provide controlling safety and a comfortable ride. Figure 1 shows the shock absorber base assembly.

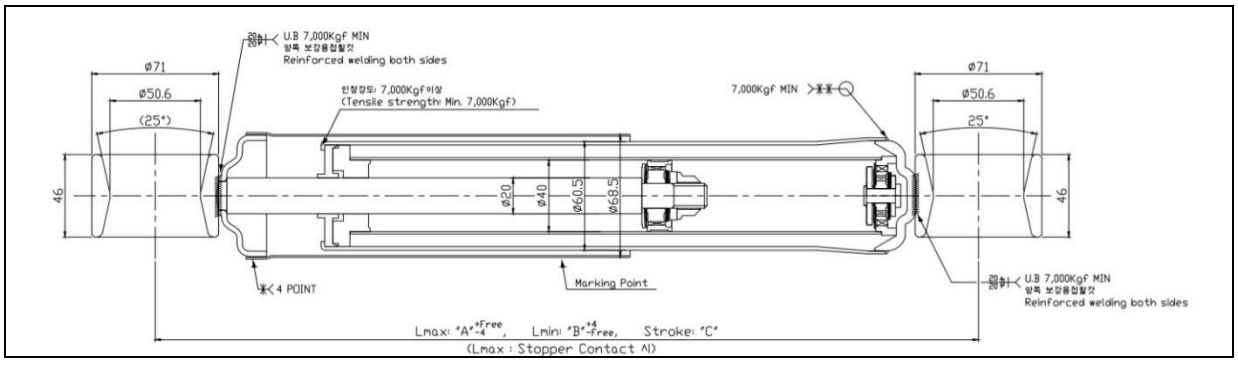


**Figure 1. Shock Absorber Base-assembly**

The process of the base assembly, as shown in Figure 2, consists of a 'cutting'

process, which cuts the pipes in proper length according to each vehicle specification, a 'chamfering' process, which removes the burr at both ends of the cut, an 'expanding and shrinking' process for welding of other parts, and finally, a ‘welding’ process that connects each part.

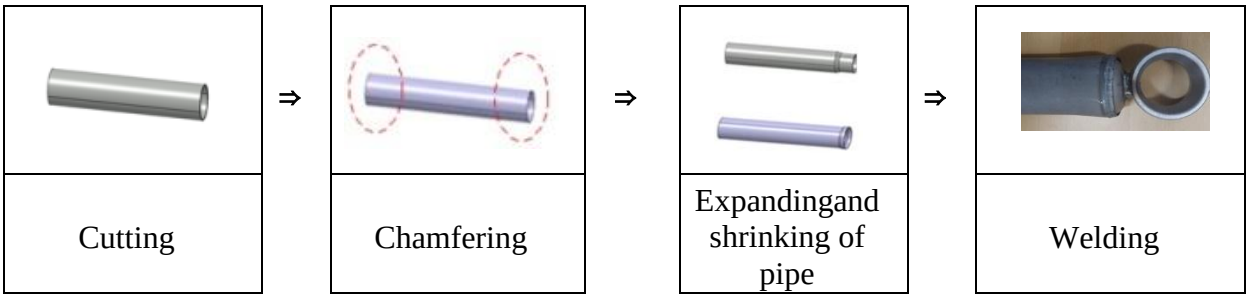


**Figure 2. Shock-absorber base assembly process configuration**

In the manufacturing technology of the base assembly, which is a part of the shock absorber, the general method of bonding the base CAP and the EYE is performed by CO2 reinforcement welding [8] and resistance welding such as spot welding. Figure 3 shows the welding of CAP, EYE, and pipes.

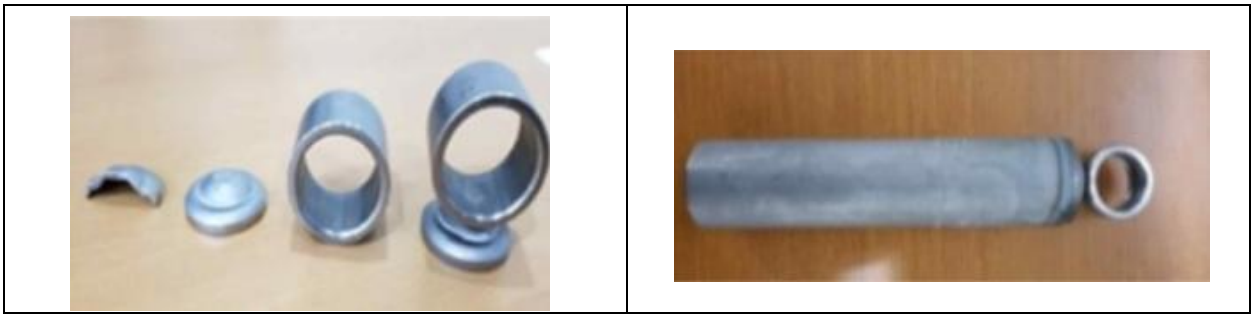

**Figure 3. Welding of the CAP, the EYE and the Pipe**

### 2.2.*The need for technology development*

The subject companies of this study, which mainly produce repair parts, are characterized by having a demand for a variety of vehicle shock-absorber. When these various items are ordered, a manufacturing system that can supply the products quickly and flexibly should be operated accordingly. A base assembly is usually, as shown in Figure 4, produced in 42 combinations, depending on the type of vehicle, including three kinds of the base CAP and fourteen types of the EYE that is welded to it. This has very difficult problems, which should be solved simultaneously, such as responding to various demands of customers and managing the defect rate.

November-December 2019
ISSN: 0193-4120 Page No. 566 - 574

**Figure 4. Example of welding combination of CAPs and EYEs**

In the process of welding the EYE to the top of the base CAP, the welding should be performed at a precisely median value without any top-to-bottom mismatch or shaking. However, due to the nature of the shape in which a circle meets another circle, the structure has difficulties to precisely match the concentric circles, the preparation time is excessive, and the causes of multiple failures always exist. At the same time, the process must be carried out while modifying the manufacturing format to suit the varieties of at least 42 different types of products. In order to solve these problems, it is necessary to develop a co-use welding technique that eliminates the cause of defects in top-to-bottom mismatch and shaking, and enables quick and flexible welding for a variety of types of products.

## 3. Details of technology development

### 3.1. *Process Analysis*

The base assembly welding process can be categorized into six element works viz., set-up of the device, loading the parts, descending welding electrode, power supply and welding, ascending the welding electrode to home position, and assembly unloading as in Figure 5. Welding to the base CAP and EYE of the base assembly has the characteristics of the shape where a circle meets another circle and must be placed at the center using a precise median value. The error caused by run-out results in the defective product. In addition, a dedicated tool by which work can be resumed promptly without replacing tool even for a variety of products by improving the process which increases the set-up time due to replacing the device according to the size of the EYE should be re-designed and developed. Figure 6 shows the welding work currently practices in the shop floor.

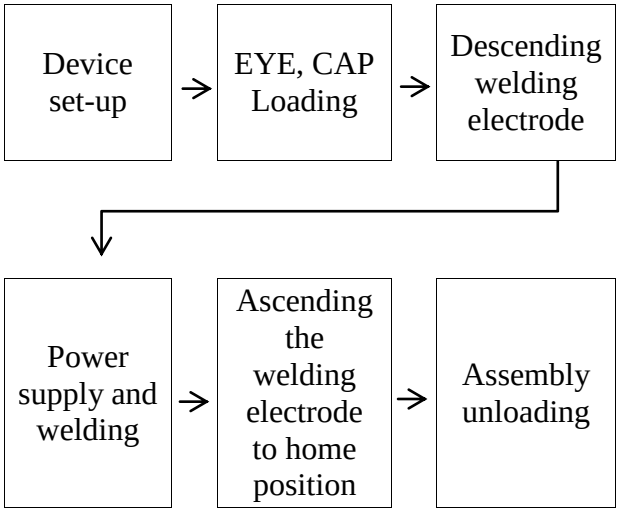


**Figure5. Construction of element work of welding process**

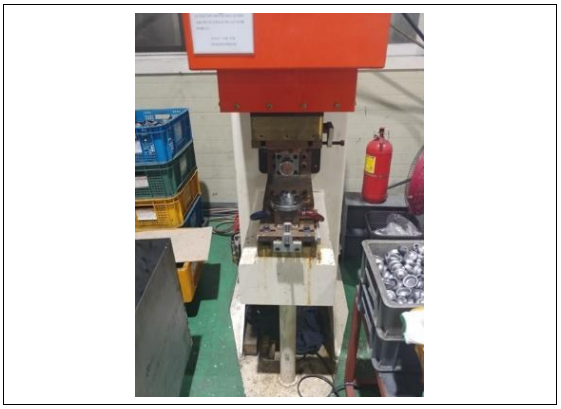

**Figure 6. Conventional welding process before adopting developed method**

### 3.2. *Simulation Analysis*

The shock-absorberVirtual production technology is a useful tool for developing new products, new equipment, and new manufacturing systems. 3D simulation is being used as a useful tool to analyze effectiveness of automation. During 3D simulation, mechanical analysis as well as simulation for the discrete events [9,10,11,12] are performed.Figure 7 shows a drawing of co-use welding jig for base assembly. In this study, CATIA which is a mechanical system analysis simulation package with 3D function was used to validate structural and functional effectiveness of the improved process to analyze mechanical function of co-use welding jig technology for the base assembly as shown in Figure 8.

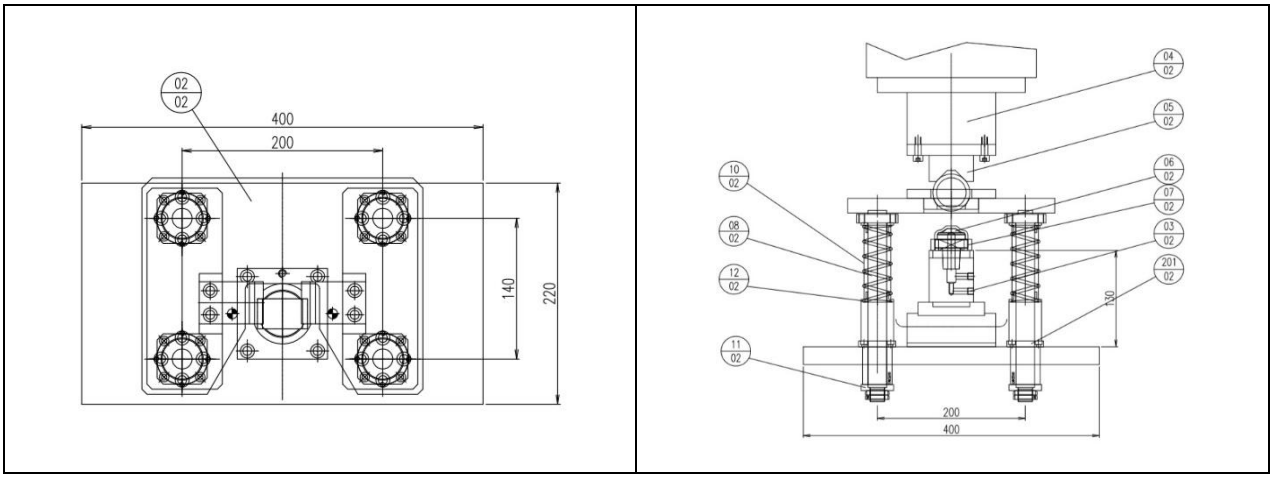


**Figure 7. A Drawing ofco-use welding jig for base assembly**

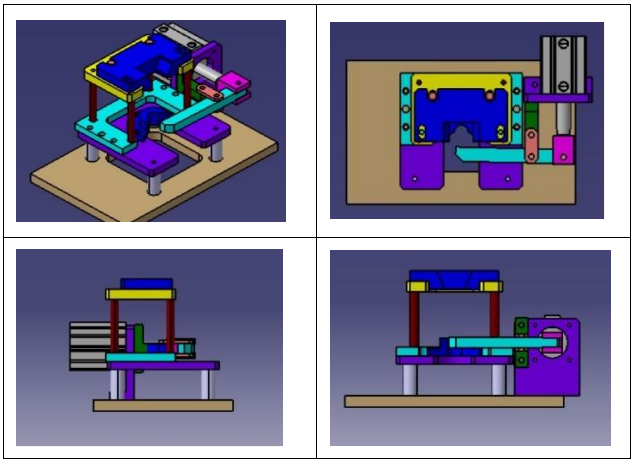

**Figure8. Example of 3D simulation using CATIA**

### 3.3. *Development of the base assembly co-use welding jig*

Virtual Welding to the base CAP and EYE of the base assembly has the characteristics of the shape where a circle meets another circle and must be placed at the center using a precise median value. In addition, it should be easy to change the manufacturing method quickly for various kinds of products, and a special tool for this should be developed. The purpose of this study is to develop the co-use welding Jig, which is a special tool that automatically matches the median value of the base CAP and EYE, can be quickly transformed into various items, and flexibly responds to demand, and to establish a

process which has less than 1 percent defect rate

The details of the development are as follows.

- The median value of the base CAP and EYE automatically matches.
- The height difference by base CAP and EYE type is automatically identified, and through this, the weld height correction is executed.
- A co-use welding jig which can freely change types of a shock absorber according to vehicle.
- without changing placing jigs according to the types of EYEs.
- . A jig that prevents error due to problems such as vertical slip and contraction during heating in the base CAP assembly welding and production

| Developed tool | Functions |
|---|---|
|  | Upper jig: Fixing a common jig which can be co-used regardless of the size of EYE and adjustment of the median value |
|  | Lower jig: to regulate CAP run-out during welding |
|  | Spring: to correct height automatically after welding |

**Figure 9. Co-Use Welding jig for base assembly**

The upper jig as shown in Figure 9 is a jig which fixes co-usable EYEs regardless of the product's type and automatically adjusts the median value. Whereas, the lower jig prevents run-out of the CAP and the spring corrects the height automatically after the welding done. Figure 10 shows various base assembly types where the co-use welding jig can be applied.

| | | | |
|---|---|---|---|
|  |  |  |  |
| Small types of EYE | Bolt type | Large type of EYE | Bracket type |

**Figure 10. Various Shock-absorber base assembly**

## 4. The result of technology development

The co-use welding jig technology for the base assembly enables upper jig, lower jig, and spring system be applied in the variety of types of products by automatically align the median value, control the run-out, and adjust height of the CAPs and EYEs regardless of the size of materials. With such arrangements, model change for the shock absorber base assembly becomes easy to reduce the tool change time and to make defect rate control easy. As a result, equipment that can produce shock absorbers regardless of the size of the EYEcan be constructed to efficiently respond to various demands. Figure 11 shows the application of the co-use welding jig.

**Figure 11. Improved welding process with the developed jig**

Table 1 presents the optimum welding condition for the major parameters in the welding process for CAPØ38.1 with the various types of EYEs. The parameters were set as the most suitable combination to achieve tensile strength (more than 4,000kgf) which is the target characteristics after repeating test for ten times by varying three to four parameters as against the optimum condition in the running welding process.

**Table 1: Examples of parameters setting for CAPØ38.1**

| EYE models | Height (mm) | Current (KA) | Compressive force (bar) | Power input duration (ms) |
|---|---|---|---|---|
| SZ22001201 | 12.95 | 22 | 3.5 | 200 |
| SZ22093401 | 12.30 | 22 | 3.0 | 180 |
| 5A1029 | 13.50 | 22 | 3.0 | 180 |
| 5A1281 | 12.55 | 22 | 3.5 | 180 |
| 4SA11646 | 12.70 | 22 | 3.5 | 190 |
| WSZ35A2001 | 13.20 | 22 | 3.5 | 200 |
| SZ2201601 | 12.75 | 22 | 3.5 | 200 |
| WSZ35A0501 | 12.85 | 21 | 3.5 | 190 |
| 6A1087 | 12.50 | 22 | 3.5 | 190 |
| WSZ35A1901 | 12.90 | 22 | 4.5 | 200 |

Table2 shows the pre- and post-implementation status of improvement effects after technology development such as set-up time, production volume and cycle time, and defect rate. With the co-use welding jig for the base assembly, machine set-up time was reduced by 3/5, cycle time was shortened by about 1/3, and defect rate was reduced from 13% to below 1% in terms of automatic median value setting and easiness of model changes.Accordingly, the improved jig could flexibly cope with model change by the order of variety of types of products and greatly attribute the shortening the delivery time.

**Table2: Comparison before and after technology development**

| Item | | Before | After | Remarks |
|---|---|---|---|---|
| Set-up time (set-up) | | 25min. | 5~10min. | Reduced center alignment time |
| Production volume | | 300ea/hr | 420ea/hr | - |
| cycle time | | 12sec. | 8.5sec. | - |
| Producible item | | Small EYE type | All types of shock absorber such as small EYE type, medium/large EYE type, bolt type, bracket type are producible. | All types Producible |
| Welding conditions | Electric Current | 20KA | 22KA | Decreasing time by increasing instantaneous pressing force and current. |
| | Pressing force | 2.5bar | 3.5bar | |
| | Time | 280msec | 200msec | |
| Defect rate | | 13% | Less than 1% | Initial, middle and end management |

## 5. Conclusion and future tasks

In The purpose of this study is to develop a co-use welding jig that can efficiently respond to various customer 's needs in the manufacturing process of automobile shock absorber base assembly. For this purpose, we have developed a co-use welding jig for the manually assembled part in the welding work in the base assembly manufacturing process, so that the production system that can flexibly respond to demand and produce the uniform product has been studied.

The development of the co-use welding jig technology for the base assembly enables upper jig, lower jig, and spring system be applied in the variety of types of products by automatically align the median value, control the run-out, and adjust height of the CAPs and EYEs regardless of the size of materials. With such arrangements, model changes of the processed products become easy, tool change preparation time can be reduced, and the defective product control becomes easy. As a result, equipment that can produce shock absorbers regardless of the size of the EYEcan be constructed to efficiently respond to various demands. In the future, researches about design and development of flexible manufacturing system that efficiently cope with the market changes are needed by analyzing various parameters of characteristics of unit process and between process by expanding the scope of the research till pre- and post-process after developing the technology of this project.

## 6. Acknowledgement

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