The new technology in the automotive industry by using tailor welded blanks

YAN Qi

Abstract: Tailor welded blanks are defined as two or more sheets of blanks with equal or different thickness, strength, or surface coatings welded together before forming process in the automotive workshop. Using tailor welded blanks in the body-in-white structure can obviously reduce the weight of the car and reduce the material scraps in the workshop. Compared with the traditional cars, the energy consumption of cars with tailor welded blanks is reduced. The application of tailor welded blanks in the automobile industry has brought more chances for the car manufacturers and more benefits for the customers. In this paper, the history and benefits using tailor welded blanks in the automotive industry are discussed in details.

Keywords: Tailor welded blanks, Energy consumption, Automotive industry

0 Introduction
With the improvement of the living standard, more and more people are using cars as their traffic tools, so more cars are manufactured in the world and as a result, a lot of problems are generated thereafter. Energy consumption is becoming the top one problem. The more weight of the car, the more energy is consumed. Therefore, the automotive industry is consistently striving for new ways to reduce the weight of car bodies but without weakening structural stability. One of the most successful approaches to achieve significant weight reduction, while improving the structure safety, is the application of tailor welded blanks. During the period of 1993~1997, ULSAB (Ultra Light Steel Auto Body) project organized by 35 steel plants and automobile manufacturers just promoted the application of tailor welded blank in the BIW (body-in-white) structure parts. Tailor welded blanks have been widely used in the automobile structural parts such as rail, bumper, wheelhouse, door inner, floor panel, etc., and many car manufactures such as GM, VW, Ford, Toyota, Fiat have used tailor welded blanks in their automobile structural parts.

1 Tailor welded blanks
1.1 Definition of tailor welded blanks
Tailor welded blanks are defined as two or more separate pieces of flat material, dissimilar thickness, and/or mechanical properties, jointed together before forming to provide customized and superior qualities in the finished stamping. The traditional procedure in the automobile industry was to stamp the automobile parts with different thickness and different materials one by one, and then these stamped parts were welded together to form one piece of complete automobile part. With the application of tailor welded blank, the combination of different thickness and different materials is formed first by laser welding, then tailor welded blank is stamped into one piece of complete automobile part. Fig.1 shows the change of stamping procedure in the automobile industry because of using tailor welded blank.

![Traditional stamping procedure](image-url)
1.2 History
The original application was used to overcome coil width limitation. It is reported that the first application of tailor welded blanks occurred in 1985 when this technology was used in the production of front floor pans for the Audi\cite{1}. Fig. 2 shows the front floor pans just using this technology to provide wide width sheets for the car industry. However, at present situation, the technology of tailor welded blanks is widely applied in the various occasions which incorporate steel with various types and thickness. Fig. 3 shows the rail part using tailor welded blanks but with different thickness and materials. Most tailor welded blanks today embody a multiple thickness design in order to eliminate the use of extra reinforcing components. The driving force for the automobile industry applying this technology is its evident advantages. Weight reduction can improve vehicle’s efficiency. Tailor welded blanks just present the opportunity to produce automobile parts with the minimum quantity of material, thus reducing general weight.

1.3 Benefits of tailor welded blanks
By utilizing a tailor welded blank, made up of blanks of different thickness, coatings, and/or strength, the final stamped part can exhibit specific desired properties.

Tailor welded blanks can yield several benefits for the users compared with the traditional methods:

- Reduction of final car weight. In an automotive application, Tailor welded blanks eliminate the need for reinforcement, resulting in an overall reduction in vehicle body weight. The use of
different strength or thickness in a single part can simplify the whole structure of a vehicle. Low car weight means improved fuel economy that is very important to today’s energy consumption.

- Reduction of automobile parts’ number. The precision of car body structure can be improved and a lot of press equipment and working procedures can be saved. A door inner panel is taken as an example. It has a relatively deep draw depth to accommodate the design. This requires a soft and thin metal. However, the front of the same door inner, where the hinges will attach the door to the car, must be strong enough to withstand the weight and use of the door. In the traditional methods, reinforcements are required to strengthen the door inner. These extra parts require several processes in the workshop. Now, by using a tailor welded blank with a large, thin, soft piece of material jointed to a smaller, thicker, stronger piece of material, the blank can be formed and used as a one piece door inner, thus completely eliminating the previous reinforcing components.

- Improved raw material utilization and reduction of scrap. By selective using higher strength, heavier gauge materials to the specific areas where they are required, the reduction in material could be realized. By nesting various blanks during the blanking process, engineered scrap can also be obviously reduced. For example, the complex body side ring is changed from a traditional one piece blank to a tailor welded blank using 5 separated blanks. As a result, the manufacturer could reduce the engineered scrap content. Fig.4 shows the diagram of side ring using tailor welded blank composing with 5 separated blanks.

- Improvement on the functional performance. By using tailor welded blanks, the structural rigidity can be improved due to possibility for optimum selection of strength by using appropriate steel strength or gauge. Corrosion resistance can also be improved. And more importantly, the property of anti-crash can be improved greatly thanks to the reasonable combinations of lower strength/gauge and higher strength/gauge. Stampings using tailor welded blank also exhibit superior dimensional and shape accuracy compared to the traditional spot welded blanks. As a result, better fit and finish within the car are realized. This will bring about less compartment noise and fewer overall assembly defects.

- Potential to produce wide width automobiles. Automobile industry shows great concern on the wide width steel sheets while the width of steel sheets is constrained by the roller machine. Tailor welded blanks can solve this problem. Especially at present situation, supply of the steel with wide width can not meet the large demand of the market. Tailor welded blanks provide this solution.

1.4 Production methods

Tailor welded blanks consist of two or more steel sheets of varying properties which are tailored into patterns that enable the required properties to be located precisely where they are needed within the final part. Because the production of tailor welded blanks relies on the fusion process, most traditional welding methods can be used to produce tailor welded blanks. Each welding method has certain characters that will generate different results such as finished blank appearance, formability, welding speed, flexibility and capital input, etc. But most common methods to produce tailor welded blanks at present situation are mesh welding and laser welding. Fig.5 shows this two welding methods.
Tailor welded blanks are made by seam welding square butt joints using high powered welding processes. Welds produced with lasers are preferred in many instances over other methods due to its appearance quality and internal quality. In addition, the economical advantage using laser welding is apparent because sound welded joints are being produced at rapid, competitive welding speeds. Today lasers touch many aspects of our lives, even in the compact disc player we had in our daily life. The real evidence of success in the world using laser welded blanks indicates the choosing of laser welding as for the production methods of tailor welded blanks will be superior in nearly every application.

1.5 Properties of tailor welded blanks

Since tailor welded blanks have evident benefits compared with the traditional process, the car manufacturers have paid great attention to the properties of tailor welded blanks during stamping process. Research on the properties of tailor welded blanks has become the hot issue in the world. Tailor welded blanks exhibit the different properties compared with those of the base metal. Studies show that laser butt welds have higher hardness and higher strength values than the base metals. The weld develops higher hardness/strengths due to the microstructure and the stress generating during the rapid solidification of the small weld pool\textsuperscript{[2]}. The heat affected zone, in the majority of the welded joints, consists of fine, equal axial grains. Fig. 6 shows the microstructure of laser welded seam and heat affected zone. Fig. 7 shows the distribution of hardness for laser welded joints. There are a lot of evidences to conclude that good laser butt welds do not fail in the forming dies\textsuperscript{[3]}.
2 The application of tailor welded blanks

Within the automotive body-in-white structural parts, more and more typical parts such as rail, door inner, bumper, side ring, reinforcement had used the tailor welded blanks before stamping process. It is estimated that there are about 2 or 3 automotive parts using tailor welded blanks in the present car design. Especially for the expensive cars, more tailor welded blanks are used in their car design. By using tailor welded blanks, the overall anti-crash performance of the vehicle is improved. New applications for tailor welded blanks continue to increase because car designers and manufactures believe the using of tailor welded blanks in the automotive structural parts can simplify the manufacturing process, reduce the cost of production and improve the overall quality of the vehicle.

3 The production of tailor welded blanks in China

Since the tailor welded blanks have so many benefits for the car manufacturer, a lot of new cars at present market use tailor welded blanks for their structural parts. The demands for the tailor welded blanks are rapidly increasing. In China, the steelmakers play an important role in the promotion of the application of tailor welded blanks. Baoshan Iron and Steel Corp. has established the joint venture in Shanghai with Arcelor Group to produce the tailor welded blanks. This joint venture is equipped with the advanced laser welding line to produce tailor welded blanks. In the near future, the supply of tailor welded blanks for automotive manufacturers in China can be provided domestically instead of imports from abroad.

4 Conclusions

Tailor welded blank is the new technology that appears in the automotive industry in recent years. By using tailor welded blanks in the body-in-white structural parts, car weight can be greatly reduced. Lower car weight means improved fuel economy which is important in today’s energy shortage situation. Moreover, materials in the stamping process can also be better utilized and scraps in the automotive workshop will be reduced.

Using tailor welded blanks in the automotive industry is the inevitable trend for the car manufacturers.

References
YAN Qi  Director  Researcher,  International  Welding  Engineer  (IWE), Engaged in Laser Materials Processing, Tel.:0086-21-56780880-2916
E-mail:yanqi@baosteel.com