METHODOLOGY FOR MECHANICAL JOINING OF SHEETS FOR DESIGNING THE HEMMED JOINTS

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Abstract

The automotive industry is characterized by rapid development, which is the largest effort devoted to maximum production optimization. The article deals with problematics of hemmed joints in the automotive industry when main objective is to reduce production price while maintaining sufficient quality products. During joining two or more sheets of metal plates together is the greatest challenge to ensure dimensional stability of sheet metal parts, which can move against each other. This negative effect can occur during other stages of production, especially during installation, when parts may not be correctly aligned. In the article you can find new innovative solution that should meet these requirements.

Keywords: Hemming, mechanical lock, automotive industry, dimensional stability

1. INTRODUCTION

Car body is made up of many different parts, one of the biggest problem in the development of the car body is during joining of two or more sheet metal parts together. During joining two or more sheets of metal plates together is the greatest challenge to ensure dimensional stability of sheet metal parts, which can move against each other. This negative effect can occur during other stages of production, especially during installation, when parts may not be correctly aligned. Due to the problems above, the methods of fixation of hemmed joints are used. The conventional methods of fixation of hemmed joints and especially the most common used methods as “Gelation” (=partial curing of the adhesive in hem joint), the fixation of hemmed joint by resistance welding and Sperrbuckel method, have many advantages and disadvantages. The main disadvantages for most of these methods is financial demand and long times of manufacturing process. The financial demand due to the high energy consumption which is needed for these methods and also because of the required high investments costs for the technological equipment. Another big disadvantage is time required for the production process when a problem arises with the realization of mass production when the time of production is being extended. This article shows up new solution for fixation of hemmed joints. [1, 3, 5]

2. FIXATION OF HEMMED JOINTS

Fixation of hemmed joints helps to stabilize the relative positions of the inner metal plate and outer metal plate during the manufacturing process until the parts go through the paint shop, where the main stabilizing function takes cured adhesive in hem after cataphoretic painting. Fixation method further serve to maintain desired dimensions of final part during the hardening of the adhesive, which may temporarily cause different stresses due to heat on the hemmed joint. In **Figure 1** is a representation of the possible movement of the inner sheet metal part against the outer part. The fixation is used to prevent such movement. [1, 4]

Various methods are used for fixation of hems of sheet metal car body parts, such as side doors, front bonnet, and trunk lid car. Each of the different method has its specific advantages and disadvantages, there are also differences in the applicability of the various methods, depending on the size, complexity and quality of the particular component. Because of all these mentioned reasons, it can´t be determined only one suitable method as universal one. [1, 2, 3]

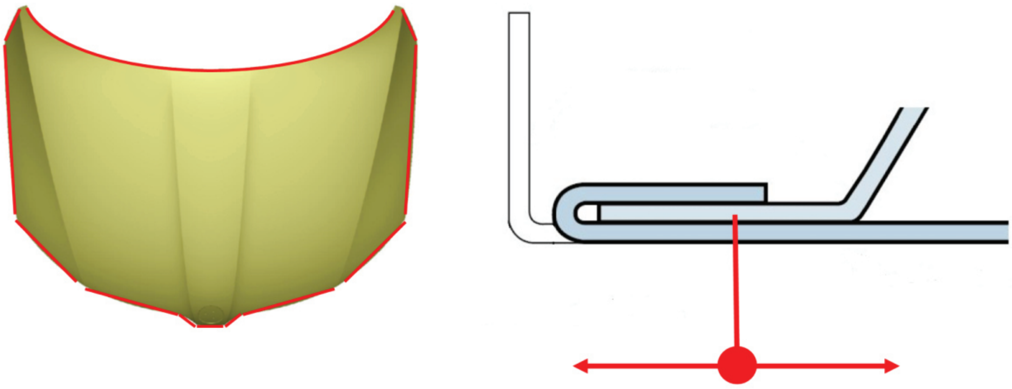


Figure 1 Possible movement of the inner sheet metal part against the outer part

3. DESIGN OF NEW SOLUTION - GROOVE FIXATION OF HEMMED JOINT

New solution envisages to prevent movement of the inner metal sheet against the outer metal sheet in both directions on the basis of a mechanical lock (**Figure 2)**. By using a special puncher and die, there are formed small grooves around the whole circumference of the component on the inner metal plate. On the hem of outer panel part, there are formed special small protrusions. These protrusions with combination of grooves are making the mechanical lock after hemming process with using a plastic deformation when the projection copies the shape of one of these grooves.

This solution creates a strong hemmed joint with mechanical lock, which leads to fix the position of joined metal sheets during production process. The car body part which is used for experiment is a front hood, where is used 18 fixing elements to ensure the stability of joined parts (**Figure 2**).

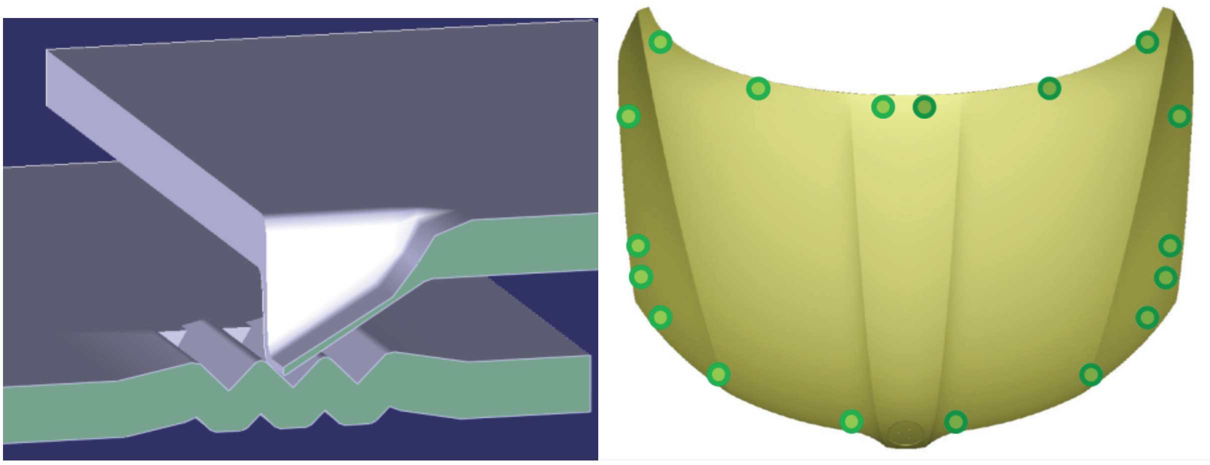


Figure 2 The principle of a mechanical lock and positions of individual fixation elements

3.1. The structural design of tools for grooves

The tool design envisages the creation of the grooving profile proposed for fixation of hemmed joints. The desired grooving profile consists of three main grooves. Due to the design of the tool it is possible to set different height of the flat surfaces of the punch and die, then the real outcome allows to produce different height of grooves.

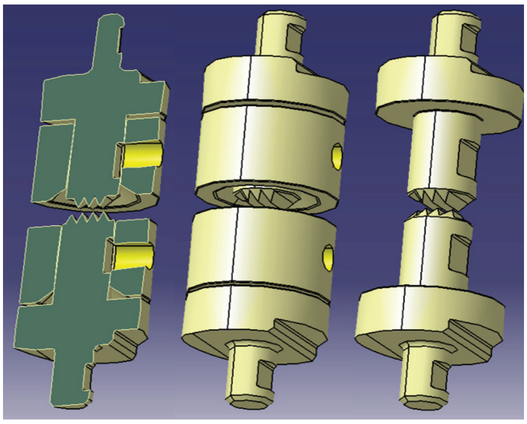


Figure 3 Tool for grooves

3.2. The structural design of tools for protrusions

Design of the punch with the die had been created to protrusions production on the outer metal sheet. In this design is implemented an integrated blank holder. The blank holder has a function to stabilize the metal sheet in correct position for protrusions. Without the use of blank holder, the production of the protrusions is not possible. Due to geometry of the punch, it would push out the metal sheet plate out of the die, and thus would prevent the creation of desired geometry.

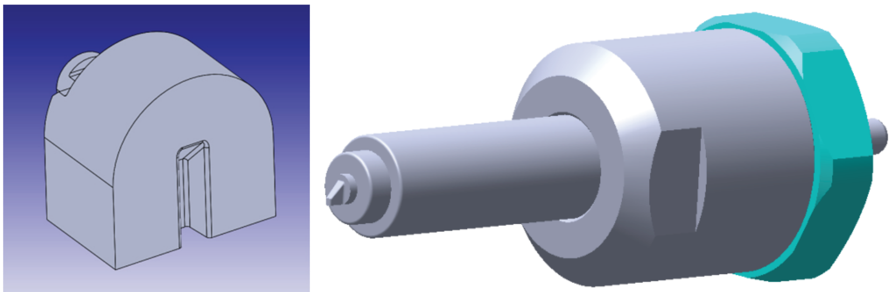


Figure 4 Tool for protrusions

3.3. Realization of the new solution

Verifying the functionality of both tools has been carried out on flat samples of material HX180BD. For the functional verification of tools have been used pneumatic plier.

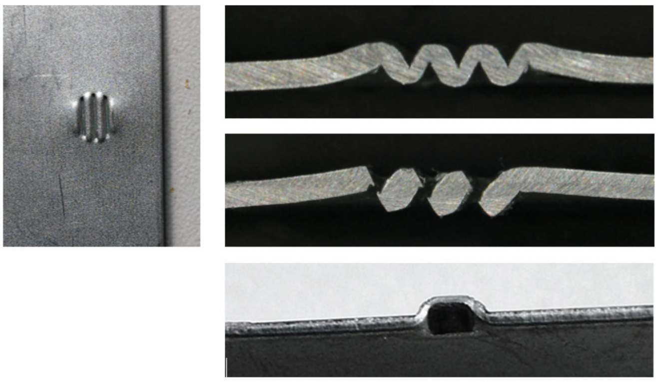
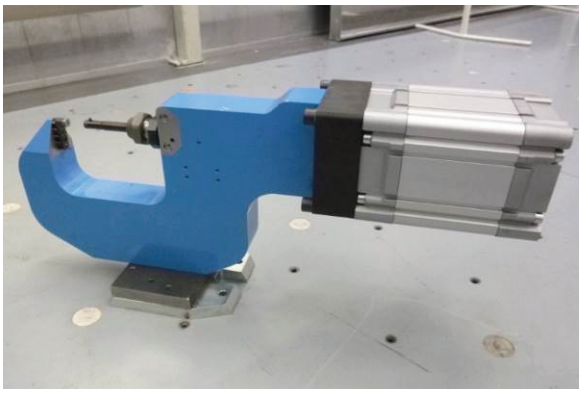


Figure 5 Experimental samples for evaluation of tools functionality

Shown below (**Figure 5**) are the pictures of experimental sample with real grooving and metallographic samples with changing groove profile. The figures show how the change of the height adjustment of bearing surfaces punch and die can affect the grooving profile. By suitable setting of the punch we can achieve the desired result, the best solution is shown in the first image.

Pneumatic pliers are used to realization of the stamping of the proposed fixation elements. The pneumatic pliers allow easy and fast tool changing. It can be operated manually or it can also be implemented into an automated process. Manual operation requires no special training, the manual operation is very simple.

With the help of a robot and special tools for holding metal sheet parts is realized the manipulation of individual parts into correct positions for making grooves and protrusions with pneumatic pliers. To choose a correct position of pneumatic pliers towards into position and operation area of robotic hand is necessary to use simulations. Thanks to the simulation is possible to find correct position to achieve all positions of defined fixation elements.



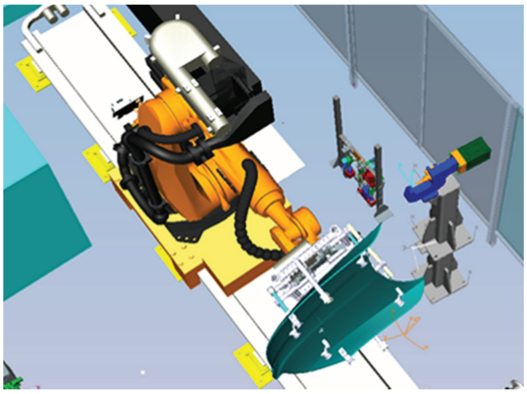


Figure 6 The pneumatic pliers (left) and Simulation of production process (right)

The stage of hemming and finishing of panel part in conventional hemming machine comes after creating functional elements fixation comes. After hemming and subsequent visual inspection, the panel part is moved to rigorous control by using a coordinate measuring machine. This check is repeated again after cataphoretic painting and the results are compared with previous values of measurement to determine stability of the hemmed joint.

4. ANALYSIS OF THE EXPERIMENT

Several pieces of front hoods were produced, where it is necessary to monitor compliance with several important criteria for the correct functioning of the proposed solution.

It is necessary to verify if there is a correct assembly of the parts together. That is, if all the protrusions on the outer sheet correctly fit into the grooves on the inner sheet. In the event that an item does not fit, it is necessary to make corrections of robot trajectories at those elements that were assessed as erroneous fixation points. In the **Figure 7** below you can see one of the correct fixation elements in correct position.

Figure 7 The hemmed joint with mechanical lock by grooving

Another criteria is monitoring of outer surface for the audit safety. Evaluation of the surface must be free of defects, e.g. bruising, scratches, scratches, etc. In this case it is necessary to focus on the positions of the fixation elements to evaluate the condition of surface. Exerting pressure during hemming must not damage the surface of the outer sheet. The grooves on the inner sheet must not be reflected in the surface of outer sheet. If the grooves would have affected the surface quality, it can invalidate the entire part. The optimal shape of the grooves on all the front hoods does not affect the reference surface at any of the tested parts. On the basis of repeated evaluation, it is possible to say that in terms of safety to the audit of grooving method of fixation that this method does not affect the surface portion of the front hood and proposed solution will be considered as optimal.

The last and also the most important criterion is the overall dimensional stability of the parts which are joined together. After the above mentioned control operations, it is necessary to perform dimensional evaluation of the part just after hemming process and subsequent repeat the evaluation after baking of paint. For control is used the precise coordinate measuring machine. During the control there are checked individual reference points along the perimeter of the hood and on the basis of comparison and results of the measurements of the part before and after the cataphoretic process is evaluated the stability of the part.

5. CONCLUSION

Based on the analysis of the experiment, it is possible to say that the hypothesis of a new method for fixation of hemmed joint has been confirmed. The proposed method of fixation has good dimensional stability of the joint. It is appropriate to optimize this solution and thus achieve shorter production time for the production of one complete panel part. Currently tested parts are made with 18 fixation points. If it would be determined that the entire panel part is stable even with a reduced number of fixation points, it will be possible to shorten the overall production time and in that context, considerable savings overall production costs.

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