CLINCHING AS AN INNOVATIVE METHOD OF STEEL SHEETS JOINING AND A TOOL OF INCREASING THE COMPETITIVENESS OF COMPANIES IN AUTOMOTIVE INDUSTRY

CLINCHING AKO INOVATÍVNA METÓDA SPÁJANIA PLECHOV A NÁSTROJ K ZVÝŠENIU KONKURENCIESCHOPNOSTI PODNIKOV V AUTOMOBILOVOM PRIEMYSLE

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Abstract
Clinching is a high speed method for joining thin steel sheets, which is based on local plastic deformation of joined sheets. The process uses special punch and a die as an active elements in joining process to form a mechanical interlock between sheets to be joined. Forming of a joint lasts only a few seconds so this method is more efficient than commonly used resistance spot welding. This paper describes clinching joining method in overview and compares clinching with resistance spot welding – mainly used method for joining steel sheets in automotive production.

Key words
Joining, Automotive industry, Clinching, Forming, Competitiveness, Manufacturing costs.

Introduction

Companies in automotive industry as long as companies in other industrial spheres are characteristic of decreasing the final price of their products – cars, in purpose to increase the number of customers and finally, maximize their profits. If companies in automotive industry want to acquire the competing advantage from manufacturing costs point of view against other companies, they must continuously improve their technological processes to decrease the technological processes costs and finally, decrease the cost of final products – cars. In car body production is spent an effort to replace the resistance spot welding by clinching method, because clinching is more productive method, which also has lower operation costs than resistance spot welding.

Mechanical joining of materials by clinching method

Clinching can be defined as direct material joining by forming technology. Clinching joining method is based on local plastic deformation of joined materials in form of sheets which is caused by bilateral interaction of punch and die during the joining process and as a result, the characteristic joint is made by bilateral clinch of joined sheets. The clinching joining process is suitable for high volume production because forming of a joint lasts for only a few seconds, different kind of materials can be joined in various combinations without damaging the protective layer or coating and without heat affection of joined materials [2].

From load transfer mechanism between the joined materials point of view clinching joining method belongs to mechanical joining of materials group and non-demounting joints group. Detailed classification from load transfer mechanism point of view can classify clinching into point-form of joints group, because during loading of the joint the load is concentrating into individual points and there is local concentration of the stress. The clinching joining method classification gives the German standard – DIN 8593 [3] :

a) according to the kinematics of the tool parts :
   - single step clinching
   - multi step clinching

b) according to the joint element form
   - clinching with local incision
   - clinching without local incision

In the Fig. 1 are schematically shown in intersection the joints characteristic for mechanical joining by clinching method. On the left is shown the joint made without using the local incision and on the right is joint made with using local incision.

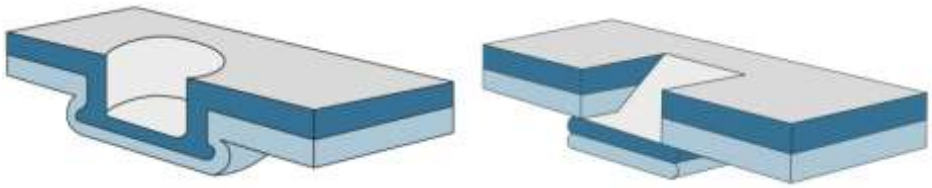

Fig. 1 Schematic illustration - intersection across the clinch joints

Single step clinching joining process or forming the joint with single stroke of the punch is shown in the Fig. 2 and 3. The whole process of joint forming is divided into four steps [4] :

1. Step : the punch and holder are moving downwards and the materials to be joined are clamped and fixed by holding force of the holder.
2. Step : By the action of the punch the materials flow into the die cavity forming a cylindrical cup from joined materials. It is important to adjust process parameters and also the dimensions of punch and die carefully in relationship with the thickness and mechanical properties of joined materials.
3. Step : by further action of the punch the thickness of the joined materials in the cylindrical cup´s bottom is reduced and the material is forced to flow in lateral direction forming a clinch between the joined materials that is needed to proper function of the joint.
4. Step : after reaching the maximum joining force (force control of the process) or maximum stroke of the punch (stroke of the punch control of the process) the punch and holder move backwards.

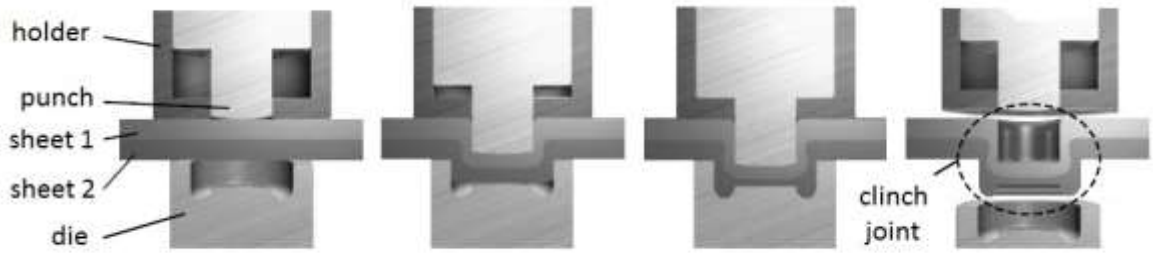

Fig. 2 Single step clinching joining process

Fig. 3 Single step clinching process – the deformation of joined materials [1]

Clinch joint geometry :

The ideal geometry of clinch joint and its characteristic zones are shown in Fig. 4. This type of joint has fully filled the volume of the die by joined sheets in the joining process, no bending, counter-piping of the sheets or excessive stretching of the upper sheet in the neck zone, both of the joined sheets are completely connected. The joint height varies from 0.4 mm to 8 mm. By clinching joining method are joined sheets that have thickness from 0.4 mm to 4 mm, whereby thickness of the joined sheets doesn´t need to be equal. The force needed to forming a joint depends on material of joined sheets, their mechanical properties and punch and die´s dimensions. The joining force can vary from 10 kN to 100 kN value.

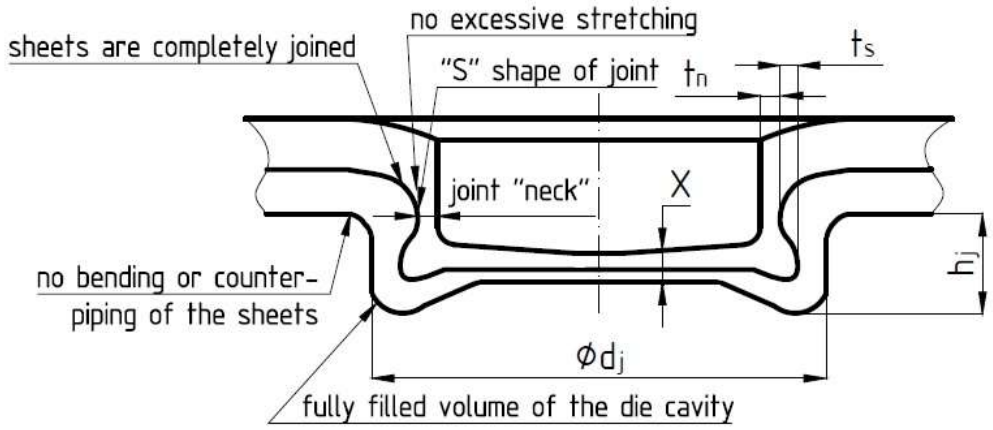

Fig. 4 The ideal properties and characteristic zones of clinch joint [5]

The fundamental dimensions of clinch joint are : t_n – neck thickness, t_s – thickness of clinch, d_j – joint diameter, h_j – joint height, X – bottom thickness of the joint. The X parameter is a parameter for non-destructive evaluation of joint´s quality, because this parameter is easy to measure directly, which doesn´t apply to parameters t_n and t_s but they play an important role in case of loading the joint.

Mechanical properties of clinch joints

Tensile strength of clinch joint is the largest disadvantage of joining by clinching in comparison with resistance spot weld. In general, clinch joints have tensile strength values one third or one half of the spot weld´s tensile strength, but joint made with twin point clinching can acquire the equal tensile strength to a spot weld. Load-displacement curves from static tensile strength test of clinch joint and spot weld are shown in Fig. 5a whereby tested material belongs into category of ultra high strength steels. It is clear from Fig. 5a, that tensile strength of clinch joint has 35% value from the overall tensile strength of spot weld.
In the case of dynamic loading by shearing both of the clinch joint and spot weld is fatigue strength higher in the clinch joint. Fig. 5b shows fatigue curves for both clinched and welded joints. With the increasing number of cycles the amplitude of stress is decreasing. In the case of clinch joints the stress amplitude at number of cycles 10^7 has value 2 kN – two and a half fold value in comparison with spot weld. Joints made with clinching joining method have superior fatigue strength.

Tensile strength of clinch joints may be increased by hybrid joining method (clinch bonding), when adhesive is being added between joined sheets during the joining process. Another approach is to add a special rivet (clinch-riveting, self-pierce riveting) into joint that rapidly increases the joint´s strength in its critical area, but adding a rivet increases the manufacturing cost of the joint and simplicity of method is unpreserved.

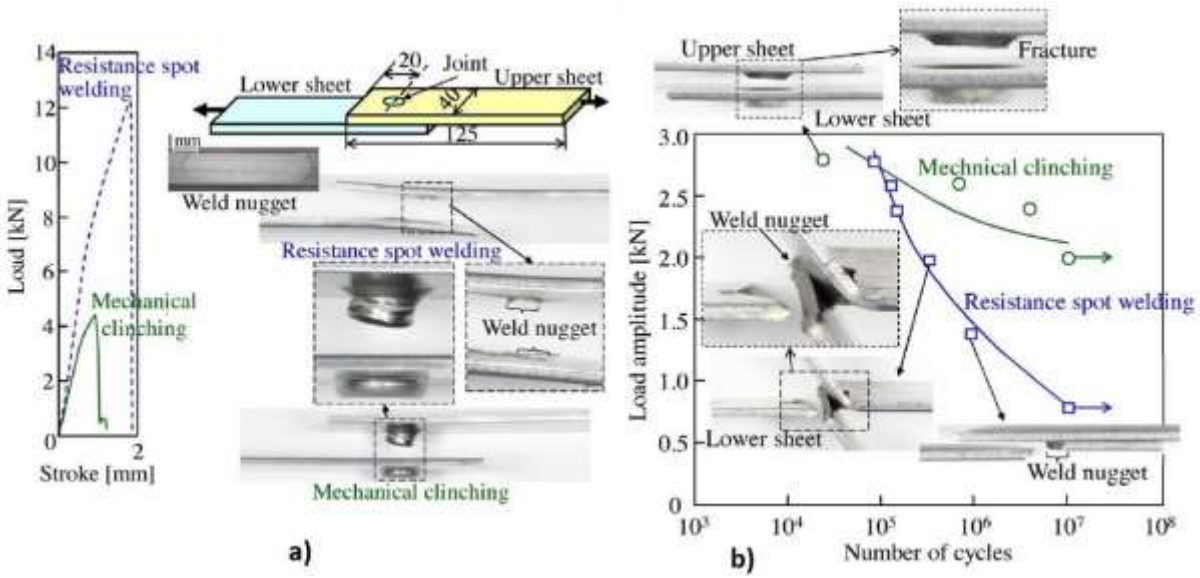

Fig. 5 Load-displacement and fatigue curves of clinch joint and spot weld [6]

Economic efficiency of clinching joining method

The most important advantage of the clinching joining method against the resistance spot welding is manufacturing and investment costs saving. The main economic advantages of the clinching joining method in relationship to investment costs :

- no ventilation equipment is needed (doesn´t apply to spot welding – vapors are produced during the welding process)
- no cooling fluid and difficult installation of cooling device are needed
- no electrical devices are needed (such as welding transducer)

Fig. 6 shows a comparison of investment and operating costs between clinching method and spot welding when manufacturing one joint by industrial robot with regard to the properties of joined material. It is clear from Fig. 6 that joining by clinching has lower investment and operating costs in comparison with the spot welding. The most important advantage of clinching is very low manufacturing costs of joints. No joining elements are needed (such as bolts, nuts, pins, grooves etc.) and because of that the joining elements costs are eliminated. The maintenance costs are also minimal, because the tool set is capable to produce 250 000 joints without (in relation to joined material properties) any maintenance. The most important advantages of clinching joining method in relation to manufacturing costs are :

- no joining elements are needed (such as rivets, bolts, grooves etc.)
- low electricity consumption by clinching joining machine during joining process
- no electricity consumption when clinching joining machine doesn´t work
- low costs for tool set change because of long lifetime of tool set
- no costs for additional post-working of joints (such as the repair of damaged zinc layer)

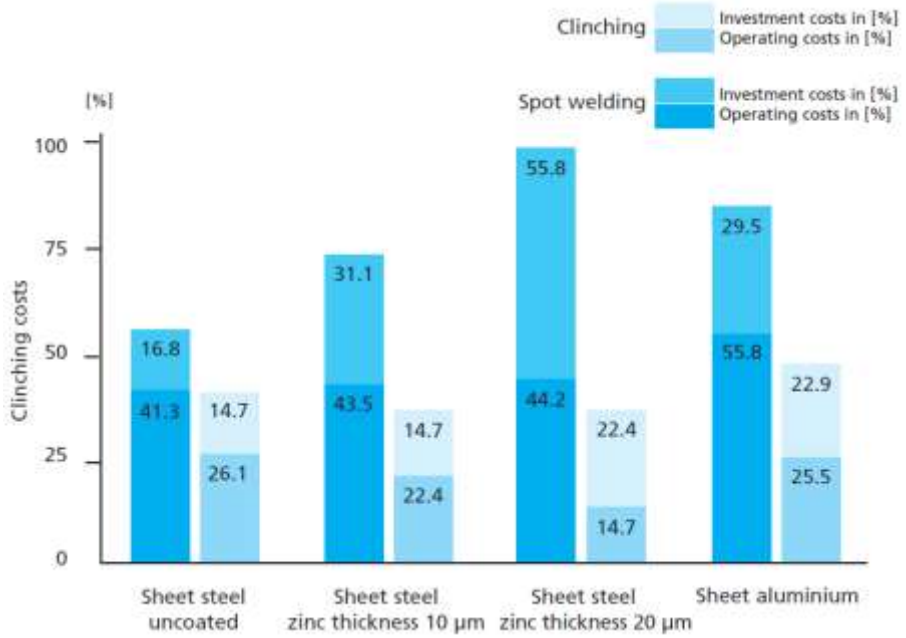

Fig. 6 Clinching and spot welding costs comparison [7]

The next important advantage of clinching is very short period of time for producing a one joint. The joining process lasts approximately 0.5 s depending upon the punch stroke and joining machine construction. In the case of high degree of automation it is possible to produce a large amount of joints – it is possible to achieve high productivity at low costs.

Clinching joining method application in automotive production

Clinching is mainly used as an alternative to resistance spot welding in automotive industry whereby joints are used in the region of automobile´s doors, front hood or splash-boards. Automobile producers such as Mercedes Benz, Audi, Volvo, Porsche, BMW and others use the mechanical joining of materials by clinching method in car body production. Fig. 7 shows the application of clinching method in car body production.

Fig. 7 Clinching joining method application in car body production

Besides the automotive industry is clinching used for example in electrical engineering industry for manufacturing steel sheet constructions – Fig. 8.

Fig. 8 Clinching joining method application in electrical engineering industry

Conclusion

The implementation of innovative technological processes is a way how to reduce the final products price and preserve the competitiveness of companies in given industrial sphere. Companies in automotive industry are not exception. In this paper, the mechanical joining method – clinching was presented as well as its advantages according to technical and economical point of view. Because of these advantages, automotive industry nowadays spends an effort to replace the resistance spot welding by clinching joining method.

Key words

Joining, Automotive industry, Clinching, Forming, Competitiveness, Costs.

Acknowledgments
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