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About Resistance Performances of Round Clinch Processed by the Joining Sheet Metal in One-Piece-Die

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ABSTRACT

The paper presents the clinching joint and some experimental determinations of the resistance performances of round clinch processed in one-piece-die.

The experimental research was made on different tickness steel fastened sheets and the clinching point in transversal and axial direction with shear tensile test pieces and peel tensile streght pieces was mechanically tested.

The paper is also concerned with experimental determinations and the performances of joint after the repression operation.

It was obtained same results with practice utility concerning press joining steel and resistance of joint clinched depending on sheet thickness and diameter size.

KEYWORDS: clinching, joining sheet metal, cold forming.

1. Introduction

Cold forming sheet metal joining proceedings are utilised accordingly with the form and size jointed pieces, physical and mechanical joint features, automation possibility, joining expenses and so on.

Between these joining systems used in mechanical structures obtaining, with a large utilization is spot welding, because the automation possibilities and as a result, a high productivity in joints processing and a low processing cost.

Because the decrease weight trend in automotive industry, in the last period is developing an alternative assembly technique that is competitive with spot welding.

Thus it was improved a new cold forming joining method that looks like clamping fastening process, but the joint is making by simultaneous deformation fastening of two pieces material, named clinching joining.

The main application of the clinching joining is not only in automotive industry, but also diverse structures of apparatus for heating, air conditioning, ventilation, sheet-metalworking industry, diverse metallic structures and so on.

The joining technique by clinching can be used to steel and stainless steel materials as well as aluminium and non-ferrous materials in a low cost effective, environmentally friendly process being an alternative at spot welding.

The joining method, at a glance, presents the following advantages: joints can be checked without damages, no consumable items, low energy use, no thermal load on joining zone, no damage to surface finishes on workpiece, interim layers of film or adhesive can be incorporated in most cases, no pre or post treatment required, very good joint reproducibility, environmentally friendly workplace, no fumes or noise. Also, provides minimum maintenance costs, permit joining pieces processed from difficult joining materials by spot welding [1, 2].

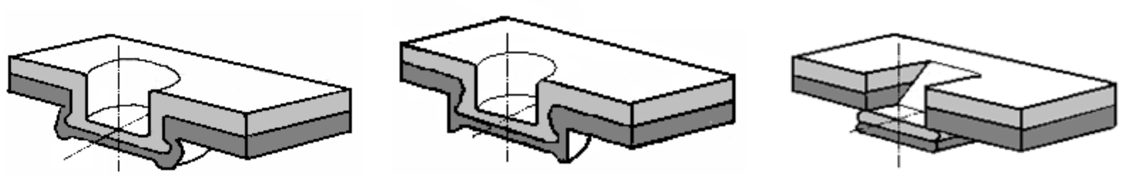
The joining quality is influenced by a complex factors determined by joining equipment, joining element parts, joining tools and joining process.

The joining system can be incorporated into existing press systems or custom built machines. It can be integrated within manual machines and into robotic equipment systems.

Clinching is fairly new technology, used mainly for high-volume. It used for joining metal sheet of 0,5 *mm* to about 3 *mm* thickness, up to total joint thickness of about 6 *mm*. As the joint is made by plastic deformation of the sheets, the materials should have sufficient ductility to avoid cracking. The greatest sheet thickness over this value determines the growth of deformation forces [1, 2].

The joining tools are function by joining type.

The joining process can be with or without incision, with round or rectangular joint (fig. 1). The round joining is for sealed joints with no surface cutting and rectangular joining incorporating surface cutting, particularly for very hard materials or stainless steel.



a). b). c).

Fig. 1. *Forms of joint clinch with or without incision*
a- round joint without incision processed in one-piece-die;
b- round joint without incision processed in segmented die body;
c-rectangular joint with incision

More utilized joint elements are these with round form, without incision and rectangular form with incision [3].

Clinching with round joint has the advantage of forming a leak-proof mechanical interlock that possesses better fatigue strength as compared to spot welded joints. The process can be automated and has low cycle times with extended tool life, in excess of 200.000 joints. Clinching can be monitored in real time for quality control and does not produce a heat affect zone [3, 4].

The advantages of the segmented die body process compared to the one-piece die process have decisive over one-piece dies. Thus, very high head stress values due to better back-flow of the material are possible because the dies open during the clinch process enabling the material to flow sideways. and more flexibility when clinching materials of different sheet thickness with one tool set.

Clinching joint process at the segment die body produces a flat closing head ($H_1<H_2$, fig.3 and fig.4). No material build up (especially with galvanised or coated surfaces) caused by high radial force within the die. The die cannot burst due to reduction of die volume. This means the dies can have a longer service life, no stripper on the die side to remove the material from the die, which can cause problems, particularly in automated systems, and the materials cannot stick to the die thus allowing a slimmer tool design on the side, thus providing better access to the workpiece [5, 6]. Also, a clinching two thickness sheet metal, with the same clinching parameters, the joint resistance is elder when the clinch is processed in segmented die body comparatively with the processing in one-piece-die [3].

The primary disadvantage of clinching is that the static strength of the joint is only one-half to three-quarters of that provided an equal size spot welding. The basic mechanism of this joining process has not been well studied and there exists a scarcity in experience and knowledge.

2. Experimental Determinations of the Round Joint Clinching Processed in a One-Piece Die

The speciality literature presented few information about joining sheet metal projection and particularly to the joint design correspondingly with joining resistance.

It was projected and realised a clinching equipment with one-piece-die process with changeable tools what permits clinched joints processed with different joints diameters, different sheet metal thickness and different work parameters (fig. 3).

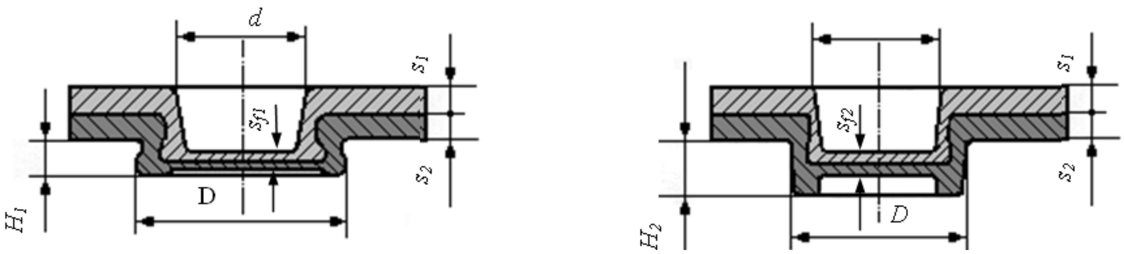
On the equipment with 5 *mm* and 8 *mm* diameter size punch and was joined clinching samples of carbon steel sheet metal drawing (*FeP 03 Am*) with strength 320 *MPa*, and 0,5, 0,75, 1, 1,25, 1,5 *mm* thickness. The clinching mould was assembled on a PAI 25 pressing machine and the forces were measured by a mechanical translator with strain gauges, a digital strain meter and an oscilloscope with memory (fig. 4).

The samples test was processed to test joint clinched at shear and peal stress. The shear test piece is represented on figure 6 and peel tensile strength piece on figure 7. The tests were made on a test sheet metal machine in Cold Forming Laboratory of the Mechanical, Mechatronical and Management Engineering Faculty of Suceava University (fig5).

From experiments effectuated and by procesing datums it was obtained same results what graphical represented on figure 8 and 9.

The force values what was represented on graphics, was the most values of damage forces joints clinched for different thickness of punch-side sheet as well as different thinness of joint depth.

In a joint between materials of different thickness the joining of "thick into thin" produced the stronger joint than "thin into thick" (from the punch side). On graphics this values was presented.



a). b).

Fig. 2. *Geometry of round clinch*
a- geometry of round clinch processed in segmented die body
b- geometry of round clinch processed in one-piece-die

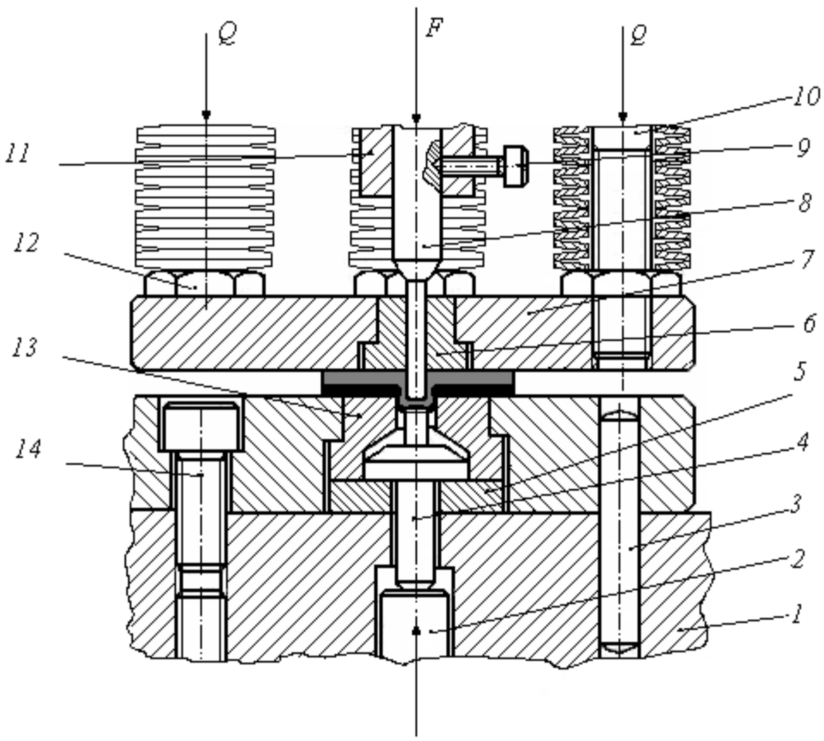


Fig. 3. *Work zone of clinching mould*
1- base plate; 2- extractor; 3- cylindrical peg; 4- counter punch; 5- pressure plate; 6- guiding piece; 7- detachment plate; 8- cylindrical punch; 9- fastening screw; 10- tie bar; 11- disc spring; 12- sleeve; 13- screw nut; 14.- one piece die; 15- fastening screw

Fig. 4. *Clinching process stand view*

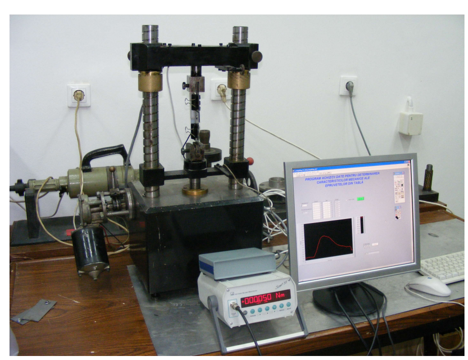


Fig. 5. *Resistance of clinch joint determination stand*

An optimum clinch must fulfil two seemingly opposing criteria. To achieve the ideal static tensile strength the measurement c_1 must be as great as possible. However, the so-called "throat" c_1 (fig.10) should be as large as possible to achieve the optimum dynamic and shearing tensile strength. The choice of targeted parameters determined by the operating conditions can provide the joint with the maximum possible strength. A good compromise for most application is represented by the following formula:

$$c_1=c_2=1/2 \text{ thickness of punch-side sheet} \quad (1)$$

The radial extrusion pressure sheet material calculated in depth zone what determined to achieve of the relation (1) was included in the interval 1000-1200 *MPa*.

The relative thinness values of joint depth (s_f/s_1+s_2, fig. 4) with maximum strength were included in the interval 0,4-0,5, while unilateral interstice *j* between punch and die are definite by the relations:

$$j=(D-d)/2 \quad (2)$$

in which s_f, s_1, s_2,, *D* and *d* have the significance from fig. 4.

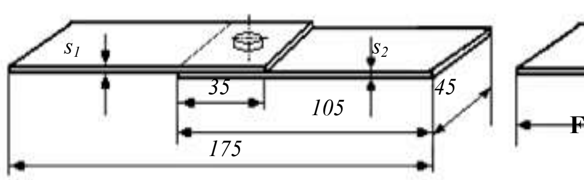


Fig. 6. *Shear tensile test piece*

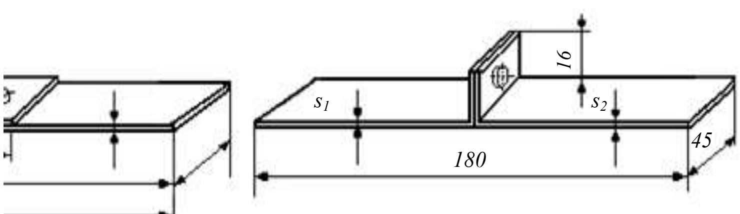


Fig. 7. *Peel tensile strength piece*

The graphics analysis mentioned praises that static of the peel joint tensile strength test is only-half of that provided by shear tensile strength test

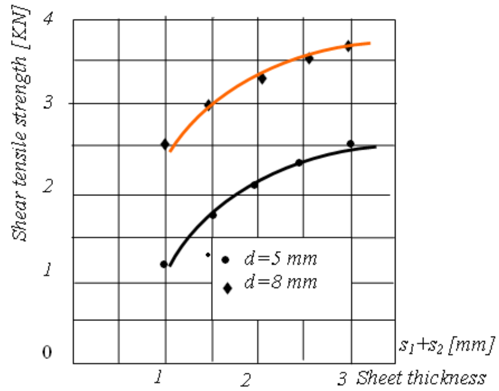


Fig. 8. *Sheet thickness and joint clinch diameter size influence upon shear tensile strength*

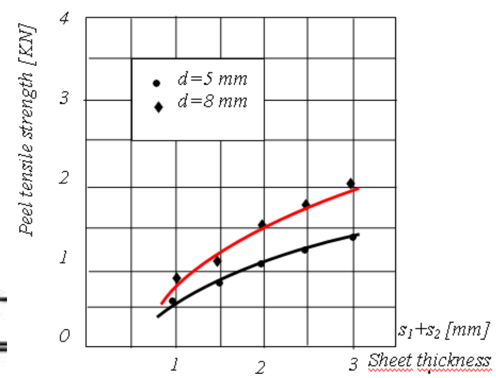


Fig. 9. *Sheet thickness and joint clinch diameter size influence upon peel tensile*

Also, the joint with 8 *mm* diameter size is stronger than a 5 *mm* size diameter at similar thickness and the same material combinations.

To obtain a better resistance of joining sheet metal and a pleasant aspect, the joint clinched was repression with diverse deformation degrees, *E*. The detail of deformation zone and the joined pieces are presented in fig. 11 and fig. 12.

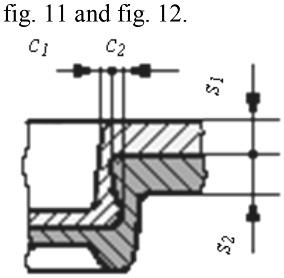


Fig. 10. *Joint clinched detail*

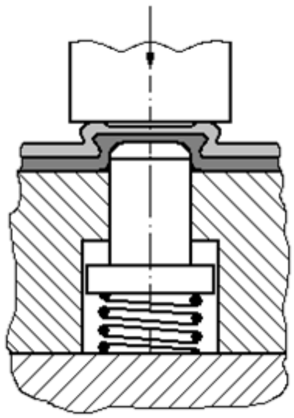


Fig. 11. *Repressing joint clinch*

It was established that the joint clinched resistance increase about 25% for deformation degrees to 15-20%, then the joint clinched resistance rests constant, and decrease after 40% deformation degrees.

The resistance of joining sheet metal varying with the thickness $s_1=s_2=1$ *mm* and deformation degrees is presented in fig. 10

From point of view of the joint clinched resistance, a deformation degree repression is not justified by a rate higher that 20%. On the other hand, with the deformation degree increase, decreases the joint clinch higher and becomes more aesthetically, being thus noticed in fig 8*, b* and *c*.

The resistance of the joint sheet metal varying with the workpieces thickness s_1+s_2 are presented in fig. 12. Being thus noticed in figure that the resistance of joining sheet metal increase varying with the increasing of thickness of joining pieces. At the same time in figure it observe a increasing of the shear resistance force with about 25% at a repressing wit 40% deformation degree.

For the samples peel tensile strength, by repressing increases the resistance about 10%, because is not a breaking of inside part of joint clinch, but take notice a peel of joint clinch.

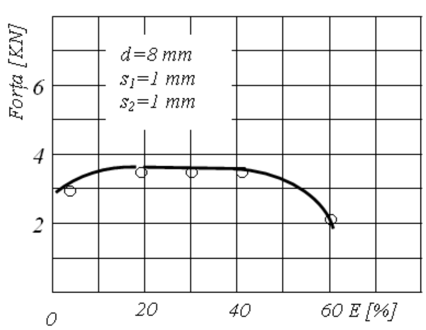


Fig. 12. *Shear tensile strength of joint function by deformation*

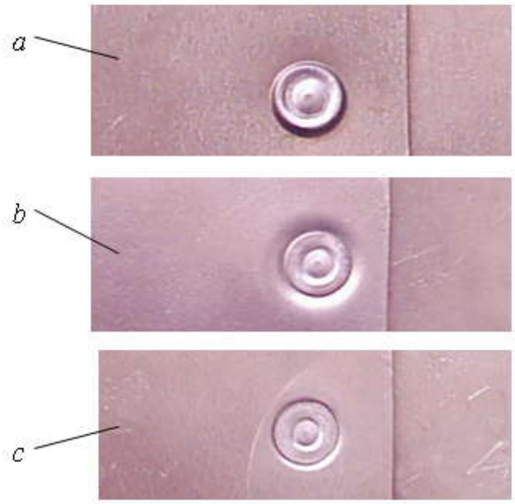


Fig. 13. *Joint clinch*
a-unrepressing; b-repressing E=20%; c-repressing E=40%

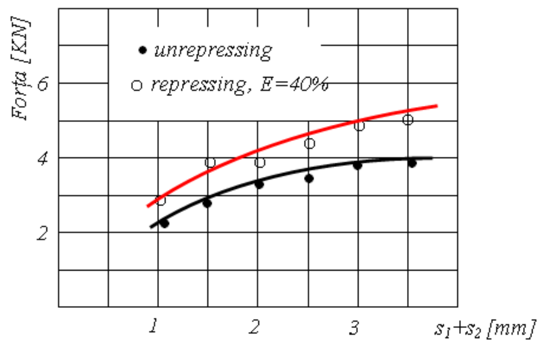


Fig. 14. *Sheet thickness influence upon shear tensile strength, d=8 mm.*

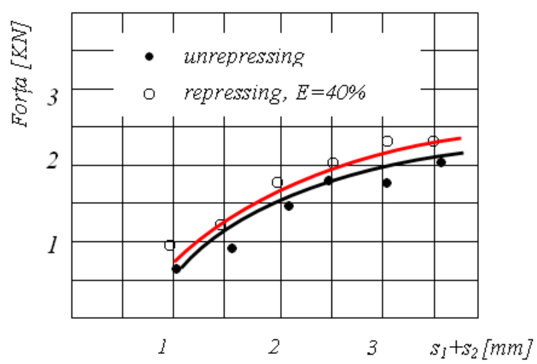


Fig. 14. *Sheet thickness influence upon peel tensile d=8 mm.*

For all that, after 40% deformation degrees carrying capacity of joint clinch decreases. This decreasing is because of joint clinch deformation what diminish the clinch between the joining pieces, and finally decrease the resistance of joint clinch sheet metal.

3. Conclusions

The cold forming joining sheet metal by clinching is a modern method, without consumable materials, fast and easy automation, long tool life, health and safety implication are small, because generates little noise, no fume, no heat, what can be realised in more variants, with low costs than joining by spot welding.

Clinching sheet metal method can be a performance joining if it fulfils a technological conditions series. Among these we find again: relative thickness of punch-side sheet, relative thinness depth joint values, radial pressure extrusion of the depth joint, the deformation sense,(thick into thin). The joining pressure may provide a specific joint clinched geometry.

The static of the peel joint tensile strength test is only-half of that provided by shear tensile strength test.

To obtain a better resistance of joining sheet metal and a pleasant aspect, the joint clinched was repression with diverse deformation degrees. Experimental determinations show that the resistance of joining sheet metal varying with the thickness and deformation degrees.

In order to make an accurate prediction of strength of the joint clinch in any application it is need to carry out tests on the original sheet metals.

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