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LIFE ESTIMATION OF HSS HOLE PUNCH TOOL IN A FINE BLANKING OPERATION

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ABSTRACT
Blanking or piercing 0is one of the most commonly used sheet metal manufacturing processes in the industry. Having a good understanding of the fundamentals and science behind this high deformation shearing process can help to improve the tool life. The HSS Punch tool is used to punch the 12mm thickness of sheet metal (suspension arm) to make a fine blanking component. The punch tool is shear the 12mm thickness of sheet metal the effect of bur formation, Punch-die clearance, tool tip geometry causes tool get failure. The interaction between punch, stripper plate and sheet metal of 12mm thickness is first studied experimentally by using different geometry of Punch tools, since a fundamental understanding of the behaviour of the components at different loads at high speeds. By the experimental results select the best performed tool and that punch tool material is analysed by conducting material testing by reference of its specification they are chemical analysis, hardness test, thermal and micro testing. The stress distribution is determined by using Ansys simulation for both punch tool and the sheet material (12mm thickness suspension arm). The life estimation of HSS flat punch tool is calculated theoretically and compares it with the ansys simulation results and determines the safety factor of the tool.

Keywords: Life estimation, stress analysis, workbench, blanking

I. INTRODUCTION
The heat exchanger is a device in which the efficient heat transfer from one fluid to another takes place. In the Fine blanking Operation works on the principle of press technology and employs special press, precision tool and dies. Through this process, parts are obtained in almost completed form and ready for assembly. Apart from this, part are obtained with cleanled sheared surfaces over the material thickness. The sheared surface obtained by this operation is of good quality and high dimensional accuracy.In the fine-blanking operation, a precise die with punch and die clearance of approximately 0.5 % of material thickness is required along with a triple action press to clamp the material during the shearing operation. The 3 actions in the press provide:

1. Shearing pressure
2. counter pressure
3. V-ring pressure

These must be in constant through the stroke to ensure good quality parts. Its recommended that the press in fast approach stroke and a slow shearing speed of 4-15mm/s. Press capacities ranging b/t 40-1400 tons are now available for usage.In the blanking operation a series of phases in which the sheet metal undergoes deformation and separation Punch contact : The punch first touches the fixed sheet. At impact, a compressive stress Rapidly builds on the punch and passes the shock wave through it. Deformations: The punch force is applied on the sheet, first causing a elastic and then plastic deformation. Shearing and crack formation: The stresses increase, shearing occurs followed by fracture. Fracture begins from both the punch end and die end of the sheet. That shows complete fracture of the material takes place. BreakDown: If the sheet material has a high strength or is thick, a large force is required for the blanking operation. During shear and fracture phase, compressive forces are stored in the tool. When complete fracture occurs, there is an instant release of these compressive forces. These generate shock which can lead to breakage of the punch.

Stripping : The punch moves down to the bottom dead centre and ejects the part / slug. At the bottom dead centre, the punch motion is reversed. There is friction between stock and the surface of the punch, which causes the sheet to lift along with the punch.

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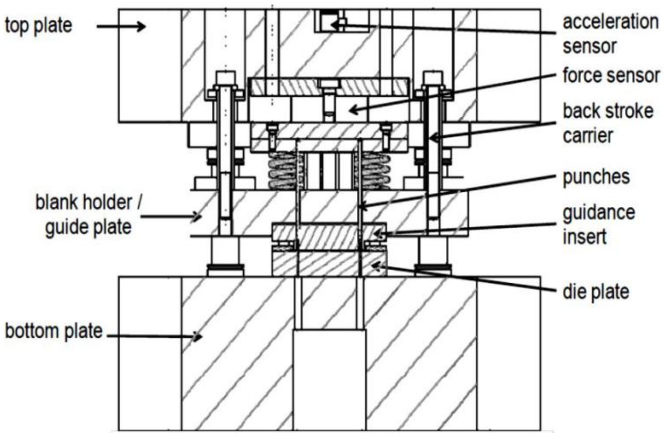

Fig 1; Tooling commonly used in high speed blanking

The Tool generally used in high speed blanking. A high speed blanking operation in the manufacturing of small electronic components consists of the following steps:

a. Ram moves downwards bringing the stripper plate to come in contact with the blank
b. Further downward motion of the ram enables the stripper springs to apply pressure on the stripper plate and in turn on the blank
c. Blanking operation occurs
d. Punch moves further down until BDC
e. Upward motion of the ram, punch rubs sheet in opposite direction
f. Punch is stripped off the sheet by the stripper plate
g. Stripper springs are released and stripper plate bounces off the sheet

II. METHODOLOGY AND MATERIALS

1. Understand the punch-sheet material and punch-stripper plate interaction in high speed Blanking.
2. The affect of blanked edge quality by experimenting the influence of various parameters like punch shape, Punch/die clearance, stripper pressure.
3. Select the best punch tool geometry to blank the 12mm thickness of the material.
4. Check the punch tool by chemical analysis, hardness testing, dimensional analysis, micro testing
5. Calculate the shear strength of the punch tool by mathematical formulas and stress distribution by ansys result.
6. Check the stress distribution of 12mm thickness metal plate by applying different pressure to the flat tool.
7. Calculate the Life estimation of HSS punch tool by analytical method and compare that in ansys solution.
8. Determine the factor of safety and select best one.

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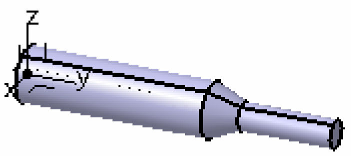
Model of Flat type M2 grade HSS Riveting Punch And Part (Suspension arm)



Fig;2;Model of flat type M2 grade riveting punch (Design in using CATA V5 software)

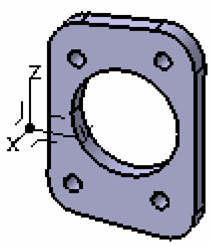


Fig3 ; Geometry of Part (suspension arm) obtained by punching operation (12mm thickness of sheet material)

III. COMPONENT ANAYLSIS OF M2 GRADE RIVETING PUNCHES

Chemical Analysis

Similarly failed component sample is given for other metallurgical testing such as chemical, hardness and microstructure. One segment of a failed component and one cylindrical portion is given for testing .The chemical analysis of the sample is carried out by using optical emission spectrometer, the result is given below,

Table no 1; Chemical Analysis

ELEMENT	OBTAINED %CYLINDRICAL SEGMENT[Min]	MAXIMUM	SPECIFICATION% AISI M2
C	0.872	0.955	Regular C 0.78-0.88 High C 0.95-1.05
Si	0.290	0.326	0.20-0.45
Mn	0.246	0.277	0.15-0.40
P	0.0026	0.025	0.03max.
S	0.007	0.006	0.03max
Cr	3.758	3.779	3.75-4.50
Ni	0.27	0.262	0.30max
Mo	4.773	4.805	4.50-5.50
V	1.766	1.759	1.75-2.20
W	6.181	6.278	5.50-6.75

Hardness Test;

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Table no 2

Segment sample	OBTAINED HARDNESS IN HRC	AVERAGE
Surface hardness	57,56,57	56.67
Core hardness	60,59,59	59.33
Cylindrical sample	**OBTAINED HARDNESS IN HRC**	**AVERAGE**
Surface hardness	57,56,57	56.67
Core hardness	57,58,58	57.67

Heat treatment report

Table no 3; Vacuum Heat Treatment Process

1.Stress Relieved At	600*C
2.Pre HEAT At	600*C
3.Pre heated at	850*C
4.Pre heated at	1050*C
5.Hardened at	1170*C
6.Tempered at	560*C For 2 and Half Hours 3 Tempering
7.No. Of Pieces checked	10 No.s

Micro testing;

Metallurgical Test Report

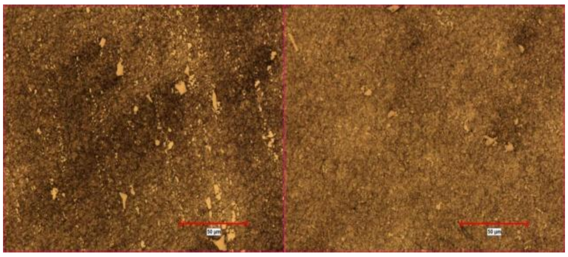

Fig (a) Traverse *Fig (b) Longitudinal*
Fig 2; MICRO: Uniformly distributed carbides on fine tempered marten site

Chemical composition conforms to AISI M2 grade.Surface and core hardness is uniform Microstructure is homogeneous throughout the section. No significant inclusions are observed in cylindrical sample, where as oxide inclusion associated with carbide banding observed in segment sample away from the fractured area.Grains are fine and homogeneous Retained austenite, coarse angular carbides, clusters, segregation of carbides, network from of carbides are not observed in both the samples.

The punch plane surface relieved that , the crack initiated at one location, from the end of tooth profile and outer side wall , propagated radial towards outside and fractured. Adjacent to the fracture, deep punch marks and micro cracks observed at the end of tooth profile. Opposite to the fractured surface no damages are seen. More than 50% of the area is intact.The alignment and the material being punched may be studied.

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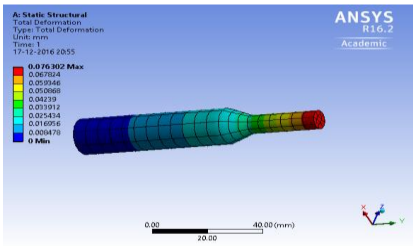
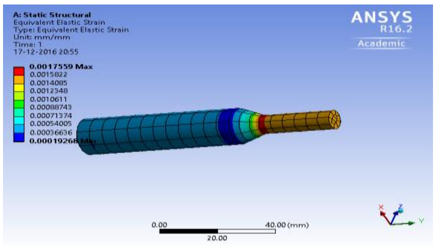
Stress analysis for Flat type HSS Punch Tool

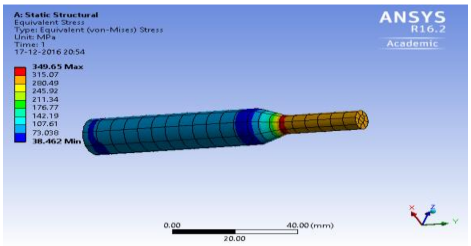
The applied Pressure is 300MPa



(a)



(b)

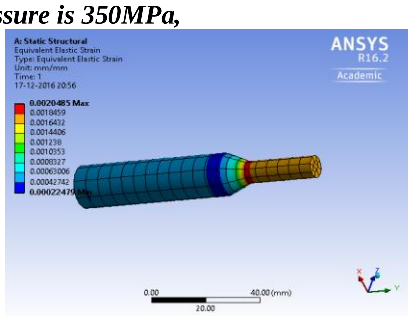


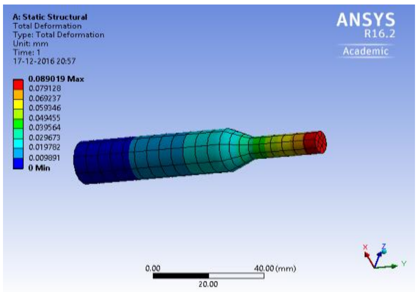
(c)

Fig (a) Deformation of Flat punch tool (b)Strain Flat Punch Tool (c) Von Mises Stress

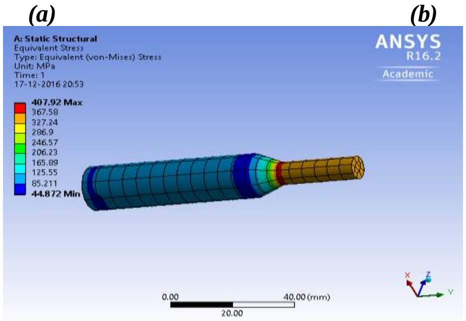
1. 1.The Flat Type tool is used to punch the sheet metal, it is fixed in tool as cantilevers beam, the pressure 300MPa is applied at the tip end, the deformation accurse the tool will save up to 10000 parts produce, then the scaling, bur formation on the tool, this is effects the smooth shear.
2. The Pressure applied to the tool is 300MPA ansys results shows that,
   Max. Deformation = 0.076mm
   Max. strain rate =0.00175
   Max. Von Mises Stress=349.65 MPA

The applied Pressure is 350MPa,





(a) *(b)*



(c)

Fig (a)Ansys results of Strain (b)Deformation(c)Von Mises Stress

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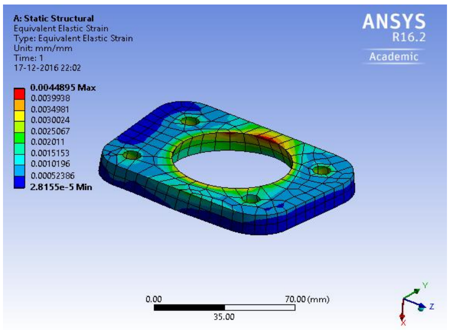
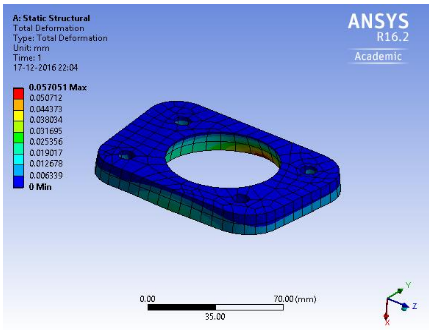
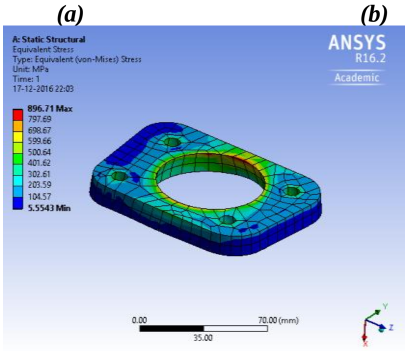
1. The Flat Type tool is used to punch the sheet metal, it is fixed in tool as cantilevers beam, the pressure 350MPa is applied at the tip end, the deformation accurse the tool will save up to 10000 parts produce, then the scaling, bur formation on the tool, this is effects the smooth shear.
2. The Pressure applied to the tool is 350MPA ansys results shows that,
   Max. Deformation = 0.089mm
   Max. strain rate =0.0020
   Max. Von Mises Stress=407.92 MPA

Ansys results for 12mm sheet material when Flat punch tool is used as punch; 300Mpa,





(a) *(b)*



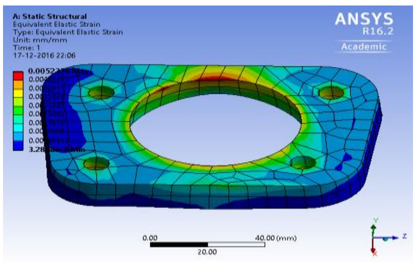
(c)

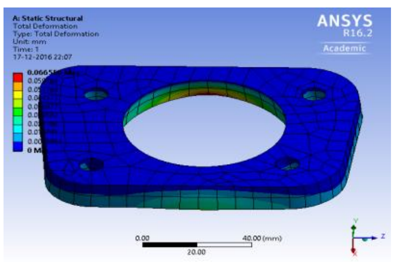
Fig (a) Ansys results of Strain (b)Deformation (c)Von Mises Stress

The sheet material is blanked by flat tip tool the ansys result obtained,

1. 1.The Flat Type tool is used to punch the sheet metal, the pressure 300MPa is applied on the surface of sheet metal. Then the scaling, bur formation on the tool, this is effects the smooth shear.
2. The Pressure applied to the tool is 300MPA ansys results shows that,
   Max. Deformation = 0.057mm
   Max. strain rate =0.00448
   Max. Von Mises Stress=896.71 MPA

Ansys results for 12mm sheet material when Flat punch tool is used as punch; 350Mpa,





(a) *(b)*

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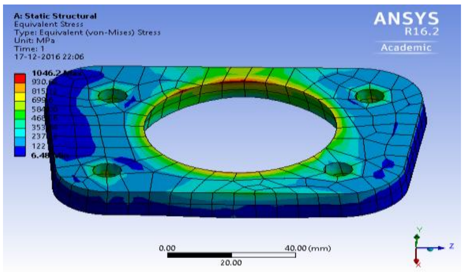

(c)

Fig (a) Ansys results for deformation(b) strain(c)von mises stress

The sheet material is blanked by flat tip tool the ansys result obtained,

1. 1.The Flat Type tool is used to punch the sheet metal, the pressure 350MPa is applied on the surface of sheet metal. Then the scaling, bur formation on the tool, this is effects the smooth shear.
2. The Pressure applied to the tool is 350MPA ansys results shows that,
   Max. Deformation = 0.066mm
   Max. strain rate =0.00523
   Max. Von Mises Stress=1046 MPA

IV. RESULTS AND DISCUSSIONS

The stress analysis and fatigue life for the given M2 Grade HSS punch tool material have been carried out under maximum temperature and steady state conditions. For all the three materials under consideration the operating speed of 4-15mm/s has kept constant throughout the analysis.From the above stress analysis it can be observed that the maximum working stress acts at the bolt area at the working temperature of around 840˚C and maximum von mises stress induced is within the permissible limits for all the materials which are considered for the stress analysis.Factor of safety (FOS) is a term describing the structural capacity of a system beyond the applied loads or actual loads. A calculated ratio of strength (structural capacity) to actual applied load. This is a measure of the reliability of a particular design.

$$FOS = \frac{yield\ strength}{von - mises\ stress}$$

Strain life approach is used to calculate the fatigue life cycle of the above three materials and I used Muralidharan and Manson equation to calculate life of the equation is as below

$$\frac{\Delta\epsilon}{2} = 0.623\left(\frac{S_u}{E}\right)^{0.832}(2N_f)^{-0.09} + 0.0196(\epsilon_f)^{0.155}\left(\frac{S_u}{E}\right)^{-0.53}(2N_f)^{-0.56}$$

Where ϵ_f = fatigue ductility coefficient

S_u = Ultimate stress

$\Delta\epsilon$ = obtained strain

E = Young's modulus

N_f = Number of cycles

$$\frac{0.00204}{2} = 0.623\left(\frac{520e6}{2e9}\right)^{0.832}(2N_f)^{-0.09} + 0.0196(0.257)^{0.155}\left(\frac{520e6}{2e9}\right)^{-0.53}(2N_f)^{-0.56}$$

N_f= 37616987.38=3.7e7 cycles

$FOS = \frac{550}{407.92}$ **FOS = 1.34** $FOS = \frac{550}{349.65}$ **FOS = 1.57**

The factor of safety is obtained for two applied pressure 300MPA and 350MPA. In that 300MPA is the best Pressure for more life of tool.

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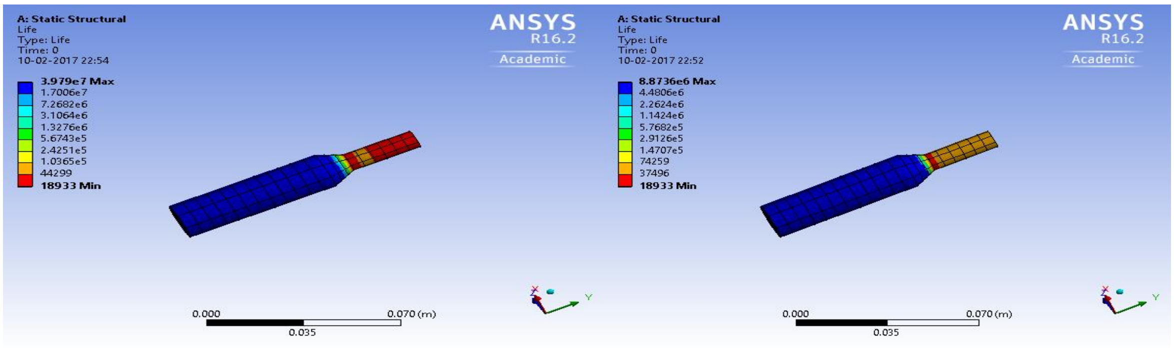
Ansys Result for Life Estimation



(a) *(b)*

Fig8; Life estimation of flat tool for the pressure 300MPA (a), 350MPA (b)

Table no. Comparison of theoretical and ansys solution

Load in MPa	**Life Estimation of Theoretical calculation in Cycles**	**Life Estimation of Ansys solution in Cycles**	**Factor of safety**
350	8270317.84=8.2e6	8.87e6	1.34
300	37616987.38=3.7e7	3.97e7	1.57

Table no.Conversion of Number of cycles into Number of Parts

Load in MPa	**Life Estimation Result in cycles**	**Life Estimation=Number of Cycles/ Strokes Per Minute(450SPM) in Parts**
300	37616987.38=3.7e7	83,594
350	8270317.84=8.2e6	18374

V. CONCLUSION

The understanding of the punch, stripper plate and sheet interaction at high speed blanking. Areas that need attention to reduce vibrations and improve robustness of tooling are identified. The fine blanking operation for 12mm thickness of sheet material, flat tool tip is selected as best punch tool compared to double shear, single shear, and cone type by experimentally and by Finite Element Analysis Method. The component analysis is gives the hardness, chemical, material property of HSS tool, Micro testing gives the information about uniformly distributed carbides on fine tempered marten site. Finite element analysis for given tool and the material gives the maximum stress, strain and deformation results for 300MPA and350MPA. The number of cycles is calculated by using formula and gets the result that tool failure at 18374 SPM when Applied pressure is 350 MPA, 83,594 SPM for 300MPA.The Factor of safety 1.34 and 1.57.So the conclusion is 300MPa of pressure is applied on the punch tool get the more fine blanked parts and tool life will be more.

VI. ACKNOWLEDGEMENTS

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