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DESIGN AND MODIFICATION OF PIERCING DIE TO INCREASE TOOL LIFE AND PRODUCTIVITY

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ABSTRACT:

Now days, manufacturing sectors replaced most expensive and casted components by means of sheet metal parts. From this phenomenon the cost of the products and the weight of the components are reduced as much as possible. The cost of tooling in sheet metal industries contributes a considerable part to the overall cost of manufacturing a component. It is therefore imperative to keep down this cost by ensuring that the tool works for a long period in production without interruption. In this project a Piercing Die is design and develop which consist of number of parts like housing, punch, punch holder, striper, cutting die, top plate, bottom plate etc. for piercing a 12 hole work piece, by considering various important parameters of die such as Causes of bur, causes of failure of punch, cost effect of failure, tool life, productivity etc. These problems bring the piercing die to improve tool life, increasing productivity, without increase in trial cost in design.

KEYWORDS: Piercing Die, Piercing Punch, Bohler K110, Alcroma Coating (AlCrN), CATIA V5, Ansys Workbench 14.5.

I. INTRODUCTION:

In this project different aspects of Sheet metal press tool dies are explained in details. The topics cover in this project include: what is Press tool, its importance and types, how it is operated, study of Rotor flange 12 hole piercing die and its design and development of some parts of piercing die. Press tool manufacturing is one of the widely emerging trends in production area. Basically sheet metal components are produced using press tools. As the name it suggests press tool means manufacturing the sheet metal components by applying the predetermined force. The components manufactured using this process possess high dimensional accuracy therefore automobile and aircraft firm depend largely on press tools [1]. To provide holes and blanks for high strength metal sheets, conventional press blanking/piercing is widely used because of its high productivity and cost performance. However, for precise holes conventional press blanking/piercing shows poor quality with rough sheared surface, and generally needs further finishing operations such as lathing or grinding [4]. The cost of tooling in sheet metal industries contributes a considerable part to the overall cost of manufacturing a component. It is therefore imperative to keep down this cost by ensuring that the tool works for a long period in production without interruption. One way of achieving this objective is to reduce the stress on the tool during punching/blanking [5].

II. COMPONENT STUDY:

Name of Component – Rotor Head Flange
Material – Fe 510 C UNI10025-92 / ST52
Thickness – 10/12mm

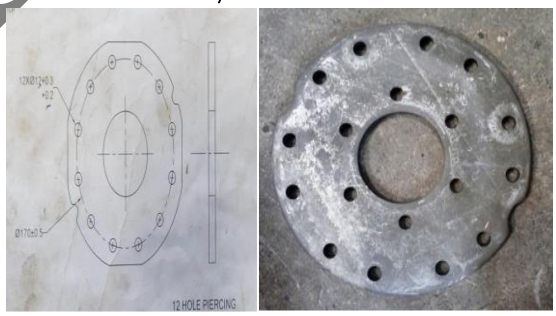

Fig. 1.Hole Piercing Design& job

Depending on one page report and observation we found the following manufacturing issues in Die,

- Punch broken after certain lot in between 500 to 1200 jobs.
- Central diameter and individual diameter of 12 holes issue.
- Stripper plates loosen due to wear and tear between punch and punch holder due to excessive load.
- Job Ejection issue during removal of job from die.
- Chip off of punch during operation.
- Due to failure of die job production get disturb and effects on delivery time and quantity.

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Fig. 2. Photographs of Job and Punch Issues

2.1 IMPORTANT CONSIDERATIONS IN PIERCING PUNCH DESIGN:

- The design of punch mainly depends on the plan area to be pierced.
- Its design is also depends upon the pressure which is required to penetrate through the work piece.
- Depending on the method of mounting punch in die.
- The punch must withstand maximum piercing pressure.
- Small punches required support to avoid breakages.
- The hole pierced in the sheet is a tapered one, with minimum opening equal to punch size near the top.
- The maximum size of the hole at the bottom depend on the die opening which depends on die clearance
- The punch is made equal to the hole size shown on component.
- Heavy burr observe on the edges of holes.

Chemical Composition and Mechanical Properties/ Physical Properties, Bohler K110 material is used in High-duty cutting tools, blanking and punching tools & small moulds for the plastics industry where excellent wear resistance is required. Increased demands for improved productivity and cost efficiency K110 is more suitable. Dimensionally stable, high car bon, high-chromium (12%) steel. Particularly suit able for air hardening. Good toughness.

Table -1 Chemical Composition Bohler K110

C	Si	Cr	Mn	Mo	V
1.55	0.30	11.30	0.30	0.75	0.75

Table -2 Mechanical Properties/ Physical Properties

Properties	Values
Density	7.70 Kg/Dm3
Thermal Conductivity	20.0 W/(M.k)
Specific Heat	460 J/(Kg.k)
Electrical Resistivity	0.65 Ohm.
Modulus of Elasticity	210 X 103 N/mm2
Elongation Fracture	1.54 %
Fracture Toughness	14.8 Mpa/m2
Yield Point	1999 MPa

2.2 THEORETICAL CALCULATIONS:

A. SHEAR FORCE CALCULATION

Shear Force = L x T x τ

L = Length of Cut in mm (From CAD Data)
T = Thickness in mm
τ = Shear Strength in Kg/mm2

Material used for Rotor flange is Fe 510/ ST-52 so, Tensile Strength is 490-630 N/mm2

Shear strength = 50% of tensile strength for a round punches,

So, Shear strength = 315 N/mm2
Dia of punch is 12.35mm

Therefore,
Circumference = 2πr
= 2 x π x 6.175
= 38.7987 mm

There are 12 punches used in die,

So, total length of cut is,
L = 38.7987 x 12 = 465.5840 mm
τ = Tensile Strength in Kg/mm2 = 315/9.81 = 32.11 Kg/mm2

Shear Force = L x T x τ
= 465.5840 x 12 x 32.11
= 179398.82 Kg

B. STRIPPING FORCE:

Stripping Force = 20% of Total Shear Force
= x 179398.82 = 35879.76 Kg

C. PRESS FORCE:

Press Force = Total Shear Force + Stripping Force
= 179398.82 + 35879.76
= 215278.58 Kg

Press force in Tonnage = 215.278 Tons
Approx. 215 Tons

D. PRESS TONNAGE:

Press Capacity = (Total Shear Force + Stripping Force) / 70%

The ratio of the punch diameter to the stock thickness must satisfy the condition

d/t= 1.10 minimum
=1.0291

Where,
d = punch diameter

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t = thickness of punched material

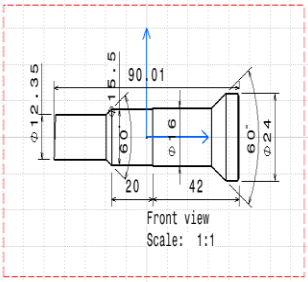
This is less than allowed.

2.3 PIERCING PUNCH MODEL ANALYSIS:

ANSYS is the tool to analyze the part of solid modeling in the solid works. It provides the stress result with the design cycle. It helps to predict the part to perform under load. Whenever the problem arise related to design, need of comprehensive analysis of the product is required.

As the prime objective of this paper is to analyses the rigidity characteristics of a punch with various design features, it is perfectly justified to set the top surface of the punch fixed. Thus the boundary condition corresponds to simply setting those nodal points on the top surface to zero [5].

ANALYSIS OF MODIFIED PUNCH MODEL - K110 MATERIAL:



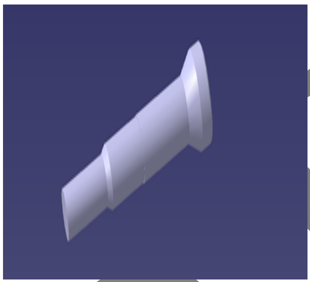
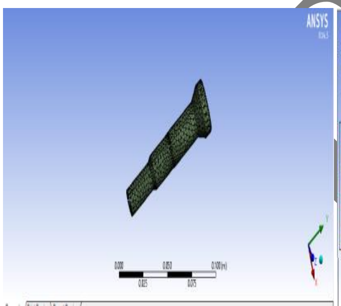


Fig.3. Modified Punch Design

Fig. 4. Punch Model Modified (2D) & (3D)



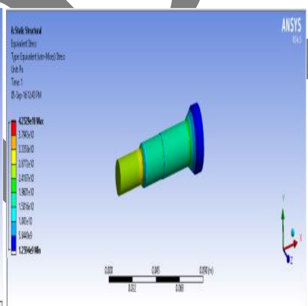
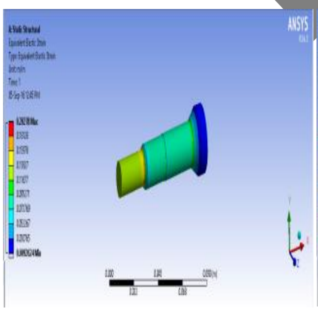


Fig. 5. Meshing of Punch Model Modified (3)

Fig. 6. Von-Mises Stress Distribution Modified (3)



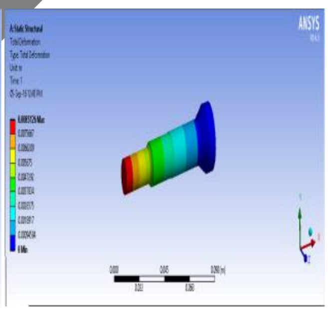


Fig. 7. Strain Distributions Modified (3)

Fig. 8. Total Deformations Modified (3)

Table -3 Average Cost of One Punch

Punch	Material Cost	Turning cost	Vacuumed Hard Cost	Grinding Cost	Coating Cost	Total cost
D2 Punch	54/-	18/-	32/-	85/-	-	189
K110 Uncoated	140/-	20/-	40/-	90/-	-	290
K110 Coated	140/-	20/-	40/-	90/-	1060/-	1350

III. EXPERIMENT AND RESULT:

On the basis of analysis data a proper suitable material K110 is ordered from the supplier. Rough Turning design is given to the operator to make a punch ready for the heat treatment. The shape and size of the material get changed after heat treatment, so proper tolerances are given on machining. These tolerances are given on the basis of material deflection behavior on heat treatment. Heat Treatment given is Vacuum heat treatment.

Heat treatment specification
=Heat treatment + Double tempering
Categorization - Normal
Require Hardness – 56 to 58 HRC

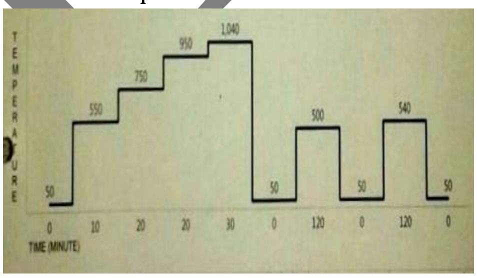
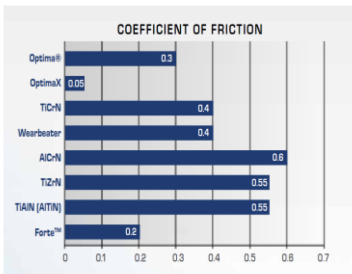


Fig. 9. Graph Temperature vs. Time (min)

3.1 COATING FOR PUNCH:

Table -4 Coating Properties

Coating Material	COF	Micro Hardness	Coating Thickness(µm)	Residual Stress (GPa)	Max. Service Temp. (C°)	Coating Temp. (C°)	Coating Colour	Coating Structure
AlCrN	0.35	3500	As per application	-0.3	1100	<500	Bright Grey	Monolayer



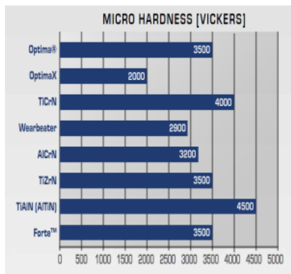


Chart -1 Coefficient of Friction[Source:www.oerlikon.com]

Chart -2 Micro Hardness [Source: www.oerlikon.com]

ADVANTAGES:

- Tools are heavily stressed in production with high mechanical and thermal strain. These demands fulfilled by ALCRONA PRO, the top level all-rounder for cutting, punching and die casting.
- With this coating we were able to significantly excel the performance curve.
- This results in an extremely wear resistant coating with excellent hot hardness and thermal shock stability.
- Significantly increased cutting speed possible.
- Increase utilization and productivity.
- Broad application range.
- Vastly improved tool lifetimes compared to conventional all-round coatings.
- Top results in both wet and dry machining and at the highest of cutting speeds.
- Increased machine utilization and productivity.
- Significantly strengthened performance profile.

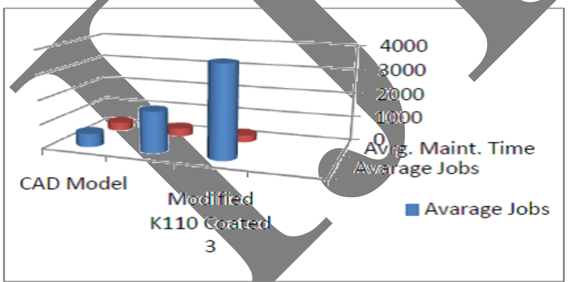
3.2 TRYOUTS:

In experimental set up we prepares a die set up by changing the punch one by one with suitable new designed punch holder and check the proper alignment. Alignment of the die is very important to maintain the proper Central Distance of all 12 punches.

Table -5 Comparison

Punch	Cost/ Punch	Average no. of jobs/batch	Average Production rate/ punch	Average Production Cost/ punch	Rework	Maint. Time
D2 Punch	189	550	153	26775	Require	
K110 Uncoated	290	1700	500	87500	Less Rework	Same
K110 Coated	1350	3740	1100	192500	No Need of Rework	

Chart -3 Graph of Produced Jobs vs. maintenance time



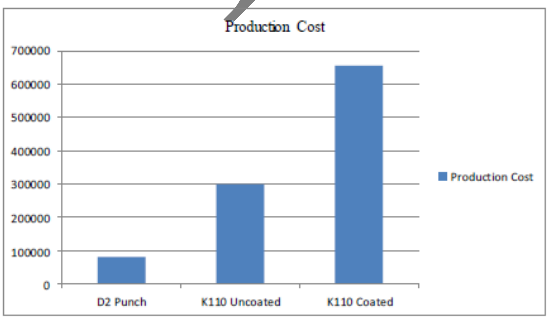


Chart -4 Graph of Produced Jobs

IV. CONCLUSION:

This thesis is completely described about the Piercing Punch die parts individually through analytical calculations and these parts are analyzed by the finite element methods with close meshing analysis. This die design specifically designed for the JBMS, Pvt. Ltd. industry which is facing the problems regarding their own criteria. By implementing this type of die design to compete few recommendations such as,

- Increase of production rate/batch
- Increases Tool Life
- Get a possible product in a die
- Reduction of man power
- Decrease the maintenance cost, Rework cost, man power require

As in this we used K110 material which is highly cost material but gives sufficient hardness for coating Alcroma (AlCrN) coating and applying against probably hard raw material with high thickness. Coating gives good coefficient of friction which helps to remove punch from the job during production. Which leads in log life of punch, eliminate burr, dimensional accuracy etc.

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