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DESIGN STUDY OF PIERCING TOOL AND AlCrN COATING FOR PRECISION PIERCING AND PRODUCTION EFFICIENCY

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Abstract— **Punching is the most cost effective process of making holes in strip or sheet metal for average to high fabrication. It is able to create multiple shaped holes. Burr formation is common sheet metal defect and Burr control / de-burring is an important issue for industrialist and engineers. This leads to rework and quality problem of part. It can be minimize by selecting the optimum or best punch-die clearance give a significantly longer tool life by minimizing tool wear. 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. It can be achieved in the punching of holes in a larger thickness circular steel plate using punches of different outer diameters, convex double-shear angles, convex lengths give better results. Hard PVD coatings can be successfully used in piercing applications, even on softer tool steels, thus leading to reduced friction and wear as well as to lower costs of the tool. AlCrN gave the lowest COF and helps to improve the life of tool resulting in improved production efficiency.**

Keywords— **Piercing Punch, Punch Geometry, Tool life, Bohler K110, Alcroma Coating (AlCrN), CATIA V5, Ansys Workbench 14.5.**

I. INTRODUCTION

Burr formation is common sheet metal defect and Burr control is an important issue for industrialist and engineers. It is produced in all shearing & cutting operations. In sheet metal parts burr is usual but after a specified limit it takes a form of defect. This leads to rework and quality problem of part. Predicting the die and tool replacement time in the blanking process is very important in terms of product quality and cost efficiency. In order to predict tool life, tool wear must be observed constantly and the product defect rate must be analyzed. Punching is the most cost effective process of making holes in strip or sheet metal for average to high fabrication. It is able to create multiple shaped holes. Punch-die clearance is a well-known parameter affecting both tool life and edge quality of parts in blanking and piercing. Selecting the optimum or best punch-die clearance can give significantly longer tool life by minimizing tool wear. The process behavior in the punching of holes in a larger thickness circular steel plate using punches of different outer diameters, convex double-shear angles, convex lengths was investigated.

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. by using the finite-element technique. 3-D finite-element models of various types of punching/blanking tools have been developed, these models enabling the analysis of the effects of variations in tool geometry on the punching/blanking force and on the deformation of the punch.

Böhler K110material is used in High-duty cutting tools, blanking and punching tools & small moulds for the plastics industry where excellent wear resistance is required. It is difficult to machine the material in the hardened state (58 HRc). Possibility of reducing lubrication and replacing expensive tungsten carbide material in blanking/piercing through introduction of hard tool coatings. Results show that hard PVD coatings can be successfully used in blanking/piercing applications, even on softer tool steels, thus leading to reduced friction and wear as well as to lower costs of the tool. AlCrN gave the lowest COF, the COF and wear reduced with increased speed, except for the test involving AlCrN in air where the COF increased with increased speed. AlCrN exhibited the shortest running-in process and lowest steady-state COF was found to have the least wear. TiN, TiAlN/AlCrN and AlN/TiN which exhibited similar wear resistance, had lower wear resistance than AlCrN but higher wear resistance than TiAlN. Some suggestions are offered as to how the efficiency of a punching/blanking tool can be improved.

II. Modelling of Punch

The punch geometry is shown in Fig. 1. In the present analysis the punch fillet provided adjacent to the intersection of diameters D and D2 is taken into account in order to represent the actual element geometry.

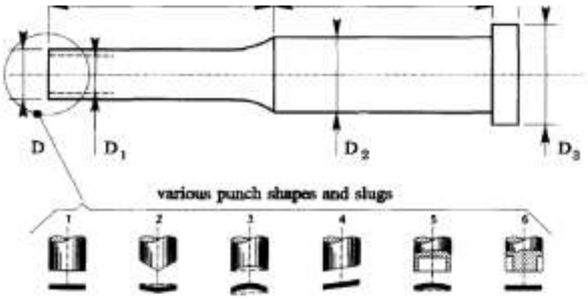

Fig. 1. Punch configuration with various punch shapes and slugs.

Fig. 2 depicts the nodal representation of the different punches considered.

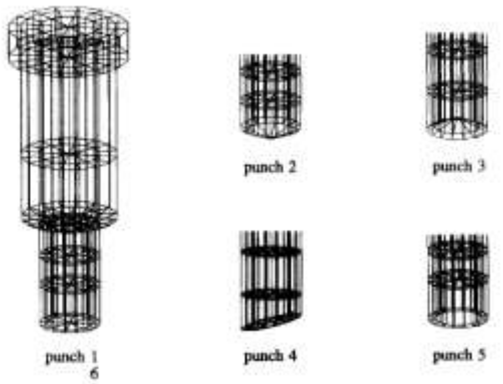

Fig. 2. Finite-element models of the punches: (1) a punch with a flat face; (2) a punch with balanced convex shear; (3) a punch with concave shear; (4) a punch with one-way shear; (5) a punch with an inverted cup-shaped face; and (6) a punch with sintered hard metal around its circumferential cutting edge.

A. Boundary condition

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

The top plate of the die-set containing the punch along with the upper head of the press tends to deflect as the thrust is applied to the punch [6]. Consequently, the top plate of the die-set carrying the punch follows the lateral movements of the top head of the press. To account for these movements, the nodal points on the top surface of the punch should be given a prescribed displacement equivalent to the amount of deflection of the die-set at the punch head section. it is perfectly justified to set the top surface of the punch fixed

B. Punch Load

For the analysis of punch deformation, a static load corresponding to the punching load is defined. Young's modulus and Poisson's ratio for the punch material are to be provided. When assuming that the mechanics of punching is based on pure shearing, the instantaneous punching forces Fp.

In the experiment 350 tons machine is used for piercing a job.

That amongst the rigidity characteristics evaluated for all types of punches, the punch with balanced convex shear, 2, shows the best performance suggests that this type of punch can reasonably be recommended in practice in order to reduce the stress on the tool and thus to enable thicker or more resistant stock to be punched on the same press or to permit the use of a lower-rated press. That the radial deformations of punches with balanced convex and concave shear have a minimum value within the shear angle range of 17°-22 ° suggests that a shear angle of 20 ° can be proposed safely for practical purposes.

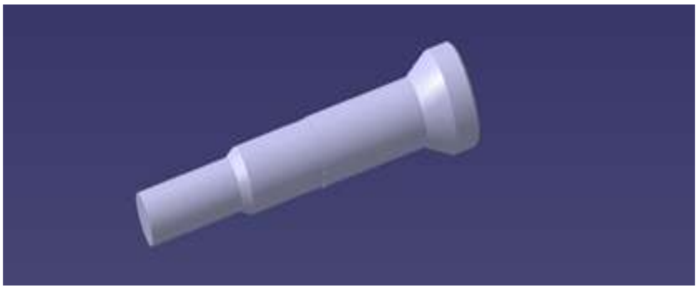

Fig. 2. Punch Model Modified (2D) & (3D)

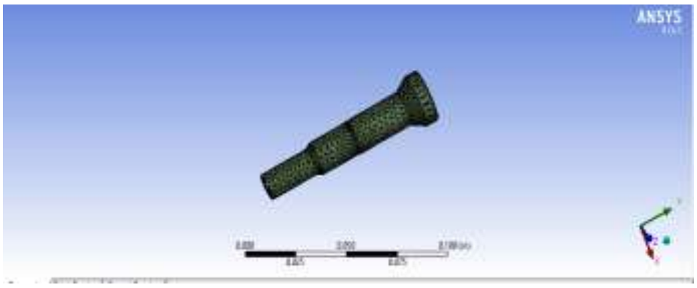

Fig. 3. Meshing of Punch Model Modified (3)

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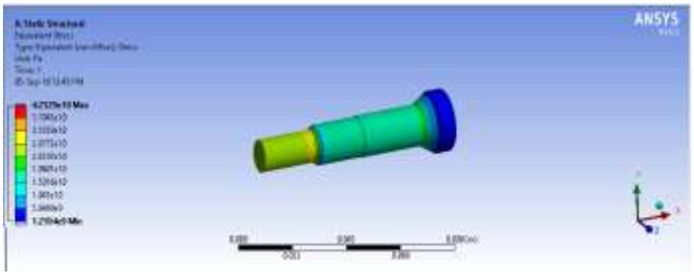


Fig. 4. Von-Mises Stress Distribution Modified (3)

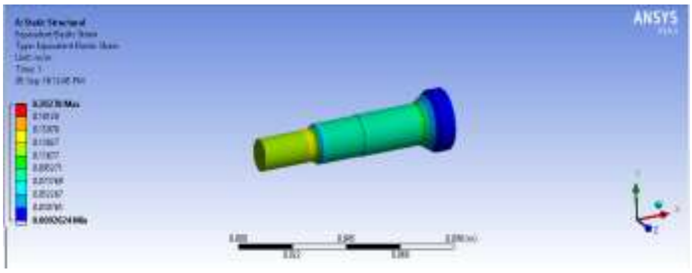


Fig. 5. Strain Distributions Modified (3)

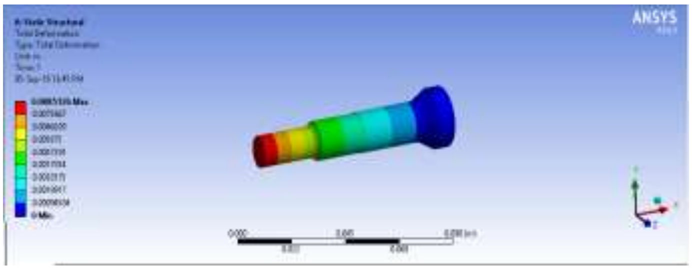


Fig. 6. Total Deformations Modified (3)

III. Material Selection And Coating

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

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

Table -3 Coating Properties

Coating Material	COF	Micro Hardness	Coating Thickness (μm)	Residual Stress (GPa)	Max. Service Temp. (C^o)
AlCrN	0.35	3500	As per application	-0.3	1100

Coating Temp. (C^o)	Coating Colour	Coating Structure
<500	Bright Grey	Monolayer

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

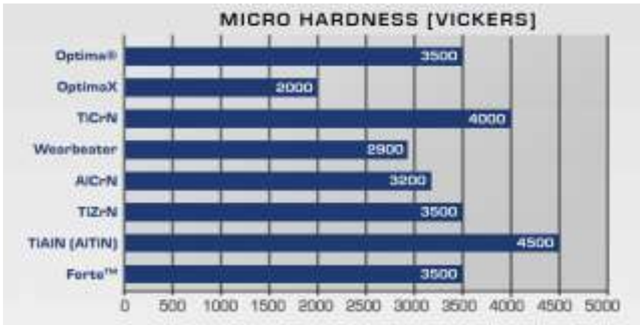


Chart -2 Micro Hardness [Source: www.oerlikon.com]

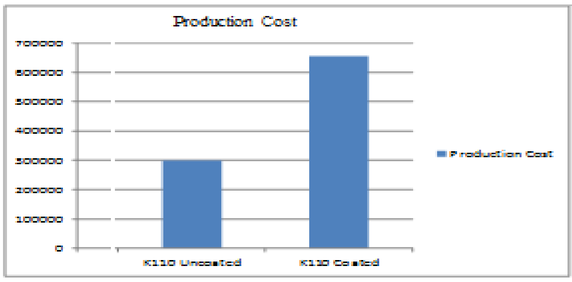
IV. Experimental Results

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 -4 Comparison

Punch	Cost/ Punch	Average no. of jobs/batch	Average Production rate/ punch
K110 Uncoated	290	1700	500
K110 Coated	1350	3740	1100

Average Production Cost/ punch	Rework	Maint. Time
87500	Less Rework	
192500	No Need of Rework	



V. CONCLUSION

The present study on punch design has resulted in the development of 3-D finite-element models of various types of punches and demonstrates the usefulness of these models in solving practical problems involving a range of design parameters.

That the radial deformations of punches with balanced convex and concave shear have a minimum value within the shear angle range of 17°-22 ° suggests that a shear angle of 20 ° can be proposed safely for practical purposes.

In blanking, contact stress on the punch obtained using FE analysis of blanking can be used as an indicator of experimental punch wear.

The clearance vs. geometry curve can be used to design variable punch-die clearance for blanking applications to improve punch life, as illustrated with an application in production.

Tool life for a punch with a convex double-shear angle of 20° is greater than that of 12.5°. The effect of the convex length of the punch on the tool life for a convex double-shear angle of 20° is significant gives improved tool life.

Bohler K 110 is used, which is a costly material and has got peculiar characteristics which make it difficult to machine. Therefore, the selections of optimal parameters are important to minimize the higher unit cost per machined part by hard part turning 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.

In this study, the stiffness of the press machine was not considered, but it is an important factor that has an effect on product quality and tool wear when the blanking process is performed. Therefore, if the stiffness of the press machine is applied to the FE model.

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