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Modification in Manufacturing Process by Analysis of Bushings

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Abstract— **This document prescribes a model investigation the effect of potential parameters influencing the blanking process and their interaction. The blanking process optimization carried out by using Trial and Error Method, Finite Element Method (FEM), Catia Designing Software in order to achieve the intended model objectives**.

***Index Terms*— Bushings, blanking, piercing, embossing, Etc.**

I. INTRODUCTION

A bushing is a type of vibration isolator. It provides an interface between two parts, damping the energy transmitted through the bushing. A common application is in vehicle suspension systems, where a bushing made of rubber, metals separates the faces of two metal objects while allowing a certain amount of movement. This movement allows the suspension parts to move freely, for example, when traveling over a large bump, while minimizing transmission of noise and small vibrations through to the chassis of the vehicle [1]. A rubber bushing may also be described as a flexible mounting or ant vibration mounting. Most high-speed inline internal combustion engines are prone to torsional vibration of their crankshafts; the straight six and straight eight engines being particularly prone to this problem due to their long crankshaft length. Although straight eight engines faded from the marketplace in the 1950s, many straight six engines have and still do feature crankshaft vibration damping utilizing rubber bushes.[2] Variations of the weight, rubber volume and mix, give these dampers a very wide field over which they can operate. These bushings often take the form of an annular cylinder of flexible material inside a metallic casing or outer tube. They might also feature an internal crush tube which protects the bushing from being crushed by the fixings which hold it onto a threaded spigot. These bushings often take the form of an annular cylinder of flexible material inside a metallic casing or outer tube. They might also feature an internal crush tube which protects the bushing from being crushed by the fixings which hold it onto a threaded spigot.

Many different types of bushing designs exist. An important difference compared with plain bearings is that the relative motion between the two connected parts is accommodated by strain in the rubber, rather than by shear or friction at the interface. Some rubber bushings, such as the D block for a sway bar, do allow sliding at the interface between one part and the rubber.[4]

II. PROBLEM STATEMENT

In very starting we used single metal i.e. steel for manufacturing of bushing. But when it came to wear testing due to hardness of steel it gets lots of crack and it does not allow to take impact loading. We also used heat treatment for steel. Melting point of steel is very high (1400K). But after heat treatment we came to know that oxidation at surface and scale formation occurs. This phenomenon also destroys its surface finish. We used many single metals generally used for bushing but all in vain. Some are failing at wear test and some are due to cracks.

Then we used bimetallic strip, it is also used as a standard material for bushings. This bimetallic strip acts as composite in which qualities of individual material remains same. This bimetallic strip made of steel and copper (as base material), tin and lead as additives (also known as phosphor bronze). Main motive behind adding additives is to increase wear strength, corrosive resistance

During manufacturing of bushing, a rectangular bimetallic sheet moves into the press machine and final product i.e. bushing comes out. This press machine consist of four dies one after another in a row.

These four dies are likewise stamping, embossing, punching and blanking. Whole process of making bushing is at room temperature. This process is also called cold working. If ductility decrease material can be cold worked.

Cold working carried out below the recrystallization temperature and as such there is no appreciable recovery of metal. Cold working leads to distortion of grains. Cold working improves ultimate tensile strength, yield and fatigue strength but reduces corrosion resistance of metal. During process, impact strength and elongation are reduced.

Cold worked part may carry better surface finish. Cold working is preferred where work hardening is required. Unlike hot working, it distorts the grain structure and does not provide an appreciable reduction in size. Disadvantage of cold working is all four dies falls down simultaneously on sheet performing respective impression. All four dies create a sudden impact on sheet at that time problem arises in sheet because both materials have different qualities like hardness, ductility, stiffness, brittleness, wear resistance. During stamping process no problem occurs because force required for stamping is low with respect to material strength. Second dies is embossing, after embossing it was found that there are cracks at edges.

Reason for that is during cold working material get harder due to residual stress and when there is sudden impact on material it is unable to take load. At the end process i.e. blanking (it is the operation of cutting out a piece of the required shape from a metal sheet using punch and a die) edges of blank got curved shape.

III. METHODOLOGY

The methodology to achieve the objects presented in previous section is subsequently described. Two main procedures are carried out firstly, a theoretical formulation of the model and secondly, an experimental verification.

A. INTERPRETATION

a. Heat Treatment

Mechanical heat working of a metal is a simply plastic deformation preformed to change the dimensions, properties and surface conditions with the help of mechanical pressure. Depending upon the temperature and strain rate, mechanical working may be either hot working or cold working, such that recovery process takes places simultaneously with the deformation.

The plastic deformation of metal takes place due to two factors i.e. deformation by slip and deformation by twin formation. During deformation of metal is said to flow, which is called as plastic flow of the metal of the metal and grain shapes are changed. If the deformation is carried out at higher temperature, then the new grain start growing at the locations of internal stresses. When the temperature is sufficiently high, the grain growth is accelerated and continues till the metal comprises fully of new grains only. The process of formation of new grains is called recrystallization and the corresponding temperature is called recrystallization temperature of metal. Mechanical working of metals above the recrystallization temperature, but below the melting or burning point is known as hot working. Every metal has a characteristic hot working temperature range over which hot working may be performed. The upper limit of temperature depends of metal, prior deformation and impurities within the metal.

Due to hot working, no residual stresses are introduced in the metal. Hot working refines grain structure and physical properties of metal. Any impurities in the metal are disintegrated throughout the metal. Porosity of the metal is minimized by hot working and the metal is in plastic state, larger deformation can be accomplished and more rapidly. Special care should be taken during hot working because at high temperature, a rapid oxidation or scale formation takes place on the metal surface which leads to poor surface finish and loss of metal and close tolerances cannot be obtained, excessive expenditure on account of high tooling cost occurs.

b. Grinding

Grinding is process of imparting the good surface finish and high dimensional accuracy to the components with the negligible removal of material, by the use of rotary abrasive tool called grinding wheel. Grinding wheel made of fine grain of abrasive material act like single point cutting tool. Grinding wheel revolving at high speed is brought in contact with the work piece. Generally for more material removal from casting, forging, elements and removal of sharp corner, burs or unwanted projection from work piece rough grinding is used.

This grinding is also known as non-precision grinding. Basically the grindings are of two types rough and fine grinding. By grinding operation slot on bushing surface can be created without being cracked, which occurred during embossing.

c. Clearances

Effect of clearance is that during metal cutting, the shape of the punch is similar to die opening except that, it is smaller on each side. This difference in dimensions between die and punch is known as clearance. In piercing operation, where the hole in sheet metal is to be accurate and the output is wastage, the punch is made to the hole size. The die opening size is obtained by adding a clearance to the punch size. In the blanking operation, where blank is the desired part, the die opening size is same as blank size and the punch size is obtained by subtracting the clearance from die opening size. Clearance of various metals, are given below:

For brass and soft steel	C =5 % of thickness
For medium carbon steel	C =6 % of thickness
For hard steel	C =7 % of thickness
For aluminum	C =10 % of thickness

The total clearance between the punch and die size will be twice of these values. These clearance are only for blanking and piercing operation.

Generally, the clearance is calculated by using following relation,

Sometimes angular clearance is provided below the straight portion of the die surface. Angular clearance is provided to enable the blank to clear the die easily and fall freely of the die block. If angular clearance is not provided, the punched blank would remain stuck in the block. It is generally, ¼ degree to 3/2 degree per side but mostly up to 2 degree is provided.

d. Material properties studied

Actually bushings are made up of bimetal outer is steel and inner is copper alloy (copper 80%, tin 10%, lead 10%). Outer is steel for the strength of bushings and copper alloy is used to reduce the friction. We thought on heat treatment on the material but for that we studied the material properties of bushings.

Tin (Sn)
Melting Point is 505.08 K (231.930c)
Critical temperature is 2320c
Density : white (beta) 7.365g/cm3, Gray (alpha) 5.769 g/cm3
Thermal Expansion: 22.0 µm/Cmk at 250c
Shear Modulus: 18 Gpa

Lead (Pb)
Melting Point is 600.61 K (327.460c)
Critical temperature is 300-3500c
Density : 11.34g/cm3
Thermal Expansion : 28.9 µm/Cmk at 250c
Shear Modulus : 5.6 Gpa

Copper (Cu)
Melting Point is 1357.77 K (1084.620c)
Critical temperature is 85530c
Density : 8.96g/cm3
Thermal Expansion : 16.5 µm/Cmk at 250c
Shear Modulus : 48 Gpa

A. By seeing all these Properties we came to know that lowest temperature would be 2320c that will not affect properties of material and this may help to reduce the material flow or cracks occurring problems during embossing but heat treatment should be done before these processes.

B. Also the shear modulus is the thing we had consider, it is the ratio of shear stress to shear strain

Though it deals with force, area, length, change in length. All these factors except force are constant only the variable parameter is force so we have calculated the force these are given below,

7.5 Cutting Forces

While cutting operation, as punch moves downward into the material, it need not penetrate the stock thickness to affect the complete rupture of the part. The distance which the punch enters into the stock to cause rupture is called as penetration, and generally it is given in terms of the percentage of stock thickness. The percentage penetration depends on the material being cut and thickness of the material.

Percentage penetration of different materials:

Problem also arises during cutting of metal sheet because it is assumed that bottom of punch and die block lie in parallel plane. But due to this very high force is exerted for a very short period of time on the material, resulting in shock or impulse conditions.

7.5.1 Force calculations
We have, Length (l) = 71.29 mm
Breadth (b) = 41.65 mm
Thickness (t) = 2.38 mm
Perimeter of blank is given by
P'= (2 π r1/4)*2 + (2 π r2/2)*2 + (2 π r3/2) + 2.40
P'= (π*0.4) + (2* π*0.88) + (2 π) + 2.40
P'= 15.4662

P''=2P'

P''= 30.9324 mm2

Total Breadth of Blank Considering Perimeter
B'= 41.65 + 30.9324 – (2*8.32)
B'=55.9424
Area of Rectangular Blank = 2(l+B')*t/3
Area= 201.8716mm2
Ʈs= Fmax/Area
Therefore,
Fmax= 55*201.8716
As Ʈs= 55kg/mm2
Fmax= 11.11 tonnes

IV. RESULTS AND DISCUSSIONS

1. By using heat treatments to the bimetallic strip it is clear that we have to use lowest temperature to compensate the melting of alloyanh hence the minimum temperature of them is selected i.e.232^{o}C. This temperature can be used for preheating to cope with metal flow.
2. This preheating also allow the press to consume less energy as metal becomes soft and ductile this causes less complications in calculation of forces.
3. Force calculation suggest that this 11.11 tonnes is the sufficient force required to cut the strip which further saves the precious energy and also decreases the production cost as well.
4. As this force calculations are simple, it can be used for wide range of products of varying thickness, size and shape.
5. We have used CATIA V5 software for 3D graphic and stimulation which will suggest us how the actual model will look like and how will it work.

7. CONCLUSIONS

1. For increasing the production rate, decreasing production time and removing of crack occur during the blanking process we designed fine blanking die block for KSPG Automotive.

2. By using CATIA design of fine blanking die block was manufacture.

3. Testing was done by research and development department of KSPG Automotive.

4. After the testing the production rate is 4.2 lakhs per week (i.e. 35000 units in one shift of two daily).

5. The percentage of acceptance is 99.991 %(means out of 100, 00, 00 around 90 are rejected).

6. Crack getting at the end of bushing is negligible.

7. Curve is generated at the end of bushing in conventional manufacturing process and the problem is arising

at the high speed vehicle. By using of fine blanking process the curve generating at the edge is eliminated and the bushing performance is good at the high speed.

8. The problem arising at the meshing of two end of bushing is reduce that's why life of a bearing is increase by 32 %.

9. Metal flow ability at the time of blanking process is reduce by 27 %.

VI. LITERATURE REVIEW

The process of identifying process influencing parameters of blanking process includes an exhaustive literature review of the factors that have been suggested by various authors. Literature review was performed by collecting articles from various journals, and various popular research related sites viz. Science Direct, IEEE, Emerald, Springer Link and various free articles from internet. Literature from journal papers and conference studied for various press tool works parameters optimization are reviewed. S. K. Maiti, A. A. Ambekar, U. P. Singh, P.P. Date, K. Narasimhan,et.al [1], they evaluate the influence of tool clearance, friction, sheet thickness, punch/die size and blanking layout on the sheet deformation for thin M. S. sheet. The punch load variation with tool travel and stress distribution in the sheet has been obtained. The results indicate that a reduction in the tool clearance increases the blanking load. The blanking load increases with an increase in the coefficient of friction. These observations are very similar to the case of blanking of component of large size. Further, these effects are very similar in the case of both single and double blanking. An inter blanking site distance of about twice the sheet thickness is good to reduce the thinning of sheet at the intermediate regions between the two blanking sites.

Ridha Hambli et.al [2], presents industrial software called BLANKSOFT dedicated to sheet metal blanking processes optimization. The code allows for the prediction of the geometry of the sheared profile, the mechanical state of the sheared zone, the burr height, the force–penetration curve, and the wear evolution of the punch versus the number of the blanking cycles. The approach is based on an original theoretical investigation formulated from plasticity theories. This program is designed by considering several factors, such as material and geometry of product as well as the wear state of the tool. The numerical results obtained by the proposed programs were compared with experimental ones to verify the validity of the proposed software. Model and analysis the relationships that describe process variations. This investigation shows that, in order to minimize the blanking force, the clearance should be set at 10%, however, to minimize the fracture angle and the fracture depth, it is preferable to set the clearance at 5%. When the clearance is set at 10%, the process is slightly more robust to tool wear, as far as the blanking force response is concerned. Whether clearance should be set at 5% or 10% ultimately depends on the priorities of the practitioners.

F. Faura, A. Garcia, M. Estrems et.al [3], they proposed a methodology to obtain optimum punch-die clearance values for a given sheet material and thickness to be blanked, using the finite-element technique. To determine the optimum clearance, the diagonal angle and the angle of the direction of crack propagation for different clearances were calculated. The influence of clearance on diagonal angle and angle of the direction of crack propagation, from which it is seen that as the clearance increases, diagonal angle increases proportionally while angle of the direction of crack propagation remains nearly constant. At the point of intersection, the direction of crack propagation coincides with the diagonal line, and so the cracks emanating from the punch and die meet, resulting in a cleanly blanked surface. Hence, this value of clearance is taken as the optimum clearance. The optimum clearance for the values of the parameters used in this work is between 11 and 12%. It is observed that punch penetration increases as the c/t ratio increases.

R. Hambli, S. Richir, P. Crubleau, B. Taravel et.al [4] elaborates blanking process and structures of the blanked surfaces are influenced by both the tooling (clearance and tool geometry) and properties of the work piece material (blank thickness, mechanical properties, microstructure, etc.). Therefore, for a given material, the clearance and tool geometry are the most important parameters. They use simulation of an ax symmetric blanking operation with ABAQUS- explicit software for a given sheet material. A damage model of the Lemaitre type is used in order to describe crack initiation and propagation into the sheet. They use four materials for testing with four different elongation (30%, 47%, 58%, and 65%).They show that the optimum clearance decreases as the material elongation increases. The results of the proposed experimental investigation show that there is no universal optimal clearance value. Whether clearance should be set at 5% or 10% ultimately depends on the priorities of the practitioners.

Emad Al-Momani, Ibrahim Rawabdeh et.al [5], Represents a model investigates the effect of potential parameters influencing the blanking process and their interactions. Finite Element Method (FEM) and Design of Experiments (DOE) approach are used in order to achieve the intended model objectives. They use Design of Experiments (DOE) technique by selecting the experimental levels for each selected factor.

The clearance to be in five levels (5, 10, 15, 20, 25) % of the sheet metal thickness, blank holder force to be in two levels (0, 3000N) and sheet metal thickness to be in four levels (0.5, 0.6, 0.7, 0.8) mm. Perform a factorial experimental design in order to take high-level interactions. Develop a Finite Element Model (FEM) that represents the existing process in order to evaluate the quality of the inputs. Compare the two techniques (FEM and DOE) and analyze the results to get the proposed optimal set of parameters. Simulations are conducted on commercial FEM software package ABAQUS/Explicit. In their article, they show that, in order to minimize the burrs height, the clearance should be set at about 5 % with almost no blank holder force.

Ridha Hambli et.al [6], describes a methodology using the finite element method and neural network simulation in order to predict the optimum punch–die clearance during sheet metal blanking processes. A damage model is used in order to describe crack initiation and propagation into the sheet. The proposed approach combines predictive finite element and neural network modeling of the leading blanking parameters.

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