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Design and force analysis of sheet metal operations using press tool for plate leveler

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ABSTRACT

Sheet metal operations are commonly used for producing various components of automobiles and home appliances. This paper deals with a review of literature on tools used for sheet metal operations and their design and analysis. The objective of this paper is to study the various operations and tools used for sheet metal processes like blanking, piercing and forming etc. with their pros and cons. The comparison of results is discussed for various designs for compound tools and combination tools. On the basis of results the new combination tool will be proposed for plate leveler component used in domestic refrigerator. The combination tool can be used to carry out dual operations namely piercing and forming simultaneously. Presently the piercing and forming operations are carried out independently on separate machines by using separate tool in many of the industries. However, use of combined tool will reduce process time, operator fatigue and tool cost.

Keywords— *Sheetmetal, Press Tool, Force Analysis*

1. INTRODUCTION

Sheet metal shaping procedures are a basic piece of current industry since they take into account creation of excellent items with complex geometry at low assembling expenses. They make it conceivable to deliver a wide scope of the drawn parts, beginning from the little metal extravagant products over the vehicle body components to the huge basic components of air-or rockets. The greater part of them can be fabricated as the completed items without need for further machining. Innovative advancement in sheet-metal working outcomes from the for an expansion in efficiency and exactness of the drawn-parts. Sheet metal is having high strength and provides good surface finish. It is best economical for mass production. Sheet metal components are produced by blanking, piercing and forming operations. Blanking is a process of removal of a portion of a material from sheet metal of necessary thickness and width. Piercing involves making closed profile holes in sheet metal. The part sheared off from sheet became scrap whereas the part in which the hole is made is the work piece to be used. Forming is the process of deforming sheet metal work piece into desirable shape. However, in this process material is not removed from the work piece. The sheet metal processes are carried by using press tool. These press tools are classified into various types such as simple die, progressive die, compound die and combination die. The cost of tooling in sheet metal working contributes a substantial cost of producing part. Hence it is very essential to use proper combination press tool for most economical mass manufacturing of components.

2. PROBLEM IDENTIFICATION AND DEFINITION

At present some industries are performing all three operations blanking, piercing and forming on separate machines. Hence there is a scope to develop a combination tool for performing two operations at one stroke on single machine such as the combination of piercing and forming operation. Today customers are more and more quality & cost conscious. To satisfy the need of the customer any industry needs to adopt an effective approach towards the better process, which involves less cost to the company and also maintain or improve the level of quality. Now increasing number of companies are realizing that by applying new approach towards process concept they will be able to control the quality and cost.

(a) The expense of tooling in sheet metal enterprises contributes an extensive part to the general expense of assembling a segment. It is along these lines basic to hold down this expense by guaranteeing that the instrument works for a significant stretch underway without interference.
(b) From literature survey it is found that the use of combination tool for combined operation is most economical and essential for mass manufacturing component.

3. OBJECTIVES

(a) To study sheet metal operations.
(b) To design press tool for combined operation.
(c) Modelling and analysis of the tool.

4. LITERATURE REVIEW

Amol Bhanage, et al. [1] carried out design of combined press tool for shock absorber mounting using fundamental equations of die design they designed and manufactured die for Rear Engine Anti-Drive bracket (R.E.A.D) used for shock absorber mounting. They reported that this combined press tool result in and improved productivity with economical manufacturing process with lower cost of the product.

Anudeep S et al. [2] presented design and analysis procedure to develop blanking and bending press tool for anchor bracket component used in brake assembly unit of automobiles. He carried out design and modelling of press tool. Further punch and die analysis are done using Computer Aided Engineering (CAE) software. His result indicates that use of integrated computer aided design /computer aided engineering software result in better accuracy of design and design process time is reduced compared to traditional design method.

Bhatt Raghav H et al. [3] had developed combined tool for depression and piercing operations done in rim manufacturing plant. These operations are done for fitting the valve stem which protrudes out of the wheel for inflating tubes and tyres. This combination tool was implemented in rim manufacturing plant which resulted into reduction in rejection percentage, reduction cost per rim, reduction in toll down time etc.

Gaurav C Rathod et al. [4] carried out press tools to produce a particular component in large quantity, out of sheet metals. The completely different sorts of press tool constructions result in different operations particularly blanking, bending, piercing, forming, drawing, isolating and shaving etc. usually metals having thickness but 6mm thought of as strip. Sheets are considered as plate, if its thickness is above 6 mm. the applying of press operations are wide utilized in several industries like food process, packing, defence, textile, automobile, craft and lots of aside from producing trade. They have developed and analyzed the press tool to carry out piercing and notching operation combinedly. The combined press tool analysis show that it is compatible with existing mechanical press using separate tool for each operation.

Nilesh N. Patil et al. [5] carried out different types of metal forming operations such as stamping, punching, shearing and bending in which they studied shearing process which under comes perforating, lancing, notching, punching and parting etc. As forming processes are which undercomes roll forming, stretching, bending and drawing. Mechanical press used for sheet metal process in which they have studied sheet forming operations, press, punch or ram and set of dies. They carried out two common-die bending actions used such as V die and Wiping die. Here AutoCAD software and visual-LISP used for customization tools. Sheet metal forming characteristics of metal plays a key role in which they studied importance of elongation, yield point elongation, residual stresses, spring back and wrinkling.

Pawan Kumar Rai et al. [6] have identified various sheet metal processes which produce burr. e.g. blanking, punching, notching. They have used Pareto diagram which shows importance of controlling burr to reduce rejection. They have used cause effect diagram to find factor causing burr. The various factors identified are operator awareness, skill of operator, raw material grade and thickness. Press machine alignment etc and finally they concluded that taking care of all about factor will result in better part quality and tool life.

Pritam B. Bhawar et al. [7] has designed a progressive die for blanking, piercing process. Further he has carried out simulation for the blanking and piercing process. He reported that use of progressive die results in accurate component. Modelling of progressive die elements has done using AutoCAD software. The above progressive die was used on hydraulic press with the capacity of 250KN.However the actual capacity required was 237.08KN with factor of safety 1.25. Materials used in progressive die are Working Tool Steel (WPS), Mild Steel (MS), Oil Hardening Non-shrinking Steel (OHNS).

Pratik Phadnis et al. [8] studied completely different operation done on single setup of die enter single stroke, presently these operations are done on 3 separate setups that resulting in scale back the assembly rate and increasing cycle time with value in addition.

Ramegowda D et al. [9] studied press tool for producing sheet metal components in large volume by applying an external force with the help of a machine tool called press. Press apparatus activities were partitioned into cutting, non-cutting and crossover press activity. The parts fabricated utilizing this procedure and it gives high dimensional exactness subsequently vehicle segment, flying machine firm etc. The motivation behind doing investigation was to avert the expensive tryouts and along these lines the quality and pace of generation.

Ram Jogannavar et al. [10] studied a designing press tool to replace the process of horizontal milling. In horizontal milling process, for clamping and operational time required is more. So, with the help of a prèss tool they obtained increase in productivity. They studied raw material properties for die and punch in which chemical properties are carbon, silicon, vanadium and magnesium such as physical properties in which Poisson ratio, young modulus, shear modulus, thermal conductivity and specific heat. Press tool method is cheaper than milling process whereas cost can be saved per year by using press tool operation method rather than using horizontal milling process.

Rupali Chavan et al. [11] This paper related to industrial part in which they used progressive die which performs two or more operations subsequently in a single stroke. They used SolidWorks 2013 software for modelling parts 3d quick press. Design of progressive die comes underneath in which die clearance is different for different material such as for ductile material clearance is small and brittle material having large clearance. In this paper they executed Finite Element Analysis (FEM) and they got result of critical components of die wherein piercing punches, bending punches, bottom plate, top half plate and pillars, piercing blocks which are in acceptable range.

Subramanyam Pavuluri et al. [12] has carried out study of punch and its analysis carried out by using different materials such as mild steel, HcHcr and steel alloy with high carbon. In the analysis the efficiency of press tool is determined the defect such as punch cracking and die corrosion leads to inefficient interactions between the punch and the die which increases the damage of the press tool ultimately reflects increase in the cost. The Blanking operation is carried out on machine mechanical type. In mechanical type the press machines may be 1, 2, 3 ton etc. Analysis of punch for blanking operation is done by using solid works software.

Surabhi S.B et al. [13] studied experimental factors for tool life selection in which tool life and accuracy depend on variety of factors such as replaceable die, inserts and selection of material for tools etc. Unigraphics software program is used for modelling a progressive tool for Arc chute plate. The application of arc chute plate used for critical component (MCB) when short circuit overload condition. The experimental studies revealed new D2 steel which is a High Carbon High chromium steel resulted in tool life of 10 lac

components and old tool life of oil hardened nickel steel was 1 lac components.

Yatish G et al. [14] carried out that tool making is one of the trades, which requires detailed study, structural analysis and process before proceeding with any practical work. The success of any tool largely depends on the process analysis and design analysis of the tool

5. METHODOLOGY

Methodology is often represented as a framework that contains the elements of the work based on the objectives and scope of the project. a good framework will present the view of the project and be used to organize or extract the information simply. This includes the assorted steps concerned like literature study, design, testing part, etc.

(a) Identification of problem: Very first step is to identify and define the problem. For this, data collection regarding that specific work area is important. After identifying problem the definition and statement of problem is necessary which can clear the concept.

(b) Objective of project: Project objective describes the status that should be achieved at the end of project. It represents a data management in step with the 3 dimensions of magic triangle (quality, time and cost).

(c) Literature survey: A literature survey or review during a project report is that section that shows the assorted analyses and research created within the field of your interest and therefore the result is revealed, taking under consideration the various parameters of the project and therefore the extent of the project.

(d) Identification of process parameters: The parameters regarding press tool clearance between punch and die, tolerance, material , cost, stipper etc

(e) Trial runs to established range of parameters: For controlling the quality in established range of parameters trial runs are mandatory.

(f) Design optimization: Design improvement is an engineering design methodology using a mathematical formulation of a design drawback to support choice of the design style among several alternatives.

(g) Production of sheet metal: Sheet metal operations in which number of operations such as blanking, piercing and forming operations by press tool we do production that is used for day today life blades , automobile parts, aeroplane parts, refrigerators parts etc

(h) Result analysis: If the rejection percentage is more then again design rectification is done on that and the new design is checked by taking trials.

6. IDENTIFICATION OF PROCESS PARAMETERS

(a) Stage 1: Plastic Deformation The stock material has been placed on the die and the punch is driven towards the die. The punch contacts the stock material and exerts pressure upon it. When the elastic limit of the stock material is exceeded, plastic deformation takes place.

(b) Stage 2: Penetration As the driving force of the ram continues, the punch is forced to penetrate the stock material and the blank or slug is displaced into the die opening a corresponding amount. This is true shearing part in of the cutting cycle, from which the term "Shearing action" is derived.

(c) Stage 3: Fracture Further continuation of the punching pressure that causes fractures to start at the cutting edges of the punch and the die. Under proper cutting conditions, the fractures extended toward each other and meet. When this occurs, the fracture is complete and the blank or slug is separated from the original stock material. The punch then enters the die opening, pushing the blank or slug slightly below the die cutting edge.

(d) Stage 4: As the punch completes the down stroke up to the lower point, the component of slug is pushed through the die opening. Strictly speaking this action is a consequence of the dynamic fracture at the stage 3 and only in certain case the push through takes place where the punch takes place where the punch travels beyond the land of the die. This is the simplest approach on the shearing action. Before dealing with the details of the phenomenon, the attention is drawn on the same other allied factors which calls for deeper deliberations on the shearing process.

7. DESIGN OF BLANKING OPERATIONS

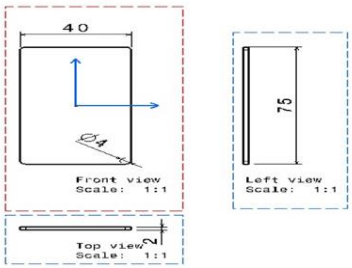

Fig. 1: Blanking operation

1. Shear Force Calculation

Shear Force = Length of cut × Thickness× Shear Strength

Shear Strength = 240 N/mm^2

Shear Force = 2 (L + B) × t × τ_{max}

= 2 (75 + 40) x 2 x 240

= 110400 N = 110.4 KN

2. Total Shear force

Total Shear force = 2 × Shear force = 2 × 110400

= 220800 N = 220.8 KN

3. Stripping Force

Stripping Force = 20% of total shear force

= 0.2 × 220800

= 44160 N = 44.16 KN

4. Press Force

Press Force = Total shear Force +Stripping Force

= 220800 + 44160

= 264960 N = 264.96 KN

5. Press tonnage /capacity

Press tonnage /capacity = Press Force/ Press Efficiency

= 264960/0.70

= 378514.28 N = 378.51 KN

= 38.58 Tons

Design Calculations for piercing operations plate leveler diameter 11.5

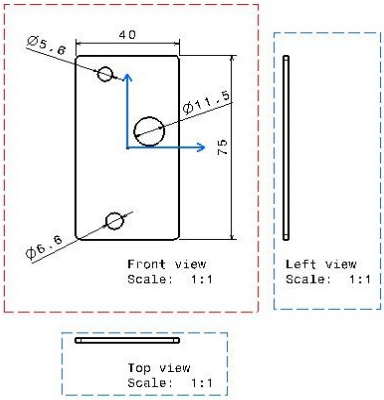

Fig. 2: Piercing operation

1. Shear Force Calculation

Shear Force = Length of cut × Thickness× Shear Strength

Shear Strength = 240N/mm^2

Shear Force = 2 x π × r × t x τ_{max}

= 2 x π × 5.75 × 2 × 240

= 17341.59 N = 17.34 KN

2. Total Shear force

Total Shear force = 2 × Shear force

= 2 × 17341.59

= 34683.18 N = 34.68 KN

3. Stripping Force

Stripping Force = 20% of total shear force

= 0.2 × 34683.18

= 6936.63 N = 6.9366 KN

4. Press Force

Press Force = Total shear Force + Stripping Force

= 34683.18 + 6936.63

= 41619.81 N = 41.61 KN

5. Press tonnage /capacity

Press tonnage /capacity = Press Force/ Press Efficiency

= 41619.81/0.70

= 59456.87 N

= 59.45 KN=6.06 Tons

Design Calculations for piercing operations plate leveler diameter 6.6

1. Shear Force Calculation

Shear Force = Length of cut × Thickness × Shear Strength

Shear Strength =240 N/mm^2

Shear Force = 2 x π × r × t x τ_{max}

= 2 × π × 3.3 × 2 × 240

= 9952.5655 N = 9.95256 KN

2. Total Shear force

Total Shear force = 2 × Shear force

=2 × 9952.5655

= 19905.131 N = 19.90 KN

3. Stripping Force

Stripping Force = 20% of total shear force

= 0.2 × 19905.131

= 3981.0262 N = 3.9810 KN

4. Press Force

Press Force = Total shear Force +Stripping Force

= 19905.131 + 3981.0262

= 23886.1572 N = 23.8861 KN

5. Press tonnage /capacity

Press tonnage /capacity = Press Force/ Press Efficiency

= 23886.1572 / 0.70

= 34123.08 N = 34.1230 KN

= 3.478 Tons

Design Calculations for piercing operations plate leveler diameter 5.6

1. Shear Force Calculation

Shear Force = Length of cut × Thickness × Shear Strength

Shear Strength =240 N/mm^2

Shear Force = 2 × π × r × t x τ_{max}

= 2 x π × 2.8 × 2 x 240

= 8444.60 N = 8.4446 KN

2. Total Shear force

Total Shear force = 2 × Shear force

= 2 × 8444.60

= 16889.2 N = 16.88 KN

3. Stripping Force

Stripping Force = 20% of total shear force

= 0.2 × 16889.2

= 3377.84 N = 3.3778 KN

4. Press Force

Press Force = Total shear Force + Stripping Force

= 16889.2 + 3377.84

= 20267.04 N = 20.26 KN

5. Press tonnage /capacity

Press tonnage /capacity = Press Force/ Press Efficiency

= 20267.04 / 0.70

= 28952.91 N = 28.95 KN

= 2.95 Tons

Design Calculations for forming operations plate leveler

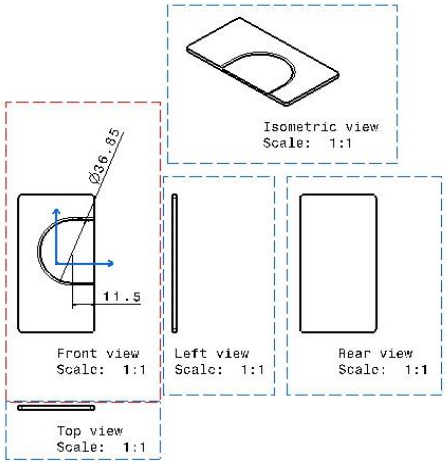

Fig. 3: Forming operation

1. Forming Force

Forming Force = t × h× S_{ut}/1000

= 2 x 28.5 x 400

= 22800 N = 22.8 KN

Forming Force=Component thickness (mm)×Forming length in X and axis (mm× Ultimate tensile strength) (N/mm^2)

= 2 × (34.2 + 28.5) × 400

= 50160 N = 50.16 KN

2. Pad Force

Pad Force = 25 % of forming force

= 0.25 × 50160

= 12540 N = 12.54 KN

3. Total Force

Total Force = Forming force + Pad force

= 50160 + 12540

= 62700 N = 62.7 KN

4. Press Selection

Press Selection = Forming Force/Press efficiency

= 50160 / 0.70

= 71657.14 N = 71.65 KN

=7.304 Tons.

8. CONCLUSION

During the visit to press tool components industry manufacturing plate leveler, determined that, at present the firm is using separate tool for piercing and forming operations on two different machines. It was decided to use combined tool for piercing and forming operations to manufacture plate leveler. Literature review on design & analysis of combination tool the is done. It was found, there is scope for developing

combination tool which will result into enhancing the productivity and saving in tool cost. Desgin calculations of force analysis for manufacturing of plate leveler component for blanking ,piercing and forming operations is presented in this paper.Further it is proposed to do simulation and analysis for combined tool for plate leveler.

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