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DESIGN AND SIMULATION OF DRAW DIE FOR FUEL FILLER CAP

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ABSTRACT

The plastic forming process of sheet metal takes an important place in sheet metal operation. The traditional techniques of tool design for sheet forming operations used in industry are experimental and expensive methods. In this study the work is focused on design of draw tool for cylindrical cup formation with the determination of forming results, punching force, blank holder force and the thickness distribution of the sheet metal which will help to decrease the design time and cost which will lead to reduce the production cost and time. In design, the concept of maximum varying blank-holder force (VBHF) over the punch stroke is used in order to eliminate cracks on deep drawn cup product, instead of using maximum constant blank-holder force. The constant blank holder force during the process is frequently not capable to prevent the crack effectively. With varying blank-holder force obtained using coil springs, the metal was easily flowed into the die flow ability through smaller blank-holder force at start, and then the blank-holder force is increased steadily to prevent excessive metal flow and wrinkling. Using integrated Computer aided design and finite element analysis approach the draw tool is designed. The design is validated by using features of Computer aided design -clash tests and kinematic simulation, running finite element analysis, verifying materials from standard die design hand-book and doing expert check. After validation the draw die is manufactured and tested on mechanical press for 50kN force. The output obtained from draw die is checked on co-ordinate measuring machine at various points on the surface to check the shape of output part produced.

KEYWORDS: Die, Press, Drawing, Blank, Sheet Metal, Forming, Strength,Punch

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I. INTRODUCTION

Drawing process has been an important manufacturing process to produce automotive parts of good strength and light weight. Sheet-metal forming processes are technologically among the most important metalworking processes. Products made by sheet-forming process include a very large variety of different geometrical shapes and sizes, like simple bend to double curvatures even with deep recesses and very complex shapes. Typical examples are automobile bodies, aircraft panels, appliance bodies, kitchen utensils and beverage cans. Sheet-metal forming processes are widely used in the manufacturing industry. It is usually involved in developing and building tools namely die and punch. Usually, tools are costly and the cycle time for building them is long. However, once die and punch are built, the tools can be used to produce a large amount of products. Therefore, sheet-metal forming is a simple and efficient manufacturing process. Great productivity and low production cost can be expected for commercial scale production. As mentioned that the flat sheet of metal is formed into a 3-D product by deep drawing process. The basic tools of the deep drawing process are blank, punch, die and blank holder.

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II. LITERATURE REVIEW

Chandra Pal Singh et al. This paper is highlighting recent research work and results in deep drawing. Deep-drawing operations are performed to produce a light weight, high strength, low density, and corrosion resistible product. These requirements will increase tendency of wrinkling and other failure defects in the product. Parameters like as blank-holder pressure, punch radius, die radius, material properties, and coefficient of friction affect deep drawing process. So a great knowledge of process is required to produce product with minimum defects.

Pradeep M Patil et al. This paper reports on the initial stages of a combined experimental and finite element analysis (FEA) of a deep drawing process. A deep drawing rig was designed and built for this purpose. Punches and dies of various geometries were manufactured. It has also been observed from the work to date that the speed of drawing plays an interesting role, in so far as, the higher is the speed the further is the draw, which is not entirely as expected.

Dipak Sudam Patil et al. Scope of Work: Evaluate the part design for draw ability. Review the existing die designs for similar components. Generate a General Layout of the Die for the subject part. Analyze the part for Draw operation using appropriate CAE software for Forming/Draw simulation. Interpret the results.

Kadhim M. Abed et al. In this research, the deep drawing dies are designed by using a "computer – aided designed calculating system" to save time and facilitate the design process. Also finite elements method (FEM) is used to simulate the drawing process to select the best die design. The computer aided design system, which was linked to drafting package (AutoCAD) to plot the deep drawing dies.

III. METHODOLOGY

❖ **ELEMENTS AND DESIGN PARAMETERS OF DRAW DIE**

BASIC DRAW DIE STRUCTURE

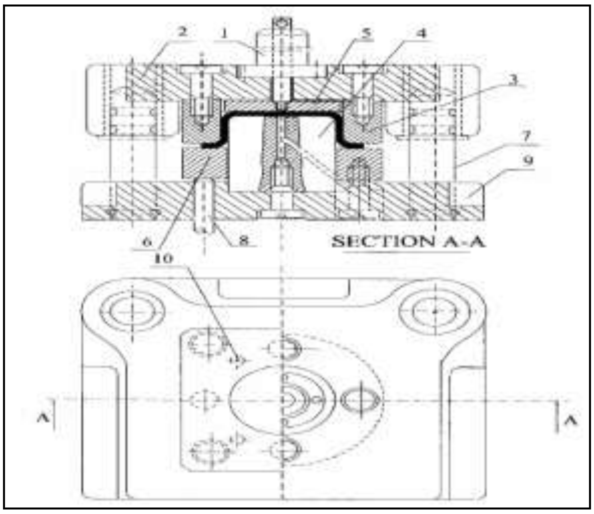


Fig. Layout of Draw Die

1. Shank- Shank is mounted on upper shoe for some mechanical press to connect upper shoe with ram.
2. Upper shoe - It is a part of the die, fixed to ram of the press with the help of clamping screw or shank. It moves along the ram and guided by guide pillar or wear plates mounted on lower shoe. It has cavity shape, as of the output component. The panel will flow in this cavity and take up the shape of cavity. The shape of the cavity and shape of the punch are same, only they have clearance which depends on the value of metal metal thickness. Upper shoe may be cast type or made up of steel plate based on the requirement of the design.
3. Die drawing ring – It is fixed on upper shoe with the help of screw and dowel. It has same shape of punch with clearance; the clearance value depends on sheet thickness and material of sheet. Inner edge of Die drawing ring which is contact with the sheet metal, has radius.
4. Punch -Punch has same shape of output component required from the die. It is mounted on lower shoe with help of screw and dowel. It is a rigid part. It forces sheet metal to flow in to cavity of die draw ring.
5. Upper pad – It is mounted on upper shoe with help of side pillar or safety screw or both. It has only one-degree of freedom along vertical direction; other degrees of freedom are locked by guide pillar or wear plate. It has pressure source such as gas spring, coil spring or elastic rubber. It holds the sheet metal before the start of operation by the force provided by pressure source.
6. Bank holder – This part of the die is mounted on lower shoe of the die. It has single degree of freedom in vertical direction. Its function is to hold the blank and provide necessary holding force for the drawing of the sheet metal. The force is provided to the blank-holder by coil springs or gas springs or cushions in the press. It is moves along the upper shoe, due to force of upper shoe.
7. Guide pillar– It is the guiding component used for the alignment of upper shoe and lower shoe during the operation. It is also used for the guiding of blank holder in the lower shoe.
8. Cushion pin– It is the source of force for the blank-holder. The selection of cushion pin is based on force required for blank-holder, travel of the blank-holder and space available.
9. Lower shoe - It is a part of the die, fixed to bolster of the press with the help of clamping screw. Lower shoe may be made by casting or made up of steel plate based on the requirement of the design. Various elements are mounted on the lower shoe like guide pillars and wear plate for upper shoe, guide pillars and wear plate for blank-holder, blank-holder, coil springs or gas springs for blank-holder, punch for drawing operation, bottom block etc.
10. Elastic stop – It is a pressure source of upper pad which provides force to hold the sheet metal at proper location before the start of deformation of

sheet metal, and it limits the displacement of upper pad in vertical direction.

IV. DESIGN CALCULATIONS

Input parameters-

Sheet metal (Input part) details-

Table 1 Material Details

Sr no	Parameter	Value
1	Material specification	EDD-513
2	Dimension	110mmX110mmX0.8mm thick
3	Ultimate tensile strength (S_t)	350 MPa
4	Yield strength (S_y)	165 MPa
5	Meananisotropycoefficient of the material (R_n)	1.46
6	strength coefficient of material(k)	501MPa
7	strain hardening exponential(n)	0.241

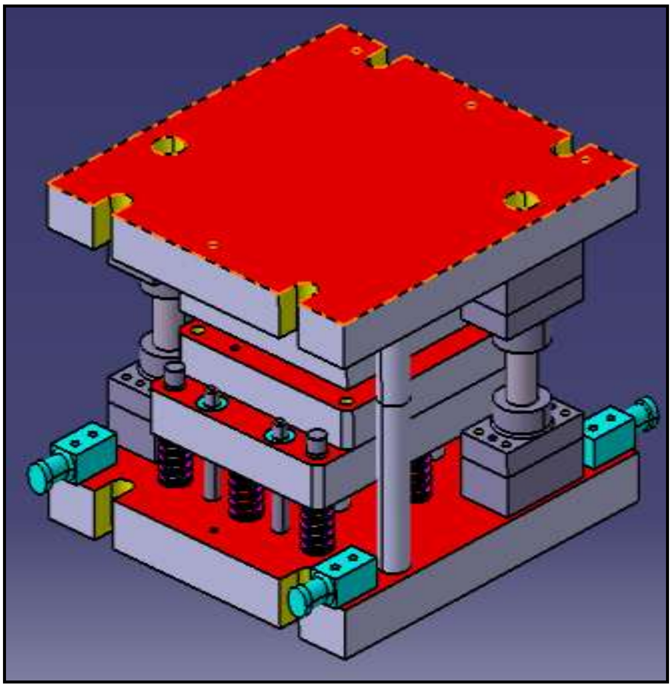
Press data –

- Shut height -340mm
- Clamping slot dimension-50mm (thick) X 30mm (width) X45mm (depth) for M28 camping bolt,pitch of clamp slots from center of press is 75 mm.
- Front to back maximum size -650mm
- Left to right maximum size-550mm
- Number of strokes per minute-20
- Make-union
- Maximum capacity-160 ton

DESIGN VALIDATION AND EXPERIMENTAL ANALYSIS

DESIGN VALIDATION

The design model is prepared using CATIA V5 CAD software



For the validation of design following points were considered.

Clash test –Using CATIA V5 CAD software, the feature clash test, is used to check the clashes of the elements of the die in die working condition.

Kinematic simulation - Using CATIA V5 CAD software the feature kinematic simulation is used to check the clashes of the elements of the die during the actual working stroke of the die.

Verification of the materials – the materials used for the various components of the die are checked against standards given in "**DIEDESIGN HANDBOOK**"of SME publication.

Finite element analysis- Main components of draw die were analysed for maximum compressive force of 50 kN.

Expert Check – the design was checked by team of Design engineer and the production engineer for the validation

EXPERIMENTAL ANALYSIS-

After the validation, the tool is manufactured and assembled on the basis of CADmodel, material selected, standard parts selected. The detailed drawing for machining and bill of material was issued to production planning department

Based on the CAD design and bill of material, die is manufactured

Fig Manufactured Draw Die.

The tool manufactured was tested on mechanical press for its function. Force of 50 kilo Newton was applied on the tool. The output obtained from the tool was tested on co-ordinate measuring machine for surface profile checking.

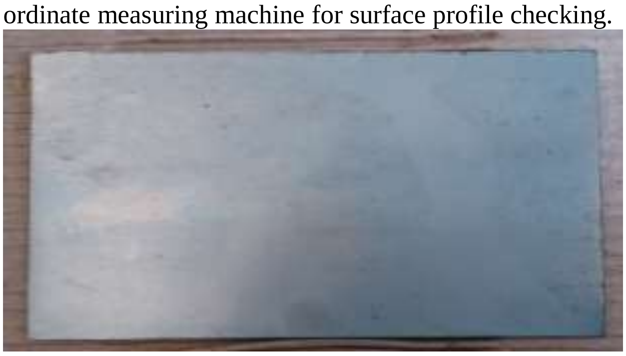


Fig Input Part

Fig Output Part with Variable Blank-Holder Force

V. CONCLUSIONS

Based on the project work following conclusions are drawn.

1. Using analytical formulae, we can calculate different parameters of draw die and forces for operation and verify them with Finite element analysis. This early prediction of parameters and forces avoids trial and error based experimental work which is costly and time consuming.
2. Use of variable blank-holder force instead of constant blank-holder force ,increases the formability of material, reduces the wrinkles on panel and improves the surface finish of the panel.
3. Use of analytical calculations and finite element analysis for the design of elements of draw die such as punch, blank-holder, draw steel etc. helps to predict the cause of failure of elements and provides way to improve the design. It also helps for the optimization of materials used for the elements of die.
4. Use of computer aided design helps to predict the possible clashes in the design .It also provides option of kinematic simulation to visualize the actual working of tool and find out if any errors are present.
5. From the C.M.M. report of the component produced on the machine

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