

Process of Press Tool Design and its Manufacturing for Blanking Operation

Subramanyam Pavuluri¹, B.Rajashekar², B.Damodhar³Assistant Professor, Department of Mechanical Engineering, MLR Institute of Technology, Dundigal, Hyderabad,
Telangana, India²¹U.G. Student, Department of Mechanical Engineering, MLR Institute of Technology, Dundigal, Hyderabad, Telangana,
India^{2&3}

ABSTRACT: Press tools are used to produce a particular component in large quantity, out of sheet metals where particular component achieved depends upon press tool construction and its configuration. The different types of press tool constructions leads to different operations namely blanking, bending, piercing, forming, drawing, cutting off, parting off, embossing, coining, notching, shaving, lancing, dinking, perforating, trimming, curling etc. Generally metals having thickness less than 6mm is considered as strip. Blanking is one of the sheet metal operations where we produce flat components of prerequisite shape. In Blanking the required shape periphery is cut and cut-out piece is called blank. The press tool used is for blanking operation is called as blanking tool, if piercing operation it is piercing tool and so on based on operation that we perform. The application of press operations are widely used in many industries like food processing, packing, defence, textile, automobile, aircraft and many apart from manufacturing industry. In this connection an attempt is made on to learn the press tool design, materials, manufacturing used for press tool and calculations involved in it. In this work, a real time design of a simple blanking press tool and manufacturing of a prototype is made along with analysis where the output is a circular piece having diameter of 20mm. The press machine is of mechanical type.

KEYWORDS: Blanking, Die Design, Manufacturing, and Analysis;

I. INTRODUCTION

High rate production industries generally use press machines. Thickness can vary significantly, although extremely small thicknesses are considered as sheet and above 6mm are considered as plate. Thickness of the sheet metal fed in between is called its gauge. Sheet metal is simply fed in between the dies of press tool for any press operation to perform. The reciprocating movement of punch is caused due to the ram movement of press machine. The press machine may be of electrical type, mechanical type, pneumatic type, manual type and hydraulic type. In today's practical and cost conscious world, sheet metal parts have already replaced many expensive cast, forged and machined products. The common sheet metal forming products are metal desks, file cabinets, appliances, car bodies, aircraft fuselages, mechanical toys and beverage cans and many more. Due to its low cost and generally good strength and formability characteristics, low carbon steel is the most commonly used sheet metal because high carbon composition gives high strength to the material. The other sheet metals used are aluminium and titanium in aircraft and aerospace applications.

The purpose of this paper is to examine the causes for these seemingly contradictory results. An attempt will be made here to review the previous studies to look into future possibilities of various die designs. The various authors considerations are taken into account with their presents in building up the work and their statements are as follows:

Mr. Amit D. Madake et.al.[1] He states that sheet-metal die is an inseparable constituent of the development process of any given automotive or consumer appliance. In most of the cases, this accounts for a high proportion in the tooling needs of the large size and structural member in any automotive like the chassis and the BIW.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

K.Kishore Kumar et.al.[2] explains that before converting raw materials to a finished product we need an accurate design of the product and also data required for manufacturing. If the design is not accurate then defects will occur in the manufactured product, small mistakes in designing a product makes the manufactured product useless so more amount time is allotted for designing new product. Gasper Gantar et.al.[3] states that the selection of most appropriate design and technological solutions to produce certain mould should capture technical performance economical issues as well as environmental impacts occurred during the mould life cycle. An approach is presented to support the selection of alternative mould design solutions in the early design stage. Sachin Ramdas Jadhav et.al.[4] He explains sheet metal forming problems are typical in nature since they involve geometry, boundary and material non-linearity. Drawings part involves many parameters like punch and dies radius, clearance, lubrication, blank holding force and its trajectories etc. So designing the tools for part drawing involves a lot of trial and error procedure. Vishwanath M.C. et.al.[5] He states that in this work the use of a software namely Pro/E for designing a progressive die to manufacture cup for the oil filter has been incorporated. A progressive die is a multiple station die. In this work authors have designed a progressive die which has two stages of operation. The former operation is piercing and is followed by blanking.

T. Z. Quazi et.al.[6] prescribes a model investigation the effect of potential parameters influencing the blanking process and their interaction. The blanking process optimization carried out by using Design of Experiment (DOE), Finite Element Method (FEM) with ANSYS Package, Simulation with ABAQUS-Explicit software, Blank soft Software and Neural Network Amol Totre et.al.[7] refers about forming processes employed in high volume production, blanking is one of the most widely used separation techniques. Still, analysis of blanking is mainly based on phenomenological knowledge.

Samadhan D. Bhosale et.al.[8] His aim is to apply the quality tools to find out the root causes of the quality problems related to manufacturing of mechanical seal. The modes of defects on production line are investigated through direct observation on the production line and statistical tools like Check sheets, Histogram, Pareto analysis, Cause and Effect diagram etc are used in enhancing the process by continuous monitoring through inspection of the samples. Jai Hindus S et. al.[9] He assists the die designer to design press tool dies for the online maintenance in the press itself and to reduce the tool failure due to the dynamic actions of the press tool in the press.

The press machines may be of 1 ton, 2ton, 3ton etc. based on the amount of tonnage acting on the sheet. For general specifications and diagram of press machine see Fig: 1 and Table.1 shown below:

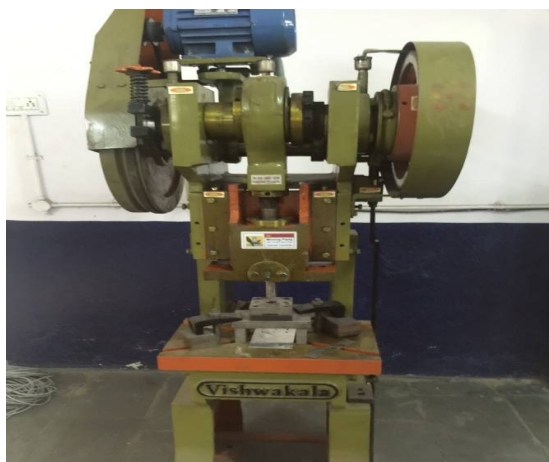


Fig: 1 Mechanical Press Tool Machine

Table.1 Specifications of 10 ton Press Tool Machine

SPECIFICATIONS	10 ton
Bed Size LR x FB(mm)	482x318
Bed to ram bottom(mm)	243
Bed to ram bottom(mm)	51
Adjustment of slide(mm)	25
Bloster thickness(mm)	67
Bed opening(mm)	100
Shank hole dia	32
No of strokes per min(mm)	735
No of strokes per min(S.P.M)	55
Motor power(H.p/R.P.M)	1.5/1440

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

Before design of tool it is necessary to understand the configuration of it and its components of press tool are in Fig: 2 The press tool consist of the punch , the die holder are used for fixing the die to the press machine. Die holder also used for supporting the rigidity of the die and its main function is to hold the punch. Backing plates are used at three locations in a die basically. It prevent the components to go deep inside the holder due to the force of press operation.

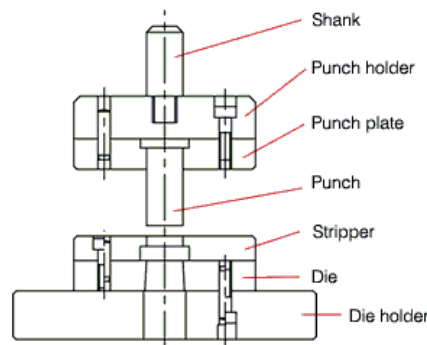


Fig: 2 Principle of Press Tool Die

Backing plates are also used for preventing the parts from getting detached and for adjusting the height of the die. A punch plate is used for the purpose of holding the punch during press operation. The main function of a stripper is to remove scrap, very frequently it is made to have important secondary functions of guiding the tip of the punch during press operation . Die plate determines the output of the press function and also the cutting is of sheet is done . For proper function clearance is left between the punch and die plate where the clearance depends on the sheet metal thickness and the type of material. The materials used for punches are powered high speed tool steel and punch dimensions determines the output of the press function. This paper is presenting the key factors and procedure involved in the manufacturing of blanking press tool and the procedure is below.

II. METHODOLOGY

(a) SELECTION OF MATERIALS

Press tools are generally made using HCHCr, Steel alloys with high carbon. But before that based on many factors like cost, strength, hardness, strain and many parameters selection should be made. The materials used are generally selected are D2,EN31.Mild Steel is used as supporting plate. Apart from that materials like D3, high carbide materials, chromium steels and high speed steels are also used. The properties of the materials used in the experimentation are tabulated below:

- (i) **En31:** EN31 is a high carbon Alloy steel which achieves a high degree of hardness with compressive strength and abrasion resistance that are acceptable for many automobile applications such as heavy duty gear, shaft, pinion, cam shafts. It is neither externally brittle nor ductile due to its lower carbon content and lower hardness. For properties of En31 shown in Table No.2, 3 and 4

(ii)

Table.2 Properties of En31

Chemical Composition (%)				
Carb on	Silic on	Manganese	phosphor ous	sulphur
0.18	0.35	1	0.05	0.05

Table.3 Physical properties

Melting point	Density
1421 ⁰ C	7.7 x 1000 kg/m ³

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

Table.4 Mechanical Properties and Thermal properties

Elastic modulus	Rockwell hardness	Izod impact	Thermal properties
190- 210 GPa.	62	77.0 J	Thermal expansion 10.4 x10 ⁻⁶ / °C

(ii) **D2 STEEL:** This alloy is one of the Cold Work, high carbon, high chromium type tool steels. D2 is a deep hardening, highly wear resistant alloy. It hardens upon air cooling so as to have minimum distortion after heat treatment. Used for long run tooling applications where wear resistance is important, such as blanking or forming dies and thread rolling dies. For properties of D2 steel as shown in Table.5 and 6

Table.5 Chemical composition

Chemical Composition (%)							
Carbon	Silicon	Manganese	Chromium	Sulphur	Phosphorus	Vanadium	Molybdenum
1.6	0.6	0.6	13	0.03	0.033	1.1	1.2

Table.6 Physical properties and Mechanical properties

Density	Rockwell hardness	Elastic modulus	Yield stress	Tensile strength	Melting point
7810 kg/m ³	65	215000N/ mm ²	450N/ mm ²	750N/ mm ²	1540 ⁰ C

After material selection is done we have to design the press tool according to the calculations shown below.

III. MODELLING

The materials used for making above blocks are mild steel and HCHCr. The material for the punch and the die block is HCHCr (EN31 and P20) whereas for base plate and guide block it is mild steel (H13 and EN8) . Punch and Die block should have high strength compared to base plate and Guide block. So high strength materials are used for punch and base. By comparison on many factors like strength ability, Machinability, thermal properties, load factor and cost factor EN31 and EN8 suits best. So EN31 selected for punch and base, EN31 for die and guide block.

a) Punch and Die Block

The main function of the punch is to strike the sheet metal, which is attached to the hub of the power press machine. The striking power is dependent on tons capacity of machine. The punch is fitted by means of tapering at its top locked by a nut. The dimensions of punch are and its drawing in AUTOCAD 2014 as shown in below drawings. The shape and dimensions of the product to be achieved depends on design of Die block. The product is of coin type shape with 20mm dia. Clearance should be there between punch and Die block, otherwise we cannot perform the operation. Clearance is given based on the thickness of sheet and it is about 10% of sheet thickness. If we consider sheet thickness as 2mm then positive tolerance should be given as 0.2mm for die block.

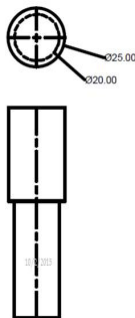


Fig: 3 Punch

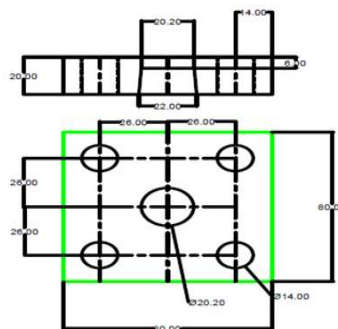


Fig: 4 Die Block

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

b) Guide Block and Base Plate

The Guide block is just a supportive block that acts as intermediate between the punch and the Die block. The main function is to oppose the Shear force and perform sheet metal operation. The drawing and dimensions is shown in Fig:5 for the guide block. The Base plate or bottom plate is placed at the end of the configuration where the work piece or scrap goes down. Here the punch moves down with high force, so in order to prevent the breakage of Die high strength material is used and placed as bottom plate. So base plate and punch are made of same material. The diagram and dimension for Base plate is shown in Fig: 6 below:

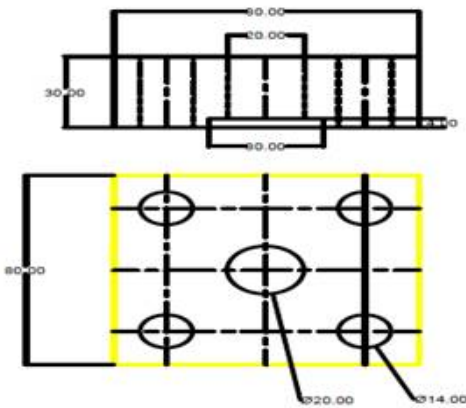


Fig: 5 Guide Block

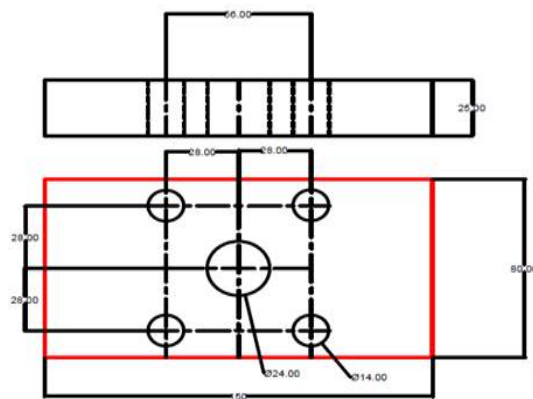


Fig: 6 Base Plate

c) ASSEMBLY

The assembly of all four parts including the screwing is shown below with front and top view:

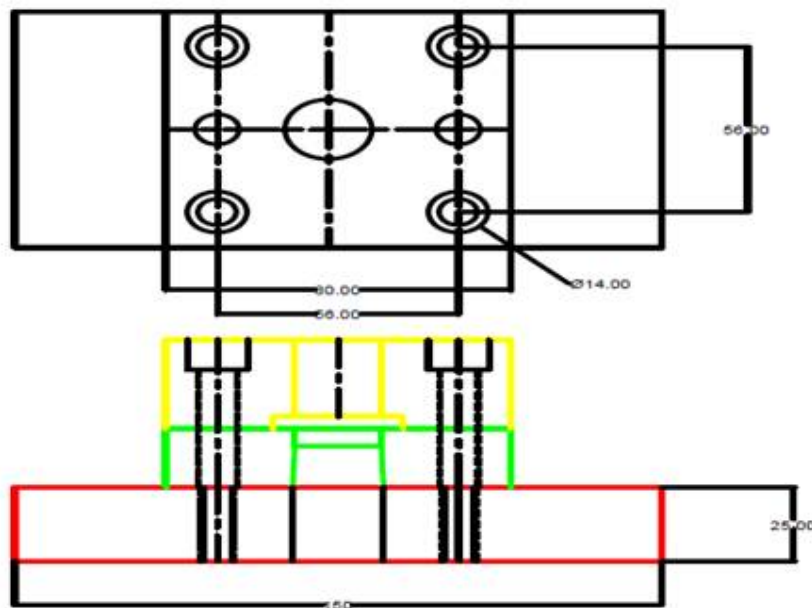


Fig: 7 Assembly Diagram

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

DESIGN CALCULATIONS

The strip layout is presented in Fig:8. The calculation is done on strip to find out the following steps

% of strip used = (Area of component x 4) / Length of strip x width of strip

Shear force = $(K \times L \times T \times S) / 1000 \text{ tons} = (1.5 \times 2 \times 3.141 \times 10 \times 0.5 \times 420) / 1000 = 1.97 \text{ tons}$

Where, K = 1.1 to 1.5 (constant based on clearance), L = length of cut in mm, T = thickness of cut in mm

- S = Shear strength of material in kg/mm^2
- Stripping force = 10% of shear force = 0.2 ton
- Net force = Shear force + Stripping force = $1.97 + 0.2 = 2.2 \text{ ton}$

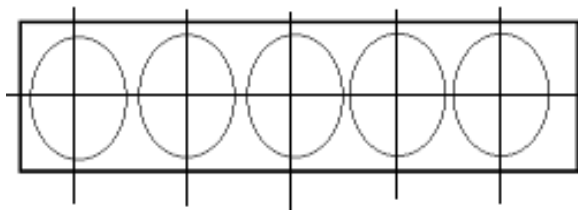


Fig: 8 Strips

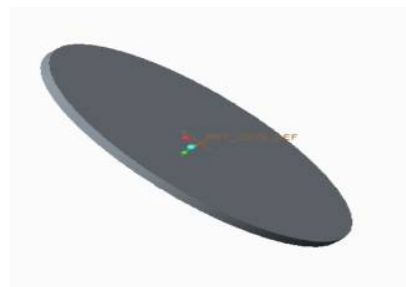


Fig: 9 Blank

The shear force, stripping force, net force and their respected values are as follows 1.97, 0.2, 2.2 tons

The blank is shown in Fig: 9 and the calculations for it is done as follows

Press tonnage = $1.2 \times \text{Total force} = 1.2 \times 2.2 = 2.64 \text{ tons}$

Thickness of die plate = $3\sqrt{Fsh} = 4.2 \text{ mm}$

Thickness of punch holder = $0.5 \times t_d = 0.5 \times 5 = 2.5 \text{ mm}$ (t_d = thickness of plate selected)

Similarly by substitution t_d values we get

Thickness of bottom plate = $1.5 \times t_d = 7.5 \text{ mm}$

Thickness of top plate = $1.25 \times t_d = 6.25 \text{ mm}$

Thickness of stripper plate = $0.5 \times t_d = 2.5 \text{ mm}$

Cutting clearance = $C \times S \times \sqrt{(T_{\text{Max}}) / 10} = 0.05 \text{ mm}$

C = 0.01 - 0.005 (for accurate)

S = Sheet metal thickness, T_{max} = Based on material property (Max Stress bearable) = 1000 N/mm^2

(Or)

Cutting clearance = 4% of sheet thickness

Blank punch size = Size of Blank die - 2c

C = 6% of thickness of wall

Cutting force = $\pi \times D \times t \times F_s = 3.14 \times 0.5 \times 20 \times 2.2 = 69 \text{ N}$

Based on the output product required the calculations are made and proceeded to manufacture. Before we perform machining operations the material is already heat treated in order to achieve soft material. For D2 material to become soft material Annealing should be done. In annealing process ($1550-1600^\circ\text{F}$) is heated and slowly cooled to about 1000°F . Now machining operations should be performed except finishing process. After machining Quenching (150°F cooled), Tempering (950°F), Hardened to ($1800-1850^\circ\text{F}$) to obtain hardened material. Then only finishing operations are to be done to achieve the tool. Machining operations include lathe operation and milling operation on CNC (Computer Numerical Control). The operations done on lathe are facing and turning. Apart from that we also used drilling machine

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

for the drilling of holes and tapping operation is also performed. Milling operation is performed in CNC and its program is below:

```
N10 G00 G90 X70 Y25;
Z1 S800 M3
N20 Z-5;
N30 G01 X20 F150;
N40 G00 Z100;
N50 X25 Y50;
N60 M30;
```

IV. ANALYSIS FOR PUNCH

Press Tool Efficiency

Press tool efficiency is lost through defects accumulating in press components. As the die significantly impact the overall efficiency of the press, defects the efficiency of the press tool. When defects arise, 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 costs. Hence, to avoid, or at least diminish, elevated energy costs, the implementation of an improved press tool design, consistent with the findings of this paper, should be considered. Meshing is shown in Fig: 10



Fig: 10 MESH

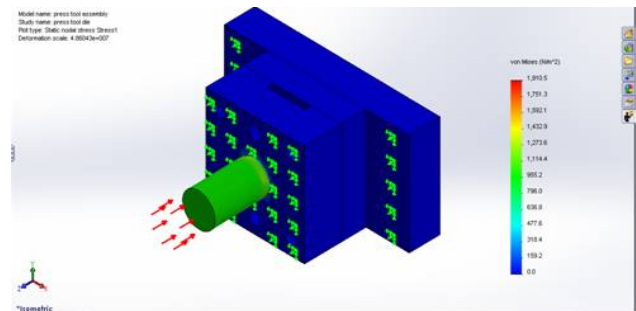


Fig: 11 Vonmises Stress

Stress analysis enables the designer to efficiently validate quality, safety, performance of the designed product. In fig: 11, 12 and 13

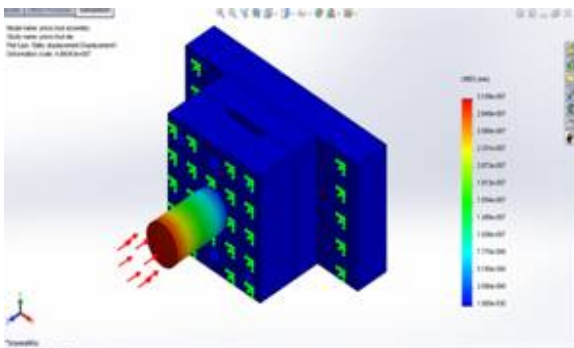


Fig: 12 Static Displacement

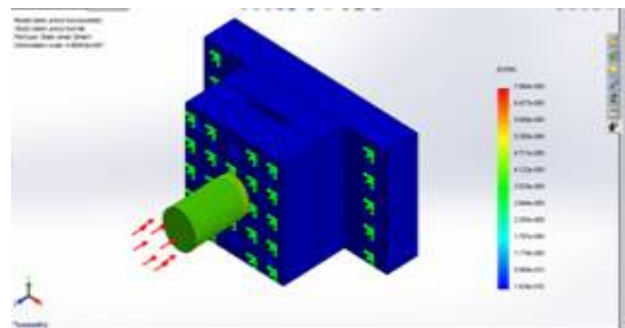


Fig: 13 Strain

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

By using the SOLID WORKS software the analysis is performed. In this software itself gets own parameters if we input the pressure value, selection of material. The result is:

The part deforms in displacements

The product is static and constant over time

The constant stress strain relationship in material.

V. CONCLUSIONS

Design of press tool for blanks made for sheet metal component has been developed by following the fundamental die design principles. The press tonnage required for the operation is below the capacity of the machine which exists. So it is suitable for its preceding press ton machine. Moreover the geometrical compatibility of the mechanical press and the designed combined press tool is excellent. The output received is

- Output product having diameter 20mm and its tonnage capacity is 2.2 tons. So it suits for above 2.5 ton press machines.

The tools generally made from steel alloys. Based on carbon composition they are classified in P type, D type, H type. of all D type is having more carbon percentage which indirectly possess more strength. They are mainly used for making of tools.

- The stress region in punch and strain displacement is found.

Therefore newly developed combined press tool is recommended in order to have an improved productivity, improved efficiency, better flexibility, more economical manufacturing process with lower cost of the product.

REFERENCES

- [1] Mr.Amit ,D.Madake, Dr.Vinayak, R.Naik, Mr.Swapnil, S.Kulkarni, "Development of a SheetMetal Component with a Forming Die Using CAE Software Tools (Hyper form) For Design Validation and Improvement", International Journal of Modern Engineering Research (IJMER) , Volume 3, Issue 3, May-June, 2013 , pp-1787-1791.ISSN: 2249-6645.
- [2] K.Kishore Kumar, Dr. A.Srinath, M.Naveen, R.D.pavan kumar, "Design of progressive dies", International Journal of Engineering Research and Applications (IJERA), ISSN: 2248-9622, Volume 2, Issue 3, May-Jun 2012, pp.2971-2973.
- [3] Gasper Gantar, Andrej Glojek, Mitja Mori-BlazNardin, MihaelSekavcnik, "Resource Efficient Injection Moulding with Low Environmental Impacts", Strojniški Vestnik-Journal of Mechanical Engineering, 59(2013)3,copy right 2013,Journal of Mechanical Engineering, All rights reserved.DOI:10.5545/sv-jme.2012.661 pp:193-200.
- [4] Sachin Ramdas Jadhav, Sunil Hiranman More, Swapnil S. Kulkarni," Die Design for Formed Component using inputs from FEA for determining the most suited values for the Design or Process parameter", International Journal of Advanced Engineering Research and Studies E-ISSN2249-8974 /April-June,2014/95-98.
- [5] Vishwanath M.C, Dr. Ramni, Sampath Kumar L , "Design of progressive draw tool", International Journal of Scientific and Research Publications, Volume 3, Issue 8, August 2013 ,1 ISSN 2250-3153.
- [6] Prof. T. Z. Quazi, R.S.Shaikh, "An Overview of Clearance Optimization in Sheet Metal Blanking Process", International Journal of Modern Engineering Research (IJMER) Volume 2, Issue.6, Nov-Dec 2012, pp-4547-4558 ISSN: 2249-6645.
- [7] Amol Totre, Rahul Nishad , Sagar Bodke, An Overview Of Factors Affecting In Blanking Processes" International Journal of Emerging Technology and Advanced Engineering, (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 3, March 2013).
- [8] Samadhan D. Bhosale, S.C.Shilwant, S.R. Patil , " Quality improvement in manufacturing processes using SQC tools" International Journal of Engineering Research and Applications (IJERA), ISSN: 2248-9622 Vol. 3, Issue 3, May-Jun 2013, pp.832-837.
- [9] Jai hindus S."Design and development of stamping dies for online maintenance" Vol. 9, No. 4, APRIL 2014, ISSN 1819-6608,ARPN Journal of Engineering and Applied Sciences,©2006-2014, Asian Research Publishing Network (ARPN), All rights reserved.
- [10] Hairulliza Mohamad Judi, Ruzzakiah Jenal and Devendran Genasan "Quality Control Implementation in Manufacturing Companies Motivating Factors and Challenges" ISBN: 978-953-307-236-4, (2011).
- [11] Dr. Taylan Altan, Selection of die materials and surface treatments for increasing die life in hot and warm forging" Paper no 644-FIA Tech Conference, April 2011.
- [12] Hakim S. Sultan Aljibori, Abdel Magid Hamouda Finite Element Analysis of Sheet Metal Forming Process" European Journal of Scientific Research. ISSN 1450-216X Vol.33 No.1 (2009), pp.57-69© Euro Journals Publishing, Inc. 2009.
- [13] Parikshit K patel, Prof. Vidya Nair, Ashish Patel, "PFMEA(Product failure model effect analysis) of Air duct and Manufacturing process to improve product quality," International Journal of Engineering and technology and Advanced Engineering(ISSN 2250-2459,ISO 9001:2008 Certified Journal, Vol 3, Issue 5, May 2013) pp:645-653.