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Modification in Forming Die to Overcome Manufacturing Process Limitation

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Abstract—Forming of sheet metal is common and vital process in manufacturing industry. Sheet metal forming is the plastic deformation of the work over an axis, creating a change in the parts geometry. Generally, there are two parts used in forming process; one of the part is punch which performs the stretching, bending and blanking operation and another is Die block which secularly clamps the workpiece and same operation as punch. Forming processes are particular manufacturing processes which make use of suitable stresses like compression, tension, shear, combined stresses which causes plastic deformation of the material to produce required shapes. During Forming process, no material is removed i.e. they are deformed and displaced. Some examples of forming processes are Forging, Sheet metal working, thread rolling, Electromagnetic forming, Explosive forming, rotary swaging, etc. Here the problem statement of the project is to combine these two parts design in one forming die which is now manufacturing separately on two different forming dies.

Index Terms—Forming Die, Die Design, Blanking Process, Importance of Material Selection;

1 Introduction

Sheet metal is simply metal formed into thin and flat pieces. It is one of the fundamental forms used in metal forming can be cut and bent into variety of different shapes. In sheet metal working there is different parameter like Sheet metal processing, Sheet metal forming process, Shearing processes, forming processes, Finishing processes. Shearing Process involves such type of process i.e. Punching, Blanking, Perforating, Notching, Lancing. Our Project totally depends upon the forming process.

Forming of sheet metal is common and vital process in manufacturing industry. Sheet metal forming is the plastic deformation of the work over an axis, creating a change in the parts geometry. Similar to other metal forming processes, bending changes the shape of the work piece, while the volume of material will remains same. In some cases forming may produce a small change in sheet thickness.

For most operation, however, bending will produce essentially no change in the thickness of the sheet metal. In addition to creating a desired geometric form, forming is also used to impart strength and stiffness to sheet metal, to change a part's moment of inertia, for cosmetic appearance and to eliminate sharp edges.

Forming processes are particular manufacturing processes which make use of suitable stresses like compression, tension, shear, combined stresses which causes plastic deformation of the material to produce required shapes.

During Forming process, no material is removed i.e. they are deformed and displaced. Some examples of forming processes are sheet metal working, thread rolling, electromagnetic forming, etc.

All sheet-metal forming processes can be divided into two groups:

A. Cutting process: Shearing, blanking, punching, notching, cutoff, shaving, trimming, parting, lancing.

B. Plastic Deformation process: Bending, twisting, curling, deep drawing, necking, ribbing, seaming.

Generally, there are two parts used in forming process; one of the part is punch which performs the stretching, bending and blanking operation and another is Die block which secularly clamps the workpiece and same operation as punch.

Application of sheet metal forming process are Car bodies, Aircraft fuselages, beverage cans and other appliances.

1.2 Problem Statement

To achieve more than one operation in a single stage with a single forming die with less variation in the manufactured part, so to eliminate the use of CNC bending machine.

1.3 Objective

1. To overcome excess use of time.
2. To achieve conservation of energy.
3. To reduce material use and waste, to increase efficiency.
4. To minimize manufacturing cost.

2 Methodology

2.1 Review Stage

1. Study of all the Process taking place in Industry
2. Study all the parts and processing on the Forming
3. Material Selection
4. Calculation of the Designing parameters
5. Design and Fabrication of forming die
6. Testing & Calculation
7. Result Analysis & Conclusion

2.2 Final Stage

Mechanical Press Tool Machine

Principle of Mechanical Pressing Machine: Pressing any metal for getting desired shape of product. Primarily this mechanical press transforms rotational force energy into translational force which in short leads an effective press as required.

The energy in a mechanical press comes from the motor. These types of presses are generally faster than hydraulic or screw presses, (actually the screw press may also be classified as a mechanical press). Unlike some presses, in a mechanical press, the application of force varies in both speed and magnitude throughout the distance of the stroke. When performing a manufacturing operation using a mechanical press, the correct range of the stroke is essential.
Mainly there are three types of Press machine:
1) Mechanical 2) Hydraulics 3) Forging

The die may be defined as the female part of the complete tool for producing work into the process. It is also referred to a complete tool consist of a pair of mating members for producing work in press.

Types of Dies:
The die may be classified according to the type of press operation and according tothe method of operation.
A) According to type of press operation:
1) Cutting Die: This die is used to cut the metal. The common cutting dies are: blanking, perforating, notching, trimming, shaving and nibbling die.

2) Forming Die: This die change the appearance of the blank without removing any stock. These dies include bending, drawing and squeezing etc.

B) According to the method of operation:
1) Simple Dies: Simple die performs single operation for single stroke of thepress slide. The operation may be cutting or forming.

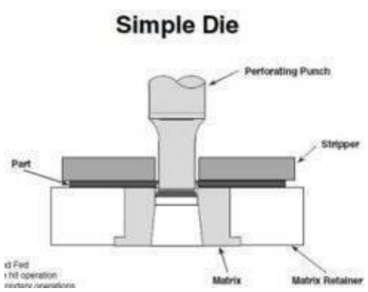

Fig.2.2.1: Simple Die

2) Compound Dies: In these dies two or more operation may be performed at one station. Such operations are considered as cutting, since only cutting operation are only carried out.

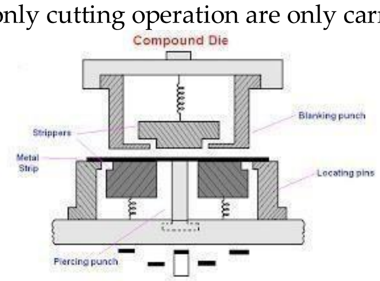

Fig.2.2.2: Compound Die

3) Combination Dies: In this operation also more than one operation can be performed at one station. It is difficult from this die in that in this die, cutting operation is combined with bending or drawing operation, due to that it is called as combinational die.

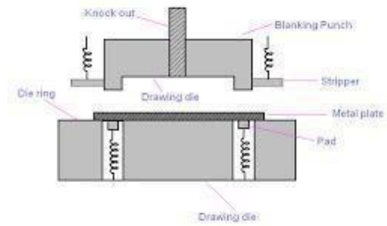

Fig.2.2.3: Combination Die

4) Progressive Dies: It has a series of operation. At each station, an operation is performed on a workpiece during a stroke of press. Between the strokes, piece of the metal sheet is transferred to the next station. A finished workpiece is made at each stroke of the press. While the piercing punch cuts the hole in the stroke, the blanking punch the blank out of the portion of the metal in which the hole has been pierced at each station. Thus after the first stroke, when only hole will be punched, each stroke of a press produces a finished washer.

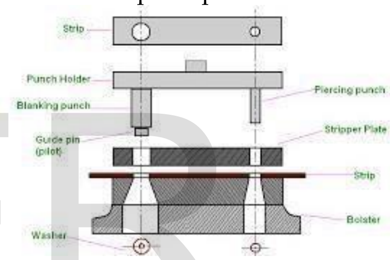

Fig.2.2.4: Progressive Die

5) Transfer Dies: Unlike the progressive dies, where the stroke is fed progressively from one station to another. In transfer dies the already cut blank are fed mechanically from one station to another.
In manufacturing industry, **Nesting** refers to the process of laying out cutting patterns to minimize the raw material waste. Examples include manufacturing parts from flat raw material such as sheet metal.
Such efforts can also be applied to additive manufacturing, such as 3D printing. Here the advantages sought can include minimizing tool movement that is not producing product, or maximizing how many pieces can be fabricated in one build season.
One difference from nesting of cut pieces is that 3D parts often have a cross section that changes with height, which can cause interference between adjacent parts as they are built up. To minimize the amount of scrap raw material produced during cutting, companies use proprietary nesting software. The software analyses the parts (shapes) to be produced at a particular time.
Using algorithms, it then determines how to lay these parts out in such a way as to produce the required quantities of parts, while minimizing the amount of raw material wasted. Off-the- shelf nesting software packages address the optimization needs. While some cater only to rectangular nesting, oth-

ers offer profile or shape nesting where the parts required can be any odd shape.

These irregular parts can be created using popular computer-aided design (CAD) tools. Most of the profile nesting software can read IGES or DXF profile files automatically, a few of them work with built-in converters. An important consideration in shape nesting is to verify that the software in question actually performs true profile nesting and not just block nesting. In block nesting an imaginary rectangle is drawn around the shape and then the rectangles are laid side- by side which actually is not profile nesting. There remains scope for waste reduction.

Nesting software must take into account the limitations and features of the machining technology in use, such as: ◎ Machining cannot take place where the raw material is clamped into place; ◎ Some machines can access only half of the material at a particular time; the machine automatically flips the sheet over to allow the remaining half to be accessed; When punching, the width of the punch tool must be considered; ◎ Shearing may be permitted only in certain areas of the sheet due to limitations of the machinery; Nesting software may also have to take into account material characteristics, such as: ◎ Defects on material that must be discarded; ◎ Different quality areas that must match corresponding quality levels required for different parts; ◎ Direction constraints that may come from a printed pattern or from fiber direction; Material may be cut using off-line blanking dies, lasers, plasma, punches, shear blades, ultrasonic knives and water jet cutters.

3 Material Selection

Material Selection is one of the most important parameter because we have to plan for any potential consequences that certain materials may present. Selecting the proper material may led to production rate and gives the project the best chance of success.

Materials preferably used for forming dies are:

1) HCHCR: HCHCR steel is Cold Work Steel with High Carbon High Chromium contents. The Quality with high wear resistant and toughness properties due to Vanadium addition of 0.90%. Normally it supply condition is an Annealed and will offer hardness to reach 57-59 HRC. It can be machinable in the annealed condition.

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2) OHNS: OHNS steel is a general purpose tool steel that is typically used in applications where alloy steels cannot provide sufficient hardness, strength and wear resistance. Chemical composition of OHNS is Carbon 0.94%, Manganese 1.2%, Silicon 0.30%, Chromium 0.50% and Vanadium 0.15% OHNS steel is a non-shrinkage steel.

3) EN31: EN31 is a quality high carbon alloy steel which offers a high degree of hardness with compressive strength and abrasion resistance. This EN31 was RM for wire cutting.

4) 20MnCr5: 20MnCr5 is an alloy steel, carburized steel, high strength and toughness, good hardenability. 304 stainless steel is a common material in stainless steel with a density of 7.93 g / cm3, also called 18/8 stainless steel in the industry. 20MnCr5 is used for materials with a required core tensile strength of 1000 – 1300 N/mm² and just right carrying resistance as boxes, piston bolts, spindles, camshafts, gears, shafts and other mechanical controlling materials.

5) EN8: EN8 steel bar or threaded steel bar is a tough-hardening medium carbon steel that is usually used for creating axles, shafts, gears, bolts, and studs. EN8 steel can be machined very simply. It can be flame or induction hardened to produce a good surface hardness with moderate wear resistance.

6) D3: D3 steel, also known as 1.2080 (Werkstoff), is an air hardening, high-carbon, high-chromium tool steel. It displays excellent abrasion/wear resistance and has good dimensional stability and high compressive strength.

7) D2: D2 steel is an air hardening, high-carbon, high-chromium tool steel. It has high wear and abrasion resistant properties. It is heat treatable and will offer a hardness in the range 55-62 HRC, and is machinable in the annealed condition.

8) SKD11: SKD11 Tool Steel is a high-carbon and high-chromium alloy tool steelthat is used for making long-life high-precision cold-work dies. SKD11 tool steel has good wear resistance and size ability after heat treatment

9) P20: P20 Mold Steel is a versatile, low-alloy tool steel that is characterized by good toughness at moderate strength levels. The steel is commonly used for plastic injection mold cavities and tooling and for die casting dies for zinc.

10) M.S: Steel is more resistant to corrosion. Mild steel can be further strengthened through the addition of carbon. The basic difference is that s/s has very little carbon and is alloyed with

chromium, nickel, molybdenum and other elements to improve its mechanical and chemical properties.

Sr.no.	Name of Parts	Material Used	Chemical Composition
1	Upper Plate	M.S.	Approximately 0.05% to 0.25% Carbon, 0.70% to 0.90% Manganese, Silicon maximum upto 0.40%.
2	Lower Plate	M.S.	
3	Razor Blade	M.S.	
4	Bush	20MnCr5	Carbon 0.20%, Manganese 1.25%, Silicon 0.25%, Chromium 1.15% and Sulphur <0.035%.
5	Pillar	20MnCr5	
6	Punch	OHNS	Carbon 0.94%, Manganese 1.2%, Silicon 0.30%, Chromium 0.50% and Vanadium 0.15%.
7	Die Block	OHNS	
8	Broaches	OHNS	

Table.3.1: Material Selection

4 DESIGN

The shape and dimensions of the product to be achieved depends on design of Die block. The dimensions of punch are and its drawing in CATIA V5 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 10mm 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 3mm then positive tolerance should be given as 0.3mm for die block. The 2-D Design of the material and 3D Design is very necessary of the design of the forming die.

4.1 2D Design

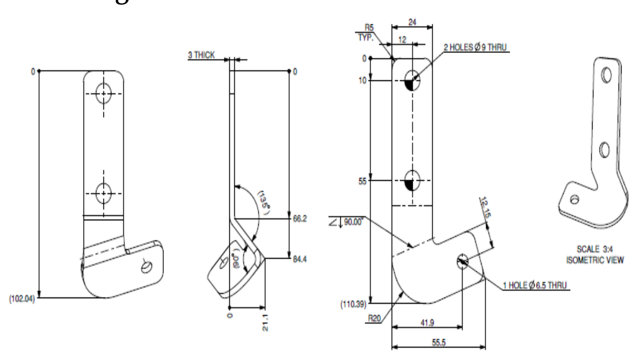

Fig. 4.1.1: 2D Part-1

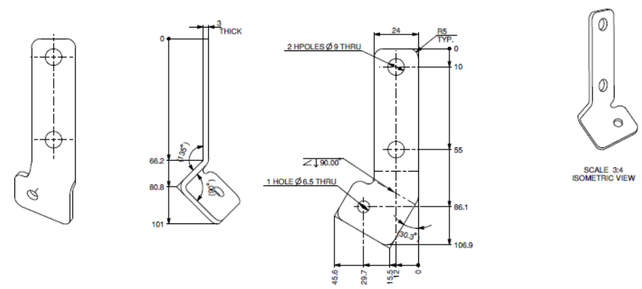

Fig.4.1.2: 2D Part-2

4.2 3D Design

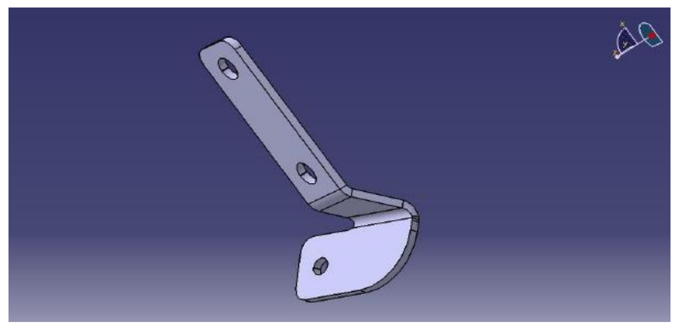

Fig.4.1: 3D Part-1

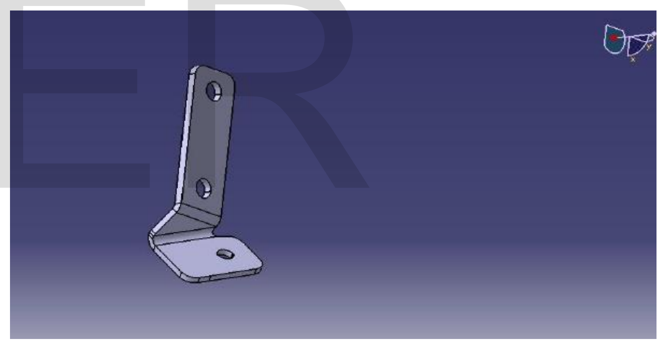

Fig.4.1: 3D Part-2

5 CALCULATIONS & EQUATIONS

5.1 Flow Chart for Design

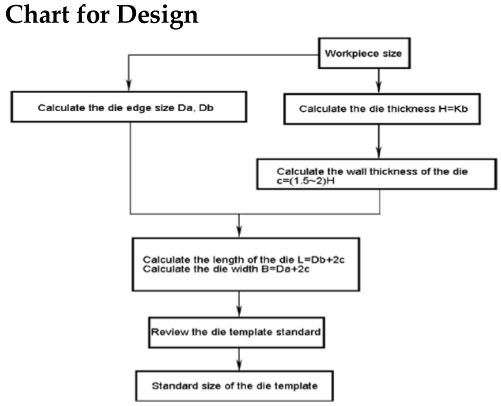

Fig.5.1: Flow Diagram for Design Calculation

According to the maximum external dimension of the workpiece, b = 254.1 mm

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According to the thickness of the material, t = 3 mm & K=0.4 then the dimension of the die can be calculated as follows:
H = Kb = 0.40 * 254.1 = 103 mm
Taking c = 30 mm (1)
Then: L = Da + 2c
= 74 + 90 + 2*30
= 224 mm B = Db + 2c
= 74 + 2*30
= 134 mm
This is the calculated external dimension of the die. Accordingly we know the actual die size should be:
= L*B*H
= 200*100*103 mm^3

5.2 Blanking Force: It refers to the pressure required when blanking. This refers to the maximum value during blanking.
Blanking Force F = KLTτ
F = Blanking Force L = Cutting Length
T = Material Thickness
τ = Material Shear Strength (**Shear strength** is the load along a plane that is parallel to the direction of the **force,** shear force could vary from 200-300 MPa, 1 Pascal is **equal** to 1.0E-6 **N/mm2**, or 1.0E-6 **MPa**.)
K = Safety Factor, generally K=1.3
Blanking Force = KLTτ
= 1.3 * 254.1 * 3 * 200
= 198.198 kN

5.3 Unloading Force: It refers to the force required to unload the workpiece or waste material from the punch and die.
Unloading Force = Kx * F
Kx = Coefficient of unloading force Unloading Force = Kx * F
= 0.03 * 198.198
= 5.94 kN

5.4 Thrust Force: It refers to the force required to push the workpiece or waste material in the blanking direction from the die.
Thrust Force = Kt * F
Kt = Coefficient of thrust force Thrust Force = Kt * F
= 0.045 * 198.198
= 8.91 kN

5.5 Ejecting Force: It refers to the force that pushes the product out of the hole of the die by counterpunching the direction of the die.
Ejecting Force = Kd * F
Kt = Coefficient of ejecting force
Ejecting Force = Kd * F
= 0.05 * 198.198
= 9.9 kN
No. of Blanks = Height of the die Orifice/Sheet Thickness
= 6/3 =2

5.6 Calculations of Nesting Process:
Size of strip layout is:-105*1250 (mm)
Input Weight = L*B*T*Density of Mild Steel (L length, B width, T thickness)
= 105*1250*3*(7.85*10^-6)
= **3.02 Kg**
Weight of part is 0.062 Kg and in one strip layout, 42 parts are made. So, Finish Product Weight = 0.062*42
= **2.23 Kg**
Finished Product Weight/ Input Weight= 2.23/3.02= **0.74**
i.e. in our project, we used **74%** of raw material.

6 3D Design of Forming Die

6.1. 3D Design of Punch & Die Block

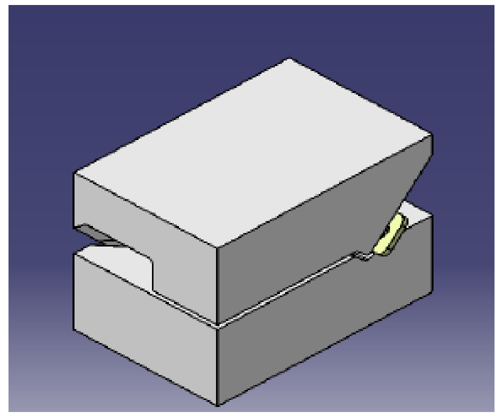

Fig.6.1: Punch & Die Block

6.2. 3D Design of Die Block& Punch Block

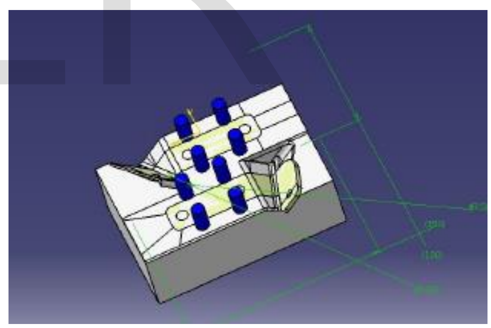

Fig.6.2.1: Die Block

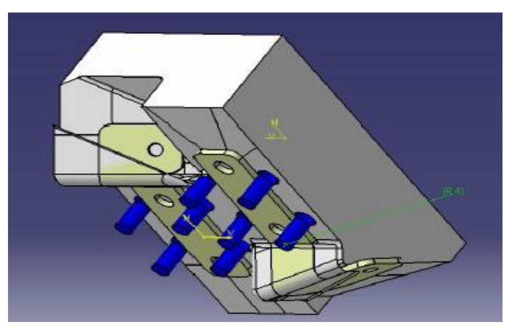

Fig.6.2.2: Punch Block

6.3 3D Design Dimension of Punch & Die

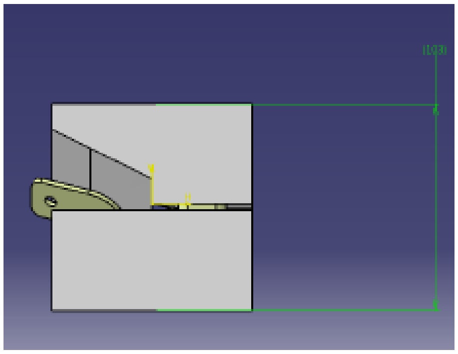

Fig.6.3.1: Dimension of Punch & Die

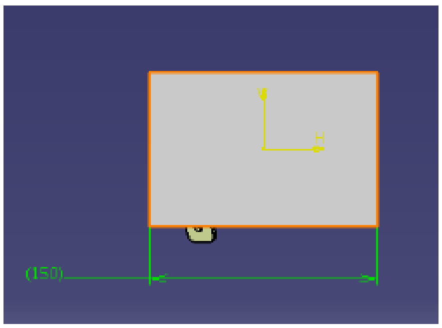

Fig.6.3.2: Dimension of Punch & Die

7 Result Analysis

7.1 Tentative Time Result:

Sr.no	Types of times	Time taken on CNC Bending for 100 Parts	Time taken on Press Tool Machining for 100 Parts
1	Setup Time	88	54
2	Inspection Time	5	8
3	Handling Time	3	2
	Total Time	96	64
	% change	Time reduced by 33.33% using Press Tool Machining	

Table.7.1:Tentative Time Result

7.2 Final Time Result:

Sr.no	Types of Times	Time taken on CNC Bending for 100 Parts	Time taken on Press Tool Machining for 100 Parts
1	Setup Time	88	47
2	Inspection Time	4	7
3	Handling Time	3	2
	Total Time	95	56
	% change	Time reduced by 40.63% using Press Tool Machining	

Table.7.2:Final Time Result

7.3 Reduced Time Chart Analysis

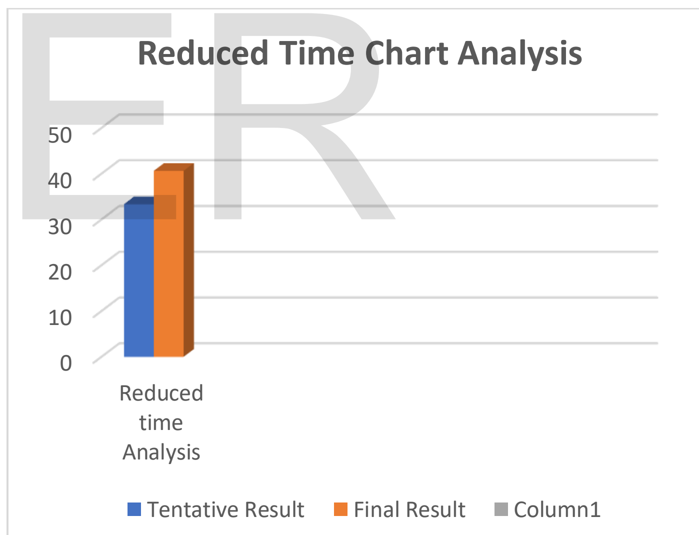

fig.7.3: Reduced Time Chart Analysis

8 Discussion

Sheet Metal Forming is one of the known, easy and most accurate process. In this project, we did get to know the classification of all the material that are used for the production of the forming die. We studied the properties of all the material needed for the forming die. We also studied Calculation of the Design of the forming Die and Nesting Process. We also got to use Testing equipment's like Height Gauge, Vernier Caliper, Micrometer, Radius Gauge, DFT meter, Bevel protractor, Snap Gauge, CMM, Thread Plug Gauge, & Fixtures. As this is Industrial Project we studied the work flow of the industry. We studied all the machineries working in the industry like M1TR, Lathe machinery, CNC, NC, VMC, Press Tool Machine.

There Working Capacity, Cutting Capacity, Traverses, Power, there Designing Parameters and more of all the machines. In this project also studied the types of Blanking Process forces applied on the workpiece through the die. We also studied all the types of dies used in the industries.

9 Conclusion

The main objective of the project is obtained with proper material selection so that life expectancy of forming die is increased. The Time Management of the whole process also plays major role in Multi-Operational Dies as now we have increased Production Rate with less manufacturing and transportation cost.We studied the Analysis of the forces on the sheet metal in the Blanking Process In these Project we studied different types of steel grades used for forming dies.

10 Future Scope

All the major Manufacturing Industrial Sectors are working on Press Tool Machining.Customers can be satisfied when time required for manufacturing parts will be reduced which led to decrease in the cost per part. Major Automobile sectors are focusing on design section for multi-operational dies. 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.

11Acknowledgment

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