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Failure Analysis of Press Tool

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Abstract- This study investigates the failure of a blanking die used to produce busbar connecting element parts on a mechanical press. During operation, the tool broke early than expected life. due to cracks. forming at the die center. This failure resulted in reduced production of the product. The analysis revealed high stress concentrations at the center of the die. These areas aim to identify the causes of the failure by studying the design closely and using finite element analysis with ANSYS software. A 3D model of the press tool was created by using NX software. The stress distribution is more where the cracks appeared in the failed tool. Poor clearance and design in the die increased these stress peaks. Recommendations are for improve press tool by adding same changes in design to reduce stress concentration, and improving material selection or heat treatment to improve toughness and fatigue resistance. That steps improve tool life, lower failure frequency, and enhance the reliability of busbar component element

Keywords— Press tool, Blanking operation, Crack in die, CAD model, Press tool analysis, Tool life, Manufacturing, Rubber Block in die.

I. INTRODUCTION

Press tool are important part of the manufacture industry, especially for high volume production of sheet metal components. These tools are used to cut, bend, form, or shape metal sheets into desired profiles with precision and consistency. In this project, the press tool is specifically used to produce busbar connecting elements, That use in electrical power distribute system like connecting busbar and ensure reliable electrical flow. Failures in press tools is cracking, premature wear, and dimensional inaccuracies directly affect production efficiency, quality, and overall operational costs. A single failure can cause machine downtime, delay deliveries and increase maintenance expenses. Therefore, study and analyzing such failures is crucial for improve tool life, optimizing manufacturing performance, for achieving better production. The present study focuses on failure analysis of a blanking press tool used for manufacturing component of busbar as connectors. The analysis involves understanding the causes

II. PROBLEM STATEMENT

The failure has observed in blanking press tool used for producing busbar connecting elements. The problem includes cracking at the die center it is get tool breakage. As shown in fig.

These issues lead to:
- Increased machine downtime.
- Reduced product quality and rejections.
- Higher maintenance costs.
- Increased frequency of tool replacement.

Blanking press tool failure
Hence, there is a strong need to identify the root causes of these failures, improve the design, and enhance the overall performance and life of the press tool.

Project Scope
The scope of project includes the complete analysis, design, simulation, and testing of a press tool used for busbar component manufacturing. The study is help the remove gap between theoretical tool design and practical performance under real working conditions.

III. LITERATURE REVIEW

A literature review is done with specific area for understanding the press tool design procedures according to standards, analysis, and the material for the die and other component in press tool. The different type research paper we study same are follow with their objective and result.

Gaurav C. Rathod et al.,[1] studied the combine piercing and notching operations into a single press tool to improve efficiency. That paper help for detail cutting-force calculations, optimum punch and die clearance, and material selection withstand forces from a 200-ton press. The big problem involves manage extremely high cutting forces, reducing tool wear for complex loading during piercing and notching.

Subramanyam Pavuluri et al.,[2] explore the entire process of designing a simple blanking tool to create a 20 mm circular blank. Material selection, die and punch design, strip layout, tonnage calculations, and stress analysis using SolidWorks to ensure safe punch behavior. Their findings show that the design operates safely below the stress limits and works efficiently on a 2.5-ton press. The paper has same challenges like tool wear, punch cracking, and die corrosion.

Chandranath M. et al.,[3] studied the blanking, forming, and bending processes with multi-stage press tool design. It is validated through simulation utilizing FEM analysis. The gasoline filter bracket operates safely because the Von-Mises stresses in the punch and die remain below the yield limits of D2 tool steels. Choosing the appropriate material to avoid tool failure under repeated loads, calculating forces for three operations are some of the challenges.

Sunesra Anees Asfak et al.,[4] this paper outlines a complete workflow from process planning to design, By using 3D modeling, analysis, and optimization. embossing, blank, pierce, and bend operations with a Compound die. The 3d simulation use to check stresses in punches, die. blocks and Belleville springs. That confirm components stay within safe stress limits. Their main contribution is optimizing the stripper plate and spring design to reduce tool size without losing strength. Challenges involve spring failure due to excessive stress, material shrinkage during embossing and the balancing compact design with safe load distribution in multi-operation dies.

Rupali Chavan et al.,[5] the studied design for a four-station progressive die using SolidWorks and 3D Quick Press for operations like cropping, piercing, and bending. They show force calculations, safe stress levels validated by FEM. The study confirms that model of progressive die deflection and stress limits ensuring dimensional accuracy and long tool life. Challenges include maintaining alignment across multiple stations, calculating exact bending forces, and min. material waste while keeping the strip layout cost effective.

Rakesh Lilhare et al.,[6] the studied press tool design is creating a bracket component that involves blanking and bending operations. The study includes develop strip layouts, calculating forces and design plate thickness based on shear forces. ANSYS analysis shows the deflection and stress in die plates that stay within allowable limits to confirm the structural safety of design. Challenges in managing high cutting forces, achieving a high level of dimensional accuracy for the bracket, and ensuring tool rigidity to prevent misalignment or excessive deflection.

Amit Jharbade et al.,[7] this paper analyzes the design and static structural analysis of press tools using the software ANSYS. The application of FEA helps in achieving optimization in geometry, stress analysis, and deformation analysis, which improves the performance of press tools. Previous studies indicate that the application of FEA improves efficiency and reduces costs.

Aniket Pagar et al.,[8] This study helps the design and development of press tools for the manufacturing of sheet metal components and a focus on compound dies that execute simultaneous blanking and piercing operations. Previous studies have shown that optimized design, material choice and proper clearance can all lead to higher productivity, lower costs, and fewer defects. It gives information about problems like stress concentration and burr formation, that shows how important it is to do accurate analysis and set up dies in a way that makes tools last longer and work better.

Hrishikesh Bhogade et al.,[9] this study reviews the design and development of press tools with the focus of improving productivity with SMED methods. Previous research projects investigated tool design, material selection and die analysis through the utilization of CAD/CAE tools. It talks about problems like tool wear, optimizing clearance and changeover time. The results show that optimized design and quick changeover strategies greatly improve efficiency in manufacturing, cut down on downtime, make a manufacturing more flexible overall.

Krishnaguru.P.P et al.,[10] this paper explores the design and manufacturing of press tools for blanking operations, emphasizing die design principles, material selection and process calculations. It shows how CAD modeling and finite element analysis can be used to measure stress, deformation and how well a tool works. The study focuses on optimizing clearance, force and tonnage to enhance efficiency, precision and tool longevity, thereby guaranteeing economical and superior sheet metal manufacturing.

In existing studies provide strong foundations in press tool design, force calculation, FEM simulation, and optimization operation process plan. The same research gap remains unexplained. Most of the papers focus on design individual or multi-stage press tools but not deep investigation into tool life prediction models, fatigue analysis, and real time wear monitoring under continuous industrial production. There is limited analysis on the change from fully blanking operation to half blanking operation, especially for small geometric sections behaving like cantilever beams critical for minimizing deflection and fracture. Optimization efforts on largely target area for stress reduction, material selection, strip layout efficiency, vibration control, and thermal effects during high speed operation. The better framework for integrating design, simulation, cost optimization, and in service tool performance is not available, that shows the need of smart and intelligent press-tool design methodology.

Objectives

- To study causes of press tool failure.
- To design a press tool.
- To simulate the press tool operation.
- To manufacture the press tool.

Material Selection

Select a proper material for design a press tool is first step. Because, the material properties are deciding press tool dimension to minimize cost for meet required performance of press tool target. The selected material is follows:

A.HCHCR (D2) Material

HCHCR, High Carbon High Chromium is also called D2 steel. It's a cold work tool steel containing high carbon is equal to 1.5% and high chromium is around 12%. Gives very high hardness typically 55–62 HRC, excellent wear, abrasion resistance and good dimensional stability after heat-treatment. It is air hardening, moderately machinable in its annealed state, and commonly used for punches, dies, shear blades, knives, slitting tools, and other applications requiring long life under abrasive conditions. It offers limited toughness and is not fully stainless despite its chromium content.

Mechanical Propertiecs of D2 steel:
Ultimate Strength is1020 N/mm2 .
Hardening Temp. is 790 -820 oC.
Wear Hardness is High.
Machinability is Poor.
Yield Stress is 450 N/mm2.
Tensile Strength is 750 N/mm2.
Maximum Hardness is 55 to 62 RC.
Chemical Composition of D2 Steel:
Carbon is 1.5 to 1.75%.
Manganese is 0.2 to 0.4%.
Chromium is 11%.
Tungsten is 0.4 to 0.5%.
Vanadium is 0.1%.
Analytical Calculation
Punching Area = 204 $mm2$
Blanking Area = 243 $mm2$
Punch and Die size:
c = k × t ×√(τmax/10) (For all side)
Here,
k = Const. = 0.01
t = Sheet thickness = 2 mm
(τmax = for HCHCR = 360 $N/mm2$)
c = 0.01 × 2 × √(360/10)
c = 0.12
Strip Layout and Economy factor:
Scrap(S) = 1.2 × 2 = 2.4 mm
Pitch(p) = 76 mm
Width(w) = 12 mm
Area(A) = 465 mm2
Number of Rows = N =1
Economy factor = (A×N)/(p×w)×100
= (465×1)/(76×12) × 100
= 50.98
= 51%
Die Clearance
Clearance per side = 0.12 mm
Die Calculation
Blanking operation,
= component size – 2 (clearance)
W = 12 – 2(0.12) = 11.76 mm
L = 73 – 2(0.12) = 72.76 mm
Piercing operation,
= component size + 2 (clearance)
length = 31 + 2(0.12)
= 31.24 mm
arc = 6 + 2(0.12)
= 6.24 mm
Cutting force fsh
Cutting force = L × s × τmax
Here ,
L = Perimeter of element in mm.
s = Sheet thickness in mm.
τmax = Ultimate τ of sheet in N / mm2.
L= 169.60 mm
s= 2 mm
τmax = 220 N/mm
Cutting force (f_sh) = 169.60 × 2 × 220
= 74,624 N
= 7,606.9317 Kg
Tonnage force on press
Tonnage force on press = 1.2 × fsh
= 1.2 × 7.607
= 9.1284 Tonnage
Tonnage force on press = 10 Tonnage
Stripping Force (f_st)
·: Applied force on strip
f_st = 10 % of cutting force
·: i.e., f_st on this case
f_st = 10 % of 74624
f_st = 7462.4 N

Strength of Bolt
Strength of Bolt = Stripping force/(No. of Bolts)
= 7462.4/4
= 1865.6 N per Bolt
Overall force required,
$f_t = f_{sh} + f_{st}$
Here,
fsh = Shear force
fst = Stripping force
So, Overall force(f_t) = 74,624 + 7462.4
= 82086.4
= 8.3676 Tonnes
= 9 Tonnes
Overall tonnage required for machine
Consider 20% FOS ,
$f = 1.2 \times$ Overall force
Overall tonnage required for machine
$= 1.2 \times 9$
= 10.8 Tonnes
= 11 Tonnes
Hence ,
Thickness of Die plate [Tdie plate]
= 3fsh
$= 3 \times 7.607$
$= 22.821 \approx 25$ mm
Thickness of Top plate
$= 1.5 \times$ Tdie plate
$= 1.5 \times 25$
= 37.5 mm
Thickness of knockout plate
$= 0.5 \times$ Tdie plate
$= 0.5 \times 25$
= 12.5 mm
Topside Punch Holder plate thickness
$= 0.75 \times$ Tdie plate
$= 0.75 \times 25$
= 18.75 mm
Bottom side Punch Holder plate thickness
$= 0.75 \times$ Tdie plate
$= 0.75 \times 25$
= 18.75 mm
Thickness of Bottom plate
$= 2 \times$ Tdie plate
$= 2 \times 25$
= 50 mm
Topside and Bottom side Back plate thickness
$= 0.5 \times$ Tdie plate
$= 0.5 \times 25$
= 12.5 mm
CAD Design
Connecting Element
Press tool Assembly
Die
Assembly of Press Tool
Analysis of Die
Boundary conditions
RED Colour :- Force in downward direction.(11 Tonnes)
Blue Colour :- Fixed support at side and bottom.
Material:- HCHCR.
Stress Analysis
Stress Results

Min. Stress	Max. Stress	Avg. Stress
8.8978e-002	13.029	2.621

Deformation Results
Deformation Analysis

Min. Deformation	Max. Deformation	Avg. Deformation
0	2.7901e-003	4.6847e-004

IV. PROBLEM CAUSES IDENTIFICATION

From the analysis and simulation, it was found that the cross-section of the die part was very small. Because of this, the die could not handle the heavy load properly during operation. The smaller section created more stress in that area, which made the tool weaker and occurs crack during the blanking process due repeated stress.

From this observation, it can be said that to improve tool life by the design should be slightly modified so that the stress is spread evenly across the tool. This will make the press tool stronger, reduce cracking, and increase its working life

V. CONCLUSIONS

This study investigates the failure of a blanking press tool used in manufacturing busbar connecting elements. Analysis of die by FEA simulation and identify excessive stress concentration at the centre of the die that cause of crack formation. Insufficient structural support increases the stresses during operation.

Redesign the die to increase cross sectional area and ensuring uniform stress distribution for improves tool durability. Material selection strategies can further reduce fatigue induced failures. By this improvement will increase press tool life, minimize production downtime, and enhance the overall reliability of the manufacturing process.

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