Analysis of die block

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ABSTRACT

In the metal formed industries die is an important tool for fabrication of metal formed product. At the same time failure of tool steel take place because of many numbers of causes and insufficient material selection criteria. Under this paper we have taken the three samples as die materials i.e. EN-31, D-2 and D-3 to find out the different causes of die failures. Main objective is to study the effect on the hardness of tool steel after heat treatment processes. In this paper we compare the present range and expected range properties of material. These terms providing a numeric value based on a compilation of data to quantify a failure rate and the resulting time of expected performance. The numeric value can be expressed using any measure of time, but hours is the most common unit in practice. Fracture surface displays typical ductile fracture, and the outer and inner surface of the part punched off is full of little bowings around which there are many micro cracks caused by the stretch stress under biaxial strain/stress state. This survey also helps to find out the failure mode appraisal in inner lower control arm and die with their preventive methods.

Keywords— Heat treatment, Hardness, Failure mode, Fracture, lower control arm.

I. INTRODUCTION

Metal forming is one of the manufacturing processes which are almost chip less. These processes are mainly carried out by the help of presses and press tools. These operations include deformation of metal work pieces to the desired size and size by applying pressure or force. Presses and press tools facilitate mass production work. These are considered fastest and most efficient way to form a sheet metal into finished products. Die design and manufacturing are important steps in metal-forming product development. Without suitable die, metal-forming processes are often crippled or rendered totally inefficient. To have the die which has long service life, the design and manufacture of die must be well conducted.

A. Industrial Need:

Currently, the industrial goal of the forming simulation is summarized in three main groups.

- **Time reduction:**
  - Early checking of producibility of work pieces
  - Reduction of the development times
  - Reduction of the try-out-times
  - Quick response to modification wishes

- **Cost reduction:**
  - Cheaper products
  - Reduction of die costs
  - Press down sizing
  - Increase of reliability

- **Increase of product quality:**
Optimal selection of the workpiece material
Production of more complicated parts
Know-how accumulation for new materials
Process repeatability

A. Press Tool:

Commonly used tools which are major components of press working are punches and dies. Punch is an important part of the system which is fastened to the ram and forced into the die where work piece to be processed is supported. Die is a work holding device, designed specifically for a particular design of a product. Die is rigidly held on the base of the press. Die carries an opening which is perfectly aligned with the punch and its movement. Both die and punch work together as a unit and this is called a die set. Punch and die both are made of high speed steel. Die is the part where strength and wear resistant both properties are required. So normally working surface of the die is made of satellite or cemented carbide. Tool steels are broadly divided into six categories like cold work, shock resisting, hot work, high speed, water hardening, plastic mould and special-purpose tool steels. Among them, cold work tool steels are the most important category, as they are used for many types of tools, dies and other applications where high wear resistance and low cost are needed.

During manufacturing and forming process cracking is a major problem, also at punch nose cracks are normally seen, the paper will focus on these areas and try to find best possible solutions for failure modes in an automobile inner lower control arm component.

C. Tool Steel Failures

Failures of punch in manufacturing operation generally results one or more of the following causes:
1. Improper design
2. Defective material
3. Improper heat treatment and finishing operations
4. Overheating and heat checking (crack caused by temperature cycling)
   4. Excessive wear
5. Overloading
6. Misuse
7. Improper handling

II. PROBLEM DEFINITION

A. Products:

The company organization is one of the most reputed organizations engaged in manufacturing and supplying of Sheet Metal Press Component and Engineering work fabrication, Press Tools and Jigs & Fixture which is established in the year 2007. Furthermore, they are also engaged in providing services to our esteemed clients like the Sheet Metal Auto Component. The team members look after the diverse needs of the clients and deliver the product as per their specifications. Some of the products and services offered by them are:

These products are manufactured under the guidance of some of the qualified and talented professionals. These professionals assure to deliver the products according to the needs of the clients and deliver them on time.

Jig & Fixture Manufacturer
Sheet Metal Automobile Components

Though the operation produces components the Die get damaged after 20-30 components. During forming process because of forces exerted in the press, failure of die block is a major problem, in lower control arm component of Bolero.
B. Problem background

![Fig 4 the Blanking and Cam Piercing Die](image)

Fig 4 the Blanking and Cam Piercing Die

![Fig 5 The die block is braking near the Ф 40mm hole due to punch force.](image)

Fig 5 The die block is braking near the Ф 40mm hole due to punch force.

![Fig 6 Die block of Cam Piercing Die](image)

Fig 6 Die block of Cam Piercing Die

C. Problem Definition:

The components of Lower Control Arms LH & RH have piercing, trimming and squeezing press operations. This operation is doing on Cam piercing die in the single cut by press tool. In the piercing operations, after 20-30 components the die gets damaged near the Ф40mm hole of die block. This failure occurs in die plate may be because of:

1. Material property
2. Force analysis
3. Design of Die

![Fig 7 breakage or failure in die block from design point of view, the critical areas of COMPONENTS ARE](image)

Fig 7 breakage or failure in die block from design point of view, the critical areas of COMPONENTS ARE

III. OBJECTIVES AND METHODOLOGY

A. Objectives

i) To analyse and prevent the defects in inner lower control arm and pinch nose failure.

ii) To optimize punch tool material so as to reduce the failure and improve MTBF.

iii) To analyse and reduce secondary issues which may lead to rejection of component.

B. Methodology

Methodology consists of application of scientific principles, technical information and imagination for development of new or improvised Inner lower control arm and punch to perform a specific function with maximum economy and efficiency.

The problem statement for the current project is to investigate the die failure by using material selection, Heat treatment method, and validate with experimental method.

C. Methods to Be Used

1. Flow process chart
2. Product and process FMEA
3. Cause and effect diagram
5. Experimental methods.

D. Cause and Effect Diagram

Some of the major factors leading to Punch failures are described below. Although these factors apply to make punch, many are also applicable.

![Fig 8 Fish bone diagram](image)

Fig.8 Fish bone diagram

1 Man- Common cause of punch failure is the failure of the operator or a programmable robot to remove a formed part from the die before loading it with another blank.
2 Material - The proper design of punch is as important as the proper selection of punch material. Punches may be made in segments and pre-stressed during assembly for improved strength.

3 Method - The proper handling, installation, assembly, and the aligning of punch are essential. Over loading of tools and dies can cause premature failure.

4 Machine - In punch and die assembly positioning of punch and punch back and bottom plate is important. At the same time alignment of punch and clearance between punch and die is necessary to avoid the wear.

5 Measurement - Punch are subjected to high stresses and high temperature during their use, factors which cause wear and (hence) shape changes. Punch wear is important because when the die shape changes, the parts, in turn have improper dimension.

6 Design - In order to withstand forces in manufacturing process, a punch must have proper cross-sectional and clearance. Sharp corner, radii, and the fillets, as well as abrupt changes in cross section, act as stress raiser and can have detrimental effects on punch life.

7 Measurement - Punch is subjected to high stresses and high temperature during their use, factors which cause wear and (hence) shape changes. Punch wear is important because when the die shape changes, the parts, in turn have improper dimension.

IV. SELECTION OF TOOL MATERIAL

A. Requirements of Good Tool Materials

The requirement wise choice of tool steels is important when punches are designed in order to insure good wear performance. Specifying more costly tool steel than is justified by punch wear requirements is wasteful.

1. That is readily machineable.

2. That it will resist stresses imposed in service without fracture.

3. Attractive for other purposes than pure tool applications. For this reason, tool steel is a better choice than construction or engineering steel for strategic components in the different industries.

4. Likewise, press tool parts that wear rapidly requiring downtime for replacement and high repair costs should be designed for good wear resistance.

5. The punch repair activity should carefully track punch repair costs as an aid to achieving the most cost effective tooling material and processing methods.

6. This information should be used to update the punch standards for each type of tooling. In this way, tooling dependability can be continuously improved and costs minimized.

Fig. 9 Graphical representation of Number of Pieces Vs Unit cost

B. Materials

1. D-2 and D-3: - Type D2 and D-3 are the High-carbon High-chromium tool Steels. The principal steels of wide application for long-run punch steels in this group. Grade D2 containing 1.50% carbon is of moderate toughness and intermediate wear resistance. Grades D3 contains additional carbon, which increases wear resistance, however, the toughness is somewhat lower. Selection between the grades is based on the length of run desired, machining and grinding problems. D2 containing molybdenum, are quenched in air and have low size change when hardened.

2. EN-31: - EN-31 is a high quality alloy steel giving good ductility and shock resisting properties combined with resistance to wear. This steel is basically known as bearing steel and used for bearing production in industrial sector. Grade en-31 contains carbon 0.92% carbon is of the medium strength and toughness with 1.42% chromium to lower the wear resistance properties of tool steel.

Table I

Chemical Composition of Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>C %</th>
<th>Si %</th>
<th>Mn %</th>
<th>S %</th>
<th>P %</th>
<th>Cr %</th>
<th>V %</th>
<th>W %</th>
<th>Mo %</th>
<th>Ni %</th>
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<tbody>
<tr>
<td>EN-31</td>
<td>0.9</td>
<td>0.2</td>
<td>0.3</td>
<td>0.00</td>
<td>0.0</td>
<td>1.4</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>D-2</td>
<td>2.3</td>
<td>0.4</td>
<td>0.2</td>
<td>0.00</td>
<td>0.0</td>
<td>12.0</td>
<td>1.0</td>
<td>0.0</td>
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<tr>
<td>D-3</td>
<td>1.5</td>
<td>0.5</td>
<td>0.3</td>
<td>0.00</td>
<td>0.0</td>
<td>11.0</td>
<td>0.0</td>
<td>---</td>
<td>1.0</td>
<td>5.0</td>
</tr>
<tr>
<td>D-4</td>
<td>1.5</td>
<td>0.5</td>
<td>0.3</td>
<td>0.00</td>
<td>0.0</td>
<td>11.0</td>
<td>0.0</td>
<td>---</td>
<td>1.0</td>
<td>5.0</td>
</tr>
<tr>
<td>D-5</td>
<td>1.5</td>
<td>0.5</td>
<td>0.3</td>
<td>0.00</td>
<td>0.0</td>
<td>11.0</td>
<td>0.0</td>
<td>---</td>
<td>1.0</td>
<td>5.0</td>
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Table II
Mechanical properties of materials

<table>
<thead>
<tr>
<th>Material</th>
<th>EN-31</th>
<th>D-3</th>
<th>D-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness/Dia. In mm</td>
<td>16.96</td>
<td>16.56</td>
<td>16.37</td>
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<tr>
<td>Area in mm²</td>
<td>226.00</td>
<td>215.47</td>
<td>210.55</td>
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<tr>
<td>Gauge</td>
<td>85.00</td>
<td>83.00</td>
<td></td>
</tr>
<tr>
<td>Length in mm</td>
<td>104.98</td>
<td>85.26</td>
<td></td>
</tr>
<tr>
<td>Final GL in mm</td>
<td>111.02</td>
<td>97.20</td>
<td>82.00</td>
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<tr>
<td>Yield load in KN</td>
<td>158.90</td>
<td>204.56</td>
<td>91.68</td>
</tr>
<tr>
<td>Ultimate Load in KN</td>
<td>491.23</td>
<td>451.11</td>
<td>413.77</td>
</tr>
<tr>
<td>Yield Stress in MPa</td>
<td>703.08</td>
<td>949.37</td>
<td>724.09</td>
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