Machining Performance Optimization For Minimizing Material Losses By Thickness Variation Method

Jayabalan C, Logesh M, Ramesh G, Selvam M, Palani S

Abstract: In this project a problem is identified and analyzed, modified and resulted. The problem identified in this project was thickness gets varied in mass production of brake linings which leads to various material losses during grinding operation. The thickness variation is mainly obtained during preforming and curing operation. In this project a problem is identified by various strategies of man, material and mould. Various analyses were taken on the strategies and concluded with a problem. The solution to the problem was obtained on the detailed study of the strategies and arrived with different alternatives. On that the best alternative is the designing of a plate which gives a permanent solution to the problem. In this project a plate is introduced in mould of performing machine to reduce thickness avoiding material losses. This project mainly deals with increase in productivity, time consumption and fulfilling customer satisfaction.

Keywords: Machining; optimization; material; designing; productivity; customer satisfaction.

1. INTRODUCTION

Raising the quality of work pieces is one of the most important objectives in modern production systems, which supervise technological processes in real-time (on-line) is a must to ensure their continuous operation with high efficiency and quality.[9] Preforming is a process of producing the required shape by hydraulic press. The mixture of raw materials is put into the performing mould and leveling is provided to even distribution of raw materials into the performing mould. The performing operation is carried out and the desired raw materials are converted into desired shape with some amount of thickness required. Next process to be carried is the curing operation where final thickness is obtained [9]. Curing is the process of obtaining a required shape by hydraulic press and workpiece subjected to heat treatment. The thickness produced during curing cannot be reduced to initial .The cured block is then subjected under oven and cooling is preformed and then subjected to finishing line where cutting, grinding, chamfering, wear marking are carried out and the final product with required thickness is inspected and packed. The objective of the project is to reduce the variation of thickness during preforming and curing by optimization [10] techniques. An improvement in machine output at required level of thickness. To reduce material losses and to improve productivity and to reduce cost for promoting improvement in process quality and employee morale.

1.1 Importance of this project

The lead to this project helps to reduce rejection parts per million. The overview of this project is to maintain a constant range over the preformed and cured work pieces leading to avoid excess grinding operations. Due to excess grinding some mechanical properties of the material get affected, hence thickness variation must be constant to reduce excess grinding.

1.2 Problems in excess grinding

The most significant are abrasive grain and bond wear phenomena, which are responsible for most energy AE impulses generation. Symptoms of wear of the abrasive grains and the bond are primarily abrasion and cracking. Bond bridges are mainly prone to cracking, while the abrasive grains are subject to a more complex process of wear.

II LITERATURE REVIEW

2.1 Introduction

This review is about the study of preforming machine [2] used for brake lining manufacturing process [3] and study on effect of mechanical properties on grinding [4].

2.2 Study of preforming machine

2.2.1 Press

A machine has stationary bed and a ram which has constant reciprocating motion towards and away from the surface of the bed and at right angle to it. The slide instructed in the frame of the machine to produce a definite path of the motion.

2.2.2 Bottom drive

Any press with the drive mechanism located within or under the bed connection of the drive to slides or slides are within or along the upright.
2.2.3 Mechanical presses

Mechanical presses utilize flywheel energy which is transferred to the workpiece by gears, cranks, eccentric or levers. Mechanical presses can be non-geared or geared, with single or multiple reduction gear drive, depending upon the press size.

2.2.4 Single action press

A single action press has one reciprocating slide acting against a fixed bed. Process of this type, which is the mostly widely used, can be employed for many different metal stamping operation including blanking, embossing, coining, and drawing. Depending upon the depth of draw, single action press often require the use a die cushion for blank holding. In such application, a blank holder, ring is depressed by the slide against the die cushion, usually mounted in the bed of the press.

2.2.5 Knockout

A mechanism for taking out work pieces from a die, also called ejector, pull out or lift out. Crossbars, cams motion, springs or air cushions are commonly used to work slide knock outs.

2.2.6 Pneumatic toggle links

The main links of toggle press which are equipped with pneumatic cushions and a link to give air pressure controlled flexibility. These links compensate for thickness variation under the blank holder and also can be adjusted to exert different pressure at any corners of the blank holders.

2.2.7 Bolster plate

A Plate fixed on the top of the press bed for location and supports the die assembly. It usually has 7slots for attaching the lower die or die shoe .Motion to bolster plates on self energized for transferring dies in and out of the press for die fixing. Also called rolling bolster, they may be integral with or placed to a carriage. They are not to be collapsed with reciprocating bolster, the purpose of which is moving the lower die in and out of the press for feeding work pieces.

2.2.8 Cushion

An accessory for a press which provides a resistive force with motion required for some operation such as blank placing part, drawing or redrawing, maintaining uniform pressure on a work pieces and knocking or stripping also called pads or jacks. Although usually mounted in or under the press bed. They are also on the slide.

2.2.9 Slides

The pertinent reciprocating member of press, instructed on the press frame to which the punch or upper die is fastening, also called the ram. The inner slide of a double action press is called the plunger or punch holder slide. The outer slide of a double action press is called the blank holder slide.

2.3 Study of mould

Mould is a hollow form of rectangular bracket in which the work pieces are performed. The mould consist of two dies one is male die in which is connected to the ram and other female die is placed inside the mould.

2.3.1 Tool plate of female die

Tool plate is a plate which carries the mixture and when pressured by top force of ram produces the work pieces.

2.3.2 Vent gap

Vent gap is provided in the mould for free air to pass through.

2.3.4 Clearance

The distance between the tool and the mould surface is known as clearance. The clearance is provided for free movement of the tool to move vertically. The clearance value should be within 0.25 +/- 0.1

2.3.5 Bottom portion of mould

The bottom portion of the mould has a hole in which ejection pin are provided.

2.4 Study on effect of mechanical properties of excess grinding

Generally, the grinding processes[4],[11]are diagnosed through multi parametric measurements: the force components (normal and tangent), grinding power, vibration, surface temperature, acoustic emission, etc. The most significant are abrasive grain and bond wear phenomena, which are responsible for most energy AE impulses generation. Symptoms of wear of the abrasive grains and the bond are primarily abrasion and cracking. Bond bridges are mainly prone to cracking, while the abrasive grains are subject to a more complex process of wear. The figure 1 shows the effect of mechanical properties.

Figure 1: Effect of mechanical properties

The feed [14] is responsible for deflections in the work piece of the abrasive tool (in the machine-workpiece-tool system), as well as depends on the bluntness of the grains on the surface of the abrasive tool.

III PROBLEM IDENTIFICATION

The problem arises from the clearance value. Hence clearance value must be reduced to the required limit. Since clearance value is allowed to 0.25+/-0.1 limit and thickness allowed to 40±2 mm. The powdered raw material mixture travels along the clearance gap during vertical movement of tool (i.e) radius plate. Due to such problem the raw materials gets deposited on the bottom of the mould hence staging of mixture on the bottom of the mould.
mould the radius plate gets a little tilted when resting on the spilled mixture on the bottom portion of the mould resulting thickness variation. The thickness after performing should be around 40±1 and curing thickness should be around 21±1. The figure 2 shows the cut section of the perform mould and figure 3 shows the powdered mixture deposited on the bottom portion of the mould.

Figure 2: cut section of preform mould

Figure 3: mix deposition

3.1 Solution to the problem:

The problem is solved by implementing a I shaped rectangular plate screwed to the bottom portion of the mould. By this implementation the spilled mixture gets deposited on the slides of the I-plate. The plate I is provided with 20mm clearance on all sides of the plate with respect to the mould. Hence is reducing the thickness variation. The spilled mixture is cleaned every month once. Hence thickness variation is reduced in preforming machine.

IV DESIGN AND ANALYSIS

The figure 4 gives the design [5] of the I shaped plate and figure 5 shows the analysis of I plate and figure 6 shows the analysis of I shaped plate with radius plate.

Figure 4: Design of I plate

Figure 5: Analysis of I shaped plate

Figure 6: Analysis of I shaped plate with radius plate

V DESIGN CALCULATION

D=370 mm, d=250 mm, B=140mm, b=80 mm
Poisson ratio $\mu = \frac{1}{m} = 0.27$
Young’s modulus $E = 199.95 \times 10^3 $ N/mm$^2$
P=F=200 Tonnes $= 200 \times 1000 \times 9.81$
$= 1.962 \times 10^6 $ N

$L = \frac{PL}{AE}$

$= \frac{1.962 \times 10^6 \times 370}{36800 \times 199.95 \times 10^3}$

$L = 0.09865 mm$

Strain $\epsilon = \frac{L}{L}$

$= \frac{0.09865}{370}$

$= 2.66 \times 10^{-4}$

Stress $\sigma = \frac{P}{A}$

$= \frac{1.962 \times 10^6 \times 6}{36800}$

$= 53.3152 N/mm^2$

$E = 2G(1+\mu)$

$199.95 \times 10^3 = 2G(1+0.27)$

Modulus of rigidity $G=78.720 \times 10^3 N/mm^2$

$E = 3k(1-2\mu)$

$199.95 \times 10^3 = 3k(0.46)$

Bulk modulus $K=144.891 \times 10^3 N/mm^2$

Calculation of maximum shear stress

Assume shear force F=1 KN
To find centre of gravity

Since the section is symmetric about its x-x axis the center of gravity is half the depth of the section.

\[ CG = \frac{370}{2} = 185 \text{ mm} \]

To find moment of inertia

\[ I = I_1 + I_2 + I_3 \]

\[ I_1 = IG_1 + A_1H_1^2 \]

\[ = bd^3/12 + A_1H_1^2 \]

\[ H_1 = 185 - (60/2) = 155 \]

\[ = 140 \times 60^3/12 + 8400 \times 155^2 \]

\[ I_2 = IG_2 + A_2H_2^2 \]

\[ H_2 = 60 + (250/2) - 185 = 0 \]

\[ I_2 = 104.16 \times 10^6 \text{ mm}^4 \]

\[ I_3 \text{ since symmetry about} x-x \text{ axis} \]

\[ I = I_1 + I_2 + I_3 \]

\[ = (204.330 \times 10^6) + (104.16 \times 10^6) + (204.330 \times 10^6) \]

\[ I = 5.12 \times 10^8 \text{ mm}^4 \]

Shear stress in the upper flange with web[7]

\[ \sigma = \frac{F_1}{A_1} \]

\[ \sigma = 185 \times (60/2) = 155 \]

\[ q = 1000 \times 8400 \times 155/((5.12 \times 10^8) \times 140) \]

\[ q = 0.01816 \text{ N/mm}^2 \]

Shear stress in the web with upper flange[7]

\[ \sigma = \frac{F_2}{A_2} \]

\[ \sigma = 1000 \times 8400 \times 155/((5.12 \times 10^8) \times 80) \]

\[ q = 0.03178 \text{ N/mm}^2 \]

Table 1: Thickness before and after implementing

<table>
<thead>
<tr>
<th>S.NO</th>
<th>(BEFORE)</th>
<th>(AFTER)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LH</td>
<td>RH</td>
</tr>
<tr>
<td>1</td>
<td>39.00</td>
<td>44.00</td>
</tr>
<tr>
<td>2</td>
<td>40.00</td>
<td>45.00</td>
</tr>
<tr>
<td>3</td>
<td>40.00</td>
<td>44.00</td>
</tr>
<tr>
<td>4</td>
<td>41.00</td>
<td>46.00</td>
</tr>
<tr>
<td>5</td>
<td>40.00</td>
<td>41.00</td>
</tr>
<tr>
<td>6</td>
<td>39.00</td>
<td>43.00</td>
</tr>
<tr>
<td>7</td>
<td>41.00</td>
<td>43.00</td>
</tr>
<tr>
<td>8</td>
<td>42.00</td>
<td>43.00</td>
</tr>
<tr>
<td>9</td>
<td>40.00</td>
<td>44.00</td>
</tr>
<tr>
<td>10</td>
<td>41.00</td>
<td>44.00</td>
</tr>
<tr>
<td>Min</td>
<td>39.00</td>
<td>41.00</td>
</tr>
<tr>
<td>Max</td>
<td>42.00</td>
<td>46.00</td>
</tr>
<tr>
<td>Avg</td>
<td>40.36</td>
<td>43.70</td>
</tr>
<tr>
<td>Range</td>
<td>3.00</td>
<td>5.00</td>
</tr>
</tbody>
</table>

The maximum shear stress lies in neutral axis since beam is symmetric about x-x axis therefore maximum shear stress of the beam[7]

\[ q_{max} = \frac{F_1}{A} \left[ \frac{B}{D} \left( D^2 - d^2 \right) + d^2 \right] \]

\[ = 1000/(8 \times 5.12 \times 10^8) \times [140/(80(370^2-250^2)+250^2)] \]

\[ q_{max} = 0.047 \text{ N/mm}^2 \]

VI FABRICATION

The material chosen for I shaped plate is EN 31 which is a good wear resistant material. A rectangular bar of area 370*140 is taken and exact dimensions of I plate are marked and fabricated to the desired shape. Next stage of process is drilling a counter bored shaped hole with specified dimensions over the I shaped plate. The figure 7&8 shows the finished I shaped plate inserted into the perform mould and assembled view of perform mould. The table 1 shows the preform thickness before and after implementation of I plate.

Figure 7: Inserted I plate

Figure 8: After fixation of I plate

VII. RESULT AND DISCUSSION

This project is concerned with the production and manufacturing. The objective of this project is to reduce material losses during production of brake lining in our concerned project esteem. The results have concluded that the project accomplished on the perform mould have led to reduction of material losses. The cornered vision over the project is to increase the customer satisfaction and to increase productivity. The lead to this project helps to reduce rejection parts per million. The overview of this project is to maintain a constant range over the preformed and cured work pieces leading to avoid excess grinding operations. The result avoids the chances of excess grinding preventing mechanical properties losses. The Figure 9&10 shows the no of rejected parts per week and the amount of material losses reduced after implementation.

<table>
<thead>
<tr>
<th>S.NO</th>
<th>(BEFORE)</th>
<th>(AFTER)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LH</td>
<td>RH</td>
</tr>
<tr>
<td>1</td>
<td>39.00</td>
<td>44.00</td>
</tr>
<tr>
<td>2</td>
<td>40.00</td>
<td>45.00</td>
</tr>
<tr>
<td>3</td>
<td>40.00</td>
<td>44.00</td>
</tr>
<tr>
<td>4</td>
<td>41.00</td>
<td>46.00</td>
</tr>
<tr>
<td>5</td>
<td>40.00</td>
<td>41.00</td>
</tr>
<tr>
<td>6</td>
<td>39.00</td>
<td>43.00</td>
</tr>
<tr>
<td>7</td>
<td>41.00</td>
<td>43.00</td>
</tr>
<tr>
<td>8</td>
<td>42.00</td>
<td>43.00</td>
</tr>
<tr>
<td>9</td>
<td>40.00</td>
<td>44.00</td>
</tr>
<tr>
<td>10</td>
<td>41.00</td>
<td>44.00</td>
</tr>
<tr>
<td>Min</td>
<td>39.00</td>
<td>41.00</td>
</tr>
<tr>
<td>Max</td>
<td>42.00</td>
<td>46.00</td>
</tr>
<tr>
<td>Avg</td>
<td>40.36</td>
<td>43.70</td>
</tr>
<tr>
<td>Range</td>
<td>3.00</td>
<td>5.00</td>
</tr>
</tbody>
</table>
The results have concluded that major rejection of parts is due to thickness variation which is obtained from the accumulation of mix on the bottom portion of the perform mould. The mix accumulation is due to clearance between the tool and the side portion of the perform mould which must be limited to 0.25±0.1, but the problem obtained in clearance is around 0.8 which is too much to detect. Required level thickness is attained, Material loss is deducted, Improvement in process quality, Reduction in process rejection rate, Improvement in customer satisfaction, to avoid continuous monitoring of inspecting the work piece. These projects are overview to increase in benefit of management and to the increase in customer satisfaction. Due to excess thickness in preforming and curing operation it is necessary to do excess grinding on the cured work pieces and by the way the mechanical properties of the material of the material gets affected ,in introducing the project the required thickness is obtained increasing in customer satisfaction.

REFERENCES:
1. An FEM-based approach for tool wear estimation in machining Amir Malakizad1,* Hans Gruber1 ,Ibrahim Sadik1,2 , Lars Nyborg1 from (2016)research article
3. Experimental study of brake lining materials with different manufacturing parameters by sachin kumar patel , Prof., Jain. From college of CIT university,2015
4. Influence of grinding parameters on surface temperature and burn behaviors of grinding rail B. Lin, K. Zhou, J. Guo. Q.Y. Liu, W.J. Wang+ Tribology Research Institute, State Key Laboratory of Traction Power, Southwest Jiao tong University, Chengdu 610031, China
7. Referenced by design data book published by PSB publication in topic static and variable stresses page no 50-100
8. Referenced from the textbook of manufacturing technology written by Dr. Vijayaragavan published by laxmi publications in chapter 4 page no 100-125.
10. Study on effect of mechanical properties in grinding and machining by Pawelstowski, Koszalin University of Technology Mechanical Engineering Department in year 2016.
11. Simulation-based machining condition optimization for machine tool energy consumption reduction WonkyunLeea , Jaesang Parkb and Byungr- Kwon Min.
13. The effect of process parameters on grinding forces and acoustic emission in machining tool steel 1.2201/nc10 by Pawelstowski ,Koszalin University of Technology, Mechanical Engineering Department.
14. TOOL WEAR MECHANISM AND ITS RELATION TO MATERIAL REMOVAL IN UTRASONIC MACHINING JINGSI WANG1, 2*, KEITA SHIMADA1, MASAYOSHI MEZUTANI1 AND TSUNEOMTO KURIYAGAWA.

AUTHORS PROFILE

Jayabalan C was born in Sundararajapuram, Virudhunagar district, Tamilnadu, India in 1969. He received the B. Tech degree in Automobile Technology from M.I.T, Anna University, Chennai, India in 1995 and the M.E., in Manufacturing Engineering from M.I.T, Anna University, Chennai, India in 2007. He has 22 years teaching experience and working as an Associate Professor in the Department of Mechanical Engineering in R.M.K. Engineering, Kavarpetatt, Chennai, India. Presently doing Ph.D., in the field of Nano Fluid in Anna University.

Logesh M was born in Chennai, Tamilnadu, India, in 1985. He received the B.E., degree in Mechanical Engineering from Dr. MGR Engineering college, Chennai, Tamilnadu, India in 2007, and the M.Tech degrees in CAD/CAM from Vellore Institute of Technology, Vellore, Tamilnadu, India in 2010. He has 9 years of experience in teaching and research and working as an Assistant Professor in the Department of Mechanical Engineering, Vel Tech Multitech Dr. Rangarajan Dr. Sakunthala Engineering College, Avadi, Chennai-600 062. His research area include Advanced Manufacturing Technology, welding, Material Science, etc., He published more than 20 research papers through National and International Journals and Conferences. He is a Life member of MISTE in professional bodies.

Ramesh G obtained his Bachelor’s degree in Mechanical Engineering from University of Madras, Masters and Ph.D. from Anna University Chennai. He has 18 years of teaching experience in various Engineering colleges. His area of specialization is Welding, Composites, Machining, material science...
Machining Performance Optimization For Minimizing Material Losses By Thickness Variation Method

He has published over 30 research papers in various international journals and conferences which includes Scopus and Science citation indexed journals. He is an authorized research supervisor of APJ Abdul Kalam Technological University, Kerala. He is a reviewer for the Journal named “Journal of Manufacture”, Part A-Sage publications. He has delivered guest lectures in various universities and state affiliated engineering colleges in the topic composites and machining. He has conducted many seminars and conferences by received funds from various funding agencies. He is working as Professor in MEA Engg College, Perinthalmanna, Kerala.

Selvam M was born in Ramanathapuram, Tamilnadu, India, in 1988. He received the B.E., degree in Mechanical Engineering from Anna University, Chennai, Tamilnadu, India in 2010, and the M.E., degree in Thermal Engineering from Anna University, Chennai, Tamilnadu, India in 2013. He has 7 years of experience in teaching and research and working as an Assistant Professor in the Department of Mechanical Engineering, Vel Tech Multitech Dr. Rangarajan Dr. Sakunthala Engineering College, Avadi, Chennai-600 062. He has currently doing postdoctoral studies from Anna University. He has an extensive investigation of his research about alternative fuels, Biofuel and Renewable energy and he has participated in several international conferences, seminars, congresses, symposiums are around the Country. In addition, he has numerous published articles included in the Science Citation Index (SCI), and a Citation Report of Web of Science Core with an h-index = 2.

Palani S was born in Madurai, Tamilnadu, India, in 1967. He received the B.E., degree in Mechanical Engineering from M.K. University, Madurai, Tamilnadu, India in 2003, and the M.E., and Ph.D. degrees in Manufacturing Engineering from the Anna University, Chennai, Tamilnadu, India in 2005 and 2013, respectively. He has 13 years of experience in teaching and research and working as an Associate Professor in the Department of Mechanical Engineering, Vel Tech Multitech Dr. Rangarajan Dr. Sakunthala Engineering College, Avadi, Chennai-600 062. His research area include Advanced Manufacturing Technology, Artificial Intelligent Techniques, Machine Vision, On-line Monitoring, Material Science, Bio-Fuel, Heat Exchanger etc., He published more than 100 research papers through National and International Journals and Conferences. He is an authorized Research Supervisor for Anna University and Guiding more than 7 Ph.D., research scholars. He was awarded as a “Distinguished Scientist” by Venus International Foundation -Research Awards-VIRA 2016. He is a Life member of MISTE [LM91981] in professional bodies.