DESIGN OF VULCANIZER FOR SPIN CASTING TECHNOLOGY

THESIS

This is Submitted to Fulfill Prerequisite of Industrial Engineer of International S-1 Program

Written by:

Geovanni Garias Pradhana
04 14 04085

INTERNATIONAL INDUSTRIAL ENGINEERING PROGRAM
INDUSTRIAL TECHNOLOGY FACULTY
ATMA JAYA YOGYAKARTA UNIVERSITY
YOGYAKARTA
2009
“Every human has four endowments—self awareness, conscience, independent will and creative imagination. These give us the ultimate human freedom... The power to choose, to respond, to change.”

~ Stephen R. Covey.

This Thesis is dedicated for
Mom, Dad and My Sister
And also for My Girl
FOREWORD

This final report is one of the prerequisite to finish the undergraduate study program in Industrial Engineering Department, Industrial Technology Faculty, Atmajaya Yogyakarta University.

I am so grateful to many people who encouraged, and help me to finish this final report. On this opportunity, I would like to thank:

1. Jesus Christ, for His blessing and guidance.
2. Mr. Paulus Mudjihartono, S.T., M.T, as the Dean of Industrial Technology Faculty, Atmajaya Yogyakarta University.
3. Mr. Parama Kartika Dewa SP, S.T., M.T., as the Head of Industrial Engineering Department, Industrial Technology Faculty, Atmajaya Yogyakarta University.
4. Mr. Hadi Santono, S.T., M.T., as the Head of International Class of Industrial Engineering, with those never ending break through.
5. Mr. Theodorus B. Hanandoko, S.T., M.T., as first adviser, who had spent plenty of time to give guidance, direction, inputs and correction in writing this final report.
6. Mr. Paulus Wisnu Anggoro, S.T., M.T., thanks for all those advice and jokes.
7. Mr. B. Kristyanto, S.T., M.Eng.,PhD as head of LPPM, thanks for supports.
8. Mr. Ashari and his crews at Hari Mukti Teknik Workshop, thank you the input, the idea of machine construction, and warm welcome.

10. Mr. and Mrs. Benny for supporting us with warm welcome house.

11. My parents, thanks for supporting my life. Dad, your junior now ready to take over you.


13. My friends TIKI Batch 2004, finally, we’re in the same level. Thank you.

14. Aunt Na’ families at Kelapa Gading Jakarta for warm welcome during the research of silicon rubber.

15. All those who haven’t mentioned, thank you.

I realize that this final report has not perfect but I hopes that this final report can be useful and can be developed in a further research.

Yogyakarta, June 2009
CONTENTS

COVER ................................................................................................................. i
AUTHORIZATION .............................................................................................. ii
ACKNOWLEDGEMENT ..................................................................................... iii
FOREWORD ...................................................................................................... iv
CONTENTS ....................................................................................................... vi
TABLE CONTENTS ............................................................................................. ix
FIGURE CONTENTS ......................................................................................... x
APPENDIX CONTENT ....................................................................................... xii
ABSTRACT ......................................................................................................... xiii

CHAPTER 1 INTRODUCTION
1.1. Background ................................................................................................. 1
1.2. Problem Statement ....................................................................................... 2
1.3. Research Objectives .................................................................................... 2
1.4. Scope of Research ....................................................................................... 2
1.5. Research Methodology ................................................................................ 4
1.6. Report Outline ............................................................................................. 5

CHAPTER 2 LITERATURE REVIEW .................................................................. 6

CHAPTER 3 BASIC THEORY
3.1. Spin Casting ................................................................................................ 8
3.2. Silicone Rubber ......................................................................................... 14
3.3. Tin .............................................................................................................. 18
3.4. Design Method .......................................................................................... 19
3.4.1. Creative Method .................................................................................... 19
3.4.2. Rational Method ................................................................................... 22
3.5. Tree Diagram ............................................................................................. 25
3.6. Electrical Component ............................................................................... 28
3.6.1. Metal-Sheathed Tubular Element ........................................... 28
3.6.2. Thermostat ........................................................................... 29
3.6.3. Thermocouple .................................................................... 30
3.7. Design and Calculation Formulas ........................................... 31
  3.7.1. Shear Stress ..................................................................... 31
  3.7.2. Energy Conservation ............................................................ 32
  3.7.3. Design of Bolt and Thread ................................................ 32
  3.7.4. Power Screw ..................................................................... 34
  3.7.5. Machine Cost .................................................................... 35
3.8. Variability of Material Properties ........................................... 35
  3.8.1. Aluminum ........................................................................ 35
  3.8.2. Cast Iron .......................................................................... 36
  3.8.3. Asbestos .......................................................................... 37

CHAPTER 4 DATA
4.1. Silicone Rubber Specification ................................................ 38
4.2. Experimental Data .................................................................. 39
4.3. Cost of Material ..................................................................... 40

CHAPTER 5 DATA ANALYSIS AND DISCUSSION
5.1. Design Analysis ................................................................. 41
  5.1.1. Clarifying Objectives .......................................................... 41
  5.1.2. Establishing Function .......................................................... 43
  5.1.3. Setting Requirement ............................................................ 43
  5.1.4. Determining Characteristics ................................................ 44
  5.1.5. Generating Alternatives ....................................................... 47
5.2. Design of Vulcanizer .............................................................. 53
  5.2.1. Basic Construction ............................................................... 53
  5.2.2. Design Flow Chart .............................................................. 55
  5.2.3. Design of Power Screw ....................................................... 56
  5.2.3.1. Analysis of Power Screw Design ....................................... 56
5.2.4. Design of Upper Support.................................................. 57
5.2.5. Design of Flange................................................................. 58
5.2.5.1. Analysis of Flange Design............................................. 59
5.2.5.1.1. Analysis of Flange for Heating box.................... 59
5.2.5.1.2. Analysis of flange for Power Screw............. 60
5.2.6. Design of Middle Support............................................... 61
5.2.7. Design of Lower Plate.................................................... 62
5.2.8. Design of Lowest Plate.................................................. 63
5.2.9. Heating Element............................................................. 64
5.3. Design of Mold Frame......................................................... 65
5.3.1. Analysis Design of Mastering Mold Frame............. 66
5.3.2. Design of Spin Casting Mold Frame.......................... 68
5.4. Design of Gating and Venting............................................. 69
5.4.1. Center Gating and Mold venting............................. 70
5.5. Analysis of experimental result.......................................... 71
5.6. Analysis of production time on the experiment of “UAJY Keychain” ......................................................... 73
5.7. Analysis of Production Cost of Vulcanizing Process................................................................................. 74

CHAPTER 6 MANUAL INSTRUCTION
6.1. Machine Unit........................................................................ 75
6.2. List of specification............................................................. 76
6.3. The Operational Procedure................................................ 76

CHAPTER 7 CONCLUSION
6.1. Conclusion........................................................................... 81
6.2. Suggestion........................................................................... 83

REFERENCES
APPENDIX
## TABLE CONTENTS

Table 2.1. Comparison of current research and previous research ........................................ 10  
Table 3.1. Properties of some silicone rubber................. 18  
Table 3.2. Correction Factor of power transmitted... 34  
Table 4.1. Specification of Silicone Rubber............... 38  
Table 4.2. Experimental Data ......................................................... 39  
Table 4.3. Data Of Material Cost.............................. 40  
Table 4.4. Data of Component Cost............................. 40  
Table 5.1. Setting Requirement of Silicone Rubber... 43  
Table 5.2. Morphological Chart for Silicone Rubber  
Vulcanizer............................................................................. 44  
Table 5.3. Morphological Chart for Silicone Rubber  
Vulcanizer............................................................................. 46  
Table 5.4. Weighted Objective for Vulcanizer............. 48  
Table 5.5. Morphological Chart for Silicone Rubber  
Vulcanizer............................................................................. 49  
Table 5.6. Weighted Objective Evaluation for  
Vulcanizer............................................................................. 52  
Table 5.7. Component of Machine Cost for Vulcanizer 74  
Table 6.1. Vulcanizer Specification................................ 76  
Table 7.1. Specification Table............................................. 82
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Parts are arranged on silicone rubber</td>
<td>8</td>
</tr>
<tr>
<td>3.2</td>
<td>Mold is assembled with locknuts and Sprayed</td>
<td>9</td>
</tr>
<tr>
<td>3.3</td>
<td>Vulcanization</td>
<td>10</td>
</tr>
<tr>
<td>3.4</td>
<td>Gating Venting</td>
<td>11</td>
</tr>
<tr>
<td>3.5</td>
<td>Spinning</td>
<td>12</td>
</tr>
<tr>
<td>3.6</td>
<td>Pouring</td>
<td>12</td>
</tr>
<tr>
<td>3.7</td>
<td>Pouring Illustration inside spin</td>
<td>13</td>
</tr>
<tr>
<td>3.8</td>
<td>Removal Parts</td>
<td>13</td>
</tr>
<tr>
<td>3.9</td>
<td>Silicone Rubber Chain</td>
<td>14</td>
</tr>
<tr>
<td>3.10</td>
<td>Example of tree diagram</td>
<td>28</td>
</tr>
<tr>
<td>3.11</td>
<td>Metal-sheathed tubular element with one coil having one terminal at each tube end</td>
<td>29</td>
</tr>
<tr>
<td>5.1</td>
<td>Objective tree of vulcanizer</td>
<td>42</td>
</tr>
<tr>
<td>5.2</td>
<td>Black box of silicone rubber vulcanizer</td>
<td>43</td>
</tr>
<tr>
<td>5.3</td>
<td>Sketch of Vulcanizer</td>
<td>53</td>
</tr>
<tr>
<td>5.4</td>
<td>Flow Chart for designing the vulcanizer</td>
<td>55</td>
</tr>
<tr>
<td>5.5</td>
<td>Upper Support for Vulcanizer</td>
<td>57</td>
</tr>
<tr>
<td>5.6</td>
<td>Bolt in Flange</td>
<td>58</td>
</tr>
<tr>
<td>5.7</td>
<td>Middle Support of Vulcanizer</td>
<td>61</td>
</tr>
<tr>
<td>5.8</td>
<td>Lower Plate of Vulcanizer</td>
<td>62</td>
</tr>
<tr>
<td>5.9</td>
<td>Lowest Support of Vulcanizer</td>
<td>63</td>
</tr>
<tr>
<td>5.10</td>
<td>Scheme of pressure in mold frame</td>
<td>66</td>
</tr>
<tr>
<td>5.11</td>
<td>Silicone Rubber Size</td>
<td>66</td>
</tr>
<tr>
<td>5.12</td>
<td>Silicone Rubber Mold Frame Size for mastering</td>
<td>67</td>
</tr>
</tbody>
</table>
Figure 5.13. Silicone Rubber Mold Frame Size for Spin Casting

Figure 5.14. Design of spin casting Mold

Figure 5.15. Design of Center Gating Venting

Figure 5.16. Vulcanized Spin Casting Mold

Figure 5.17. Result of Spin Casting Mold

Figure 5.18. Arrow Diagram of Vulcanizing Process

Figure 6.1. Vulcanizer Machine

Figure 6.2. Thermocouple Setting

Figure 6.3. MCB Turning On

Figure 6.4. Frame Preparation

Figure 6.5. Turning Handle

Figure 6.6. Inserting the frame

Figure 6.7. Pressing The Frame

Figure 6.8. MCB turning off

Figure 6.9. Pulling Out The Frame

Figure 6.10. Open The Frame

Figure 7.1. Both of Silicone Rubber Mold

Figure 7.2. Result of Vulcanizing and Spin casting Process
APPENDIX CONTENTS

Appendix 1. Engineering Drawing
ABSTRACT

The spin casting technology basically need a vulcanized mold to be placed into spin casting machine and also the silicone rubber as the material of the mold. The spin casting machine has been constructed in UAJY in 2007, but it did not use the cured silicon rubber already. It was applied to RTV silicone rubber. The experimental works showed that using uncured silicone rubber in spin casting tend to produce inappropriate shape of products because of its elasticity. Hence it brings to the need of constructing vulcanizer for spin casting technology, by selecting the appropriate type of silicone rubber to be vulcanized.

The design of vulcanizer machine is conducted using Rational Method and tree diagram. The tree diagram is used to identify the objectives needed in vulcanizer itself, and then the rational method is used to set the technical requirement of good vulcanizer and also to choose the best material alternatives based on the objectives.

By the end of the research, a vulcanizer machine is obtained 4000 watt of power supply and dimension of 500 mm x 445 mm x 811 mm. It also can produce maximum heat 400°C and produce maximum pressure around 2500 pounds. While the machine cost per hour is IDR 7,000.00.