Mitigation of Rejection in Spring Manufacturing by using TRIZ Method

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Abstract— In this research the researcher has tried to reduce the rejection in manufacturing of spring Method applied for it is an innovative problem solving tool. Researcher collected the all process data pertaining to rejection in spring manufacturing. Data was analyzed by activity-based-costing (ABC analysis). To select the process where is most rejection, most wastage of cost occur and then applying TRIZ method in the process and suggested the manufacturer to reduce the rejection in process & improve the product rate and quality of product.

Keywords— Spring manufacturing industry, TRIZ, Rejection

I. INTRODUCTION

Today many big organizations involved in producing products with least rejection. The rejection of product may be due to any such reason which had not been considered as prominent. As we do know that as a material has a structure, unit cell, atom, proton neutron, and electron. Change in the material structure may take place due to disturbance of any one of them. In the same way if we divide a big problem in to number of small problem and solve them in a sequel then we have a solution of a big and complicated problem. Researcher did the same thing to find the main cause of rejection at different stages of manufacturing process of spring.

II. METHODS AND TOOLS OF TRIZ

V. Tsourikov research of over fifty years on Creativity and Inventive Problem Solving has led to many different classifications, methods and tools of invention. Inventive problem “as contradictions or conflicts” One of the first findings of Altshuller was that “inventive problems are those that have contradictions/conflicts” TRIZ defines two kinds of contradiction, “physical and technical”. Technical contradictions are the classical engineering “trade-off”. The desire state can’t be reached because something else in the system prevents it. In other words, when something gets better, something else gets worse. He defined 39 basic properties and 40 principles for solving problems containing contradiction in any two of 39 properties.

This he gave in the form of a contradiction table of size 39*39 with each cell giving up to 4 principles. That may be used to eliminate the contradiction.

Physical Contradiction

Yu. Murashkovsky introduces TRIZ with 6 classical ways to resolve “physical contradiction” and these are known as “separation principles for “physical contradiction”:

1. separation in space
2. separation in time
3. separation at micro level; transition to sub system
4. separation at macro level; transition to super system
5. separation in condition convert to technical contradiction
6. convert to technical contradiction

Technical Contradictions Matrix (39x39) and 40 Inventive Principles:

Contradiction appears while trying to improve one desirable property another desirable property deteriorates! Conventional problem solving generally leads to a compromise solution. As mentioned before, the most inventive solution is obtained when a technical problem containing a contradiction is solved by completely eliminating the contradiction.

List Of The 39 Features

1. Weight of moving object.
2. Weight of stationary object
3. Length of moving object
4. Length of stationary object
5. Area of moving object.
6. Area of stationary object:
7. Volume of moving object
8. Volume of stationary object
9. Speed
10. Force
11. Stress or pressure
12. Shape.
13. Stability of the object's composition
14. Strength
15. Duration of action by a moving object
16. Duration of action by a stationary object
17. Temperature
18. Illumination intensity * (jargon)
19. Use of energy by moving object
20. Use of energy by stationary object
21. Power * (jargon)
22. Loss of Energy
23. Loss of substance
24. Loss of Information
25. Loss of Time
26. Quantity of substance/the matter
27. Reliability
28. Measurement accuracy
29. Manufacturing precision
30. External harm affects the object
31. Object-generated harmful factors
32. Ease of manufacture
33. Ease of operation /simplicity
34. Ease of repair
35. Adaptability or versatility
36. Device complexity
37. Difficulty of detecting and measuring:
38. Extent of automation:
39. Productivity

List Of The 40 Principles
Principle 1: Segmentation
Principle 2: Taking out
Principle 3: Local quality
Principle 4: Symmetry
Principle 5: Merging
Principle 6: Universality
Principle 7: "Nested doll"
Principle 8: Anti-weight
Principle 9: Preliminary anti-action
Principle 10: Preliminary action
Principle 11: Beforehand cushioning
Principle 12: Equipotentiality
Principle 13: The other way round
Principle 14: Spheroidality - Curvature
Principle 15: Dynamics
Principle 16: Partial or excessive actions
Principle 17: Another dimension
Principle 18: Mechanical vibration
Principle 19: Periodic action
Principle 20: Continuity of useful action
Principle 21: Skipping
Principle 22: "Blessing in disguise" or "Turn Lemons into Lemonade"
Principle 23: Feedback
Principle 24: Intermediary
Principle 25: Self-service
Principle 26: Copying
Principle 27: Cheap short living objects
Principle 28: Mechanics substitution
Principle 29: Pneumatics and hydraulics
Principle 30: Flexible shells and thin films
Principle 31: Porous materials
Principle 32: Color changes
Principle 33: Homogeneity
Principle 34: Discarding and recovering
Principle 35: Parameter changes
Principle 36: Phase transitions
Principle 37: Thermal expansion
Principle 38: Strong oxidants
Principle 39: Inert atmosphere
Principle 40: Composite materials

III. Case Study

Identification Of Problem

We begin with “5W’s and an H” of Innovation. Ask this question of every system so that the system function and problem is identified.

W1. Who has the problem?
W2. What does the problem seem to be? What are the resources?
W3. When does the problem occur? Under which circumstances?
W4. Where does the problem occur?
W5. Why does the problem occur? What is root cause? And How does the problem occur? How can the problem be solved?
### Table 1
**Chart of process, cost, time, or rejection**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Process Path</th>
<th>Cost per day (approx.)</th>
<th>Time in process (minutes)</th>
<th>Rejection in bar</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Raw material (A)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2.</td>
<td>End tapering (B) 1-2</td>
<td>28000</td>
<td>0.83</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>Bar heating (C) 2-3</td>
<td>38000</td>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>4.</td>
<td>Coiling (D) 3-4</td>
<td>9000</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>5.</td>
<td>Quenching (E) 4-5</td>
<td>15000</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>6.</td>
<td>Tempering (F) 5-6</td>
<td>35000</td>
<td>120</td>
<td>3</td>
</tr>
<tr>
<td>7.</td>
<td>End grinding 6-7</td>
<td>18000</td>
<td>25</td>
<td>-</td>
</tr>
<tr>
<td>8.</td>
<td>Shot peening (H) 7-8</td>
<td>16000</td>
<td>60</td>
<td>-</td>
</tr>
<tr>
<td>9.</td>
<td>Crack testing (I) 8-9</td>
<td>10000</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>10.</td>
<td>Primer painting (J) 9-10</td>
<td>7000</td>
<td>0.30</td>
<td>-</td>
</tr>
<tr>
<td>11.</td>
<td>Scraging (K) 10-11</td>
<td>8000</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>12.</td>
<td>Load testing (L) 11-12</td>
<td>10000</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>13.</td>
<td>Painting redoxide &amp; black paint (M) 12-13</td>
<td>14000</td>
<td>0.40</td>
<td>-</td>
</tr>
<tr>
<td>14.</td>
<td>Spring packaging (N) 13-14</td>
<td>8000</td>
<td>180</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 2
**Column chart of cost rejection**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Process Path</th>
<th>Cost per day (approx.)</th>
<th>Cost in Time (approx.)</th>
<th>Cost of Rejection Bar (approx.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Raw material (A)</td>
<td>-</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2.</td>
<td>End tapering (B) 1-2</td>
<td>28000</td>
<td>2200</td>
<td>4400</td>
</tr>
<tr>
<td>3.</td>
<td>Bar heating (C) 2-3</td>
<td>38000</td>
<td>3200</td>
<td>0</td>
</tr>
<tr>
<td>4.</td>
<td>Coiling (D) 3-4</td>
<td>9000</td>
<td>3700</td>
<td>4400</td>
</tr>
<tr>
<td>5.</td>
<td>Quenching (E) 4-5</td>
<td>15000</td>
<td>4200</td>
<td>0</td>
</tr>
<tr>
<td>6.</td>
<td>Tempering (F) 5-6</td>
<td>35000</td>
<td>5200</td>
<td>15000</td>
</tr>
<tr>
<td>7.</td>
<td>End grinding &amp; chamfering (G)</td>
<td>18000</td>
<td>4200</td>
<td>8000</td>
</tr>
<tr>
<td>8.</td>
<td>Shot peening (H) 7-8</td>
<td>16000</td>
<td>6700</td>
<td>0</td>
</tr>
<tr>
<td>9.</td>
<td>Crack testing (I) 8-9</td>
<td>10000</td>
<td>8600</td>
<td>20000</td>
</tr>
<tr>
<td>10.</td>
<td>Primer painting (J) 9-10</td>
<td>7000</td>
<td>7700</td>
<td>0</td>
</tr>
<tr>
<td>11.</td>
<td>Scraging (K) 10-11</td>
<td>8000</td>
<td>8000</td>
<td>0</td>
</tr>
<tr>
<td>12.</td>
<td>Load testing (L) 11-12</td>
<td>10000</td>
<td>8500</td>
<td>20000</td>
</tr>
<tr>
<td>13.</td>
<td>Painting redoxide &amp; black paint (M) 12-13</td>
<td>14000</td>
<td>8600</td>
<td>0</td>
</tr>
<tr>
<td>14.</td>
<td>Spring packaging (N) 13-14</td>
<td>8000</td>
<td>10000</td>
<td>0</td>
</tr>
</tbody>
</table>
Under what circumstances?

Que 1: who has the problem?
Ans: factory management

Que 2: what does the problem occur? What is root causes?
Ans: improper heat treatment of tempering.

Que 5: why does the problem occur? What is root causes?
Ans: hardness depend on the temperature, time and duration of cooling in tempering. The root cause of improper heat treatment of tempering.

Que 6: how does the problem occur? How can be solve?
Ans: after tempering process change in structure of spring. We can solve this problem it will maintain the tempering temperature, cooling and heating time during heat treatment.

**Table 3**

<table>
<thead>
<tr>
<th>S. N. No.</th>
<th>Process</th>
<th>Path</th>
<th>Cost per day (approx.)</th>
<th>Cost in Time Min. (approx)</th>
<th>Cost of Rejection</th>
<th>Total</th>
<th>Short by Per.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Tempering</td>
<td>5-6</td>
<td>3.5</td>
<td>0.52</td>
<td>1.5</td>
<td>5.52</td>
<td>15.30</td>
</tr>
<tr>
<td>2.</td>
<td>Bar heating</td>
<td>2-3</td>
<td>3.8</td>
<td>0.32</td>
<td>0</td>
<td>4.12</td>
<td>11.42</td>
</tr>
<tr>
<td>3.</td>
<td>Load testing (L)</td>
<td>11-12</td>
<td>1</td>
<td>0.85</td>
<td>2</td>
<td>3.85</td>
<td>10.67</td>
</tr>
<tr>
<td>4.</td>
<td>Crack testing (I)</td>
<td>8-9</td>
<td>1</td>
<td>0.72</td>
<td>2</td>
<td>3.72</td>
<td>10.31</td>
</tr>
<tr>
<td>5.</td>
<td>End tapering (B)</td>
<td>1-2</td>
<td>2.8</td>
<td>0.22</td>
<td>0.44</td>
<td>3.64</td>
<td>9.59</td>
</tr>
<tr>
<td>6.</td>
<td>End grinding &amp;</td>
<td>6-7</td>
<td>1.8</td>
<td>0.57</td>
<td>0</td>
<td>2.37</td>
<td>6.57</td>
</tr>
<tr>
<td>7.</td>
<td>Shot peening (H)</td>
<td>7-8</td>
<td>1.6</td>
<td>0.67</td>
<td>0</td>
<td>2.27</td>
<td>6.29</td>
</tr>
<tr>
<td>8.</td>
<td>Painting redoxide &amp;</td>
<td>12-13</td>
<td>1.4</td>
<td>0.86</td>
<td>0</td>
<td>2.26</td>
<td>6.26</td>
</tr>
<tr>
<td>9.</td>
<td>black paint (M)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Quenching</td>
<td>4-5</td>
<td>1.5</td>
<td>0.42</td>
<td>0</td>
<td>1.92</td>
<td>5.32</td>
</tr>
<tr>
<td>11.</td>
<td>Spring packaging</td>
<td>13-14</td>
<td>0.8</td>
<td>1</td>
<td>0</td>
<td>1.8</td>
<td>4.99</td>
</tr>
<tr>
<td>12.</td>
<td>Coiling (D)</td>
<td>3-4</td>
<td>0.9</td>
<td>0.37</td>
<td>0.44</td>
<td>1.71</td>
<td>4.74</td>
</tr>
<tr>
<td>13.</td>
<td>Scraping (K)</td>
<td>10-11</td>
<td>0.8</td>
<td>0.8</td>
<td>0</td>
<td>1.6</td>
<td>4.43</td>
</tr>
<tr>
<td>14.</td>
<td>Primer painting (J)</td>
<td>9-10</td>
<td>0.7</td>
<td>0.77</td>
<td>0</td>
<td>1.47</td>
<td>4.07</td>
</tr>
<tr>
<td>15.</td>
<td>Raw material (A)</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total</td>
<td>36.07</td>
<td>=100</td>
<td>99.96</td>
<td>100</td>
</tr>
</tbody>
</table>

**TRIZ Method And Contradiction Matrix Based Solution Of Tempering**

Que 1: who has the problem?
Ans: factory management

Que 2: what does the problem occur? What are the resources?
Ans: improper heat treatment of tempering process the hardness of spring not within limit. Due to change in structure of spring material.

Que 3: when does the problem occur? Under what circumstances?

**Table in increasing order of percentage of rejection**

Que 4: where does the problem occur?
Ans: during tempering process. Under the variation in heating temperature or cooling process.

Que 5: why does the problem occur? What is root causes?
Ans: hardness depend on the temperature, time and duration of cooling in tempering. The root cause of improper heat treatment of tempering.

Que 6: how does the problem occur? How can be solve?
Ans: after tempering process change in structure of spring. We can solve this problem it will maintain the tempering temperature, cooling and heating time during heat treatment.

**Final Problem**

Hardness of spring goes out of limit because of improper heat treatment during starting and end of process. It mean

1. Flow of material is not same for all.
2. Heat temperature for all spring is not same.
3. Cooling time and quality of oil is not same for all.

<table>
<thead>
<tr>
<th>Temp.</th>
<th>Quantity of substance</th>
</tr>
</thead>
<tbody>
<tr>
<td>22,35,2,24</td>
<td>3,35,40,39</td>
</tr>
</tbody>
</table>

**According To TRIZ Solution**

35. **Parameter change**
   a) change an object’s physical state (e.g. to a gas, liquid or solid)
   b) change the concentration or consistency
   c) change the degree of flexibility
   d) change the temperature

40. **Composite material**
   a) Change from uniform to composite (multiple) material.

**IV. RESULT AND DISCUSSION**

Tempering is a heat treatment process. Proper heat treatment necessary from starting to end of process.
Temperature in tempering m/c should maintain for all spring (480 degree centigrade). The hardness of spring should be in range 415-450 HBN for chrome moly spring steel. To make the hardness of spring within limit we have to keep constant flow of spring through the tempering m/c. with this cooling time and temp it should remain constant. And maintain the consistency.

V. CONCLUSION

After the use of TRIZ method in all process of manufacturing we suggest few changes in processes to reduce approximately 17.7 % of rejection in spring manufacturing.

<table>
<thead>
<tr>
<th>SN</th>
<th>Process</th>
<th>Path</th>
<th>Cost per day</th>
<th>Cost in Min.</th>
<th>COR before TRIZ</th>
<th>COR after TRIZ</th>
<th>Save cost Per day</th>
<th>Rej</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bar heating</td>
<td>2-3</td>
<td>3.8</td>
<td>.32</td>
<td>4.12</td>
<td>4.12</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Tempering</td>
<td>5-6</td>
<td>3.5</td>
<td>.52</td>
<td>5.52</td>
<td>4.02</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>End tapering</td>
<td>1-2</td>
<td>2.8</td>
<td>.22</td>
<td>3.46</td>
<td>3.02</td>
<td>.44</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>End grinding</td>
<td>6-7</td>
<td>1.8</td>
<td>.57</td>
<td>2.37</td>
<td>2.37</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Shot peening</td>
<td>7-8</td>
<td>1.6</td>
<td>.67</td>
<td>2.27</td>
<td>2.27</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Painting</td>
<td>12-13</td>
<td>1.4</td>
<td>.86</td>
<td>2.26</td>
<td>2.26</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Quenching</td>
<td>4-5</td>
<td>1.5</td>
<td>.42</td>
<td>1.92</td>
<td>1.92</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Load testing</td>
<td>11-12</td>
<td>1</td>
<td>.85</td>
<td>3.85</td>
<td>1.85</td>
<td>2.00</td>
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</tr>
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<td>9</td>
<td>Spring</td>
<td>13-14</td>
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<td>1.8</td>
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<td></td>
</tr>
<tr>
<td>10</td>
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<td>.72</td>
<td>3.72</td>
<td>1.72</td>
<td>2.00</td>
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</tr>
<tr>
<td>11</td>
<td>Scraping</td>
<td>10-11</td>
<td>0.8</td>
<td>0.8</td>
<td>1.6</td>
<td>1.6</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Primer painting</td>
<td>9-10</td>
<td>0.7</td>
<td>.77</td>
<td>1.47</td>
<td>1.47</td>
<td>0</td>
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</tr>
<tr>
<td>13</td>
<td>Coiling</td>
<td>3-4</td>
<td>0.9</td>
<td>0.37</td>
<td>1.71</td>
<td>1.27</td>
<td>.45</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Raw material</td>
<td>-</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Mitigated percentage of rejection

HBN for chrome moly spring

REFERENCES