Commercial vehicles laminated spring manufacturing unit productivity enhancement by rejection minimization

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Abstract. Productivity plays a key role in any industry, can be improved by minimizing the rejections and down time of machine. Parabolic laminated spring plays a vital role in the suspension system of any heavy duty automotive vehicle, since it has an effect on ride comfort and vehicle dynamics. In this paper, various approaches and efforts done for productivity enhancement were discussed with an emphasis on the reduction of rejections in parabolic laminated spring manufacturing unit in India. The output of this work is reduction in production cost via minimizing the rejection, reworking, efficient and economical utilization of all input resources. This paper provides an extremely valuable practical framework to different industries that recognize the parabolic laminated spring manufacturing.

Keywords: Heavy Parabolic Leaf Spring, Rejection, Reuse, Clamps, Stress Penning, SSP Fixture.

1. Introduction

To gain the competitive advantage, laminated spring industries are actively involved to analyze and identify root causes reduce all scrap rejections and rework during the manufacturing process of the parabolic laminated spring [1]. Therefore, a new manufacturing strategy for parabolic laminated spring manufacturing unit has been proposed, developed and applied. Parabolic laminated springs are the important components of the suspension system, which perform isolation task in transferring vibration due to road conditions to body [2-4]. There are various versions of the parabolic laminated springs such as parabolic, multi parabolic and z-laminated spring [5-8]. A parabolic spring is basically a leaf or set of leaves, which are tapered in a parabolic way rather than a linear. This spring makes flexibility and carries more load of the vehicle because of this parabolic design and lack of inters leaf friction [9-12]. India is a developing country and there are many companies dealing in the manufacturing of laminated springs in India.

The objective of present work is to enhance its productivity by suggesting change of manufacturing methods and minimizing the rejections. The logical and systematic approach to solve almost any problem (Barnes, 1980) includes (1) problem definition and analysis; (2) search for possible solutions; (3) evaluation and discussing the alternatives and (4) recommendation for action [13-16]. At the time of clamp removing 85% clamps would damaged. There is used manpower for separate the rivets from the clamps also. In stress pinning machine a fixture is used which holds the leaf at stress position. This fixture is broken/bend after some time due to the carrying heavy load. In this case study those
problems are resolve by applying work study. This study was performed to minimize the rejections and increase the productivity in parabolic laminated spring manufacturing unit in India. The company Jamna Auto Industries Limited, Lucknow, used for collecting data, is the largest manufacturer of tapered laminated spring and parabolic spring for commercial vehicles in India and has been the number one supplier to Tata Motors Limited and Ashok Leyland Limited. Many more authors have also carried out research studies in this domain [17-22].

2. Methodology Used

Work study may be defined as a system of assessment of methods of working viz. ‘Method Study or Motion Study’ and ‘Work Measurement’ of manpower to obtain optimum output and efficiency to ensure growth of any organization as per Institution of British Standards. Work study examines the work performed in an organization and tries to find the best and most effective way to use the resources available, i.e. men, material, money, and machinery. Each organization, with the least time possible, aims to produce the highest quality performance. The time taken to produce an item depends on the manufacturing process and one step of the work study viz. Method study aims to find the best possible manufacturing process that takes less time and does not make the workers exhaustion. In brief, Motion study attempts to find the best way to do a job.

Method study can be characterized as the systematic investigation (i.e. documentation and critical examination) of the current method to do a job in order to establish and implement a simple, fast, reliable, effective and less fatigue technique for doing the same job at a reduced cost. This is usually accomplished by removing excessive motion involved in a particular procedure or by altering the activity sequence or the process itself. Work study is a means of increasing the production capability of the organization by reducing the waste and unnecessary operations which leads to reduction in the cost of product.

- Steps involved in work study

1. SELECT
   Job or Process to be studied

2. RECORD
   All the details concerning job using various recording technique

3. EXAMINE
   Record facts critically by asking questions like who, what, when, why

4. DEVELOP
   Most economical method

5. MEASURE
   The amount of work involved and set standard time to do that job

6. DEFINE
   New method and standard time
The new method as a standard practice

New method as agreed standard

3. Problems Identification

In parabolic leaf spring manufacturing organization, which deals in mass production, end gap and interleaf gap are contributes the 27% of total rejection created in shop floor. In this present work firstly the various problems and responsible cause of rejection in shop floor are identified.

4. Results and Discussions

4.1 Clamp Rejection

Riveting is the process used in parabolic leaf assembling in which clamp are fitted in 3/L with the help of rivet. This clamp is cover both of leafs tightly with the help of nut and bolts. Due to leaf rejection for any quality problem, removal of clamps from the leaf has to be done. M/L and 2/L remove easily but some work is required in 3/L because this clamp is riveted. It is necessary to remove the rivet; it is done by press the punch in rivet as shown in Fig. 1. During this work, rivet is removed but the clamp is bending at its center then it is not available to reuse again as shown in Fig. 2 (a). At the time of clamp removal, 70% clamps would damage. There will also be requirement of the manpower to separate the rivets from the clamps also. The cost of clamp is Rs. 17.62 per unit Approx. As per information provided by Jamna Auto Industries Limited, Lucknow, rejected 6580 nos. of clamp in last FY 2019–2020. A total cost of rejected clamps in last financial year was Rs. 115939 Approx.

![Figure 1](image1.png)

(a) Punch holder in punch press (b) Die used for riveting

At previous working this type of fixture as shown in Fig. 5 (b) was used to separate the clamp and rivet from the leaf. This is the common fixture was used to riveting the clamp in leaf and removing the clamp from leaf. It is not capable to separate the clamp and rivet efficiently from leaf, this clamp was bend on the centre hole at the time of punching and then treat as a scrap as shown in Fig. 2 (b).
Figure 2 (a) Damaged clamps (b) Scrap of clamps

After the investigation, we have analyzed that there is requirement of another fixture to remove the clamp from the leaf and also to remove the rivet from clamp. To solve the problem we designed another fixture which is fitted in old fixture at the time of removing the clamp from the leaf as shown in Fig. 3 (a). This fixture is capable to remove the clamp from the leaf and also remove the rivet from the clamp at single operation without any kind bend in clamp as shown in Fig. 3 (b). The rivet falls into the fixture automatically at bottom slot. Fig.4 illustrates the comparison between clamps removed from both the fixtures. We have saved 85% removed clamps and manpower which was being used to separate the rivets from clamps. There is also the saving of time as no need to repair or cold work for the removed clamp as now it is as fresh. Hence there is saving of Rs. 115939 per year according to last financial year data.
Figure 4. Comparison between clamps which are removed from both fixtures

4.2 SSP Fixture rejection

In stress pinning machine, we used a fixture which holds the leaf at stress position. The load is applied on leaf till straight position and this stressed leaf is clamped on fixture for stress pinning. This fixture has been broken/bend after some time due to the carrying heavy load as shown in Fig. 5 (a). After the breaking/bend of the fixture they have to purchase new fixture. They purchased 21 nos. of fixtures in year 2019-2020 from their vendor. The cost of each fixture is Rs 14500 approx which is too costly. In last two years 14 nos. of fixture are found as a scrape in their plant.

Figure 5. (a) Scrape Material (b) Rejected Fixture

Figure 6. (a) Parts Used From Old Fixture (b) Arrange Parts
In the investigation, we analyzed the types of defects in fixture. There are some defects viz. cracks found on the fabricated side. Various parts of the fixture are in good condition. These parts are cut from the scraped fixture as shown in Figure 6(a) and reused in fabricating new fixture. As shown in Figure 6(b), remaining parts are arranged from the market or other sources to complete the fixture. Previously those parts are jointed together by welding which is weaker at the time of heavy pressure, but in new design, nut and bolts are used to join the various parts of the fixture. One center rod is also removed in new fixture to minimize the cost of fixture hence only two rods are used in place of three rods. These fixtures are capable for carrying the heavy load and well stand in the SSP process as shown in Figure 7.

5. Comparison of Fixtures

![Comparison of Fixtures](image)

**Comparison of Fixtures**

**DESIGN CHANGE FOR INCREASE THE LIFE AND SAFETY**

**NEW DESIGN**

**FABRICATED OLD PART & ARRANGE PARTS**

**Table 1: Material Comparison**

| S.N. | Material  | Size         | Qty | Remarks          |
|------|-----------|--------------|-----|------------------|
| 1    | FLAT      | 90x18x1854   | 2   | GIVEN TO VENDOR  |
|      |           | 90x13x200    | 2   |                  |
|      |           | 90x13x164    | 10  |                  |
|      |           | 100x10x200   | 2   |                  |
| 2    | SIDE PLATE| 90x17x20     | 4   |                  |
| 3    | ROD       | Ø12x1870     | 2   | FROM SCRAP       |
| 4    | SPACER    | 200x110x28   | 1   |                  |
|      |           | 200x110x25   | 1   |                  |
| 5    | DOWL PIN  | Ø12x30       | 4   |                  |
| 6    | LOCK PIN  | Ø30x315      | 2   |                  |
| 7    | HEX BOLT  | M16x55       | 14  |                  |
| 8    | HEX NUT   | M16          | 14  |                  |

**Table 2: Fabrication from Rejected Fixtures**

| S.N. | Material  | Size         | Qty | Remarks          |
|------|-----------|--------------|-----|------------------|
| 1    | FLAT      | 90x18x1854   | 2   | FROM SHEARING    |
|      |           | 90x13x200    | 2   | FROM OFFCUT      |
|      |           | 90x13x164    | 10  | FROM OFFCUT      |
|      |           | 100x10x200   | 2   | FROM OFFCUT      |
| 2    | SIDE PLATE| 200x170x20   | 4   | OLD              |
| 3    | ROD       | Ø12x1870     | 2   | FROM SCRAP       |
| 4    | SPACER    | 200x110x28   | 1   | OLD              |
|      |           | 200x110x25   | 1   | OLD              |
| 5    | DOWL PIN  | Ø12x30       | 4   | NEW(Rs.11.50 each(Rs.46)) |
| 6    | LOCK PIN  | Ø30x315      | 2   | OLD              |
| 7    | HEX BOLT  | M16x55       | 14  | NEW(Rs.14.50 each(Rs.455)) |
| 8    | HEX NUT   | M16          | 14  |                  |

**Table 3: Material Comparison**

- **New Fabrication Outside**
- **Fabrication from Rejected Fixture**
- **Saved Rs. 12433 Approx.**

**Figure 7. Comparison of Fixture**
6. **Comparison of Cost Saving**

![Comparison of Cost Saving](image)

Figure 8. Comparison of the Cost Saving of Clamp and SSP Fixture in material

7. **Conclusions**

A methodology has been developed which is designed to facilitate, control the rejection and to generate productivity improvement. It is obvious that mere shortening of some operation time results in considerable saving of time, enhancement of productivity and reduction in production cost. Figure 8 illustrated about the comparison of cost saving. However, there are many aspects of industry which still remains to be probed and analyzed for more effective use of modern day industrial engineering techniques for productivity enhancement.

In India, Automobile sector is a growing on behalf of its economy, technology enhancement than becomes necessary to catch the customer demand. The technology used for manufacturing heavy parabolic leaf spring is complex to adopt in Indian leaf spring manufacturing industries. This study is useful for those industries which want to deal in heavy parabolic leaf spring or to improve the production as well as quality of parabolic leaf spring.

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