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Rejection Minimization in Parabolic Leaf Spring Manufacturing Unit in India

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Abstract - In this paper, practical means of facilitating participatory steps taken in productivity enhancement with the emphasis on rejection minimization programs in parabolic Leaf Spring Manufacturing Unit in India were reviewed. Productivity has been the key factor in any industry and it can be enhanced by minimizing the rejections and down time of machine. Parabolic leaf spring plays a vital role in the suspension system of any automobile, since it has an effect on ride comfort and vehicle dynamics. In this present work, various approaches and efforts made for productivity improvement are discussed with the emphasis on reduction of rejections in terms of End Gap and Camber Less in leaf spring in Parabolic Leaf 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 work provides an extremely valuable practical framework to companies who recognize the parabolic Leaf Spring Manufacturing.

Key words:- Heavy Parabolic Leaf Spring, Rejection, End Gap, Camber Over/Less, Stress Penning, Z-bending.

I. INTRODUCTION

Manufacturers in the 21st century will face increased customization, product proliferation, shorter product life cycle and development time, responsiveness, frequent and unpredictable market changes. To gain the competitive advantage, Leaf spring industries are actively involved to analyze and identify root causes reduce all scrap rejections and rework during the manufacturing process of the parabolic Leaf spring [1]. Therefore, a new manufacturing strategy for parabolic leaf spring manufacturing unit has been proposed, developed and applied. Parabolic leaf springs are the important components of the suspension system, which perform isolation task in transferring vibration due to road conditions to body [2]. There are various versions of the parabolic leaf springs such as parabolic, multi parabolic and z-leaf spring. A parabolic spring is basically a leaf or set of leaves, which are tapered in a parabolic way rather than a linear. This means they are thick in the middle and taper in the parabolic manner towards the ends. This spring makes flexibility and carries more load of the vehicle because of this parabolic design and lack of inters leaf friction. India is a developing country and there are many companies dealing in the manufacturing of leaf springs in India. An auto-mobile industry involved in the mass production of leaf spring at Gwalior is the largest manufacturer of tapered leaf spring and parabolic spring for commercial vehicles in India and has been the number one supplier

to Tata Motors Limited and Ashok Leyland Limited. It is now fourth in the world and first 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. The problem of End Gap and Camber Less is major cause to reject the leaf spring at the time of quality check. The quality norms for the product are made in the reference of customer requirements. For the leaf spring, end gap should not be more than 2 mm. This end gap contributes 27% of the total rejection. Some areas are identified to minimize the End Gap rejection like camber over/less, bend in the leaf at the time of z-bending, pin cambering and quenching (PCQ), stress pinning etc.

This study was performed to minimize the rejections and increase the productivity in parabolic Leaf Spring Manufacturing Unit in India. The company used for collects data, is the largest manufacturer of tapered leaf spring and parabolic spring for commercial vehicles in India and has been the number one supplier to Tata Motors Limited and Ashok Leyland Limited. Improving worker's satisfaction and productivity especially in repetitive production tasks are major concerns for management as these tasks are

monotonous, boring, fatiguing, and de motivating and consequently affect satisfaction and productivity (Shikdar and Das, 2003).

II. INVESTIGATION ON EXISTING PROCEDURE

Paul and Sen, This study is aimed at improving productivity and quality, increasing revenue and reducing rejection cost of the manual component insertion (MCI) lines in a printed circuit assembly (PCA) factory, 2006 Elsevier 367–377. T. R. Vijayaram et al. /Journal of Materials Processing Technology 178(2006)39–43, Metal casting industries are actively involved to reduce the scrap rejection and rework during the manufacturing process of the components. To achieve this, the production concerns must follow the quality control procedures without any negligence. Peiyong Qin and Mikhail Mesh (SAE 1996 and SAE APR80), Leaf spring design mainly relies on simplified models and trial and error methods. The simplified models use a three link mechanism to simulate the leaf spring behavior. The purpose of this study was to use exiting leaf spring data to develop and validate detailed multi leaf spring FEA models so that they can be used to support product development. Brayton in the study of productivity measurement observed that the loss of materials are the greatest cause due to non-utilization of material to the maximum and failure to recover increased in the cost of the material by rising price of goods produced in proportion. **E. J. Herrera** (SAE 5160, 2008): Multi-leaf springs used as suspension components in some Venezuelan buses were found to fail after a short service time. As can be the studied springs were of the semi-elliptical type and consisted of six steel leaves of which four served as major leaves and two as secondary leaves. In this work, the origin of premature failure in the springs is investigated. To this end, common failure diagnosis methods involving examination of manufacturing and failure histories, macroscopic inspection, chemical analysis, metallographic analysis, hardness measurements, static loading tests and fatigue tests, were employed.

III. METHODOLOGY USED

Work study as defined by British Standard Institution, is a generic term for those techniques particularly ‘Method Study’ and ‘Work Measurement’ which are used in examination of human work in all its contexts and which lead systematically to the investigation of all the factors which effect the efficiency and economy of the situation being reviewed, in order to seek improvements.

Actually work study investigates the work done in an organization and it aims at finding the best and most

efficient way of using available resources, i.e. men, material, money and machinery. Every organization tries to achieve best quality production in the minimum possible time. The time required to manufacture an item depend upon the manufacturing process; and one phase of work study known as Method study aims at finding the best possible manufacturing process which involves, least time and does not cause fatigue to the workers. In brief, method study or motion study aims at finding the best way of doing a job.

Method study may be defined as the systematic investigation (i.e. recording and critical examination) of the existing method of doing a job in order to develop and install an easy, rapid, efficient, effective and less fatigue procedure for doing same job at lower cost. This is generally achieved by eliminating unnecessary motion involved in a certain procedure or by changing the sequence of operation or the process itself. Work study is a means of enhancing the production productivity of the firm by elimination of waste and unnecessary operations. It helps to reduce the cost of product by eliminating waste and unnecessary operations.

Table-1. Steps involved in work study

IV. 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 shows in table-2. In this present work firstly the various problems and responsible cause of rejection in shop floor are identified.

TABLE-2. VARIOUS PROBLEMS AND CAUSES WHICH ARE IDENTIFIED IN PARABOLIC LINE

Sl. No	PROBLEMS	PROBABLE CAUSE
01	END GAP & INTERLEAF GAP	BEND IN THE LEAF AT THE TIME OF Z- BENDING
02	END GAP & INTERLEAF GAP	PCQ BEEM SETTING ON ONLY 4 BEAMS
03	END GAP & INTERLEAF GAP	STRESS PEENING CAMBER OVER / LESS
04	END GAP	PCQ BEAM PROBLEM
05	END GAP & INTERLEAF GAP	THIRD LEAF DIE LENGTH SHORT AT RR SIDE
06	END GAP & INTERLEAF GAP	TRAY USED IN OPPOSITE DIRECTION SOME TIME
07	END GAP & INTERLEAF GAP	SOLID DIE SETTING OF THE PARABOLIC USES IN OPPOSITE DIRECTION SOME TIME ACCORDING TO THE LOADING.
08	END GAP & INTERLEAF GAP & OVER SCARGING	M/L & 2/L CAMBER OVER SO INCRAGE THE ASSY. CAMBER & JENRATE THE END GAP.

Parabolic Assy. Rejections Data Is Shown In Fig-1 Which Are Identified For Month of Dec. 2010

Fig. 1. Pareto Diagram-Dec 2010

V. RESULTS AND DISCUSSION

At the time of center hole punching in leaf, Z-Bending die center locator stopper is not straight that is found in tapered condition in investigation that causes bend in the z-bending profile & also generates an end gap. The cause behind this position was not availability of support at the end of stopper hence when the leaf is in rest z- bending die center locator is found in tapered condition so while punching, punch is pressed for the center hole in leaf, some deflections are created in the z-bending profile.

To protect the bend in the z-bending profile of leaf the stand is provided with z- bending die center locator stopper, it supports the leaf at other end to eliminate the vibration due to hanging of the leaf and the position of Z-Bending die center hole locator is straight.

Before

After

In the red hot position cambering is done to the leaf at PCQ (Pin Cambering and Quenching) where the camber is provided with the help of master leaf. After the cambering process the leaf should be dipped in quenching oil in between 30 seconds. After the quenching process the leaf gets hard. By the investigation we found that in quenching period some deflections are made in leaf camber which is responsible to camber less. At the time of cambering only 4 setting pins are available to set the camber of leaf. These setting pins are also connected to the quenching tank. This setup is taken from the conventional PCQ which is not suitable for heavy parabolic PCQ. Hence 6 setting pins are provided to set the camber.

Before

After

Parabolic leaf spring is made by three leaves such as M/L, 2/L and 3/L (TML 2515 FR PARA-2782 3210 0143) both are clamped in assembling. End gap is created in leaf because the camber is not same in each

leaf, some deflections are found for many regions. In investigation we found camber of m/l and 2/l is over where as the camber of the die is found alright, so at the time of assembling gap is created between leafs at the end of leaf. This tries to maintain at the past working by changing the die by means of reduced camber. But this is not supported by system for many reasons. Therefore for removing that problem we selected the area of stress pinning where the camber of main leaf and second leaf is down with the help of using 25 mm extra plate in SSP fixture. This helps to reduce the camber of m/l and 2/l is 5 mm and the camber of third leaf is same because there is no need to change the camber. This 25 mm plate is flexible in SSP fixture which is removable and used only for m/l and 2/l.

After

The length of both ends is not same at the center point of leaf. It is different for different models as per design. In stress pinning tray (SSP Fixture) FR & RR direction were not available so sometimes tray was used in opposite direction that creates the END GAP. Hence FR & RR identification has been done on the tray by welding.

Before

After

Stress peening tray center locator pin is provided for deflect the leaf at both ends equally. At the time of stress pinning two leafs are set in stress pinning tray at a single pass, for this process both of leafs are same in dimension. These two leafs are put on the tray and both ends are clamped for the stress peening process. By the investigation we found that leaf center locator at stress pinning tray was not available. In this process some deflections were made in leaf which depends upon the arc height, amperage and conveyer speed. If leafs are not adjusted properly it deflect at both ends unequally, it may cause the camber over/less and end gap. This is also time consuming process and difficult for the human to adjust both of the leaf at the tray so to minimize the time and difficulty of human Leaf center locator on stress peening tray should be provided. The benefit of this work is that it minimizes the 25% time wasted by operator in adjusting the leaf. Hence the productivity of stress pinning is improved by 25% and also helps to minimize the end gap at the time of assembling.

Before

After

I. COMPARISON OF REJECTION RATE

VI. COMPARISON OF REJECTION RATE

Fig. 2. Cumulative % of Defect per Month

CONCLUSIONS

A methodology has been developed which is designed to facilitate, control the rejection and to generate productivity improvement. It is obvious that some positive changes are taken in operations results in control the rejection and thus enhancement of productivity. 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 where the Automobile market is raised on behalf of its economy, technology enhancement is 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 or which improve the production as well as quality of parabolic.

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