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Productivity Improvement through Automated Loading of Brake Plates into Conveyor System in an Automobile Industry

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Abstract

Objectives: The objective of this work is to implement a low cost automation technique in an auto ancillary plant for enhancing the quality and productivity by reducing time and cost. **Methods/Statistical Analysis:** Industries around the globe are keen to implement automation so as to reduce human effort and error. The present study focus on eliminating the existing drawbacks on loading of brake plates into the conveyor system for washing purpose in an automotive ancillary unit. A conceptual model was created using drafting tools and its working is validated using analysis software. **Findings:** The implementation of this low cost automation system would facilitate the management to reduce manual involvement in material handling, reduction of accidents and also in improving the safety of the workers. **Improvements:** This technique would also serve to be the most effective and efficient method for handling the machined parts thereby improving the product quality and total productivity of the organization.

Keywords: Auto Ancillary, Brake Plates, FEM, Low Cost Automation, Manual Loading

1. Introduction

Automation is defined as the technology by which a process or procedure is accomplished without human assistance. It is achieved using a program of instructions combined with a control system that executes the instructions[1]. To automate the complete process, electrical and mechanical power is needed to control the system as well as to run the program. The usage of low cost machines with only basic functions generally results in high manpower and heavy operations. Implementing complete automation results in reduced manpower but it is a complex task and also too expensive. Frequently, certain functions are over engineered by automatic solution, while other important ones are neglected. This is contradictory to the low cost and right sized equipment approach. A low cost automation is one which intelligently adapts to the individual task in a precise and effective manner. It is a technology that promises to be very useful for any kind of manufacturing organization[2].

Automation produces discrete parts at low cost and increases the use of resources by replacing workers with machinery. It reduces the physical work but still requires few labors to perform data processing, decision making and importantly material handling works. Even with automation, use of manpower is required for the flexibility of a process. They help in improving procedures when congestion occurs, to avoid deadlock, bottlenecks and exercise judgment concerning critical activities. The biggest benefit of automation saves number of labor needed to complete the work. However, it is also used to save energy and materials. It also improves the quality, accuracy and precision. Automation is achieved by several methods including mechanical, pneumatic, hydraulic, electrical, electronic devices and computers usually in combination. Complicated systems, such as modern factories, ships and

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aero planes classically use all these combined techniques. Material handling utilizes a wide range of manual, semi-automated and automated equipment and it can be used to create time and place utility through the handling, storage and control of material. Several works have been carried out on low cost estimation techniques to improve the productivity. The works carried out by authors[3–8] have proved that the low cost automation is technically and economically justified and proven its effectiveness over conventional manufacturing process.

In this work a conceptual model was created, analyzed and implemented in an automotive industry for automatic loading of brake pads in conveyor system to impart low cost automation in improving the productivity and reducing the human labor.

2. Methodology and Design of the Proposed Model

The two wheeler and four wheeler brake pad manufacturing plant was chosen for the study. The raw material (brake plates) was received from the sub-contractors. After receiving they were washed with water maintained at a temperature 70°C to remove oil contaminants. Then the brake plates were subjected to hot blasting process where they are hit by the abrasive particles with high speed for converting the smooth surface into rough surface for enhancing the bonding process of the pads on the brake plates. After blasting process, they were kept in the oven for 1 hour which is maintained at a temperature of 90°C to remove moisture content. Then the brake plates were kept in hot pressing machine for bonding of brake pads. A pressure of 150 bar for 15 minutes was maintained for pressing process. After the hot pressing process the pads were cured and painted. Then the final finishing process such as grooving, chamfering and grinding was carried out. After inspection it was ready for dispatch. In this work the washing process as stated in the first step is chosen for identifying the problem. The loading of the work plates into the conveyor system was carried out manually which consumes lot of time and human work. The efficiency of the system is also found to be affected due to manual loading. Hence an automated system for loading the work plates in to the conveyor system is proposed in this work.

Figure 1 illustrates the conveyor system for loading the brake plate for washing. In this system the work pieces for washing is fed into the tray. From this tray the work pieces are taken and loaded individually into the conveyor buckets by the labors. The manual loading of brake plate into the conveyor system is shown in Figure 2. During loading few pieces gets dropped down below the conveyor buckets. This is due to lack of concentration of manual labor. The component dropped below the conveyor buckets gets corroded due to the presence of chemical treated water which maintained at 70°C. Nowadays, there are many options available to prevent corrosion like choosing anti-corrosive materials in the real environment, design modifications to the system or components, electrochemical control, conditioning the metal and modify the environment either by removing the oxygen or adding inhibitors[9]. In order to avoid this the loading of work piece is decided to be automated. The working methodology adopted for automatic loading of brake plates is shown in the Figure 3.

Figure 1. The conveyor system.

Figure 2. Manual loading method.

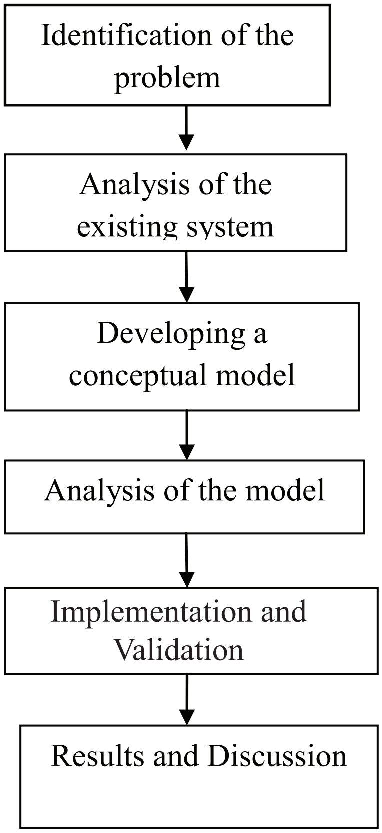

Figure 3. Working methodology.

2.1 Design of Conceptual Model

The problem identified is rectified using automatic loading of brake plates into the conveyor. The conceptual model was created using SolidWorks software as shown in Figure 4. In this system a partially partitioned tray (1) is installed to load the work piece, which can able to change the partition region when the size of the brake plate gets changes. Below this a roller (2) is provided with slot which helps to pull out the work piece from the tray. One end of the roller is powered using geared motor (4). Geared motor is provided in order to get high torque at low speed. The tray (1) is placed in a vertical direction; due to that entire weight of the brake plates in the tray is acting on the surface of the roller body. The brake plates are pulled out from the tray through the roller, which is allowed to slide in the sliding table (3) to reach the conveyor bucket. The sliding speed of the brake plates can be changed by changing the angle of the table. After sliding the work pieces were directly loaded to the conveyor system. Figure 5 shows Roller with a Slot.The roller has 4 cm slot, input to the roller is given by geared motor. The brake plates loaded in the tray is subjected to act above the roller surface. While roller starts to rotate, the brake plates above the roller gets lock in the provided slot. The front portion of the tray is provided with a small gap in order to allow the work piece (brake plate) move out of the tray. The roller is powered with a geared motor with a ratio of 100:1.

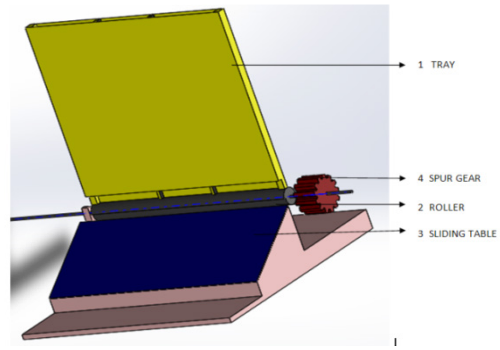

Figure 4. Conceptual model.

Figure 5. Roller with a slot.

2.2 Design of Partition Tray and Roller

The industry is producing brake pads to various customers, like TVS, Maruti, Toyota, Suzuki, Hero Honda etc. Due to the various customers, the brake plate dimensions also differ. In order to overcome that problem the partially partition tray is used. Figure 6 shows partially partitioned tray. The tray can able to change the partition region according to change in the dimension of the brake plates. The roller pulls the brake plates away from the tray which then falls into the sliding table. The sliding speed of the brake plate can be changed by adjusting the angle of the sliding table. From the sliding table the brake plates get directly loaded to the conveyor bucket and taken for washing process. The back portion of the partition tray is fully covered, in order to avoid the falling of brake plates on back side from the tray while it is pulled by the roller and front portion of the partially partition tray is provided with the small gap, which permits the brake plates to move along the direction of the roller. Table 1 shows the data collected from the industry for developing and analyzing the conceptual model.

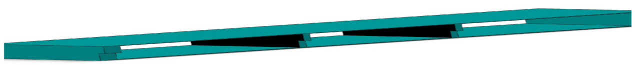

Figure 6. Partially partition tray.

Table 1. Data collected from the industry for developing the conceptual model

Data Collected from the Industry	
Length of the conveyor system	402 cm
Height of the loading region	80 cm
Distance between the buckets	6.5 cm
Average weight of the brake plate	160 gm
Average thickness of the brake plate	4 mm
Conveyor Mouth Dimensions	
No of buckets in the conveyor	324
Width of the system	37 cm
Length of the conveyor bucket	28 cm
Width of the conveyor bucket	3.5 cm
Tray height calculations	
Total no of brake plates washing per shift	1250
No of plate taken to load in the system	400
Average thickness of the plate	4 mm
Height of the tray	1.6 m
Load Calculation	
Total no of brake plate to load in the tray	400
Average weight of a brake plate	160 gm
Total weight of the brake plate	64 kg
Weight of the stainless steel roller	17 kg
Total load acting on the roller	794.61 kN
Type of Load acting on the system	UDL
Speed Calculations	
Module of two gear	2
No. of teeth on input gears	15
No. of teeth on output gear	50
N1/N2 = T2/T1	
14/N2 = 50/15	
Speed of the roller N2	4.2 RPM

2.3 System Environment and Material Selection

Materials are selected based on the workplace environment conditions. A study was carried out on the various grades of stainless steel and also its availability in market. Stainless steel with the grade of 304 and 316 are chosen since they are widely used in the chemical industry. These grades of stainless steels have good corrosion resistance, sanitary qualities and low maintenance cost. The chemical composition of the materials SS304 and SS310 in weight percentage is shown in Table 2. The brake plates were washed in the chemical bath maintained at a temperature of 70°C. SS304 is chosen as a material for the sliding table. The brake plates from the tray are pulled out by the roller to the sliding table. The angle of the sliding table determines the flow speed of brake plates to the conveyor bucket. The angle of sliding table is adjustable. When the roller pulls the brake plates to the sliding table, the sliding table guides the work pieces to reach the conveyor bucket. During sliding time, the friction is produced between the brake plate and sliding table. To overcome this problem, the sliding table is provided with lubricant. The water used for washing brake plates itself serves as a lubricant.

Table 2. Chemical composition of the work material in wt%

Grade	C	Mn	P	S	Si	Cr	Ni	Fe
SS304	0.08	2	0.045	0.03	0.75	18	10	Balance
SS316	0.25	2	0.045	0.03	1.5	26	22	Balance

3. Results and Analysis of the Conceptual Model

The solid model created in SolidWorks is converted in to neutral file format (IGES) and imported into the finite element analyzing package (ANSYS). In pre-processing stage, the material property and the required meshing process are assigned. For the meshing, tetrahedron element is chosen as element type. The material property, boundary condition and the load data are given in Table 3. In the actual working condition the steel roller is subject to rotate, but to estimate the working stress for the given load the model is assumed to be in static and linear analysis is done. Here the boundary condition is taken as simply supported, so all degrees of freedom at the both the ends of the model is arrested. In real situation the load is acting all over the length of the rod while rotating. So here the evenly distributed load condition is applied. The total weight of the work piece (brake plates) is converted to its equivalent force and it the evenly distributed load condition is applied and the problem is solved. The stainless steel roller of 316 grades is taken for load carrying analysis in Ansys. Free tetrahedron mesh is chosen for the model as shown in Figure 7.

The roller which is used for pulling the brake plates from the partition tray to the sliding table is constrained with the boundary conditions which is simply supported at its two ends. Figure 8 shows the roller with the applied boundary conditions. The roller is also subjected to an uniformly distributed load with support at two ends. The entire weight of the system load is 795 kN. The roller is taken to the load carrying test in Ansys. The Figure 9 shows the picture of the roller which is subjected to FEA analysis. The maximum stress found in the system is 593 N/m^2. While comparing this stress value with the tensile yield strength of material it is found to be less and within the limits which shows that the materials will not fail. But from the study it is found that the middle portion of the roller gets buckled. Figure 10 shows the picture of the roller with buckles at the centre. In order to overcome this buckling the number of plates loaded was reduced. It was observed that roller performs well without buckling with lesser load. From the study it was suggested to the plant to change the roller material with the same load carrying capacity, to avoid the buckling and wobbling effect. The proposed model helps to attain the maximum efficiency of the conveyor system. This proposed system provides the right amount of material at right time to load in the conveyor bucket. By implementing this system, the wastage of brake plates can be avoided completely. Only manual labor is required to load the brake plates into the tray.

Table 3. The material property of steel and loading condition

Density	7850 kg/m^3
Young's modules	2×10^{11} N/m^2
Poisson ratio	0.3
Tensile yield strength	2.5×10^{8} N/m^2
Load type	Uniformly distributed load
Load	795kN
Boundary conditions	Simply supported beam

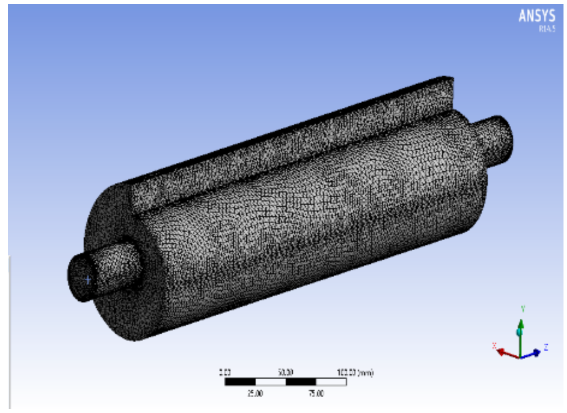

Figure 7. Tetrahedral meshed roller.

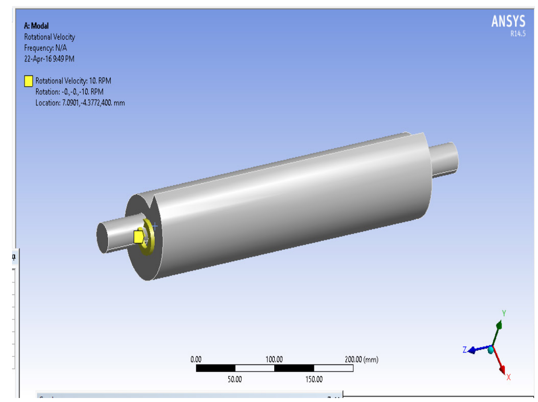

Figure 8. Roller with applied boundary conditions.

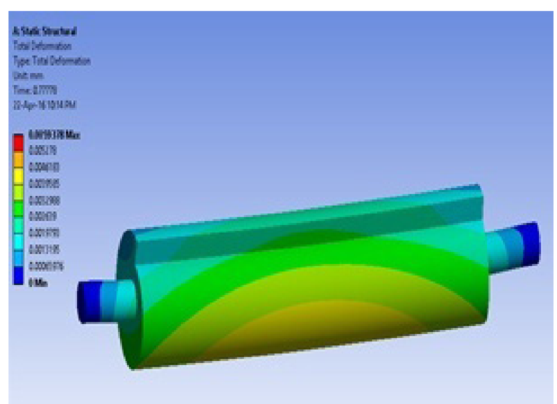

Figure 9. Analysis on roller.

4. Conclusion

The brakes are the crucial component for automobiles. There is always an increasing demand for these components, as lot of new design of vehicles emerges in the market. To meet these demands, the industries have to produce these components with high accuracy and precision and also at enhancing production rate with the existing resources. In this work an automated loading system was designed, fabricated and implemented in an automotive industry for loading of brake plates into the conveyor for washing purpose. This low cost automation mechanism is different from old mechanism, since the operation of the system is totally different as it eliminates the existing manual labor system of loading. This system also reduces the labor cost, ideal and lead time of the system. The main advantage of this low cost automation system is to reduce the operator fatigue, avoid accidents and increase the productivity of the system. This study can provide a small database for serving the industrial needs of automobile plants.

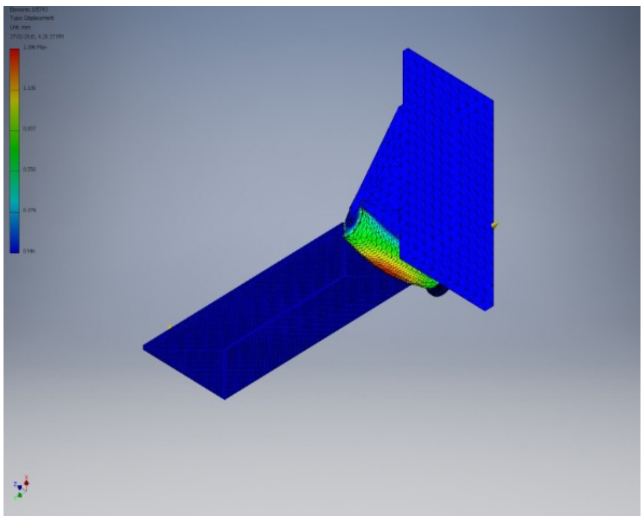

Figure 10. Buckling region of the roller.

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