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A Review on Scope, Study & Need of Setup Time Reduction for Conveyor Pulley Manufacturing

Purvi Chauhan[1], Shyam Rangrej[2], Kaustubh Samvatsar[3], Jigar Patel[4]
[1,2,3,4] Production Engineering Department, Birla Vishvakarma Mahavidyalaya, Vallabh Vidyanagar-388120
[2]shyamrang24@gmail.com
[3]kaustubhsamvatsar@gmail.com

Abstract
A systematic approach is essential for modeling and determination of optimum operating conditions which helps in process quality improvement. Moreover it attempts to provide the user with flexibility to adopt appropriate techniques based on their inherent potential. The designed solutions considering desired production requirements for intended studies can be helpful in increasing the productivity. It can be achieved by adopting lean principles and standardized processes which thereby leading to fulfillment of customer needs. The present study encompasses the different techniques for a case of set-up time reduction of conveyor pulley manufacturing. Five different techniques and a specific Mechatronics approach are considered.

Keywords- *Conveyor pulley, Lean manufacturing, Just-in-time, Kanban, SMED, 5S, Mechatronics*

I. INTRODUCTION

The conveyor pulley, located at the tail end of the conveyor allows the conveyed material to fall to the sides. The accessories, which are made of high quality material and have high load bearing capacity are conveyed on opposite side through belt conveyor. Conveyor pulleys are designed as a means to drive, redirect, provide tension to or help to track the conveyor belt. Conveyor rollers are designed to support the conveyed product be used in the bed of a conveyor as a support for the conveyed product. They are under the conveyor bed in the return section to support the return side of the conveyor belt.

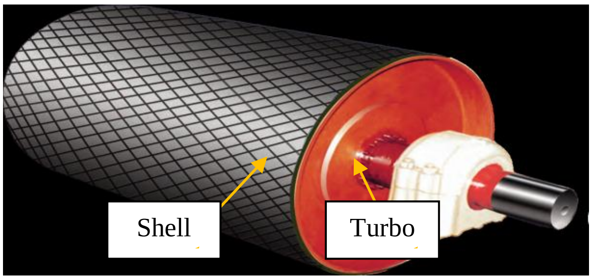

Figure 1. Conveyor Pulley

The plate for pulley shell is marked and cut using plasma cutting machine. During cutting, deformation takes place at cutting area because of high temperature. Hence, grinding and finishing are needed to be performed after cutting process. Shell thickness shall be checked by mechanical instruments. Thereafter, proper sized rectangular plates are transferred to machine shop. For bending the plate in cylinder shape roller bending machine is used as shown in Figure 2 using which approximate size of shell is made. The shell diameter is usually kept larger than required diameter. It is not possible to bend the end edges because shell edge is only in contact with one roller at one time. So, end edges are unbend after first pass of rolling.

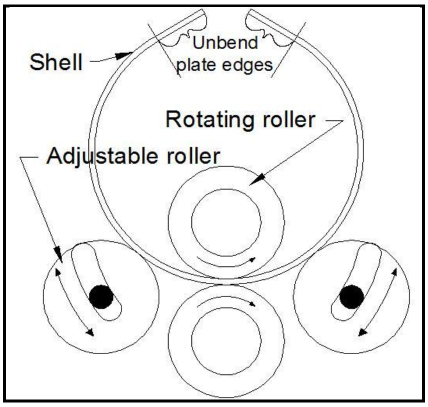

Figure 2. Four roller bending machine

To remove these unbent edges, LPG + Oxygen gas cutting machine as shown in Figure 3. In this process, cutting flame is adjusted on marked line and machine moves parallel to edges on rail path. After edge cutting, grinding and finishing operation are required. Thus, the shell becomes perfect curved. Roll bending operation is done again to obtain desired radius of curvature. The radius of shell is gradually reduced. Arc welding is done at the joining edges temporarily at four to five places at regular intervals to assure non-separation of edges. After performing some finishing operations, shell is welded perfectly by Submerged Arc Welding Process.

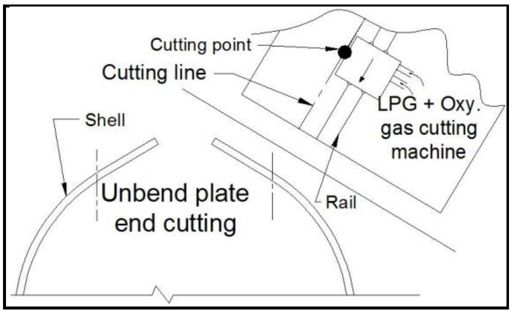

Figure 3. Shell's edge cutting by LPG + Oxy gas cutting machine

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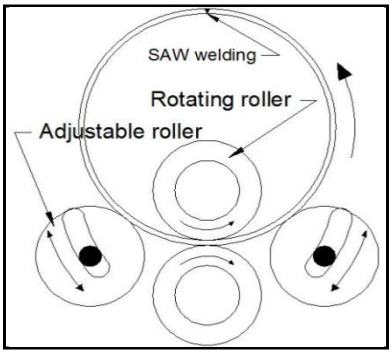

Figure 4. Rerolling of shell

Rerolling of shell is done at roller bending machine to obtain perfect cylindrical shape of shell followed by complete Ultrasonic testing or Radiography. The prepared shell and preheated diaphragm plates are welded by CO_2 welding. Weld geometry is shown in Figure 5. All other machining operations are carried out after welding & stress relieving.

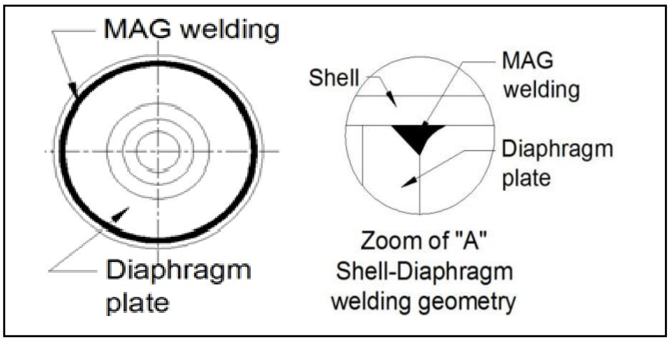

Figure 5. MAG welding and weld geometry

Further, balancing is done by static balancing machine as shown in Figure 6. Rollers are free to rotate in any direction. Shaft of pulley is placed between two rollers. In this process, the pulley is rotated in any direction. If the pulley rotates backwards direction at the end of movement, it indicates static imbalance. Proper balance weight is attached with the help of arc welding to remove the unbalance mass.

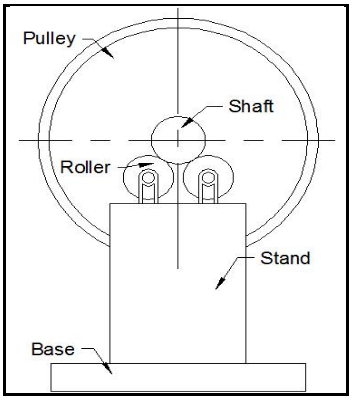

Figure 6. Balancing of pulley

Designed special purpose equipment is able to accommodate conveyor pulleys and rotate it at required speeds. All the components are designed in such a way that they can carry the loads and moments during working conditions. Design calculations of shaft, slideways, gear rings etc. are done by taking high the factor of safety to avoid chances of failure. By using this special purpose equipment, it is possible to reduce time up to 60-70% by reducing the setup time as well as synchronizing the welding on both the sides of conveyor pulley simultaneously.

II. LITERATURE REVIEW

Reginaldo Guirardello et al [1] worked on an optimization approach for the design of chemical plant geometric layout. And they solved problems using mixed integer linear programming models. Different techniques are studied in order to do an automatic routing of a process plant layout. The procedure is based on a (partially arbitrary) selection of node positions where pipes can be routed, respecting restrictions of safety and minimum distances from components. These nodes are connected by arcs that avoid the physical space of components.

V. Madhusudanan Pillai et al [2] presented Design of robust layout for Dynamic Plant Layout Problems. The general strategy for a multi period layout planning problem is adaptive approach. This approach for Dynamic Plant Layout Problem (DPLP) assumes that a layout will accommodate changes from time to time with low rearrangement and production interruption costs, and that the machines can be easily relocated. As a solution procedure for the proposed model, a Simulated Annealing (SA) algorithm is suggested, which perform well for the problems from literature and QAPLIB website. The application of suggested model for robust layout to cellular layouts has given better results as compared to the robust cellular layout model of literature.

Stefan Bock et al [3] presented a detailed layout planning for irregularly-shaped machines with transportation path design. By defining a production system's basic structure and material flows, the layout determines its operational performance over the long term. However, most approaches proposed in the literature provide only a block layout, which neglects important operational details. Hence, it introduces an integrated approach which allows a more detailed layout planning by simultaneously determining machine arrangement and transportation paths.

Dilip Chhajed Benoit Montreuil et al [4] made Flow network design for manufacturing systems layout. They presented a shortest rectilinear flow network problem by defining and formulating as an optimization problem. A Lagrangean relaxation of the problem gives separable, linear-time solvable, shortest-path problems.

Q. Duan et al [5] presented improved ant colony optimization algorithms for determining project critical paths. The authors pointed out the numbers & placement of logical dummy activities associated with AoA(Activity-on-arc)-based networks can pose serious problems. The test results strategy indicate that AoN (Activity-on-node)-based ACO algorithms (ant colony optimization) are more effective & efficient in finding critical paths than AoA-based algorithms.

R. Sundar et al [6] presented a review on Lean Manufacturing Implementation Techniques. In this paper, an attempt has been made to develop a lean route map for the organization to implement the lean manufacturing system. Analyses of the exploratory survey results are summarized

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in this paper to illustrate the implementation sequence of lean elements in volatile business environment and the finding a unified theory for implementation of lean elements. This implementation structure reduces the Setup time, overall cycle time and reduces manufacturing system divergence.

Hardik Gangadia et al [7] presented Design & Modeling of Special Purpose Equipment for Shell-Diaphragm Welding in Conveyor Pulley. At present, in many material handling industries, need and capacity of conveying equipments are increasing rapidly. Conveyor pulleys have been recognized as the most necessary component of the conveyor system resulting in increasing demand of conveyor pulley. Various types of pulleys are used for conveying systems. Here, a focus is on the high-tension pulleys where the use of custom made engineered welded steel pulley is dictated due to its higher capacity and ease of manufacturing. Requirement of various sizes conveyor pulleys are there as a result of various size of conveying systems to be designed. It is now compulsory for the conveyor pulley manufacturers to increase their production rate. To be specific, industries want a special purpose machine which in turn can prove useful for various diameter and length of pulleys at low cost. So authors designed a special purpose equipment for Shell-Diaphragm Welding in Conveyor Pulley adopting which set up time can be reduced.

S.S.K. Deepak [8] presented Applications of Different Optimization Methods for Metal Cutting Operation which shows a comparison between different optimization approaches. The proposed research can be very helpful for industries to determine the optimal cutting parameters and improve the process quality. The comparison will also be beneficial in minimizing the costs incurred and improving productivity of manufacturing firms

Nor Azian Abdul Rahman et al[9] presented Lean Manufacturing Case Study with Kanban System Implementation with objectives to determine how the Kanban system works effectively in multinational organization and to identify factors hindering Malaysian small and medium enterprises (SME) from implementing Kanban. The authors also suggested that top management commitment, vendor participation, inventory management and quality improvement are important for Kanban deployment and towards lean manufacturing.

Taho Yang et al[10] presented Lean production system design for fishing net manufacturing using lean principles and simulation optimization. Value Stream Mapping (VSM) has been made which is a useful tool for describing the manufacturing state, especially for distinguishing between those activities that add value and those that do not. It can help in eliminating non-value activities and reducing the work in process (WIP) and thereby increase the service level. This provides guidelines for designing future state VSM consisting of five factors which can be changed simply, without any investment. These five factors are (1) production unit; (2) pacemaker process; (3) number of batches; (4) production sequence; and (5) supermarket size. The five factors are applied to a fishing net manufacturing system. Using experimental design and a simulation optimizing tool, the five factors are optimized. The results show that the future state maps can increase service level and reduce WIP by at least 29.41% and 33.92% respectively.

Alex M. Akugizibwe et al[11] evaluates lean implementation across different sectors including: aerospace, rail and healthcare; listed visual management, 5S and work standardization as the most utilized lean techniques. This study supports previous findings that barriers to lean implementation and critical success factors are the same regardless of the sector or techniques used and also shows that lean successes are sometimes difficult to sustain. One limitation is that the findings cannot be generalized to a wider context especially in those sectors that had a limited data pool. They can however provide guidance to organizations when implementing a particular lean technique or the entire lean philosophy.

P. Kuhlang et al[12] introduced methodical approach connects Value Stream Mapping (VSM) and Methods-Time Measurement (MTM) and offers new distinct advantages to reduce lead time and increase productivity based on lean principles and standardized processes. The mutually aligned design and improvement of assembly and (production) logistic processes takes the workplaces, their surroundings and the supply areas as well as the overall value chain into account. The identification and exploitation of productivity potentials is realized by the joint application of VSM and MTM focusing the (work) methods, the performance and the utilization of the processes (the dimensions of productivity). The study describes principles, benefits and the procedure of application. A practical example highlights the redesign of assembly workplaces and the redesign of (production) logistic processes to reduce inventory/lead time using logistical and ergonomic aspects specially applying MTM logistic process elements.

III. TECHNIQUES OF SETUP TIME REDUCTION

3.1 Lean Manufacturing

Lean manufacturing is a systemic method for the elimination of waste ("Muda") within a manufacturing process. Lean also takes into account wastes created through overburden ("Muri") and wastes created through unevenness in workloads ("Mura"). Working from the perspective of the client who consumes a product or service, "value" is any action or process that a customer would be willing to pay for.[15]

Lean Manufacturing process has three key stages. The primary stage is To Identify Waste. According to the Lean philosophy, waste always exists and no matter how good your process is right now, it can always be better. This commitment to continuous improvement is known as Kaizen . One of the key tools used to find this waste is a Value Stream Map (VSM). This shows how materials and processes flow through the organization to bring the product or service to the consumer. It looks at how actions and departments are connected, and it highlights the waste.

The intermediate stage is to analyze the waste, and Find the Root Cause. For each waste identified in the first stage, Root Cause Analysis is performed. Other effective tools for finding a root cause include Cause and Effect Diagrams and Brainstorming.

The final stage is to solve the root cause and repeat the cycle. Using an appropriate problem-solving process,

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decide decision must be done to fix the issue to create more efficiency.[16]

3.2 Just-In-Time Concept

'Just-in-time' is a management philosophy and not a technique. It originally referred to the production of goods to meet customer demand exactly, in time, quality and quantity, whether the `customer' is the final purchaser of the product or another process further along the production line. For example: JIT concept is applied for forging industry. The reasons for implementation of JIT in forging industry are high waiting, more defects, transporting, over-production, inappropriate processing, unnecessary inventory and motion. The results after JIT implementation should change in work place layout, which may help a lot in reducing the man and material movement. And new furnace may reduce the set up time and operation time for the operation.[13] It is the means of minimization of waste during production. "Waste" is taken in its most general sense and includes time, materials and resources. JIT includes:

- Continuous quality enhancement by attacking fundamental problems
- Devising systems to identify problems and their simplification to understand and facilitate ease in management.

A product oriented layout focuses on least time to be spent on moving of materials and parts. Each worker is responsible for the quality of their own output. Development of Poka-yoke as foolproof tools, methods, jigs etc. prevent mistakes. Preventative maintenance and total productive maintenance ensuring machinery and equipment functions perfectly is required. Continuous improvement by eliminating seven types of wastes mainly waste from overproduction, waiting time, transportation, processing, inventory, motion and defective production.

Also, good housekeeping of workplace can be maintained for cleanliness and organization of available resources. Set-up time reduction increases flexibility and allows smaller batch production (where ideal batch size is 1item). A multi-skilled workforce has greater productivity and flexibility. Leveled production can smoothen the flow of products through the factory. Jidoka provides machines with the autonomous capability to use judgment so that workers can do more useful things.[17]

3.3 Kanban

Kanban is a scheduling system for lean And Just-In-Time production. It is a system to control the logistical chain from a production view point and is not an inventory control system. It is an effective tool to support continuous running of a production system as a whole and is an excellent way to promote improvement. One of the major benefits of Kanban is to establish an upper limit to the work in progress inventory and avoiding overloading of the manufacturing system.[18]

Kanban cards are the key components of Kanban system and they signal the need to move materials within a production facility or to move materials from an external supplier into the production facility. It is a message that signals depletion of products or parts. When received, the Kanban triggers replenishment of that products or parts. Thus, consumption drives demand for more production and hence, a demand-driven system is created.

3.4 Single Minute Exchange Of Die

Single-Minute Exchange of Die is one of the many lean production methods for minimizing waste in a manufacturing process. This method is an efficient way to reduce setup operations in less than ten minutes. This increases production efficiency by means of reducing waste and the time spent for changeovers. Introducing better setup practices, the production lots as well as the inventory can be reduced, thus improving overall production flow.

3.5 5S Philosophy

5S is a perfect set of five Japanese words which all start with S. It is a way of organizing and managing the workspace without creating waste. This decision making process can lead to clear understanding between employees regarding method of doing work. It is helpful to execute standardized processes. The 5S's are:

- 'Seiri' indicates tidiness or organization. It refers to the practice of sorting out all the tools, materials, etc. in the work area and keeping only essential items which thereby leads to fewer hazards and interference with productive work.
- 'Seiton' indicates orderliness. It focuses on arranging the tools and equipment in an order that it promotes work flow. Tools and equipments should be kept where they will be used which further eliminates extra motion.
- 'Seiso' indicates systemized cleanliness and the need to keep the workplace clean and neat. Cleaning in Japanese companies is a daily activity an occasional activity. At the end of each shift, the work area should be cleaned up and everything must be restored to its place.
- 'Seiketsu' indicates standardization of work practices. It refers to operations in a consistent and standardized fashion. Everyone knows exactly what his or her responsibilities are and are dedicated towards it.
- 'Shitsuke' indicates sustaining discipline and maintaining standards. Once the previous 4S's have been established, they become the new way to operate. Maintaining the focus on this new way of operating eliminates possibility of a gradual declination to the conventional ways of operating.[19]

3.6 Mechatronics Approach

Mechatronics is a synergistic combination of precision engineering, electronic control and mechanical systems. It is the science that exists at the interface among the other five disciplines: mechanics, electronics, informatics, automation and robotics.[20] Adoption of mechatronics approach in machines is necessary to improve accuracy and repeatability and decrease the lead time and requirement of labour. Maulik Vaghasiya et al [14] presented a mechatronics product which consists of servo system for two axis position control of welding positioner using PLC and HMI. The system can increase accuracy and

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precision of welding in terms position and welding speed with its direction.

IV. CONCLUSION & FUTURE SCOPE

The paper incorporates the use of all the above techniques using which, the reduction in process set up time of conveyor pulley can be made possible. The study to be done can provide a unified approach of production optimization problems. These techniques are useful for increasing productivity. Each technique has its advantages and limitations depending upon the kind of manufacturing case. Amongst all, Lean Manufacturing Technique proves to be the most appropriate for conveyor pulley manufacturing as it provides solution to improve productivity by modification in plant layout.

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