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Automation in Packaging Line of Engine

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***Abstract*—This paper discusses the design and development of an automated packaging assembly line for part level packaging in India's manufacturing industry. The goal is to create a system that can autonomously package components into cardboard boxes, with 25 micron oil film thickness on 6C components and capacity to pack more than the current requirement. The assembly line uses automation and Human Machine Interface to provide consistent oiling and packaging quality. The design includes an Infeed Conveyor, Oil Dipping Conveyor System, Oil Spray System, Air Drying System, and Oiling Assembly, as well as Carton Sealing and Strapping Machines. The system aims to reduce the need for manual labor, increase throughput, and improve quality control. Future scope includes expanding the system to handle more complex tasks and integrating it with other manufacturing processes.**

Keywords—Automated packaging, assembly line, part level packaging, oiling film thickness, cardboard boxes, conveyor, Infeed Conveyor, Oil Dipping Conveyor System, Oil Spray System, Air Drying System, Oiling Assembly, Carton Sealing Machine, Strapping Machine, component packing.

I. INTRODUCTION

In any manufacturing industry, it is important to pack the products safely. India is a developing country in the manufacturing and production sector. Transport plays a crucial part in export. The material that is required to be delivered to a long distance should be transported securely. In order to do so, the paper is focusing on delivery of the parts with the prevention of corrosion after being in contact with air for a long time.

Packaging is a type of department in any industry that deals with the security, safety and sustainability of the component packed inside. Packaging can be divided into various types including, complete knock down, semi knock down, complete built-up unit and part level packaging. We will be focusing on the part level packaging of the components.

The cost for transporting the complete built unit is more as compared to the part level. Many countries have more tax on a complete built unit than the parts, also the manufacturer doesn't need to spend money on the assembly of the component. This makes the part level packaging an inexpensive yet efficient way of transporting.

The project deals with planning of an automated line of packaging, where the major components along with hardware should be packed. The components that can be affected by the effect of air, moisture, weather, etc. are packed with oil inside it. This prevents the components from changing according to the surroundings. To provide the oiling film in the same quantity with great consistency, automation of the line is helpful. The manual technique cannot provide it with the same efficiency and output. The combination of automation and Human Machine Interface can give effectively good results.

II. LITERATURE REVIEW

Joanna Marie M. Baroro, Melchizedek I. Alipio, Michael Lawrence T. Huang, Teodoro M. Ricamara, Angelo A. Beltran Jr,present a system for automating packaging and material handling using programmable logic controllers. This system utilizes sensors such as proximity and load sensors, as well as motors and pneumatic devices, to automate the traditional packaging process. The authors observed a significant reduction in processing time of approximately 50-60%. [1]

Qiuxiao Yang, Kaibao Wang, Mingzhu Zhang, and Li Zhao propose an automated packaging system for improving the low efficiency of strain packaging. This system is specifically designed for small and medium-sized farmers.[2]

Maurizio Bevilacqua, Filippo E Ciarapica, Ilaria De Sanctis, Giovanni Mazzuto, Claudia Paciarotti, this paper shows the study that line automation yields significant improvements in increase of workstation saturation, better cohesion and reduction of man work by implementing automated assembly line.[3]

III. OBJECTIVES

Existing technique: The current method for part level packaging relies on manual labor, where workers stand on either side of the assembly line and perform tasks assigned to their respective sub stations. However, this manual method has several limitations, including a limited throughput rate due to the dependence on human labor, a higher possibility of errors, and a production process that is heavily reliant on worker availability, which can be affected by breaks, holidays, absenteeism, etc. Furthermore, the cost of not automating the process is significant, leading to a drive to implement automation in order to reduce costs and improve efficiency. The automation of part level packaging has the potential to enable the rapid completion of more complex tasks while reducing errors and the need for human intervention.

Scope: To create a system that can:

1. Develop a fully autonomous packaging process that minimizes the need for human intervention.
2. Ensure that the oiling process achieves a consistent 25 micron oil film thickness on all components.
3. Pack components into designated cardboard boxes that are compatible with shipping requirements.
4. Create a system with the capacity to pack more components than the current requirement.

IV. METHODOLOGY

A. *Design and Calculations*

Output requirements:
Length per station,
Oil sump = 1000 mm
Air spray = 500 mm
Box - pick and place = 1000 mm
Component packet sealing = 600 mm
Lip pushing = 800 mm
Box taping = 1000 mm
Stripping = 1000 mm.
Total length of conveyor = 5900 + (500*6) = 8,900 mm
Round up to 9 m of conveyor.
Speed of conveyor calculations:
60 engines packed in 150 boxes
distance / time = speed of conveyor
For time,
Boxes required per shift = 48e x (150/60) x 8 = 960 boxes
Target = 960 boxes/shift
Achieved = 960 boxes/shift (at 90mm/sec speed of conveyor)
Output speed per box takt time = (8x60x60) / 960 = 30 sec
For distance,
Distance needed to travel for 1 box output = distance of conveyor x number of stations on conveyor
= 9000/7 = 1285 mm
Output speed per box cycle time = 1285/30 = 43 mm/sec
With considering a stop of 20 second,
Final speed of conveyor = 1285/10 = 128.5 mm/sec

B. *Equipments and Working*

The packaging line requires plenty of equipment to complete the process effectively. The output considers the parameters of total components to be packed per shift precisely. The machines, along with their parameters that are required for the line, were decided on the basis of design, calculations, certain constraints and assumptions. Following is the machine requirement for manufacturing the assembly line: -

1. Oiling Assembly-

Infeed Conveyor - The infeed conveyor is a simple belt conveyor used for the system input for feeding the components to the system. It is the first and simplest part of this system.

Oil Dipping Conveyor System - It is the assembly of various separate parts combined to make a special purpose machine whose sole purpose is oiling in different ways. This machine can apply oil into three processes, dipping, spraying and brushing. Nozzles are provided on every side of this system for proper spreading of the oil. Nozzles are particularly used for the spraying purpose. Brushing process is carried out along with dipping by keeping the oil sump at specific height to carry out this process. A 25 micron 3-layer filtration system is provided for the proper dipping of components.

Oil Spray - This is the third part of this system which is operative only when a component with this process is loaded on the infeed conveyor. In all eight nozzles are provided, three each on the top and bottom and two on sides. The number of the nozzles located along every direction tends to get the component oiled from all the directions properly.

Air Drying - This is the last stage of the system. All the oiled components are passed through this system for drying. It consists of four nozzles which will be connected to the compressor supplying the compressed air with a pressure of 5 to 6 bar. This will help in removing excessive oil on the components. The excess oil will be collected in the form of mist in a separate collector location just below the air spraying nozzles.

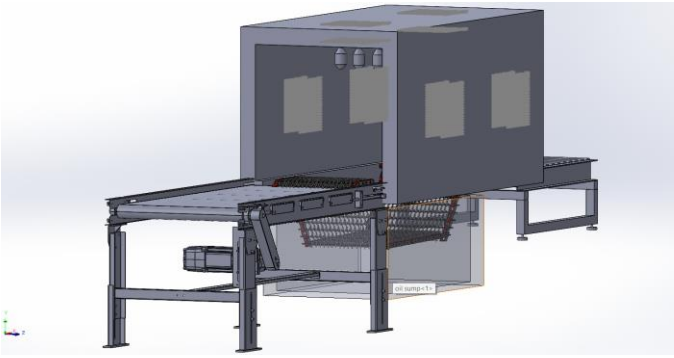

Fig. 1. Oiling assembly cad model

2. Weighing Assembly-

This system is provided just after the oiling assembly. It is important in the system for container loading. The weighing capacity of the container, according to the laws, is decided already and hence should be followed. For this purpose, the weight of the component after oiling is noted. The weighing is also necessary for the hardware as it is supplied in the terms of weight to the customer. The proportion of oil to be considered before packing the hardware. If the weight is extra, we can remove the excess oil from the packing. A sensor attached to the weighing scale will be noting the weight and maintaining it as per the standards. The weighing assembly is the last step before the component is packed.

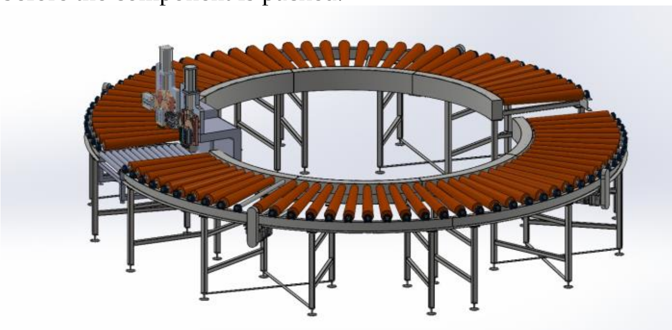

Fig. 2. Weighing assembly cad model

3. Packaging Assembly –

Carton Sealing Machine - This machine is equipped with a lid pushing mechanism that will close the lead of the box. Following with the lead pushing mechanism, box taping is also done simultaneously in this machine. The machine can apply tape to the top and bottom of cardboard boxes for sealing purposes. These are attached with the roller conveyor. Taping is the process of applying adhesive tape to a box or other face. When manually applying the tape, a tape-dispenser is frequently used. To apply tapping at the industrial level, a Carton Taping Machine is essential.

Strapping Machine - Strapping machine is used after the box taping procedure for the better packaging purpose. The machines use a band using the material of flat steel, plastic tightened around the package. Straps bundle products easily and save them from spilling. This improves containment strength securing load to a shopping pallet. The straps are made of the material which will give the suitable strength. This machine provides the straps from two sides that are opposite to the lead. Immediately after the straps are rounded to the box, they are tightened, this provides safety and extra benefits to the packaging process of the component inside. With this, the assembly comes to an end having the end product as the component packed securely.

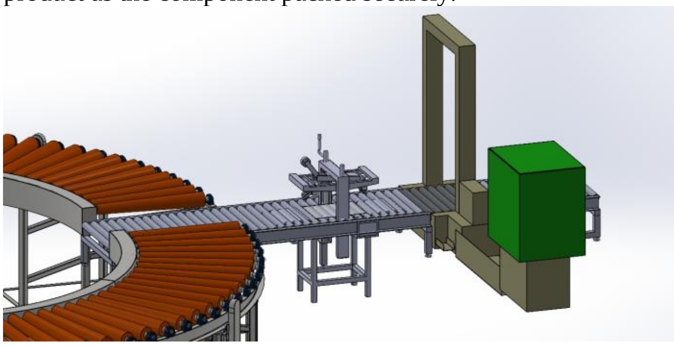

Fig. 3. Packaging assembly cad model

Working:-

The components are divided into main three categories according to the oiling to be done. Total of 148 components are too packed which are briefly divided under the dipping, brushing and spraying process. 42 components are passed through the dipping operation. All the components with the same operation are passed at one time. Then the next type of operation under the oiling stage will be carried out.

Dipping operation - The component is fed to the system through an infeed conveyor. The sensor senses the code on the product and the further changes in the system are done. The oil sump is shifted upwards to make the dipping easier. The mesh conveyor is used inside the oiling system for mixing the oil with the components. The mesh conveyor is provided with an angle of 40 degrees for dipping the component on it inside the oil sump. The procedure stops for some time when the component is inside the oil and then moves forward. While dipping is the operating condition, the spraying operation is ceased. So that patch of the assembly is empty. Next is the air spray. In all inside the oiling assembly there are three components, one inside the oil sump, one below the oil spray and the last below air spray. For the proper oiling and air-drying purpose, the packaging line is stopped for 20 secs. This won’t affect the productivity of the line. After the air spray, the component will be on the weighing scale. Once the weight is checked, the component is placed inside the box using pick and place machine. The box is further moved to carton sealing machine where the lid is closed and the box is taped. The strapping machine carries the last part and secures the box by using straps around the box.

Spraying operation - The component is fed to the infeed conveyor. When the system detects that the component has the code for the spraying operation, inside of the oiling assembly changes. The oil sump is lowered using hydraulic actuation, to make the way clear for the components to be sprayed. The process again stops when the component gets under the nozzles for the spraying purpose. The oiling sump is located below the spraying mechanism for collecting the remaining oil. Further the air is sprayed and the film is maintained. Rest of the process is same as that of the dipping operation.

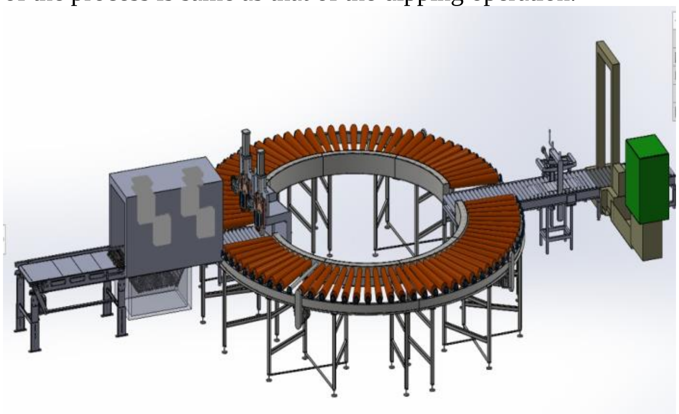

Fig. 4. Overall assembly of project

V. RESULT AND DISCUSSION

The designed automated packaging assembly line for engine parts successfully met the output requirements with a capacity to pack more than the current requirement. The line was able to autonomously package components into cardboard boxes with 25 micron oil film thickness, providing the same quantity of oiling film with great consistency. The line's speed calculations showed that it could pack 60 engines in 150 boxes with a target of 960 boxes per shift. The speed per box takt time was 30 seconds, while the speed per box cycle time was 128.5 mm/sec, with a stop of 20 seconds.

The packaging line required various equipment, including an Infeed Conveyor, Oil Dipping Conveyor System, Oil Spray System, Air Drying System, Weighing Assembly, Carton Sealing Machine, and Strapping Machine, to complete the process effectively. The Infeed Conveyor was used to feed components to the system, while the Oil Dipping Conveyor System was a special purpose machine that could apply oil into three processes: dipping, spraying, and brushing.

The Air-Drying System consisted of four nozzles connected to a compressor supplying compressed air with a pressure of 5-6 bar. The Weighing Assembly was used for container loading, noting the weight of the component after oiling. The Packaging Assembly included a Carton Sealing Machine with a lid pushing mechanism and box taping, and a Strapping Machine was used after the box taping procedure to bundle products easily and secure them from spilling.

VI. CONCLUSION

Automated packaging assembly lines are critical for efficiently and effectively packaging products safely in India's manufacturing industry. This study focused on the design and planning of an automated line of packaging for

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engine parts, where components were packed with oil to prevent corrosion. The results showed that an automated packaging assembly line can autonomously package components into cardboard boxes with 25 micron oil film thickness, providing the same quantity of oiling film with great consistency.

The designed packaging line's output requirements were met with a capacity to pack more than the current requirement. The line's speed calculations showed that it could pack 60 engines in 150 boxes with a target of 960 boxes per shift. The packaging line required various equipment, including an Infeed Conveyor, Oil Dipping Conveyor System, Oil Spray System, Air Drying System, Weighing Assembly, Carton Sealing Machine, and Strapping Machine, to complete the process effectively.

In conclusion, the designed automated packaging assembly line for engine parts was successful in meeting the output requirements and provided an efficient and effective way to package components with minimal human intervention. The use of automation and human-machine interface provided consistency in the packaging process, ensuring that engine components were packaged securely and according to specific requirements.

VII. FUTURE SCOPES

The automated packaging assembly line designed in this study can greatly benefit the Indian manufacturing industry by providing an efficient and cost-effective solution for part level packaging. However, there is still room for further improvements and advancements in the field of automated packaging.

1. One potential area for future research is the integration of Artificial Intelligence (AI) and Machine Learning (ML) into the packaging line to enhance its automation and efficiency. AI can be used to optimize the packaging process by analyzing data on the components, the packaging materials, and the environmental conditions to ensure the highest quality packaging. ML can be used to train the system to identify any defects or anomalies in the components, alerting the operators to take corrective action.
2. Another area for future research is the use of sustainable packaging materials and practices in the automated packaging line. This can include the use of recyclable materials, reduction in packaging material waste, and minimizing the environmental impact of the packaging process.
3. Lastly, the future scope of the study can also focus on implementing predictive maintenance techniques in the packaging line. Predictive maintenance can help in identifying the potential problems and maintenance requirements of the machines before they occur, thus minimizing the downtime and optimizing the performance of the packaging line.

Overall, the automated packaging assembly line designed in this study is a significant step towards achieving efficient and cost-effective part level packaging in the Indian manufacturing industry. The future scope of the study can focus on incorporating advanced technologies and sustainable practices to enhance the performance and sustainability of the automated packaging line.

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