

Williams, Nathan
Student 2126256

ASSESSMENT B

Industry 4.0 technologies concept for uPVC profile wrap line.

Contents

1. Introduction.....	2
2. Problem identification.....	3
2.1 Health and safety.....	3
2.2 Machine uptime and efficiency.....	4
2.3 Impact to distribution.....	4
3. Implementation Methodology.....	4
3.1 Product Identification and tracking.....	4
3.2 Product loading and transfer.....	5
3.3 Machine type.....	5
3.4 System monitoring and control.....	6
4. Conclusion.....	7
5. References.....	8

1. Introduction

This report focusses on how industry 4.0 principles and technologies could be implemented within a uPVC extrusion factory, to increase productivity, reduce downtime and improve safety. 'The vision of industry 4.0 is that in the future, industrial business will build global networks to connect their machinery, factories and warehousing facilities, as cyber-physical systems which will connect and control each other intelligently, by sharing information that trigger actions. These cyber-physical systems will take the shape of smart factories, smart machines smart storage facilities and smart supply chains' (Gilchrist, 2016, p. 205).

Key processes throughout the business were reviewed considering criticality to operations, reliability and total cost of maintenance. The review highlighted the warehouse wrap line as an area with significant inefficiencies that could benefit from implementing industry 4.0 concepts. The wrap line formed a critical part of the distribution process. It is used to wrap specific quantities of uPVC profile lengths in a protective plastic shrink wrap for storage in high bay racking and warehouse picking. The process is highlighted in Fig. 1

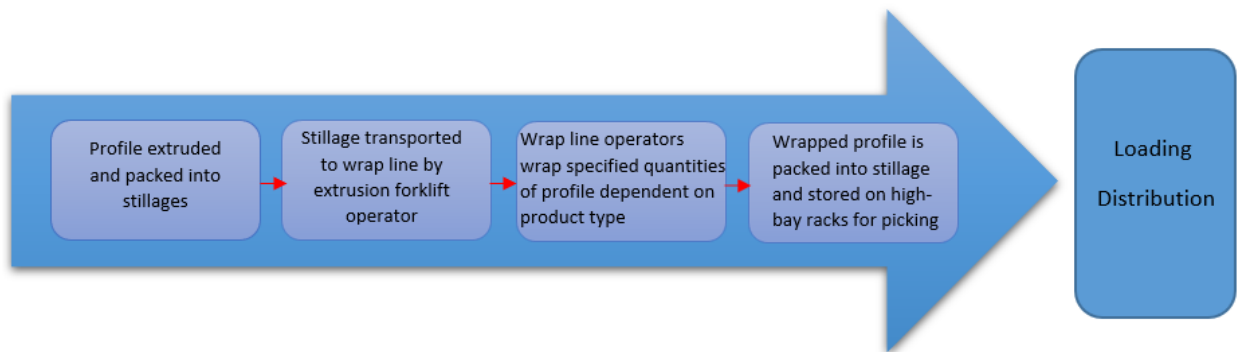


Fig.1 Flow description of product from extrusion hall to loading and distribution

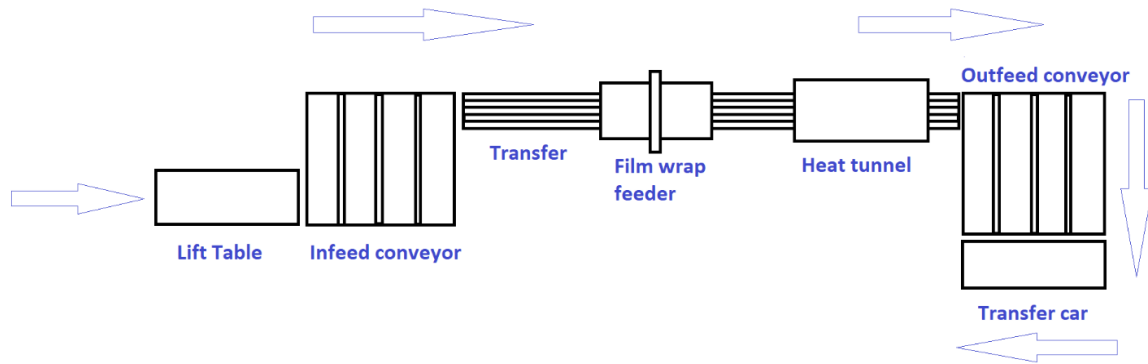


Fig.2 Flow of plastic profile through wrapping process

2. Problem identification

2.1 Health and safety

At the start of the process, full stillages were delivered to the wrap line. Operators pulled profile lengths from the stillage, banded together with elastic, then fed onto the transfer conveyor. This twisting, lifting, pushing motion, was repeated throughout a 7hr shift, causing fatigue and the potential for strain injuries. Similarly, this process was replicated at the machine offtake, where the operator pushed the wrapped profile on the transfer car to transport to high bay racking.



Fig.3 Operator pulling profile from Stillage onto infeed



Fig.4 Operator pushing profile from outfeed

2.2 Machine uptime and efficiency



Fig.5 Profile passing through film feeder

Wrapping required a minimum of two personnel to control the line, with the machine operating between the hours of 06.00 and 14.00. Resource was arranged in two shifts of two employees, working an early and a late shift. The machine's heat tunnel took 40 mins to reach temperature set point. Employee breaktime entitlements meant the machine also shut down for 2hr during that period. These two factors alone resulted in 27% downtime. Other tasks also diverted operators away from wrapping. Using a forklift truck, operators at the infeed of the line also needed to remove empty stillages and load full ones onto a scissor lift ready for transfer, this also rendered the machine idle.

The type of wrapping machine employed, also heavily impacted throughput. The process of covering profile with a plastic film, then conveying through a heat tunnel to shrink wrap, combined with

human dependency and lack of autonomy at the front end, meant line speed was slow. While observing the process throughout a normal 10hr shift, with no unplanned stoppages, a total output of 1135m of product was wrapped (5m lengths).

Machine condition and reliability caused additional disruption. Although operators could generate work requests, that fed back to a computerised maintenance management system (CMMS), the machine's inability to automatically detect early defects, resulted in unplanned downtime and reactive maintenance.

2.3 Impact to distribution

The wrap line presented the delivery process with a bottleneck. Wrapping profile to exact quantities needed for picking is critical to warehouse operations. Extended, unplanned downtime resulted in finished goods not being available to pick, lorries unable to load and late deliveries to customers. Late loading charges and backorders were commonplace, with the risk to commercial reputation jeopardised.

3. Implementation Methodology

3.1 Product Identification and tracking

To improve product identification and tracking, stillages in the production hall used to pack extruded profile, could have their own unique identity in relation to profile type. Positioned in a common position

on all stillages, quick response (QR) codes could be used to store information about the product type, including serial number, dimensions and quantity.

To enable real time tracking of finished products, each stillage could also be fitted with an active radio frequency identification (RFID) tag. Active RFID would enable traceability of up to 100m within the warehouse facility. RFID antennas could be positioned throughout the warehouse, including the wrap line to transmit data stored within the tag to a central RFID reader which would display information to the user via computer software. Vasanthamani suggests that RFID in manufacturing “completes the operation of automated production and identification, tracks resources, and traces the position of products in production lines to decrease labour costs and error rates and to maximize efficiency’ (Vasanthamani, 2020)

3.2 Product loading and transfer

The introduction of a collaborative pick and place co-bot arm, removes human dependence regarding front end loading of product. This would not only mitigate the risk of strain injuries, but also increases loading speed, improving productivity by eliminating downtime attributed to operator rest periods. Weckenborg states “By introducing stations with collaborative task execution by workers and robots, the advantages of both automated and manual production lines can be realized in a combined production system. As a result, the production efficiency and quality can increase. Additionally, the introduction of HRC can be beneficial for the workers’ states of health if the robot executes ergonomically stressful and repetitive tasks” (Jonas Schmidler, 2015, cited in Weckenborg, C. *et al.*, 2019, page 94)

A 6-axis co-bot could be selected, fitted with a suction tool. The suction tool would need to be custom made to fit inside the internal width of the stillage, with suction cups positioned on the tool head to pick the different widths determined by product quantity being wrapped. A fixed stillage loading position would govern where a new stillage was positioned and provide a datum point for the co-bot. The suction tool would also be mounted with a QR scanner. With the stillage positioned at the datum point and the co-bot resting in a home position, the QR scanner could read the QR code on the stillage. This would provide information about the wrap requirements for that product and allow the co-bot to determine the program parameters. A similar QR method was demonstrated in the ‘industry 4.0: examples of the use of the co-bot arm for digital manufacturing processes’ technical paper in 2020 (in reference list).

3.3 Machine type

The heat shrink wrapper delivers slow throughput, as the profile first needs to take up the plastic film sleeve then needs to move slowly enough through the tunnel to allow the heat to shrink the wrap. The process offers poor energy efficiency, powering 4 heating elements. To improve line speed and energy efficiency, a fully automated orbital stretch wrapper could replace the existing machine. Manufacturers such as SAT produce machines capable of around 42m/m, offering an increase of around 94% greater number of wraps (based on the same operating hours, running without stoppages).

The machine would be installed with a programmable logic controller (PLC), with product parameters coded into the controller. Machine to machine (M2M) networking would allow the co-bot arm QR scanner to read product data and communicate with the wrapper, setting new parameters such as infeed roller width (to hold and guide profile through the wrapper), line speed and product length. Gilchrist highlighted

that “M2M consist in a communication system with interoperability, which makes machines capable to understand each other, facilitating their adaptation in manufacture lines” (Gilchrist, 2016, cited in International Journal of Production Economics, 2019, p.17) Capacitive proximity sensors positioned along conveyor systems, could also be used in the PLC program for sequencing, counting and stoppage identification. At the outfeed, the transfer car could also be automated. Once a full pack was loaded, the transfer car would move to a fixed end position, using a simple hydraulic or pneumatic cylinder and guide rail system. This would also eliminate the manual handling hazard faced by the operator. Load cells fitted to the transfer car would also provide an input signal to tell the PLC when the car had been unloaded, sending the car back to a home position ready for the next load.

3.4 System monitoring and control

To give greater control, monitoring and analysis of the process, a system analysis and data acquisition (SCADA) system could be used. Data such as motor current and speed, gearbox oil temp and pressure, can be sent via the PLC to a SCADA panel view or remote computer. Alarm triggers such as plastic film change or break, could be set to alert operators. Alarms could also be sent to a maintenance tablet, improving reaction time and reducing machine downtime. SCADA would promote data driven decision making, provide live machine performance trending and coupled with the PLC software, would provide maintenance teams with the ability to interrogate defects. “The RFID tag would provide users with live product tracking. Barbosa stated “SCADA systems has made manufacturing processes ever faster and more accurate. Thus, the use of robotic arms proved to be an effective way to increase productivity in the industry” (Barbosa, 2020)

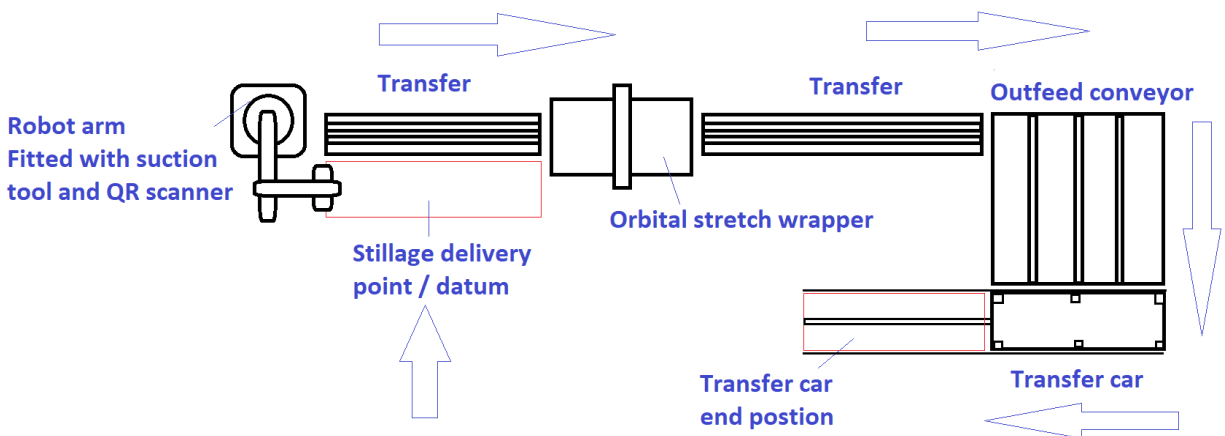


Fig 6. Wrap Line with proposed changes

4. Conclusion

In today's manufacturing environment, an organisation's ability to enhance interconnectivity, interoperability and productivity, is its ability to survive amongst its competitors. Industry 4.0 provides businesses with the infrastructure to achieve these objectives. In this assessment of the wrap line, using a collaborative co-bot could significantly increase productivity. Without deviating from commands, the co-bot could work faster for longer decreasing the risk of injury and fatigue. The change in wrapping machine type would also significantly increase line speed, reduce energy cost and, in conjunction with QR tags, could be programmed to adjust its set up conditions to suit different product quantities and dimensions. In addition to energy saving, labour costs could also be reduced. With autonomy and sequencing, the line could be operated by one individual, who would monitor the system and control product flow in and out of the area. Enhanced data transparency through SCADA and PLC systems could reduce maintenance costs and create a preventative maintenance environment, with cloud-based servers allowing system borderless visibility. Finally, the implementation of an RFID system transforms manual database location entry of bulk stock, making picking more efficient, improving 'on time in full' (OTIF) key performance indicators (KPI) boosting commercial credibility.

References

Barbosa, W. e. a., 2020. *Industry 4.0: examples of the use of the robotic arm for digital*, Unknown: Springer Nature.

Gilchrist, A., 2016, as cited in International Journal of Production Economics, 2019, p17. *The Industrial Internet of Things*. 1st ed. Berkeley: Apress.

Gilchrist, A., 2016. *Industry 4.0 the industrial internet of things*. 1 ed. Berkley: Apress.

Schmidtler, J. B. k., 2015. Fast or accurate? – Performance measurements for physical human-robot collaborations. *Procedia Manufacturing*, Issue unkown.

Vasanthamani, S. e. a., 2020. *Internet of thing for industry 4.0 Design, Challenges and Solutions*. Gewerbestrasse: Springer Nature Switzerland AG.