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OPTIMIZING MATERIAL HANDLING IN METAL STAMPING OPERATIONS: A CASE STUDY ON THE IMPLEMENTATION OF AUTOMATED GUIDED VEHICLES

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ABSTRACT

This paper discusses material handling automation challenges and future enhancements in metal stamping production at TE Connectivity. Currently, the production environment involves labor-intensive processes, where water spiders manually transport materials. This setup is non-value-added and is complicated by various sizes of reels and boxes, with a high-demand storage area. The proposed solution introduces Automated Guided Vehicles (AGVs) to automate these tasks. To validate and refine the system, discrete event simulations of current and future states were conducted. Initial simulations showed suboptimal AGV utilization, which led to iterative adjustments including task variations and traffic flow modifications, ultimately improving utilization rates significantly. Additional studies on AGV charging locations and operational scenarios helped in fine-tuning the system. This transition to AGVs not only promises operational efficiency but also improves safety and adaptability, facilitating a data-driven approach for a highly beneficial strategic decision-making in production management.

1 INTRODUCTION

Metal stamping is a common manufacturing process at TE Connectivity, a company that manufactures electrical and electronic products. A typical stamping production floor may host up to a hundred or more stamping machines operating simultaneously, each requiring a continuous feed of raw material and producing continuous stamped metal wrapped onto reels. At one of TE's production sites, operators operate the stamping machines while water spiders transport materials among storage locations, machines, and shipping areas.

There are three main issues in the current production environment. First, the water spiders transport raw materials on reels, shown in Figure 1, and finished goods in boxes, where finished reels are packed into boxes of four different sizes by the operator. This variety in reel thickness and box size adds complexity when planning for material handling. Second, since water spiders handle all material, all loading and unloading from the carts and racks are manual, making the process labor-intensive. Third, the reel storage area, aiming for an 8-hour inventory target, occupies up to 400 square feet with reels laying vertically.

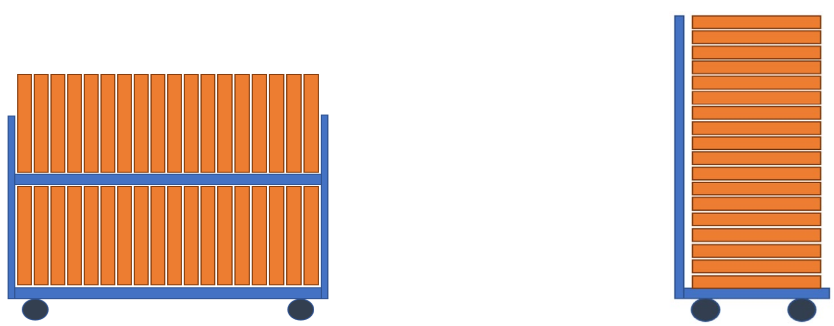

Figure 1: Current state reel cart (left) and future state reel cart (right).

2 FUTURE STATE SOLUTION

In order to enhance the efficiency of the current production system, several optimization areas have been proposed. One such area is the storage of reels. In the future state, as shown in Figure 2, reels will be stored horizontally on a standardized, smaller cart, saving space in the reel storage area and the buffer area near each machine. Additionally, operators will no longer manually pack finished reels into boxes; instead, finished reels will be automatically loaded onto carts. This automation not only saves the time of operators, but also simplifies the planning for the transportation of finished reels. Furthermore, the standard cart design facilitates the automation of cart transportation. Automated Guided Vehicles (AGVs) are proposed to transport carts of reels from storage racks to machines, and then to the shipping area.

3 OPERATIONS SIMULATION AND RESULT ANALYSIS

To better understand and plan the details for the future state, discrete event simulations for both the current state and future state have been developed. The current state simulation model serves as a baseline to validate existing production processes and includes three water spiders for material handling. This model has been validated against historical production data. Subsequently, the future state simulation model replaces water spiders with AGVs, with material now being transported on carts instead of loose in carton boxes. This future state model is used to test the new system's performance under various scenarios, helping to determine optimal tasks and paths for the AGVs. Initial manual calculations set the target at five AGVs. Assumptions of the future state model include, but are not limited to, 1) AGV speed at 0.8m/s, 2) Machine overall equipment effectiveness (OEE) between 45-55%. The first version of the future state model showed that the average utilization rate of the AGVs is only approximately 40%, significantly below their capacity. To increase utilization, a new task – transporting samples from each machine to the lab – was added to the AGV in addition to raw material and finished goods transportation. This adjustment in the second version of the model increased the average resource utilization rate to nearly 70%, showing improvement but still not reaching the maximum capacity of 85% (the maximum capacity accounts for necessary charging time for the AGVs). To further increase the AGV utilization while enhancing safety of the production floor, traffic in narrow aisles was limited to one-way only in the third version of the model, resulting in an average utilization rate increase to around 80%, which was the best solution so far.

In addition to the modifications of AGV tasks and path planning, the AGV charging location and the scenario where machine OEE is 100% had been studied. In the first scenario, three potential charging locations had been selected and compared, as shown in Table 1. In the second case, increasing the AGV speed from 0.8 m/s to 1.1 m/s was necessary to keep up with the production rate when assuming all mines operate at 100%.

Table 1: Comparison of AGV utilization across different charging locations.

	Home 1	Home 2	Home 3
Average Utilization	81.10%	76.31%	77.98%

4 BENEFIT

These simulation models have assisted in the decision-making process of purchasing and deploying AGVs for the future state production. The implementation of AGVs will automate the handling of raw material and finished goods, while also eliminating the need for machine operators to deliver samples to the lab. This change enables a reduction in headcount by 56.25%. This reduces the traffic and the likelihood of operators encountering forklifts, thereby enhancing safety. Additionally, the AGVs are expected to enhance operational flexibility, allowing the factory to quickly adapt to changes in production demand without the need for significant downtime or reconfiguration. Furthermore, by leveraging operations simulation, TE manufacturing plants can make data-driven decisions, foresee potential issues, and implement improvements with minimal risk and disruption, offering a high return on investment at a low cost.