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SIMULATION MODEL TO SELECT AN OPTIMAL SOLUTION FOR A MILK RUN INTERNAL LOGISTIC LOOP: CASE STUDY

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ABSTRACT

A discrete event simulation (DES) model was built to develop an optimal milk run strategy for collecting finished products from the production area and transporting them to the dispatch warehouse. In the current system, products are picked up manually by warehouse employees using hand pallet trucks. This system is vulnerable to delays, particularly delayed pallet collection, thus making it difficult to organize the team's work in the warehouse. The first objective of this case study was selecting the parameters for a new system that would guarantee the smooth execution of receiving and delivering finished products to the dispatch warehouse without disturbing the production lines. The second objective was to determine the amount of resources that need to be committed to achieve the desired efficiency.

1 INTRODUCTION

In milk run systems, a vehicle is sent to supplier locations following a predefined route to collect goods and deliver them to a destination point. The vehicle performs several pick-ups/deliveries on a round trip according to a fixed schedule, in a fixed sequence, and with fixed arrival times (Bocewicz et al. 2020). This case study examines the values for parameters such as time windows, number of vehicles, and route schedules to find an optimal solution to the current milk run system. The criteria to be taken into account when choosing the optimal solution are transport costs, capacity of storing inventories for products awaiting transport, the frequency of tours, and transport fleet size. Simulation approaches have proven to be the most effective methodology in the manufacturing sector (Jeon and Kim 2016). Among the existing simulation methods, DES is the most popular technique to approach production planning and control problems. To analyse the numerous sets of input parameters in the milk run problem, a simulation model was developed and a series of experiments conducted.

2 CASE STUDY

The simulation model was built in Arena® based on the layout of existing production lines (Figure 1) and an extensive statistical analysis of the empirical data describing the five-month operation period of the system. There are 10 production lines and four product groups (Gr1, Gr2, Gr3, G4), classified as "high runners," which account for more than 95% of the production volume. Due to other requirements, e.g. reported by customers to whom particular product groups are addressed, only two configurations of production lines are possible (Table 1). Each simulation experiment was launched for one week, and 100 replications were conducted. The most important output indicator was the maximum buffer size for each production line. However, the number of vehicles, loading capacity, and average and maximum route times were also taken into account. From among several different scenarios, 16 were tested. Those tested were of the following specification: two configurations with each configuration tested in the case of vehicle capacities of 3, 4, 5, and 6 products, with each vehicle capacity subset further tested for frequency of milk run routes scheduled every 30 and 60 minutes.

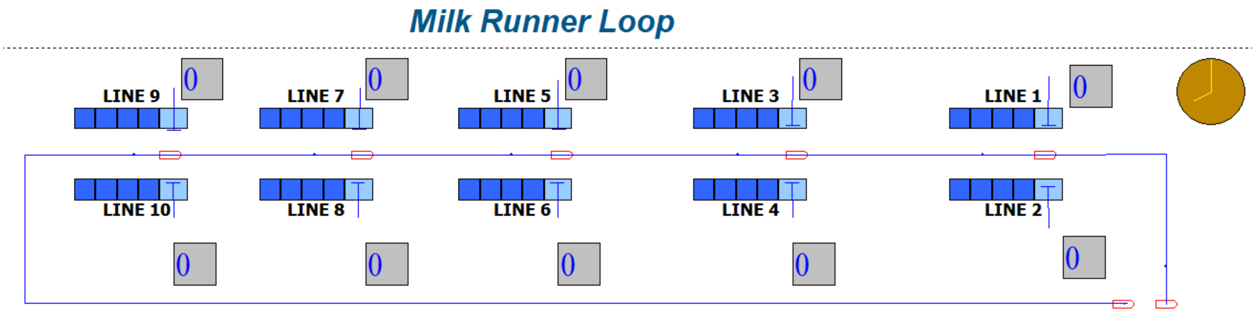

Figure 1: The layout of the suggested routing.

Table 1: Two possible configurations for the allocation of product groups to production lines.

	Line1	Line2	Line3	Line4	Line5	Line6	Line7	Line8	Line9	Line10
Conf1	Gr1	Gr1	Gr1	Gr1	Gr2	Gr3	Gr4	Gr4	Gr4	Gr4
Conf2	Gr4	Gr4	Gr4	Gr4	Gr3	Gr2	Gr1	Gr1	Gr1	Gr1

3 RESULTS

From among the 16 scenarios tested, four were considered acceptable (Table 2), and Sc2 (Scenario no 2) seems to be the most efficient. In this scenario, the capacity of the vehicle is best utilized at 56.8% compared to 45.2% (Sc3), 39.5% (Sc4), and 37.7% (Sc12). The analysis of the average and maximum route times indicates a large amount of time remaining after the run. It is also remarkable that the choice of line configuration has a significant impact on system behaviour. If we place the lines that deliver pallets the most frequently at the beginning of the route (Configuration 1), it is much easier to achieve stability in system operation. The response of each scenario to a 10% increase in the performance of all production lines was also examined. All scenarios with a 30-minute timetable retained their usefulness even after growth in production volume. Based on the results outlined above, we make the following final recommendation: the route should correspond to configuration number 1, while the frequency of milk runs should be planned every 30 minutes, and at least four wagons should be purchased.

Table 2: Details for the winning scenarios (Sc2, Sc3, Sc4, Sc12) from among the 16 scenarios tested. Header labels- Conf: Configuration (1 or 2); Freq: Frequency (min.); Cap: loading Capacity (number of wagons) of the vehicle; AC: average capacity of the vehicle; ART: Average route time (min.); MRT: Maximum route time (min.); B1 – B10: buffer sizes for 10 production lines

Sc	Conf	Freq	Cap	AC	ART	MRT	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
2	1	30	4	2.27	6.765	12.25	1	1	1	1	1	1	1	1	1	1
3	1	30	5	2.26	6.756	13.89	1	1	1	1	1	1	1	1	1	1
4	1	30	6	2.27	6.75	15.08	1	1	1	1	1	1	1	1	1	1
12	2	30	6	2.26	6.734	15.25	2	2	2	2	1	1	1	1	1	1

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