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Analysis and optimisation of a logistic warehouse in the automotive industry

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Abstract

The automotive industry is one of the most competitive sectors, in which rigour, flexibility, quality and agility constitute the critical factors of success. Warehouse activities and their associated costs play a vital role in logistic functions. Their optimisation and performance assessment may result in substantial value gains for the company. This study was developed at Continental Mabor, with the purpose of developing a proposal to restructure and optimise the company's warehouse. An analysis of the existing warehouse was carried out and the respective proposals were subsequently presented. The main goal of these proposals was to improve the efficiency of warehouse functions, reduce stock quantities and enhance the capacity to meet customer's demand. A warehouse management system (WMS) was installed and a suitable bin management solution was defined. This system consisted of a basic WMS to support stock inventory and its location. In addition, this system envisaged warehouse performance and included elements such as the inventory management Key Performance Indicator (KPI) and warehouse productivity.

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Keywords: Warehouse Management System; Bin Management; Inventory Management; Automotive Industry

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1. Introduction

All organisations wishing to be competitive cannot rule out the advantage of appropriate information systems (IS) [1]. There is a great deal of software to provide support in the solution of problems occurring in organisations' everyday activities, and the industrial sector has increasingly focused on these specific software applications to reach this goal [1, 2]. The IS can offer greater assistance to management and ensures the optimisation of the entire productive system. In this case study of the logistic chain, the IS was also used to eliminate unnecessary expenditures in time, money, materials and energy. There are various specific software programs to support warehouse management operations; one of these is known as the Warehouse Management System (WMS). Its main advantages lie in the reduction of warehouse storage space, as well as greater accuracy in stock information, higher operational speed and quality, as well as an increase in the productivity of staff and warehouse equipment [3, 4]. However, the implementation and use of such software in the context of a company presents various challenges. These are chiefly due to issues relating to its portability and integration with different existing IS, as well as the need for skilled technical staff to implement and manage the WMS [5]. The definition of a methodology to provide assistance for future WMS system implementations is thus very useful, as is the case of Schnellecke methodology. According to Atieh et al. [6], the purpose of automating the warehouse system is to control the movement and storage of products, together with the benefit of enhanced security and quicker handling. The WMS is designed to help reduce costs in effective warehouse processes, as well as to provide reliable results in comparison with manually handled systems [6].

This study was carried out at Schnellecke Portugal, which has been providing logistics services - more specifically in the area of in-house logistics - to the Continental Mabor (CM) company since 2012. These services include the management of raw material warehouses, as well as the supply of production buffers. This study's main objective was to present a proposal for the restructuring and optimisation of the company's raw material warehouse (RMW). Various proposals were presented to improve warehouse operation, with a view to doing away with a warehouse outside the factory premises. This paper is divided into five sections: section 1 constitutes the introduction; section 2 presents a review of the literature relating to the subject of IS and WMS; section 3 deals with the methodology used to carry out this study; section 4 describes all the practical work developed at the CM company and presents proposals for the WMS implementation process. It also includes all results obtained through the development of this WMS solution and, finally, section 5 presents the final conclusions.

2. Literature review

Countless technological innovations in distribution sectors have been seen over the last decade. This is largely due to globalisation, competition, rapid market changes and increasingly shorter product lifespans, which are making economies of scale the "drivers" of this change [7-11]. The logistic costs have thus taken on a pertinent role in the global production costs; indeed, they have become essential due to greater product varieties and faster responsiveness imposed by the market. Rouwenhorst et al. [6] defend that the logistics costs of warehouse activities are, to a large extent, defined during the design of the warehouse facility. Hence, it is important to implement strategic planning of this activity and of the actions defined for operational support. The use of Lean Manufacturing tools in logistics has become extremely relevant in this context since their main objective lies in cost reduction, as well as in the elimination of any waste sources within the organisation. To this end, Lean methodology tries to eliminate anything that adds no value to the end product (e.g. storage and movement of raw materials and components). However, these aspects are also considered to be of paramount importance in the value chain, since they affect customer satisfaction and the respective response efficiency to the market [12, 13]. Lean Manufacturing refers as sources of waste seven different causes: surplus production, waiting time, transport, excessive processing, inventory, movement and waste [14]. Thus, and taking the demands of logistics as well as the enumerated principles into account, it seems obvious that these should be developed and directed towards a common goal [15, 16]. The processes involved in the storage and movement of raw materials imply finding solutions for the numerous problems associated with the project itself, as well as to the operation of production/distribution systems and economic efficiency [17]. Studies reveal that, on average, the cost of Order Picking is estimated to be 55% of total operational warehouse costs [18, 19]. The warehouse facility development phase has implications for this activity's operational and global performance results, as well as for the business itself. Thus, the main objective is to run the activity at a minimum cost. Heragu et al. [20] defend that the size in area of the various "departments" in a warehouse constitutes a crucial factor, and underline the importance of forwarding, reserve and cross-dock. These authors developed an efficient mathematical model which not only allocates products to the three areas in the warehouse (minimising storage and movement costs); it also determines the size of the three areas in the warehouse according to average stock [20]. The implementation of the WMS through IS allows one to optimise warehouse operations such as inspection, stocks and loading, amongst others. The use of these methodologies has gained the support of many researchers and logisticians, in the logistics area, in an automotive industry which is increasingly competitive and demanding [21].

3. Methodology

The methodology used is based on a case study and consists of various stages. In the first stage, one presents a review of the literature, supported by scientific articles. The main objective was to acquire knowledge, look into research case studies in the same context and analyse the methodologies used. An additional objective was to obtain more detailed and in-depth information relating to WMS information systems. In the second stage, one proceeds with the analysis of storage product types and characteristics, as well as existing locations and the identification of the warehouse process. One also analyses the most adequated Lean tools for the context. In the third stage, discussion and evaluation of decisions relating to bin management implementation are presented. The fourth stage consists of the implementation of the bin management solution achieved, as well as the training of human resources according to the Schnellecke methodology. The last stage consists of a results analysis as well as the quantification of the gains achieved.

4. Implementation of a Warehouse Management System

The implementation of a WMS in a company always constitutes a challenge; in this case, this was true both for the implementer, Schnellecke, as well as the company, CM, which will benefit from the type of software implemented. Among the main challenges identified are the following ones: the need for a seamless integration of the WMS with the company's IS, the specificities of its implementation and the need for a good synchronisation between technology, human resources and the different processes in the company. The definition of an implementation methodology for the WMS system was thus extremely useful. The WMS project targeted the management of the internal raw-material warehouses (RMW) at CM, from the material reception process phase to put away in the warehouse, stock management, picking, delivery to production and the management of returnable packaging. These aspects pertain to the company itself, as well as to other companies belonging to the group.

4.1. Process analysis and diagnosis

In the first stage, an analysis of the situation was carried out in order to perceive which aspects required improvement as well as those which, through the implementation of the WMS, would no longer be necessary. The objective was to collect information which would allow one to identify the cause-effect relations for the problem under study. The analysis and diagnosis of existing warehouse solutions were undertaken. The existing RMW corresponds to an area of warehousing composed of three different warehouses into the company but located at different factory buildings and at different floors: RMW2 and RMW3 at floor 1 and 2 for chemicals, RMW2 at floor 1 for rubbers, and RMW1 at floor 0 for cords and wires (see Fig. 1). This solution was, however, unable to receive the total amount of raw material needed for production and presented also high costs regarding daily production supply. There was, therefore, a need for another warehouse outside the premises, situated at a distance of five kilometres. Consequently, this generated both additional costs in transfers between warehouses, as well as rental costs. In addition to the internal storage capacity available at the company, daily production needs approximately 10 daily lorry trips from the external warehouse. These vehicles were responsible for transporting 16 containers, corresponding to 22400 kg (due to legal load limit), which resulted in a transfer cost between warehouses of over € 5000 /month.

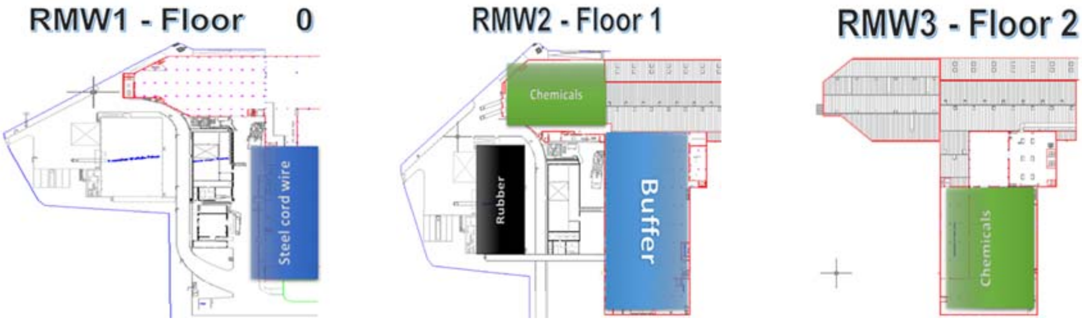

Fig. 1. Old warehouses plants - RMW1 (left), RMW2 (middle) and RMW3 (right).

At the RMW, and after reception, the storage process resorted to two different types of allocation: racks and block stacking by means of pallets. The latter relates to the receiving process since the raw materials (RM) need to wait for the quality inspection approval. After this occurred, the RM were randomly allocated to an empty bin, with capacity enough for a complete batch stock keeping unit (SKU). Various existing limitations were found: a lack of information regarding free spaces in the warehouse, no knowledge about the lots size, weight and volume, as well as to space restrictions for the allocation of the SKU. These limitations usually led to the wrong placement of the SKU batch, which resulted in time expenditure to reallocate it correctly. Another limitation encountered was related to the identification of the SKU batch being used, which carried a green sticker with the lot reference. For example, in the rubber warehouse, with an area of 1018 m^2, supply to the buffer of limited capacity (see Fig. 1-RMW2) required exhaustive search regarding the SKU batch in use,because the information only appeared on the sticker that was attached to a pallet, which had sometimes been lost. This resulted in an inefficient supply of the lot to the buffer.

The implementation of the WMS and the bin management system provided a solution and allowed for greater speed in the capacity of response to production. It enabled the agile identification of available spaces in the warehouse and their respective capacities, as well as the rapid and effective tracking of the SKU batch in production and its production schedule order. This process was based on the first-expired first-out (FEFO) criterion, due to the fact that natural rubbers and chemicals present validity periods. This solution also allowed one to meet the need to increase storage space considerably, which was also possible with the new warehouse. In the old warehouse, shelving allocation for the SKU batch racks was carried out according to the first-in-first-out (FIFO) principle, which did not potentiate full space allocation. By consulting Fig. 2, one can observe that the colour yellow corresponds to sequentially occupied shelves. This process resulted in space inefficiency and in a great waste of resources to reallocate the RM.

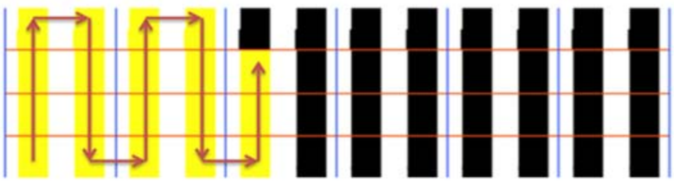

Fig. 2. Shelving solution.

4.2. Proposed WMS solution

In order to solve the problems identified in section 4.1, one proceeded with the elimination of the external warehouse, which represents both a monthly rent of € 50000 and a SKU transfer cost of € 5000. Owing to the constraints of internal warehousing and issues of cost reduction, a strategic decision was made by the customer to increase the area and build a new internal warehouse, implementing an IS to support warehousing activities - a WMS and a bin management systems. This was distributed over 3 floors, with an area of 6200 m^2 (see Fig. 3). It ensures direct access to the manufacturing zone through the first and second floors, while still maintaining those already in existence. It was then subsequently decided to initiate a project to extend the old internal warehouse (RMW1, 2 and

3). The remaining work was focused on the layout and bin location definition of the new warehouse, denominated as RMW.

Fig. 3. New warehouse.

The proposed methodology was anchored both on historic inventory and on predictions for an estimated production increase. These assumptions are assumed as the basis to allow for an analysis of the stock risks evaluation and to determine the storage capacity. Before the implementation of bin management system, an ABC analysis by rotation was carried out to provide indications for SKU organisation. One then analysed 132 references and collected all corresponding data. Following on from this analysis, it was established that there were: 11 type-A references in the rubbers group; 17 type-A references in the chemicals group; and 6 type-A references in the ropes and wires group to be positioned close to the exit. In order to define the bins, one proceeded to measure all the spaces and attributed maximum capacities to these, in accordance with average RM sizes and their respective weights. This process allowed one to optimise the area as well as create new storage spaces. Thus, a new reorganisation of space was implemented on the rubbers floor in order to maximise the spaces which could be used for storage. One should point out that the IS only provides information about the available bins with the capacity to allocate the SKU batch received. Fig. 4 represents the chemical products allocation layout after ABC analysis.

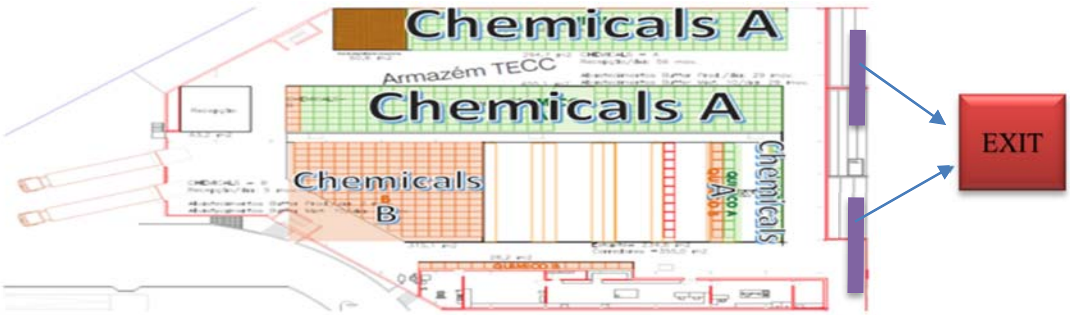

Fig. 4. Implementation of chemicals allocation, using ABC analysis results.

4.3. Implementation of WMS

The first step in an automated warehouse system consists of identifying the processes and procedures executed into a warehouse, as well as those that can be automated. During the implementation of the IS solution, one had to attribute new warehouse codification (see Fig. 5), so that this would constitute the basis for all locating activities. One proceeded with the creation of bins, which were distributed across the different warehouse areas. At the same time, one also defined the limits for the SKU batch for each bin. This will be used to transmit information to the worker when he is looking for available spaces to allocate the SKU batch. In the case of block stacking storage, the sticker was replaced by an optically scannable tag, which was positioned at 6 m height (see Fig. 5). One also created 224 bins in the rubbers warehouse, 661 bins in the chemicals warehouse, as well as 135 bins in the ropes and wires warehouse. Additionally, an analysis was undertaken to determine the resources and tool requirements for the bin management system itself: equipment (scanners to carry raw material movements in the system and fixed terminals to ensure correct operation in case of wireless network failure) and processes / human resources (creation of new storage locations and training in Schnellecke for employees). This involved a set of 5 phases: diagnosis, action planning, implementation of actions, evaluation of results and learning specifications.

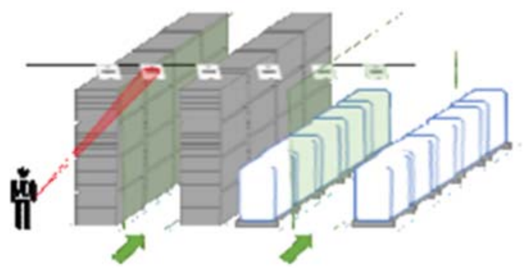

Fig. 5. Block stacking identification.

New codification of references for the warehouses was also undertaken (see Fig. 6): the first digit relates to warehouse identification; the second digit refers to the floor. Thus, the code numbers were distributed as follows: 1100 indicates the existing chemicals warehouse and 2100 to the existing rubber warehouse; 3000, 3100 and 3200 refer to the new warehouses; 4000 and 4200 are storage areas related to just-in-time (JIT) SKU production. Fig. 7 represents the structure used to develop bin codification.

Fig. 6. Storage areas.

Fig. 7. BIN management structure.

Fig. 8 presents the RMW storage area, which includes both the new and old warehouses. The codes beginning with 3XXX are related to the new warehouse, while the second digit defines the warehouse floor. This organisation of warehouse codification is extremely advantageous due to the fact that it can be expanded in the long-term.

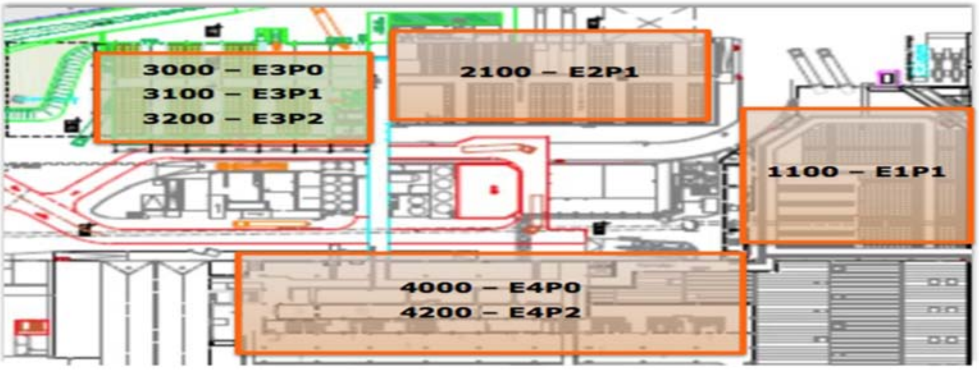

Fig. 8. Overview of all warehouses.

After having defined the new storage location warehouse and calculated the number of bins by SKU, the bin location code was developed by using 6 digits: the first two constitute warehouse identification; the second relates to the warehouse floor; the third is a letter which identifies the aisle or shelf line in the block stacking storage area; the fourth and fifth represent the shelves, and the sixth is a letter that indicates the shelf level (see Fig. 9). Fig. 10 represents a bin location in the warehouse, with the code number 1100 (E1P1), which reads as chemicals, floor 1, aisle A, shelf 01 and shelf A (ground-floor level). The WMS and bin management system also allowed one to define the KPIs. Hence, KPIs were then determined for operational management support: a number of picking, storage index and the number of deliveries to production (good issues).

XX X XX X

Fig. 9. BIN code structure.

11A01A

Fig. 10. More extensive code.

4.4. Discussion of results

The IS was implemented in March 2016, with a new storage area of 6200 m^2. This eliminated the external warehouse dependence, which represents a monthly cost reduction of €55000. The new solution proposed, which is now linked to the production area, led to a radical change in the shelves organisation, as well as in the occupancy rate of the already existing chemicals warehouse, and denominated as 1100. When sequential storage was initially adopted, average occupancy was situated at 50%. By changing to random allocation in the predefined area, this figure increased to 100%, even after all the limitations at hand were considered. The implementation of bin management improved the performance of warehouse activities and reduced response times to production requests. The daily inventory and physical counting are now automatically executed by the system so that there is a complete control of the SKUs in real time. The number of administrative operators was reduced from 4 to 2. The quantity of errors associated with the non-compliance of management policies also decreased: the WMS and bin management system now indicate the location and identify which lot is to be received next, as well as its respective storage space. In addition, KPIs were defined in accordance with information provided both by the WMS and the bin management system.

5. Conclusions

This case study was developed at Continental Mabor in its raw-material warehouses. The purpose of the work involved was to implement bin management, as well as to analyse the ensuing implications and changes thereof. In addition to the construction of a new warehouse, the already existing one was also subjected to reorganisation in order to stop the need for storage outside the company. Storage space was thus extended from 2450 m^2 to 6200 m^2 due to the construction of an area covering three floors with direct access to the factory. After an initial diagnosis and the

ABC analysis of product rotation, one established which alterations would be required in the raw-material management policies, changing from FIFO to FEFO. A new warehouse layout was determined; one also proceeded to calculate the number of bins required, in accordance with container sizes. A bin location system was developed, which considered SKU and its rotation. The WMS and bin management allowed for an increase in shelf occupancy rate, from approximately 50% to 100%. Another benefit was the elimination of the daily physical counting of existing materials and the registration of activities. As a result, two of the workers were no longer needed, and there was also a reduction in errors and delivery times to production. One also defined KPIs, which can now be measured by means of the new IS solution. The WMS and bin management enable real-time updates both of the SKUs, as well as of warehouse activity performance. They thus ensure enhanced management and the cost-efficiency of the existing spaces, which changed from a fixed and sequential allocation process to a random system in the areas defined within the warehouse and storage areas. Significant improvements were also observed in the permanent management of inventories.

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