INNOVATIVE SOLUTIONS IN FOUNDRY LOGISTICS

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Abstract

In the automotive industry, as in other industries, there is a clear drive to achieve higher efficiency in industrial processes, energy savings, waste minimization and reduction of greenhouse gases. This effort extends to both production areas and associated areas such as logistics. This is particularly true in the automotive industry, where stable and efficient logistic is an important prerequisite for a stable supply of vehicles to final customers. This is also the case in specific production facilities such as foundry plants, where important vehicle components such as engine blocks, gearboxes and clutch housings are currently produced. Foundry plants are planned to be used for production of some components of electric vehicles in the future. This paper focuses on the main specifics of Škoda Auto company foundry plant and the possibilities of applying logistics process innovations in this production plant. In more detail it also focuses on the possibilities of data collection, processing, and digitalization in connection with the transition to Industry 4.0.

Keywords: cylinder blocks, foundry logistics, innovations, digitalization

1. INTRODUCTION

In today's globalized and dynamic world, logistics plays an increasingly important role. In line with this dynamic development, the demands for speed, efficiency and quality of transport are increasing, requiring a high level of system complexity and flexibility [1]. At the same time, there is a strong emphasis on minimizing environmental impact and overall sustainability [2, 3]. Therefore, new areas are also developing in logistics aimed at resource efficiency and minimizing environmental impact, such as green logistics [4], which is related to green production [5]. There is also a drive to minimize and recover waste and losses, which is the focus of reverse logistics [6]. New trends related to the digitization of processes and Industry 4.0 are increasingly being applied in the automotive industry [7]. This is matched by the need for the progressive application of Logistics 4.0 principles too [8]. Digitization brings several opportunities to increase process efficiency, for example by the application of digital twins, which help to optimize the real process by providing a digital copy fully corresponding to the real state [9].

The automotive industry is a complex and specific industry with high demands on the quality of the resulting products. A wide range of processes and production technologies are used to produce an automobile. To achieve high quality, low production costs and at the same time deliver the product in the shortest possible time to the customer, there is a need to focus on innovation and optimization of production processes and related logistics processes [10]. This is particularly true in areas of production where energy and fuel consumption are high, such in foundries. In foundries, important components of internal combustion engines and gearboxes are produced from nonferrous metals, especially from aluminum. To achieve high process efficiency, it is important to achieve high flexibility in terms of energy resources and to maximize the use of waste energy, by minimizing heat losses [11]. The correct layout of the foundry operation and correct and efficient logistics processes are also important [12].

The main objective of this research paper is to present the benefits of individual innovations related to Industry 4.0, which contributed to the optimization of logistics processes in the Škoda Auto foundry, resulting in higher quality and efficiency of castings production.

2. SPECIFICS OF LOGISTICS IN THE PRODUCTION OF ŠKODA AUTO COMPONENTS

The meaning of expression „Logistics“ is very wide. It doesn't mean just move the products inside of the warehouse. It begins before the production even starts. To understand it well, there is really a good example at Škoda Auto company Generally, logistics is split into different areas. At Škoda Auto company there is brand logistics, which is responsible for general planning and project management. Then there are different logistic plants, for each car production (MB I, MB II and Kvasiny), for press and paint shop and at the end also for components production. In more detail we will investigate the components production and the particulate logistics.

After the individual project starts, logistics gets all demands from components production and from external customers. According to all demands the department managing the components production (in components production logistics) plans the production plan to secure all customers in time. After the plan is created, the plans are distributed to disposition which order all parts for production at suppliers. Now the first part of logistics is done, before the parts are not produced. After production comes next part of job of logistics. This is bringing the products to the warehouse after production. The last part of logistics is preparing the parts and deliver it to the customer (internal or external), that means to pack the parts and load it to a truck or a train.

For example, the Škoda foundry has Volkswagen Mexico as the customer, where are raw cylinder blocks for 1,5 l TSI (raw means, that the block must be machined before it goes to assembly of engines) delivered. First, the project team at brand logistics and the pre-series components centre had to accept and start the project. After that managing of components production gets demands from Mexico, other customers, and internal operations. According to all demands the production plan is created (must be considered by daily capacity, working days etc.). After receiving the parts for production (for example aluminium alloy) the production starts. After that the parts are going on the palette (also made by logistics) and being prepared for dispatch to our CKD centre, which is part of brand logistics. CKD centre packs all the parts for Mexico and other projects abroad for ship (container) or airfreight transport, see Figure 1 after packing the parts are ready to go to port, where are loaded for the way to the customer.

Figure 1 Cylinder blocks for 1.5 l TSI engines prepared for expedition to Mexico

3. LOGISTIC FLOWS IN THE ŠKODA AUTO FOUNDRY

In 2023, the Škoda Auto foundry will celebrate 60 years of production of aluminium castings for Škoda vehicles. In the following years until now, it has become a nationwide supplier and, in addition to the Škoda Auto Mladá Boleslav plant, supplies customers including VW Germany, VW Mexico and Audi in Hungary. The current product portfolio includes engine blocks (3 cylinders, 4 cylinders) with cylinder capacity in the range of 1.0 to 1.6 l. The annual production capacity of the engine blocks is around 1.3 million parts. Other products are clutch and gearbox housings with annual production capacity of around 800 thousand parts. The internal logistics process of the Škoda Auto foundry itself is specific. At the beginning, the necessary quantities of aluminium alloy must be ordered, stocked, and melted. The check of the purity and chemistry is also required at the input and during the melt production process. Using forklifts, the melt is distributed to the casting machines in 400 kg melt transport pans in the liquid state. Each casting machine has its own maintenance furnace. The whole production process from the molten metal to final cylinder block is shown in Figure 2.

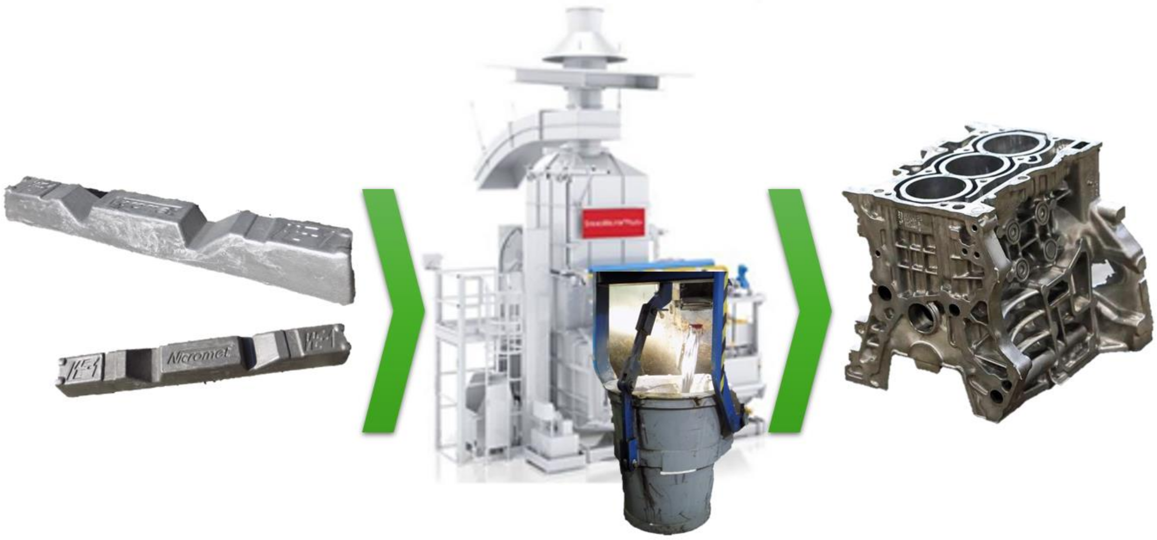

Figure 2 The procedure of cylinder block production, from molten metal to final product

The moment the final part is produced on the machine, it is automatically palletised by the robot. In subsequent operations, automatic re-palletizing and depalletizing are already used as standard. Specially designed pallets are the prerequisite for the functionality of this system, which enable the robotic loading and unloading of parts. These pallets must also be made to allow inter-operation transport by forklifts, conveyors, and autonomous trucks. In addition, the pallets must be able to withstand high temperatures, e.g. in the casting stabilisation annealing operation, where entire pallets are in the annealing furnace for around 3 hours and must withstand temperatures up to 250 °C.

In the entire foundry flow see Figure 3, only reusable pallets (steel construction) are used, or after subsequent operations starting with automatic dressing, plastic liners are inserted between the individual layers see Figure 4. These liners also ensure the stability and non-damage of these products and ensure optimal subsequent palletisation or depalletization. The finished product is palletized into standardized VW pallets with smooth strips, which are based on each customer's specifications to meet the requirements of the customer's line automation status. In case of long overseas transports (e.g. Mexico, India), the pallets are repacked in the CKD unit according to the destination and corresponding to the local climatic conditions to ensure the quality and functionality of the part also in that location.

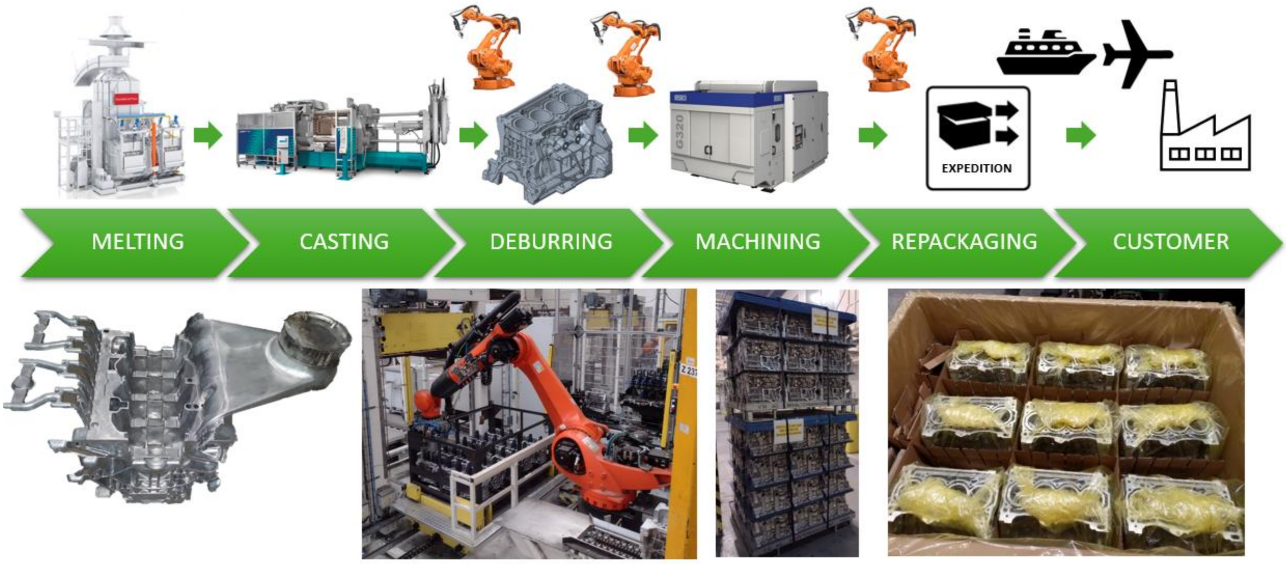

Figure 3 Schematic view of the logistics flow including inter-operational packaging in the Škoda Auto aluminium foundry

Figure 4 Packed parts ready for transport to European warehouses

4. THE USE OF INDUSTRY 4.0 IN ŠKODA AUTO FOUNDRY LOGISTICS

For quality casting it is necessary to set and monitor the correct casting parameters of the casting machine. The casting parameters for each cast piece are stored separately by each casting machine and the PLC machine is used to read and store the data online in the Cloudera data lake. These parameters include casting curves, temperature, vacuum values, speed, etc. It is then possible to work with this data and, for example, display and evaluate the data using the Power Bi report. Of course, it is also necessary to correctly identify each specific casting product. The so-called Datamatrix code (further referred to as DMC), which is stamped directly on the casting during production at the machine and the camera system reads these codes throughout the production. It is also possible to recall casting parameters and other data for the specific part backwards in the PC.

In the production of the EA211 engine blocks at the aluminium foundry, paper hangers are currently used to identify the annealing pallets. The data from the paper hangers is manually entered into the individual process devices in the process flow. We are now preparing the full record automation project. Pallets will be equipped with unique QR codes. Individual process equipment will be retrofitted with cameras to read these codes and the DMC codes of the engine block. All data about the pallets and the cylinder blocks inside will be automatically transferred via the DataPKG server from device to device within the process flow and will be accessible to users in the DataPKG system. The principle of this automatic system functionality is shown in Figure 5. Users will be the production, technical control, quality, and management staff.

Figure 5 Packed parts ready for transport to European warehouses

The automation of data transmission and the elimination of the influence of the human factor and possible errors are therefore the great benefit. Thanks to the system, the foundry gets the complete overview of the production and the tracking of possible mismatched parts during sorting operations is thus simplified. Another advantage will be the ability to monitor work-in-progress status online and edit the data using the Data PKG electronic system. Another digital innovation that was introduced last year is the automatic separation of production batches using sorting software and the use of robot for the final inspection. Previously, tracking down problematic batches involved manually tracking down individual pieces by pallet in large warehouses. This was very laborious for the staff both at our foundry and eventually at our customers. The introduction of this system therefore prevents the risk of limited batch of non-conforming parts reaching the customer. The staff saves a lot of time in manual sorting and picking in the warehouses. In the case of potential sorting operations already at the customer's site, the system also saves the costs of external companies that do the work abroad for us. The entire sorting process is therefore automatic. If the problem is detected on several machine or mould, it's enough to just enter the machine number, the date, the first and last DMC of the sorted batch and the system will start sorting automatically, including an overview of the number of sorted parts in each stage of production, and the robot will store the found parts in the separate pallet at the final check operation.

5. CONCLUSION

For the production company to be competitive in the market and meet customer demands, it is necessary to apply innovations and increase the efficiency and quality of production. It is important that the customer receives the product in the required quality, time, and quantity, whether it is an internal customer or an external customer. In the automotive industry, logistics plays an important role in all company processes. There are also specific plants with specific logistics requirements such as foundry plants. In this paper, the main aspects of foundry production at Škoda Auto were presented. Furthermore, the logistic processes in the production of combustion engine blocks were presented. Subsequently, innovations in the field of logistics processes were presented, especially the use of digitalization for identification of parts and the possibilities of storing and managing digital production data. All of this will contribute to meeting the objectives related to the digitisation of processes in the context of Industry 4.0.

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