

Application of Selected Lean Manufacturing Tools in Improving the Management of the Machining Process of Automotive Piston Castings

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Abstract

The doctoral dissertation presents research on improving the management of the machining process of pistons for internal combustion engines, using the example of the DL9 line for machining at Federal-Mogul Gorzyce. The main objective of the analysis was to increase the productivity and the production capacity of the process by applying Lean Manufacturing tools that are most suitable for piston production technology, plant requirements, and customer demands in the automotive market.

The work involved a review of existing data, such as key performance indicators (KPIs) including Overall Equipment Efficiency (OEE), Overall Asset Efficiency (OAE), and Total Effective Equipment Performance (TEEP), the level of defective products and the tools used for quality control, improvement, and maintenance of the machine park's efficiency.

Based on preliminary research, the hypothesis was formulated that only personalized Lean Manufacturing tools, verified through KPI productivity indicators, can contribute to the improvement of the piston machining process, leading to the elimination of waste, achieving the highest product quality, and controlling the consumption of technical utilities with the purpose of their reduction. The main research, based on the results of the mapping of the piston machining process on the DL9 line, enabled the identification of major improvement projects in the analyzed area and the development of a schedule for their implementation, along with indicators to evaluate the effectiveness of implementation in other areas of piston production.

Each implemented improvement was thoroughly analyzed by the Lean team under the supervision of the author, using tools such as brainstorming, Ishikawa diagrams, Pareto-Lorenz charts, SPC, Design Thinking, Cartesian Diamond, and others. The summary of KPI results after the implementation of improvements clearly demonstrated that the analysis of the actual state and proposed improvement solutions contributed to a significant increase in the productivity and the capacity of the DL9 line while maintaining the highest product quality.

The conclusions unequivocally indicate that comprehensive, long-term, and precise technological processes involving multiple operations and utilizing dozens of machines and devices must be controlled using personalized Lean Manufacturing tools, such as Andon and interoperative quality control, which leverage Industry 4.0 solutions. The diversity of the machine park in terms of age, type, and manufacturer requires a flexible approach to implementation and digitalization, aimed at collecting large amounts of data, analyzing them, and exchanging information in real-time between machines, departments, and personnel using sensors, interfaces, servers, and artificial intelligence.

The validity of the proposed solutions was verified in industrial conditions through extensive testing, which unequivocally confirmed the correctness of the research concept, and the tangible benefits include financial aspects of the piston machining process.