Thermoplastic Injection Molding Machine Setup Downtime Reduction

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Abstract *— Setup is one of the most common downtimes that affects every manufacturing organization. In a molding company, a top offender setup downtime machine (IMM 128) was identified, and a time study of the setup process was performed. DMAIC and SMED methodologies were applied to identify the potential causes related to the setup downtime. The principal cause identified was the lack of external activities performed during the setup process. Internal vs external activities analysis was performed and a total of 18 activities were converted to external by implementing a molding staging area near the machine and a mold component kit (nozzle tips) for IMM 128 was implemented. These improvements resulted in the reduction of 16 minutes and 4 seconds of each setup performed in the top offender.*

Key Terms *— DMAIC, Non-Value Added, SMED, Waste Reduction.*

INTRODUCTION

Jabil Healthcare vision is to be the most technologically advanced and trusted manufacturing solution provider by focusing to improve patient wellness and being customer focused. Jabil Cayey plant offers thermoplastic molding service to customers in the healthcare and packing industries, principally in the medical device sector. Cayey plant is pursuing to reduce the setup downtime in the thermoplastic injection molding machines to improve customer satisfaction and financial performance.

Most companies dedicated to the injection molding process do not possess the budget or find that is not cost effective to have dedicated machines for each part, then setup process is required. Setup is defined as "from the stop of production of product A until the start of production of non-defective units of product B" [1]. Setup is the top offender downtime reason for Jabil Cayey. It is critical for the company financial performance and customer satisfaction to reduce this downtime to increase the machine uptime to satisfy the customer demand.

SETUP

In the context of injection molding process, the setup will be when the molding machine X is stopped due to production order completion of Mold A and until the machine X starts production of acceptable parts of Mold B. The three main components during the setup process are the raw material (resin), the injection molding machine, and the mold. Figure 1 shows an injection molding machine with the three major components for the molding injection process which are the plasticating unit, the clamping unit, and the mold [2]. Figure 2 shows an injection mold with some of the principal components such as leader pins, ejector pins, cavity insert, etc. [3].

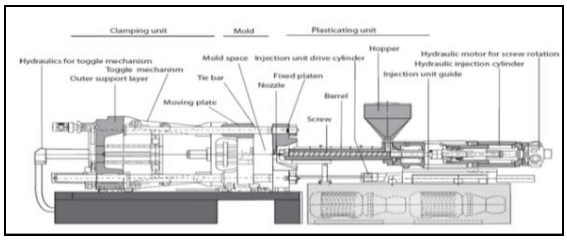

Figure 1
Injection Molding Machine

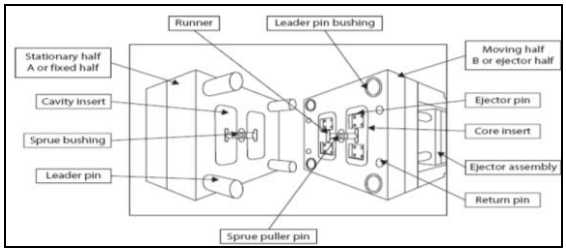

Figure 2
Injection Mold

DMAIC

The DMAIC methodology provides the necessary structure and systematic approach to manage the overall of the setup reduction project. Figure 3 shows the five phases of the DMAIC (define, measure, analyze, improve, and control) and the tools used in each phase that will support the correct formulation of the problem, the collection of data to support to validate current condition, then the 8-waste analysis of the collected data to determine the potential causes impacting the setup process, implementing, and monitoring solutions to reduce the setup process. The purpose of the 8-waste analysis is to eliminate all possible non-value-added activities from the setup process. "While this model suggests a linear progression with each phase leading to the next, there will always be some iterative work between the phases" [4].

Figure 3
DMAIC Phases

SMED

The SMED methodology is crucial in the analyze and improve phases of the DMAIC methodology. It can be divided into four phases:

- **Phase 1:** The classification of the setup activities into internal or external. Internal activities refer to activities that are performed when the injection molding machine is stopped and parts are not being produced. In the other hand external activities refer to activities that are performed when the injection molding machine is producing parts.
- **Phase 2:** Convert internal activities to external activities to reduce as much as possible the time that the machine is stopped during the setup process**.**
- **Phase 3:** Internal activities that cannot be converted to external need to be optimized to reduce the cycle time as much as possible. For example, changing from hand tools to power tools during the removal and installation of the mold.
- **Phase 4:** External activities are required to be optimized to reduce the cycle time of each activity. Since external activities focus more on the preparation of all necessary inputs for the setup process before stopping the machine, the 5S tool is essential to have all these inputs organized, identified and accessible when required to be used during the setup process.

For companies that do not have the capital to perform these investments, with performing the optimization of current activities using the SMED principles of internal and external activities will provide direct benefit in the reduction of setup process time [5].

DEFINE PHASE

The top offender downtime for Jabil Cayey is setup. The pareto chart in Figure 4 shows that setup represents 56% of all downtime.

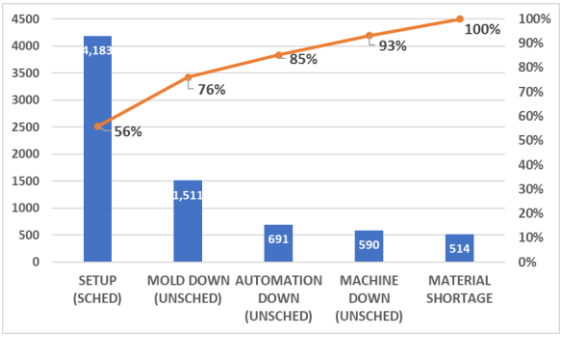

Figure 4
Downtime Reason Pareto Chart Jabil Cayey

Figure 5 shows the Jabil Cayey 1 building with the highest downtime hours due to setup with 1,454 hours that represent 35% of all setup downtime Figure 6 shows the Jabil Cayey 1

building top downtime setup offender machine is Injection Molding Machine 128 (IMM 128) with 133 downtime hours.

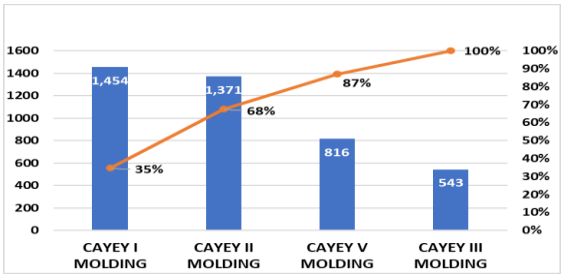

Figure 5
Downtime Reason Pareto Chart Jabil Cayey

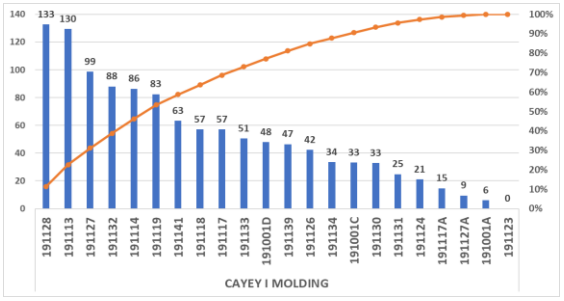

Figure 6
Downtime Reason Pareto Chart Jabil Cayey

MEASURE PHASE

A time study of a setup process for IMM 128 at Cayey 1 was performed. Figure 7 shows the distribution of the total duration between the four main steps of the setup process. It shows the total duration of the setup event was 3 hours and 4 minutes.

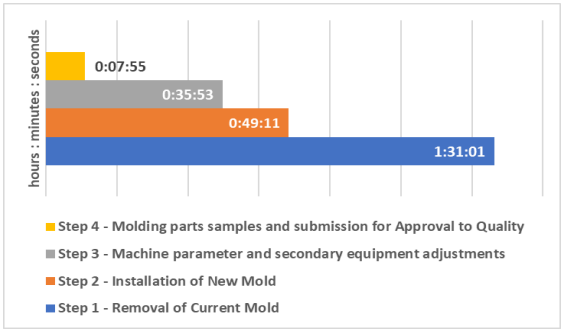

Figure 7
Time Distribution 4 Main Steps Setup Process

ANALYZE PHASE

Analysis of all activities recorded during the data collection of the setup process for top offender IMM 128 was performed. In this analysis, the activities were classified into internal or external activities to be able to apply SMED methodology. In addition, all activities were classified into value added vs non-value in order to focus on the elimination or reduction of non-value-added activities

Internal Vs External Activities Analysis

During the analysis of the setup process recorded for IMM 128, it was observed that SMED concept of internal vs external activities was not considered as part of the setup process, which means that no external activities were performed during this data collection. The focus of the analysis was related to which activities of the setup process should be converted from internal to external with the objective of reducing the setup downtime. Figure 8 shows that 34 tasks of the setup process can be converted to external activities. Figure 9 shows the top tasks with the highest time to convert to external activities

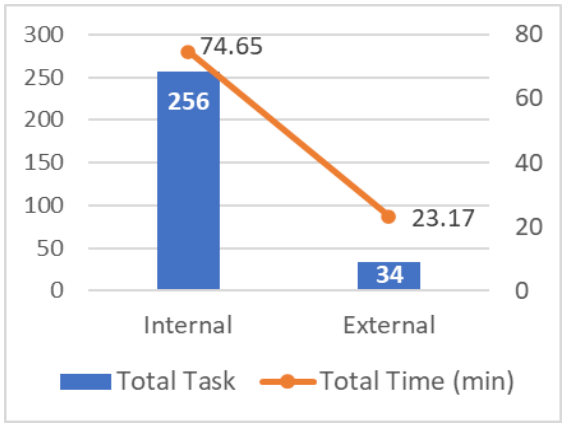

Figure 8
Internal and External Tasks Total Qty & Time

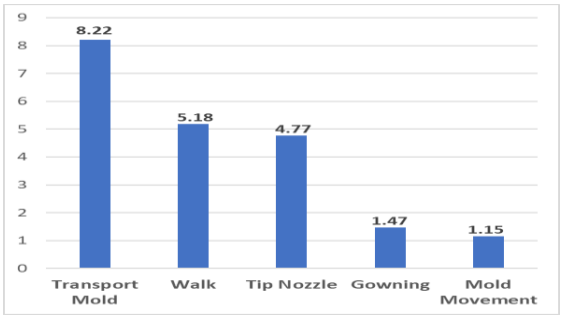

Figure 9
Top 5 Activities to analyze to convert to external

Value Added vs Non-Value Added Analysis

During the value added (VA) vs non-value added (NVA) analysis of the setup process recorded for IMM 128 it was observed that, as is usual in any process, the majority of the activities are NVA. Table 1 shows that NVA represent the 84% of the total activities and time.

Table 1
Value Added vs Non-Value-Added Setup Process Analysis

Type	Value Added	Non-Value Added
Total Task (Qty)	48	251
Total Time (min)	17.12	165.47
Total Task / Time of total (%)	16%	84%

Figure 10 shows the top five non-value-added activities to focus on the Improvement phase of the DMAIC. Figure 11 shows the Fishbone analysis performed with the Team based on the analysis of the activities in terms of internal vs external and NVA vs VA of the data collected from IMM 128. With this analysis, causes for high setup downtime were identified and the causes in red frame were selected by the team as priority for the Improvement Phase.

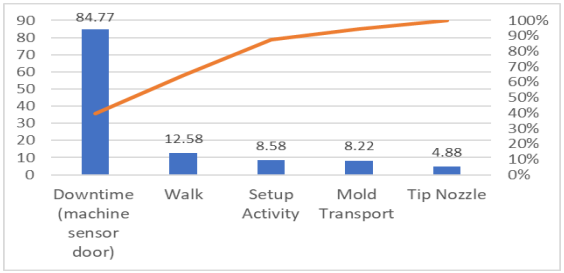

Figure 10
Top five Non-Value-Added activities (Time minutes)

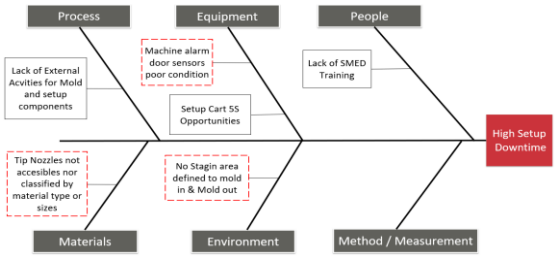

Figure 11
Fishbone based on Internal vs External and Value Added & Non-Value-Added vs Non-Value-Added activities

IMPROVE PHASE

An implementation plan was developed by the project team based on the information from the Analysis Phase. The top two actions were selected as scope of this project based on the setup downtime reduction that they provided. Figure 11 shows the improvement plan actions based on the downtime reduction provided. Molding staging area and tip nozzle kit were the improvements with the major reduction as per data collected from measure phase.

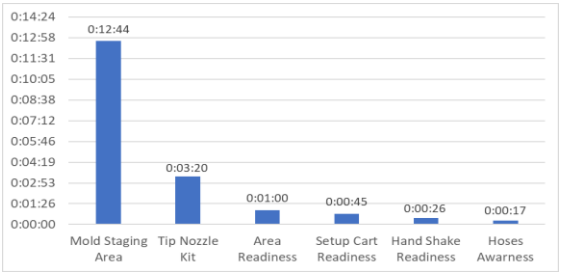

Figure 11
Improvement plan actions organized per setup reduction downtime reduction in minutes

Figure 12 shows the before and after of the molding staging area improvement implemented near IMM 128. Blue area is for the mold that enters the machine, and the red area is for the mold that leaves the machine. Figure 13 shows the tip nozzle kit by mold for IMM 128.

Figure 12
Improvement plan actions organized per setup reduction

Figure 13
Improvement plan actions organized per setup reduction

CONTROL PHASE

All personnel related to the setup process was trained in the improvement implemented. The process support supervisor of Cayey 1 was established as the owner of improvements it will be the supervisor responsibility to sustain the improvements.

RESULTS

As part of the improvement plan, the following results were obtained:

- **Interval vs External Activities:** A total of 18 from 34 possible internal activities were converted to external activities which represent a 53%. In terms of downtime setup reduction, it represents a total of 16 minutes and 4 seconds less for each setup performed in IMM 128.
- **Value Added vs Non-Value Added:** A total of 18 Non-Value-Added activities were eliminated from the setup process for each setup performed in IMM 128.
- **Setup Downtime reduction:** The average downtime per each setup was improved from 5.26 hrs to 4.99 hrs a 5% reduction based on the implemented actions.

CONCLUSION

DMAIC and SMED methodology were successfully applied as part of the project to reduce the setup downtime for the top offender Injection Molding Machine 128 at Jabil Cayey 1 building. DMAIC methodology provided the systematic approach and direction in each phase to verify that the necessary information and analysis are performed in order to achieve the reduction of setup downtime necessary to Internal vs External activities is an excellent SMED approach to reduce setup downtime with no major capital investment.

Due to time constraint the project focused only to implement the top two improvement actions. This is one of the reasons that only a 5% or 16 minutes and 5 seconds of each setup was achieved by converting a total of 18 internal activities to external activities.

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