



AN OPTIMIZATION METHODOLOGY FOR SUSTAINABLE DEVELOPMENT OF PRODUCTION LINES

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ABSTRACT

The article deals with the design of own methodology aimed at optimizing production lines. The methodology is designed to involve enterprise specialists in the process of optimization, which work is coordinated by an optimization specialist. The main objective of the methodology is that optimization helps to eliminate bottlenecks of selected processes and is sustainable in the long run. By using this methodology and applying activities downtime and waste in manufacturing can be reduced. This will be reflected in reducing manufacturing costs. The conclusion of the article describes the implementation of the methodology in a production plant.

KEYWORDS

Optimization methodology, sustainable development, production lines, bottleneck activity.

1. Introduction

Current trends, which are based on constant cost reductions, make us search for reserves that have been undetected and not used yet. Such reserves can be found in improving the long-term reduced performance due to frequent production line failures. For every manufacturing company, failures and unplanned machine and plant downtime are the sources of avoidable costs [3]. Today, in almost every enterprise bottlenecks in the production can be found that cause limitations of the performance of production lines. This is due to the varying technical levels and reliability of the production facilities and equipment. In production and project management, a bottleneck is one process in a chain of processes, whose limited capacity reduces the capacity of the whole chain. The result of having a bottleneck are stalls in production, supply overstock, pressure from customers and low employee morale [12]. The bottleneck can be represented by a component, a machine or a device that causes short or long-term performance reductions. If we want to achieve an increase in performance, it is necessary that the impact of bottlenecks on final performance is minimal. There are experts in many enterprises who can remove or reduce these bottlenecks. However, their activities need to be coordinated with management [8]. The activities of these experts in the production line are not necessary all the time but only when it is necessary. In many manufacturing enterprises, the lack of coordination and unwillingness to tackle

the problem is the main issue of optimization processes. The activity of an optimization specialist is needed to bypass these problems. The purpose of the optimization specialist is to search for problems on the production line in cooperation with other line operators, then to obtain the right people to address problems on the production line, then to control their activities and finally to coordinate line operators-management-other specialists. By achieving this we create supportive environment for introducing the idea of Industry 4.0 [10]. At the same time, such a solution of the process optimisation opens the gate to future technologies such as reconfigurable production systems and multi-agent systems, where autonomous agents take over the role of the measures' applicator, however, most maintenance software activities must be carried out by a person [6]. This article deals with the description of proprietary design for a methodology aimed at coordinating the activities of selected enterprise experts, line operators and management. This methodology used optimisation specialist during the optimization process. The final part of the article contains a specific example of solving the problem on the production line at a manufacturing plant.

2. Basic scheme and definitions of methodology

Optimization is the introduction of a condition into the optimum, thus achieving an optimal form of some-

thing. In the optimization of production lines, purposeful action to improve tasks, processes and systems can be understood, taking into account the sustainability of the measures [1, 9]. The optimization activity is aimed at increasing the production standard of the parts made in a shift, together with the optimization of the utilization of personnel [2]. The enterprise is characterized by different levels of management, who co-ordinate the production process in order to meet the planned tasks. The experience of control workers must also be used to improve the throughput of lines by applying their expertise knowledge [5, 11]. The flow chart is Fig. 1 illustrates the algorithm of the process of coordinating the optimization activities on the production line. All these activities have a single goal, which is defined at the beginning of the optimization process as a target production or as a different productivity indicator (OEE, TEEP, etc.).

Production line data acquisition and collection of older data – the first step of each project consists of analyzing existing data. As part of this step, optimization specialist must familiarize themselves with the line and the function of each part. The data collected at this stage are in particular the data on the number of pieces produced each day, the duration of the downtime on individual days, the planned daily performance, the Overall Equipment Effectiveness (OEE) and the (Total Effective Equipment Performance (TEEP) on individual days, etc. [7].

Collection of older data concerning problems on the production line from operators – this is an important step because the problems of a given production line are best known by its operators. Although they may not be able to deal with the existing problem, it is advisable to ask about their suggestions for resolving the problem. It often happens that workers are not willing to express opinions regarding the current state,

so it is not advisable to seek information at all costs but to gain their trust gradually. In this step, the completed PDCA cards may be collected. If some of the tasks have been implemented, the effectiveness of the measures can be checked and if they are still in the process, it is good in to assist in their implementation. Here it is advisable to ask the staff whether or not some cards were filled because sometimes higher ranking workers hide these cards from checking to avoid penalties for their failure to perform.

Data analysis – in this step, the collected data is analyzed, and the chart figures together with the tables are created. These are evaluated by the management for the pre-defined period of time. It is usually done for a period of one year. For this period is created a graph of production development at the time, OEE at the time, TEEP at the time and downtime at the time. The average daily performance, OEE and TEEP are selected. These values are indicators of the effectiveness of the measures implemented [4]. At the same time, the goal of optimization is determined. The goal may be the volume of production, an increase in OEE or TEEP. We strive to achieve these values within a scheduled period, for example, two months.

Selection of solution team – when we select a team, we begin with the analyzed data and from the range of determined optimization directions. The participants of solution team can be technologists, maintenance staff, a supervision worker responsible for the whole production line, a coordinator (optimization specialist), who has the function of the observer of the production line, a manager and the data analyst. In the case of higher automation of the production line there can also be an IT expert present. People can also join the solution team during the project. However, it is advisable that the number of people is not too many to avoid overlapping tasks.

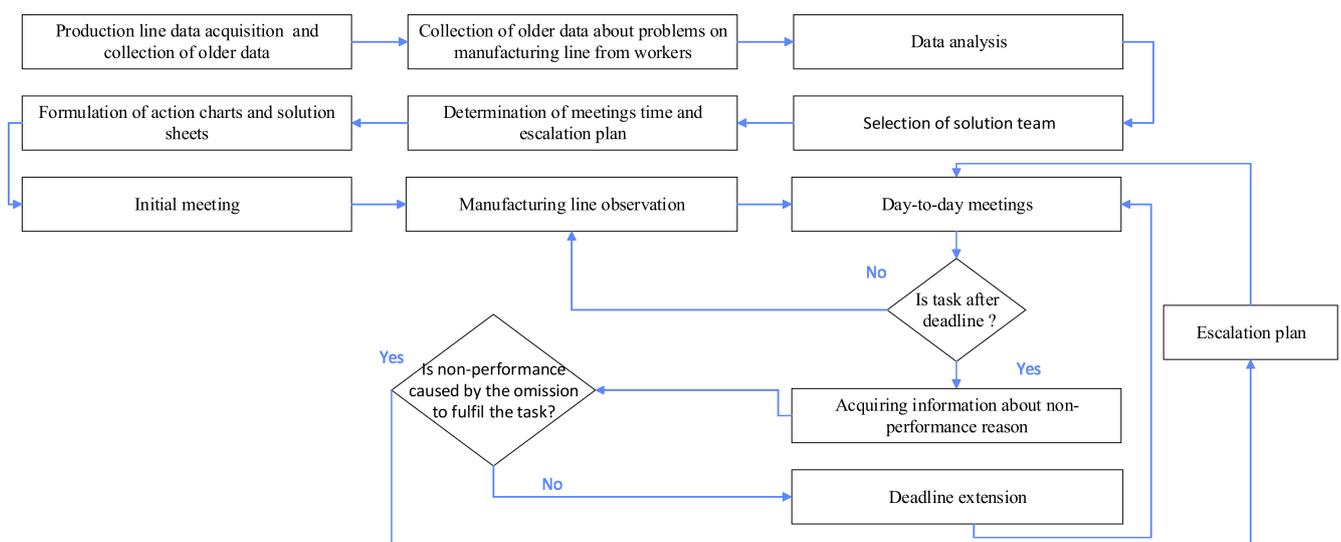


Fig. 1. Flow chart of the methodology.

Determination of meeting time and escalation plan – it is important that, when selecting the time of meetings, all interested parties are involved. Only in this way it can be guaranteed that other obligations will not be neglected during meeting. In this way, participants will be able to take part in meetings daily. A higher control element must also be involved in determining the escalation plan. There is no need to participate in meetings, but responsibility for resolving tasks is necessary. Therefore, the escalation plan is compiled. It guarantees that each member of the team knows the consequences of neglecting tasks. An example of such an escalation plan is in Fig. 2. The plan will also allow the supervisor of members of the solution team to be aware of non-fulfilment of the task (step 1), subsequently he will press, sanction and meet with the team members. If, however, this step is not successful (step 2), the information on failure to perform the task is transferred to the next level in the organization (step 3) of the enterprise responsible for the whole operation segment (step n). The goal of the escalation plan is not to demotivate people, but to ensure personal accountability. The members of the solution team are given sufficient time to solve the tasks. They have expert knowledge and necessary resources. The execution times are determined by the members themselves and, if within the time and technical options the task cannot be completed, it is extended. However, if the communications do not occur and the member does not respond to the task, the case is reported to the superior through the escalation plan after the deadline has passed. The escalation time before the next escalating stage depends on the agreement between the interested parties.

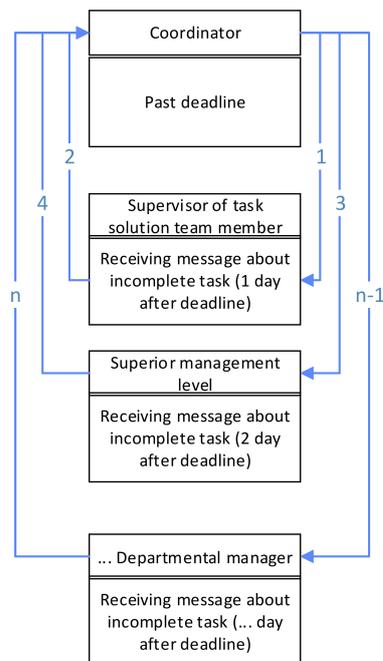


Fig. 2. Example of the escalation plan.

Formulation of action chart and solution sheets – a whiteboard that consists of rows and

columns is created to document problems, actions, and deadlines. The header contains the order number of the task, the problem, the solution, the responsible members, the due date of the problem – Table 1. It shall also be established on the basis of the compilation by each solution team member of their own list of tasks, which shall be regularly updated and where the solution team member will find only their own tasks [11]. These lists contain a description of the task and the deadline for its completion. This will speed up the communication process during meetings.

Table 1
Blank sheets for problem and action.

No.	Problem	Action for solution	Deadline	Responsible
1				
2				
3				
...				
n				

Initial meeting – the current situation in the production line is presented at the initial meeting using graphs. At the same time, the goals of the optimization project and the solution team member tasks are presented. They present the main problems of the production line and the problems that occurred the previous day.

Production line observation – the observation of the production line is carried out by one or more observers. This is usually the coordinator (optimizing specialist) himself and the support process analysts, who perform data analysis from the production line. It is important that the coordinator should communicate with the operators or mechanics about the problem encountered each time the problem is occurring. They will then be able to better explain the current issues in the production line the next day.

Day-to-day meetings – during these meetings, which take place every day, performance graphs, downtime, the average time of setting up the production line from the previous day, and the cumulative total duration of downtime on individual devices are displayed on the bulletin whiteboard. As part of the meeting, members address their tasks, where they work and what they are about to do. At the same time, the problems that arose on the previous day are discussed, and the measures, responsibilities and deadlines for solving problems are recorded on the chart of problems and actions. They coordinate their role as members of the team with other members.

Is the task past its deadline? – in the daily meeting, the time limits that have already passed are analyzed. If there are none, the team is disbanded and the coordinator continues to monitor the production line. If not, then information about responsible solution team member and the task is looked for.

Acquiring information about non-performance reason – while obtaining information, it is

necessary to determine whether a member has regularly participated in solving tasks and communicated with other members. The coordinator also communicates with the team member directly during the meeting to achieve information about the status of the task.

Is non-performance caused by the omission to fulfil the task? – if the deadline has already passed, it is necessary to ascertain whether it is due to neglecting the tasks by a team member or a problem that needs extension of the deadline (e.g. parts and tool orders).

Deadline extension – as already mentioned, if there is no failure of a team member but an exceptional event, the deadline may be extended. This time limit will be determined by the team member at their discretion and the time entitlements to complete the task.

Escalation plan – in case there is no explanation of the failure of the task and the team member refuses to cooperate. The failure of the task is reported through the escalation plan to the higher supervisory level. The coordinator shall be informed of the fulfilment or failure of the task at regular time interval set out in the escalation plan.

This daily meeting procedure lasts until the project has finished and all scheduled tasks are completed. The project assessment should follow in the form of a presentation which would outline what was achieved in relation to the set objectives and, if necessary, what could not be done. The original and current performance and the sustainability of the measures are compared. In the context of sustainability, tasks must be assigned to the member who performs supervisory duties.

3. Methodology application

The methodology was applied in a production plant. At the beginning of the whole process, there was the introduction of workers into the range of optimization, its duration and continuity. Firstly, a board was installed on which graphs were placed with data about the downtimes accumulated for the entire production line, for individual parts and, for each part of the line with the special description of the failure and its total frequency. At the same time, there was a graph showing the downtime that occurred on the previous day with its duration and description. Then, the table with problems and actions was added to the board. After the analysis of past data, a group of specialists were selected who jointly agreed on the daily meeting times. During the first meeting, on the basis of the Pareto chart of current downtimes, problems which most contribute to the downtime were picked. Then a series of actions were generated to prevent their repetition. At the same time, the problem, action, responsible team member and deadline were added to the table of problems and actions. Then, the solution sheets were created that track the time limits of the tasks and responsibil-

ities. At the next meeting, always the previous day is analyzed with the view of the problems that occurred in the production line. At the same time, solution sheets with task execution are compared to the table of problems and actions. The responsible task owners report on the actions performed and the completeness of the performance, or whether the deadline extension is required. At the same time, new tasks are assigned based on the currently occurring problems, if they are not already on the problem and action table. An example of a solution to the problem in the production line was the reduction in the downtime of the failure of the pairing software that caused a downtime of the entire assembly line. After the problem was detected, IT specialist was estimated that the two-week corrective time limit is needed. IT specialist fulfilled the task, and, thanks to the elimination of this disorder, a second bottleneck could be identified where remedy should be applied. An example of the use of the escalation plan was a problem with the inequality of input parts and the high defect rate of the products. The solution team member was selected to be the team leader of previous operation. He understood the task but did not complete it and did not communicate the reason why. After the deadline, he was contacted by the supervisors who discussed it with the accountable team leader. Afterwards, investigation was carried out concerning what caused the problem. Behind the problem, there was poor storage of hot pieces after processing, where the pieces chilled too quickly. After the problem was resolved, the task was evaluated as solved and it was reflected in the reduction of downtime due to poor quality of production input. After 35 days the required level of the TEEP on the production line was reached. Furthermore, the team leader of production line was trained and appointed to continue and maintain the board with graphs and table of problems and action. He took over daily meetings and assumed the role of the optimization specialist.

4. Conclusions

The aim of the article was to describe a methodology of own design for coordinating activities in the production lines during the optimization process. The article contains a description of the methodology flow chart, which illustrates the coordination process. Each block and activity contains a detailed description. The methodology is particularly suitable for those companies that optimize production by eliminating bottlenecks with the help of selected enterprise or external experts. They perform optimization with the participation of a coordinator (optimization specialist), who serves as support for optimization. The appropriate composition of the team and the application of their expert characteristics together with coordination can achieve higher performances in the production line. At the same time, the presence of an expert team encourages workers to exercise higher performance by solving problems that occur in the production line. The

methodology was applied at the production enterprise and where the implementation of methodology is described for one production line.

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