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IMPROVEMENT IN EXTERNAL LOGISTICS OF AN AUTOMOTIVE COMPONENT MANUFACTURING COMPANY TOWARDSCOSTS REDUCTION

Abstract: *This work was developed in a company that produces components, such as, Bowden cables and comfort systems for the automobile industry. The company's external logistics department was the place where the work was carried out. The constant need of urgent shippings in the company in order to comply with the delivery scheduled with its customers, leads the organization to have an unnecessary cost. This case study is no exception, and this type of costs represents about 33% of total transport costs, revealing a major negative economic impact for the company. For the analysis of urgent transport some quality tools were used to determine the root causes of the identified problem (high cost with urgent transport). The use of these quality tools, namely brainstorming, Ishikawa's diagram and Five Whys, allowed for greater involvement by employees from different areas. Thus, it was possible to share knowledge and, consequently, a more reliable analysis and identification of possible root-causes of the problem, as well as, the implementation of actions to eliminate them. With the implementation of the improvement actions, the urgent shipping costs were reduced by about 68%.*

Keywords: *Logistics; Quality Tools; Improvement; Brainstorming; Costs Reduction.*

1. Introduction

Now-a-days, business organizations are practicing several management systems such as quality management system (QMS) according ISO 9001 (Costa et al., 2019; Araújo et al., 2019; Bravi et al., 2019a; Santos & Millán, 2013; Sá et al., 2019; Santos & Barbosa, 2006), environment management system (EMS) according ISO 14001 (Barbosa et al., 2018; Carvalho et al., 2018; Talaprata et al., 2019; Rebelo et al., 2015)and occupational health and safety management system (OHSMS) according ISO 45001/BS OSHAS 18001, among others (Santos et al., 2014; Santos et al, 2019d; Carvalho et al., 2020; Cordeiro et al., 2020). In order to answer to market demands, the diferent sectors have been registering dynamic and competitive behaviours over the past last years (Santos et al, 2019a; Bravi et al., 2018; Santos et al., 2018a).Sometimes problems arise (Bravi et al, 2019b) that carry risks (Ferreira et al., 2019), but a good education system (Africano et al., 2019; Santos et al, 2019b) promotes people capable of solving many problems regarding the production system (Azevedo et al., 2019; Castro et al., 2020; Félix et al., 2019a; Jimenez et al., 2019a). So, new solutions areproposed (Doiro et al., 2017; Vieira et al., 2019) and improvements appear (Félix et al., 2019b;

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Jimenez et al, 2019b; Doiro et al., 2019) where lean tools (Ribeiro et al., 2019; Rodrigues et al., 2019; Silva et al., 2020) help create value (Santos et al., 2019c; Vieira et al., 2019).

The most developed companies, in order to save human and financial resources, invest in the integration of the various management systems, necessary for the proper functioning of the company, namely, the quality management system, the environmental management system, the hygiene and safety management system at work and the corporate social responsibility system, among others (Rebelo et al., 2016; Santos et al., 2016).

The present project was developed in an industrial context, in the external logistics department of a company that is dedicated to the production of components such as metallic Bowden cables and seat comfort systems for the automotive industry. The problem of urgent shipping leads companies to an extra and unnecessary cost to fulfil their commercial commitments to their customers. In most cases, it is due to the existence of gaps in planning. This particular case is no exception, as this type of costs represents around 33% of the total transport costs, revealing to have a great economic impact.

This work is divided into five Sections, starting by this one with the contextualization. Section 2 provide the theoretical support for the development of the work. Methodology used in this work is described in Section 3. Section 4 deals with the results and Section 5 highlights the best achievements performed through this work.

2. Literature review

Controlling and improving quality requires teamwork and involvement of the entire organization. In addition, the use of some types of quality tools in everyday business, helps in the analysis and identification of problems encountered (Fonseca et al., 2015; Barbosa et al., 2017). Organizations use them to identify, analyze and evaluate quantitative data collected in their processes. There are a few tools which organizations can use to solve problems and improve processes. Quality tools are essential in the collection, analysis, and visualization of data, creating a solid basis for decision making (Sokovié et al., 2009). The first seven tools are often referred to as the seven basic quality tools (McQuarter et al., 1995). Due to its greater relevance for this project, only the flowchart, Ishikawa's diagram and Pareto's diagram will be covered in detail. Other quality tools will also be addressed, such as brainstorming and the five whys.

2.1. Flowchart

For Maiczuk and Andreade Júnior (2013), the flowchart is one of the first tools to be used when studying a process. This clearly shows the sequence of all activities in a process or task (Prístavka et al., 2018). Represent in a simple, easy and orderly manner the various stages of the manufacturing process or any procedure, operation of teams and systems (Santos et al., 2017). Stevenson (2019) states that diagrams are made up of sequenced steps of decision and action, where each of them has a symbolism. The diamond shapes in the flowchart represent decision points in the process and the rectangular shapes represent procedures / activities. The arrows show the direction of the "flow" of the process steps.

According to Bauer et al. (2006), flowcharts can be used to:

- Identify and communicate the steps in a work process
- Identify areas that may be the source of a problem or determine opportunities for improvement

According to Tague (2005), the elaboration of a flowchart must follow the following steps:

- Define the process to be traced with the decision, where it starts and ends, and the level of detail used in the diagram

- Conduct a storm of ideas about the activities as in the process
- Sort the activities in a sequential way and make the connection between them
- Review the flowchart with everyone involved in the process (workers, supervisors, suppliers, customers), to confirm the veracity of the indicated process.

2.2. Pareto Diagram

Any improvement process needs to identify what is important and what is accessory(Khanam & Talib, 2015). The Pareto's diagram aims to segregate the "few vital" and "many trivial" questions (Slack, 2014).

Pareto's charts consist of bar charts, prioritized in descending order, from left to right. They show where to put the initial effort to obtain the biggest gain (Tague, 2005). The tool is named after Vilfredo Pareto, an Italian sociologist and economist, who found that 80 percent of Italy's wealth was held by 20 percent of people. Later, Joseph Juran, one of the top-quality experts, noted that this rule could also be applied to the causes of defects: 80 percent of defects are due to only 20 percent of the causes. Consequently, by minimizing 20 percent of the causes, 80 percent of the problems can be eliminated (Stevenson, 2009). According to Bauer et al. (2006), a Pareto's chart can help organizations to:

- Segregate the few major problems from many possible problems in order to focus improvement efforts on what has the greatest impact
- Organize data according to priority or importance
- Determine what the most important problems are, using data instead of perception.

The basic steps involved inbuilding a Pareto's chart are presented in detail in Figure 1 (Basu, 2008).

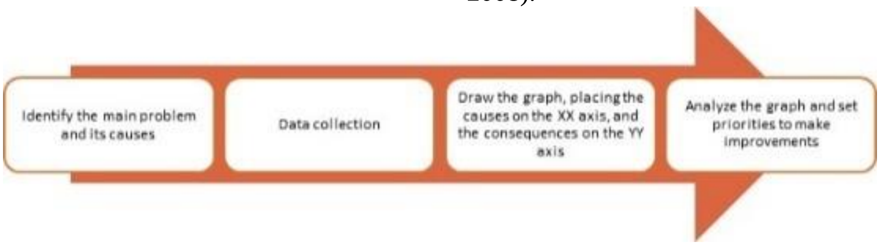

Figure 1. Methodology for drawing up a Pareto diagram (Basu, 2008)

2.3. Ishikawa diagram

The cause and effect diagram is also known as the Ishikawa diagram because it was developed by the Japanese engineer Kaoru Ishikawa. This diagram is also known as the "fishbone" diagram, due to its graphic format (Bauer et al., 2006). This tool offers a structured approach to the search for the cause or possible causes of a problem. The diagram allows, from the basic groups of possible causes, to unfold these causes down to appropriate levels of detail, finding by this way the solution of the problem (Simanová&Simanová, 2015). It is often used after brainstorming sessions in order to organize the ideas generated (Stevenson, 2009).

The basic groups can be defined according to the type of problem being analysed. Usually, for problems of an operational nature, it is suggested to adopt the 6 M's framework (machine, labour, method, materials, environment and measures) (Kenett, 2008). The Figure 2 shows the completed Ishikawa's diagram, resulting from the initial effort of a team to identify possible causes for an unbalanced production line and inefficient layout, in a study developed by (Silva et al., 2019).

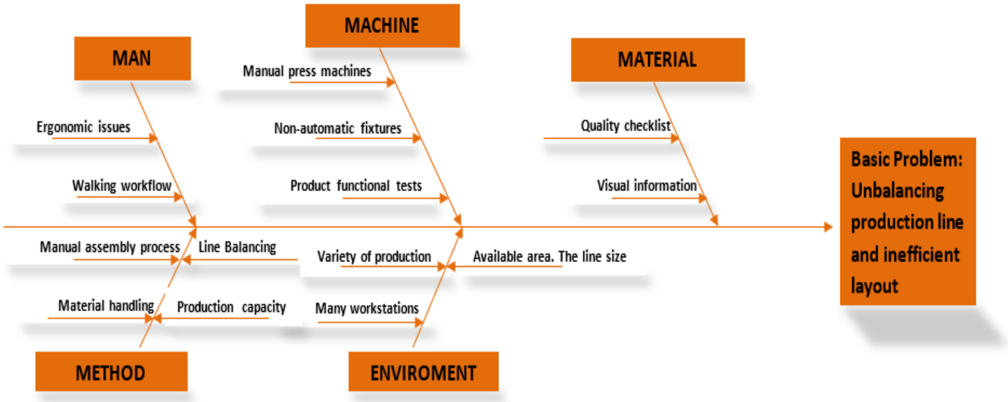

Figure 2. Example of an Ishikawa diagram (Silva et al., 2019)

However, in this particular case, only six categories (5M's) are developed, since the authors did not consider the category related to the measures relevant to the study. The basic steps involved in creating the Ishikawa's diagram are in Figure 3.

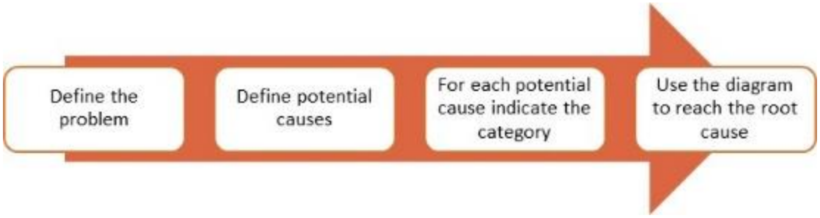

Figure 3. Methodology for creating an Ishikawa diagram (Bauer et al., 2006)

According Pinto (2011), the following recommendations should be followed when using the Ishikawa's diagram:

- When identifying potential causes, it is important to remember that it is these that matter, not the symptoms;
- After identifying all potential causes, it is important to group them, creating categories and trying to quantify the weight of each cause in creating the effect;
- Evaluate each category and eliminate duplications;
- When each "individual spine" (category of cause) and "bones" (individual causes) are in place, analyze each cause and ensure that it is a single and discrete event (otherwise it will be necessary to continue subdividing the causes sub-causes).

2.4. Brainstorming

Brainstorming is characterized as a group meeting where new ideas are sought and, therefore, the free expression of the participants must be ensured. The objective is to maximize the flow of ideas, creativity, and the analytical capacity of the group (Stevenson, 2009). According to the Osborn model (Rawlinson, 2017), this technique must have the following characteristics:

- Quantity: the more ideas directed specifically at the same problem, the better;
- Flexibility: as the search is for new approaches to solving a problem, the escape from the traditional is welcome;
- Freedom: ideas should not be criticized during a brainstorming session;

- Interactivity: the ideas presented can be improved or even combined among them, giving rise to new solutions;
- Tangibility: the ideas suggested need to be able to leave the paper and become concrete actions;
- The described tool follows certain steps described in Fig. 4.

Figure 4. Methodology for conducting a brainstorming session (Bauer et al., 2006**)**

2.5. Whys

The five whys analysis is a tool used to discover the root cause of a problem. More than ever, people solve problems by dealing with issues that are immediately apparent. Meanwhile, it can result in a quick fix solution of the problem and the probability of recurrence of the problem is huge, because only the effects have been treated. Solving problems by scrutinizing their true causes is what leaders and managers must do (Pinto, 2011).In the Toyota Production System, it is believed that by asking five times "why" the nature and solution of the problem, becomes clear. In fact, the number of times you ask questions depends on the scale of the problem (Liker & Meier, 2005). The five whys technique is a simple and effective problem-solving tool. It has the advantage of being reasonably easy to learn. Thus, there are no extremely complex concepts that need to be taught. The five whys can also be incorporated into other methodologies.

2.6. Application of quality tools

Santos et al. (2018a), conducted a project to improve non-quality cost indicators in a company dedicated to the production of buses. In the planning phase (P) of the PDCA cycle, the Ishikawa's diagram was elaborated, which allowed the identification of potential activities that generate costs due to poor quality. At Bolton General Hospital, a surgical team used the Ishikawa's diagram and the 5 Whys method to identify barriers to implementing their redesigned pathway for abdominal pain, and how these barriers could be overcome (Blumenfeld, 2015). Silva et al. (2018), in a foundry, intended to establish the main guidelines to be used in high pressure die casting in aesthetic parts, with the objective of reducing finishing operations, in order to reduce their costs. Therefore, the Ishikawa diagram was used in order to identify all the factors that may influence the lack of quality on the surface of a Zamak alloy "aesthetic part". Choomlucksana et al. (2015), in order to improve the sheet metal stamping process, brainstormed. Then, an Ishikawa's diagram was elaborated to identify the problems associated with excessive movements in the deburring process. In the end, after applying the appropriate Lean tools, the number of movement wastes decreased by about 66.53%. Costa et al. (2017), used the Ishikawa's diagram in the analysis phase of the PDCA cycle, allowing to identify the causes for the occurrence of non-conformities existing in the rubber extrusion process. Then, using the Pareto diagram, it was possible to prioritize these same causes. Lenort et al. (2017) in a project developed with the objective of finding new green / ecological and innovative solutions, with regard to the transport operations of an important world automobile producer, in a first phase, resorted to the elaboration of the Ishikawa's diagram with the objective of identifying the causes for CO2 emissions and, therefore, measures have been devised to eliminate / mitigate these causes. In a developed project, with the objective of improving a weaving process, Neves et al. (2018), used some quality tools, such as Ishikawa's and Pareto's diagrams, combined with the use of the PDCA cycle, the 5S and even the 5W2H. Through the combined use of these tools, a great impact was obtained in the improvement of the process, obtaining gains of 10% in the available time per operator.

Barbosa et al. (2017) developed a study with the objective of improving the wedge production process, and its application in the core (production of automobile tire beads). Regarding this, DMAIC methodology was used, and in the defining (D) phase they will draw up a Pareto's diagram of the non-conformities obtained in the coupons. Later, in the analysis (A) phase, the Ishikawa's diagram was used in order to determine the causes of appearing non-compliant beads. In the end, there was an improvement in the quality rate in the production of beads by 41%. Srinivasan et al. (2014), in a company dedicated to the production of ovens, resorted to DMAIC, with the objective of reducing production losses. In the define (D) phase, the Pareto's diagram was used to observe the impact of the heat exchanger performance indicators, and in the measurement (M) phase to identify the impact of the parameters influencing the performance of the heat exchanger. Finally, in the analysis (A) phase, the Ishikawa diagram was used, in order to identify the factors that make the process less effective. At the end of the project, the organization managed to obtain an improvement in the level of sigma, and consequently an annual saving of approximately € 4 500.

3. Research methodology and Project development

This study arises from the need to analyze the transport in charge of the company under study, namely the urgent shipping. This study aimed at analyzing and identifying the root causes of the high percentage of shipments using urgent transport, compared to the total shipments made by the company.

To do that, the Action-Research methodology was used. This methodology intends that the people involved in the studied problem participate actively in the search for its solution, together with the support of the researcher (Sauders et al., 2009).

4. Case Study

Production delays, planning errors, lack of materials and line breakdowns are the most frequent causes that lead to the need to organize urgent shipments, so that the material arrives on time regarding the customer needs. The excess of urgent shipments (US) then led to the need for a study, seeking to identify product families, and the root causes that led to this excessive cost, in order to reduce them.

For this study, the methodology indicated below in figure 5 was followed.

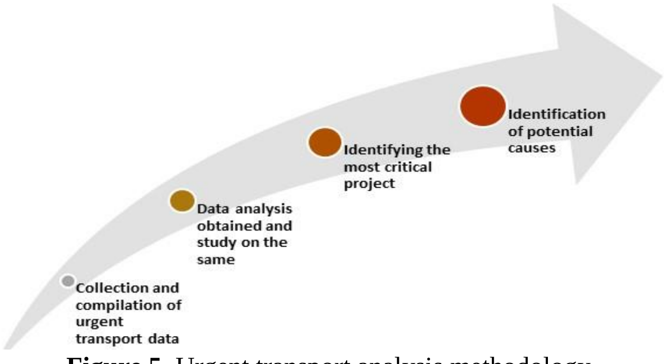

Figure 5. Urgent transport analysis methodology

4.1. Characterization of urgent shipments

In a first phase, a compilation of data / records of urgent shipments was carried out between January 2018 and May 2019. Analyzing the data for the period under study, conclusions were drawn regarding urgent shipment costs, as well as the most critical ones.

Table 1. Analysis of urgent transport in different periods

	Jan to Dec 2018	Jan a May 2019
Total costs in UT	340 359€	178 906 €
Most critical projects	KIEV408XL1 23XC519XL1 41XRG3XXL1 23XX520XL1 KIEB479EL1	23XC519XL1 23XIBKXXT1 KIEV408XL1 JCIC1YXXSC 88X139XXL1
Percentage of costs	35.7%	39.4%

Thus, from Table 1, it can be concluded that in the five months of 2019, urgent transport costs are higher than the costs during the whole year of 2018.

Regarding the most critical, it appears that two of the 2018 projects continue to be the cause of big US costs.With regard to urgent shipments, the Czech Republic stands out geographically, followed by Germany, as the two destination that generate the most urgent shipment costs.

However, as can be seen from the graph in Fig. 6, countries such as Italy, Poland and Spain individually represent, on average, transport costs of approximately 10% of the total urgent transport costs of the company under study.

Since the ultimate goal is to determine the causes of urgent shipments, it was determined that a more detailed analysis, which focused on the period of 2019, will be necessary.

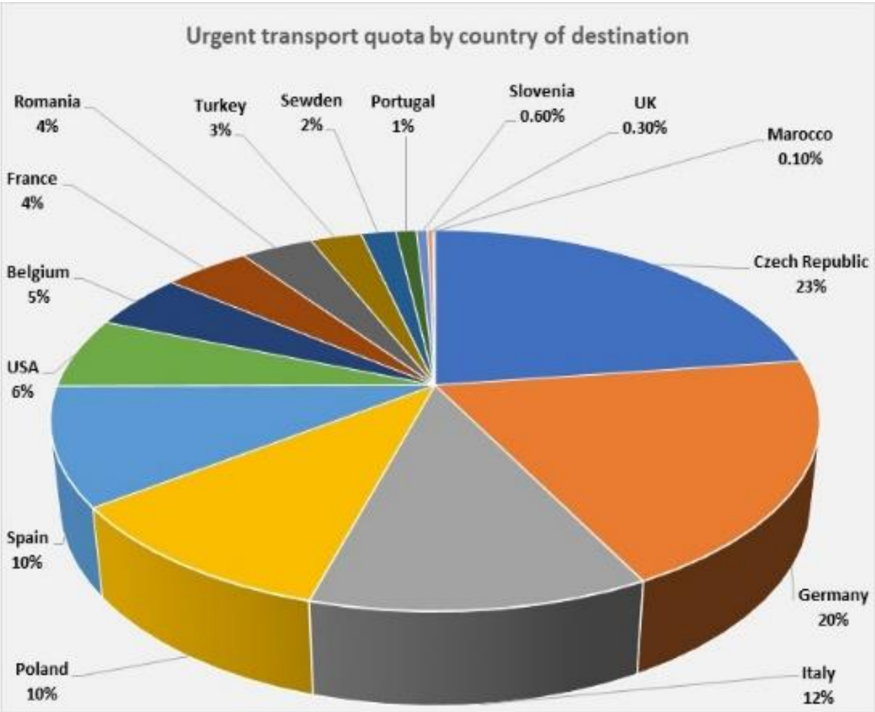

Figure 6. Urgent shipments quota by country of destination

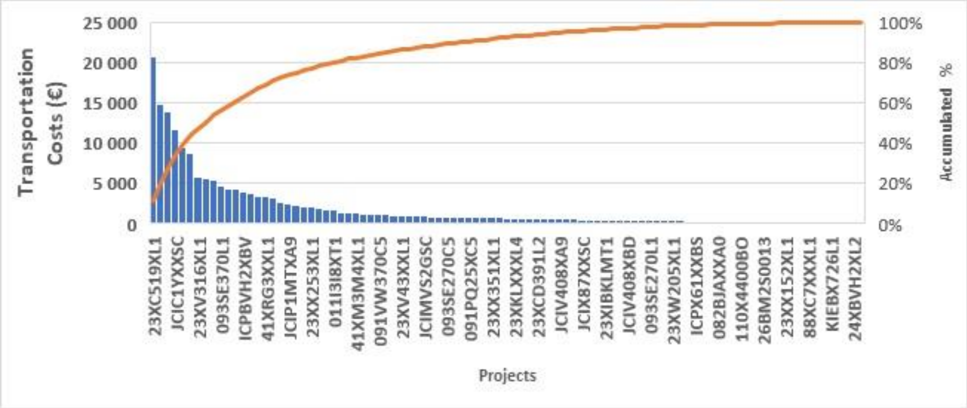

Figure 7. Pareto's diagram for urgent shipment costs in 2019 by project.

As can be seen in the previous diagram (Figure 7), there are several projects that led to the realization of US in the period related to 2019. However, in the Pareto's diagram, the existence of five more critical projects was highlighted (Fig. 7). These projects are the following ones:

- 23XC519XL1
- 23XIBKXXT1
- KIEV408XL1
- JCIC1YXXSC
- 88X139XXL1

After analyzing the "Top 5" of critical projects, in terms of urgent shipments, Table 2 was obtained.

Table 2. Top 5 of critical projects

Project	% UT Costs 2018	% UT Costs 2019	Cost Trend	Manufacturing Module
23XC519XL1	11%	12%	↑	F6
23XIBKXXT1	0,06%	8%	↑	F6
KIEV408XL1	12%	8%	↓	F2 F3
JCIC1YXXSC	2%	7%	↑	F4
88X139XXL1	2%	5%	↑	F2

Through Table 2, it is possible to see a negative trend in most projects. Since the 23XC519XL1 project is the one with the highest cost due to US, this will be the project on which this work will focus, with the objective of reducing the number of occurrences.

4.2. Analysis of improvement actions

In problem solving, the option is to identify the root causes that cause the problem to occur. After applying the Pareto's diagram, it was found that the urgent transport associated with the 23XC519XL1 project, represents the highest cost. Therefore, the focus of this project will be on the analysis of the 23XC519XL1 project, which will be called C519. The start of the improvement project followed the structured methodology indicated in Fig. 8, in order to identify the real root causes of the problem and to ensure that the number of urgent shipments will be reduced at the end of the project.

In order to identify the potential causes that lead to urgent shipments, a brainstorming session was held consisting of the following group of people:

- External logistics coordinator
- Production Director – Cable Assembly Line
- Production Director – Cable Assembly Line / Cables Injection and Small Series
- F2 planner
- F3 planner
- F6 planner

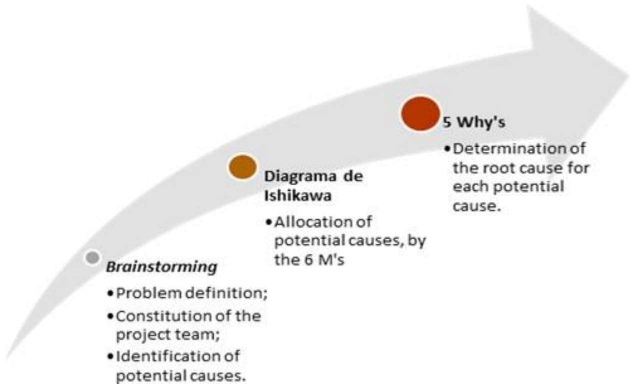

Figure 8. Methodology to identify root causes

At the end of the session, several potential causes were identified, as described below:

- Stops on lines
- Mold problems
- No teams on the lines
- Lack of trained people
- Material rejection due to quality problems
- Customer orders that exceeded forecasts
- Orders with very small quantities
- Lack of ability to produce wire
- Constant setups on wire bending machines
- Improper movements of the teams
- Line works only two shifts (instead of three)
- Issues with the labelling machine
- Loss of productivity
- Lack of people planning management
- Machines with many clearances
- Waste of time in setups
- Problems with Zamak injection
- Output too low

After this brainstorming session, it is concluded that most of the reasons that lead to urgent shipments are related to production delays (about 95%). However, there are also some warehouse problems, which lead to resort to this type of shipment, as well as quality problems and lack of material. Since the impact of production delays on urgent shioments is so significant, they will be the subject of further analysis. With regard to the C519 project, it is a new project in the company, so some of the problems identified are due to this fact. However, in brainstorming, some of the potential causes that lead to resorting to urgent transport were highlighted. In the Ishikawa's diagram shown in Fig. 9, those that have the greatest impact were identified.

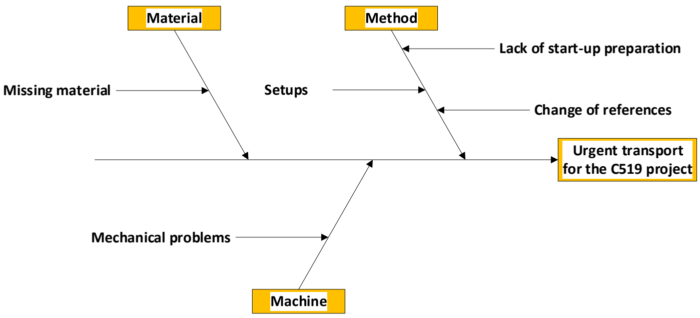

Figure 9. Ishikawa diagram on causes for urgent shipments in project C519

Moving on to the 5 Whys' tool, it can be highlight the analysis for the causes that, according to the actors closest to the process, are considered as the most critical, namely, the lack of preparation for starting, technical problems in the process and, finally, the lack of materials.

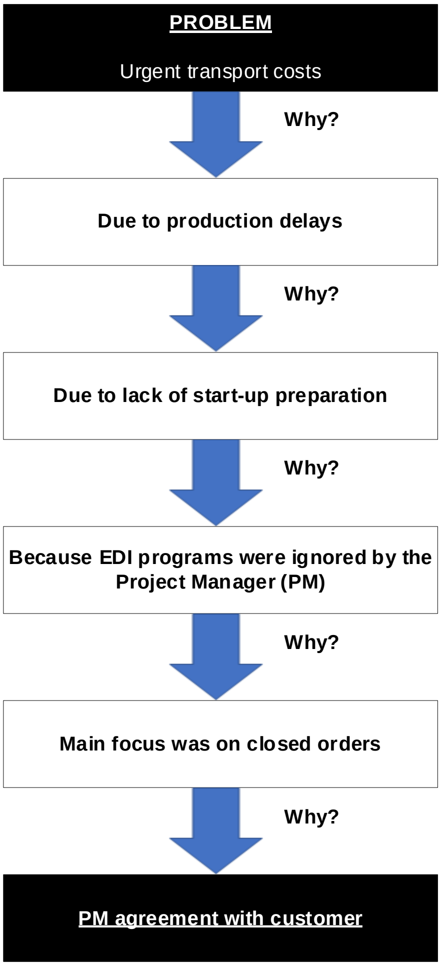

Figure 10. Analysis of the five whys for the cause PM agreement with the client in project C519

In Fig. 10, it is possible to observe with regard to the cause identified as lack of start-up preparation, that the root cause refers to the PM (Project Manager) agreement with the customer, since there was an evil understood between the two stakeholders, since for the project manager, the customer technician should only accept closed orders and not the customer's EDI (Electronic Data Interchange) programs. Therefore, the company was rejecting these orders and they were accumulated in the system and, when the situation was clarified, there were already many back orders. The applied action involved communication between the two PMs about EDI requests and, thus, the situation was clarified, and EDI programs were accepted.

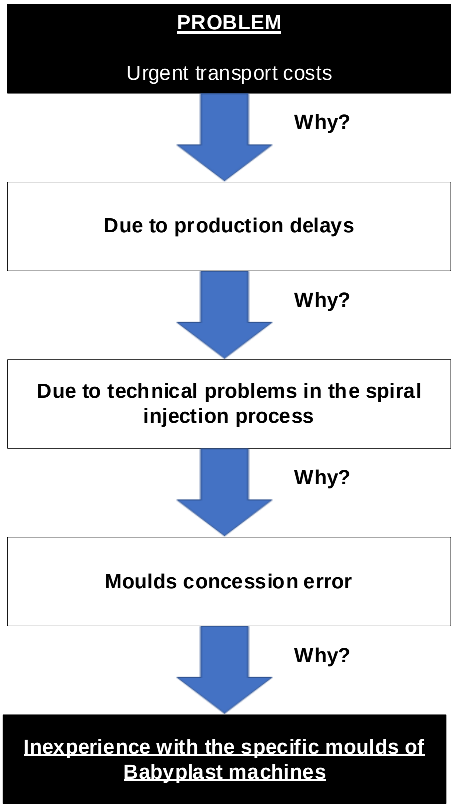

Figure 11. Analysis of the five whys for the cause "inexperience with specific moulds" in project C519

Regarding the technical problems in the spiral injection process Fig. 11, it was concluded that these existed due to errors in the design of the moulds and, consequently, the root cause was due to the fact that there is no experience with these specific moulds, since this was the first project where this type of machine was used in a more intensive way. Taking into account the root cause found, the only action taken was to elaborate lessonslearned for future projects, so that in the future these problems are minimized, or at best avoided.

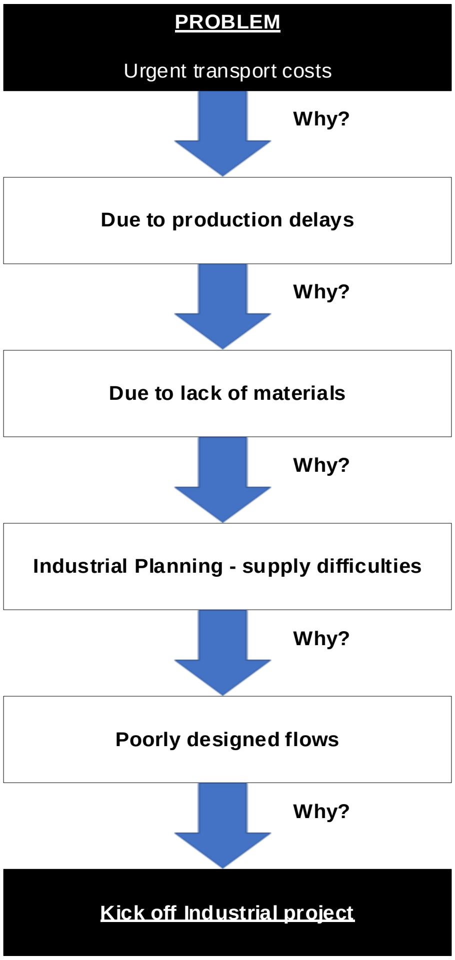

Figure 12. Analysis of the five whys for the “lack of materials” cause in the C519 project

Finally, analyzing the cause related to the lack of materials and analyzing Fig.12, it appears that, due to the industrial planning, there were difficulties in supplying the lines, since the flows were not well defined due to the industrial project. start-up phase. After identifying the root cause for the lack of materials for the C519 project, an action was followed, namely the elaboration of lessons learned related to the planning phase of industrial projects.

5. Discussion

Based on the causes previously identified, two improvement actions were taken. Regarding the lack of work preparation, the production sequences were rearranged in order to become the production flow more effective. On the other hand, the lack of external pipe, which was identified as the second most disturbing factor implying urgent deliveries, the system was parameterized and an extra batch was created, associated to a Kanban system for the cutting equipment, avoiding disruption of production. These improvement actions avoided the difficulties in deliver the final product on time, reducing the costs related to urgent deliveries in 85%

Regarding the C519 project, the first action defined (for the cause - PM agreement with the client) made possible a better understanding on how the orders would be sequenced on the production line, which allowed the realization of a recovery plan that led to a decrease on the urgency of deliveries, and consequently, decreased urgent shipments costs regarding this client. For the other two identified causes, the suggested actions led to the elaboration of lessons learned for upcoming projects that, in the future, will allow a minimization of mistakes made in the project planning phase, as well as greater learning about the Babyplast machine (mini-injection moulding machine). In concrete terms, it was not possible to quantify the impact of implementing of one of these actions.

Because there are no other works in this specific field, it is not possible to compare the results obtained and understand if they are in line with other works carried out in the same way. However, in absolute terms, the results are excellent, but there is room for improvements until the problem is completely eliminated. Thus, a PDCA cycle must be implemented in order to help the team to eradicate definitely the problem.

6. Conclusions

According to the objectives proposed for this work, it was possible to determine the most critical projects in terms of urgent shipments, namely the V408, C519 and X139 projects, with the C519 project being selected because it had the highest impact in the urgent shipment costs. It was possible through quality tools (Brainstorming, Ishikawa' diagram and 5 Whys) to determine the root causes of this problem. Actions were also taken to minimize the impact with respect to the cost of urgent shipments, however, one of them is still in the implementation phase. Therefore, in terms of urgent delivery costs, with this project, savings of 85% were achieved.

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