

POST-GRADUATION

IN

SIX SIGMA BLACK BELT

Lean Six Sigma in Mold Making Industry

Data Validated Investigation for Enriching Workplace

(D-VIEW)

Anurag Ayyagari Venkat

2172603

ABSTRACT

This report describes the work carried out from February 2018 to June 2019 under the project of *Data Validated Investigation for Enriching Workplace (D-VIEW)* in Moldetipo Group. The objective of the project was to enhance the production process through the management of the non-conformities, increasing the capacity of CNC machining and optimizing the quality of CNC machined parts. The strategies and techniques implemented contributed to the improvement of cycle time of production process, reduced production cost and increased morale among the employees.

TABLE OF CONTENTS

ABSTRACT iii

TABLE OF CONTENTS v

LIST OF FIGURES vii

LIST OF TABLES ix

LIST OF ABBREVIATIONS xi

LIST OF KPIs xi

1. INTRODUCTION 1

1.1 ABOUT THE COMPANY 1

1.2 PROCESS IN INTEREST 2

1.3 IMPORTANCE OF PROJECT 3

1.4 WORK METHODOLOGY AND REPORT STRUCTURE 5

2. MANAGEMENT OF NON-CONFORMITIES 7

2.1 DEFINE 7

2.2 MEASURE AND ANALYZE 9

2.3 IMPROVE 12

2.4 CONTROL 15

3. RENTABILITY OF CNC MACHINES 16

3.1 DEFINE 16

3.2 MEASURE AND ANALYSE 17

3.3 IMPROVE 20

3.4 CONTROL 22

4. OPTIMIZATION OF CNC MACHINING 23

4.1 DEFINE AND MEASURE 23

5. CONCLUSION 36

BIBLIOGRAPHY 38

ANNEXES-I 39

ANNEXES-II 42



LIST OF FIGURES

Figure 1: Organisation Chart of Moldetipo[1] 2
Figure 2: Process flow chart of manufacturing of an injection mold 3
Figure 3: Process Flow of NC 8
Figure 4: Pareto Chart - % Contribution by each section towards total NC cost 9
Figure 5: Pareto Chart - % Contribution by each section towards total NC occurrences 9
Figure 6: Pareto Chart - % Contribution by each problem towards total NC cost 10
Figure 7: Pareto Chart - % Contribution by each problem towards total NC occurrences 11
Figure 8: Auto Control Checklist and Calipers 13
Figure 9: Auto Control Form/Feature 13
Figure 10: Standardization of Tools 14
Figure 11: KPI-I before and after improvements. 14
Figure 12: SIPOC of CNC Machining Department 17
Figure 13: KPI-II before improvements 17
Figure 14: Status of Machines 07/09/2018 to 28/09/2018 18
Figure 15: Spaghetti Diagram of CNC Operators 19
Figure 16: Status of Machines (November) 19
Figure 17: SMED 20
Figure 18: Shop floor after 5S 21
Figure 19: KPI-II after improvements 21
Figure 20: Control document for KPI-II 22
Figure 21: Sample report of measurement software 24
Figure 22: Type 1 Gage Study of Probe 24
Figure 23: Gage and Linearity Study for Probe 26
Figure 24: Probability Plot of dL on a) Vertical, b) Normal and c) Horizontal Surfaces 27
Figure 25: Graphical Summary of dL on a) Vertical, b) Normal and c) Horizontal Surfaces 28
Figure 26: Individual Chart for dL on Normal Surfaces (a) for all subgroups (b)staged by subgroup 29
Figure 27: Individual Chart for dL on Horizontal Surfaces (a) for all subgroups (b)staged by subgroup 30
Figure 28: Individual Chart for dL on Vertical Surfaces (a) for all subgroups (b)staged by subgroup 31
Figure 29: Run Chart of cumulative deviations on (a) Vertical, (b) Normal and (c) Horizontal Surfaces 33
Figure 30: Matrix Plot of dX, dY, dZ, dL for Vertical, Normal and Horizontal Surfaces 34

LIST OF TABLES

Table 1: Project Team 5
Table 2: Timeline for Management of NCs. 7
Table 3: Identified Problems and Causes of Production 8
Table 4: Cause for Process Failures 11
Table 5: KPI-I before improvements 12
Table 6: Solution to problems of NCs 12
Table 7: Timeline for Rentability of CNC Machines 16
Table 8: Identified Statuses of CNC Machines 18
Table 9: Improvements for NBVA and NVA in CNC Machining 20
Table 10: Timeline for Optimization of CNC Machining. 23
Table 11: Return on Investment (yearly) 37



LIST OF ABBREVIATIONS

NVA – Non-Value Added

BNVA – Business Non-Value Added

CNC – Computer Numerical Control

DMAIC – Define Measure Analyze Improve Control

KPI – Key Process Indicator

NC – Non-Conformity

TPM – Total Productive Maintenance

SIPOC – Supplier Input Process Output Customer

VOC/VOB/VOE – Voice of Customer/Voice of Business/Voice of Employee

SMED – Single Minute Exchange of Die

MSA – Measurement System Analysis

DOE – Design of Experiments

SPC – Statistical Process Control

dX/dY/dZ/dL – Deviations in X/Y/Z/Cumulative deviation

LIST OF KPIs

KPI-I: Average cost of NC for each problem

KPI-II: Percentage of machining capacity of CNC section per week

KPI-III: Range of deviations



1. INTRODUCTION

Custom injection mold making has been a fast-changing, chaotic and challenging business. It has great potential for profits, but global pricing and high expenses make it strenuous. In Portugal, majority of the mold making companies are in Marinha Grande and Oliveira de Azeméis, employing around 10,000 people and exporting about 675 million euros worth products globally (Schulz, 2018). Automotive industries are the main customers but services are also provided to the aerospace, medical and domestic industries.

To survive in the global market, most companies have invested in or are having plans to invest in new five axis CNC machines, software of production management, lean management and automation equipment. This has become the need of the hour for increasing their margins ensuring shorter delivery times and quality on their products (Schulz, 2018). The perks that the companies reaped by the adoption of these methods motivated us to implement the tools and techniques from Lean and Six Sigma methodologies to enrich and enhance the workplace.

This report describes the work carried under the course of *Post-Graduation in Six Sigma Black Belt, in the School of Technology and Management (ESTG) of Polytechnic Institute of Leiria.* The project was executed from February 2018 to May 2019 in Moldetipo Group, which is the manufacturer of plastic injection molds.

1.1 ABOUT THE COMPANY

Moldetipo Group was established in 1996 and has three companies in Portugal, namely, MoldetipoII, Injectotipo and Placido Roque, all situated in Marinha Grande. Internationally, the company has its offices in Mexico (Moldetipo Mexico), China (Major Mechanical Engineering) and India (WimTipo). Moldetipo Group exports mainly to Germany, Spain, France and Mexico, which represent 80% of sales.

The group actively responds to the dynamic expectations of the market, meeting their needs through engineering solutions by optimizing and evolving the features and characteristics of the product and respective manufacturing processes. This demonstrates the strategic view point of the group.

The three companies located in Marinha Grande, referred to as Moldetipo, has a manpower of 80 people. The production department has 60 employees, the finance department has six and rest belong to sales department. In August 2018, the department of Process and Quality Management was established to improve the efficiency of production by boosting the working conditions and the process. This department comprises of two employees. Below is the organization chart of the company.[1]

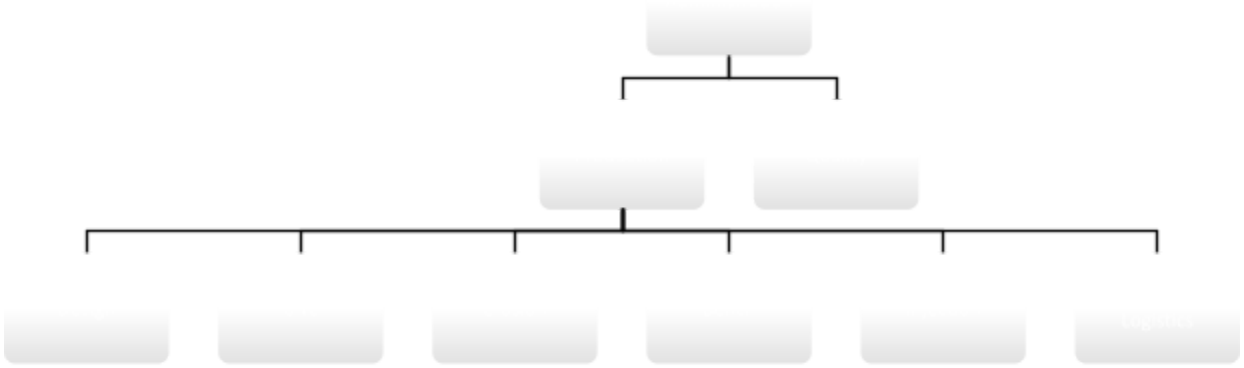


Figure 1: Organization Chart of Moldetipo[1]

1.2 PROCESS IN INTEREST

An injection mold can be explained as a set of functional elements that assist in production of injection molded plastic parts. The standard components of a mold are the clamping plates, extraction system, core and cavity plate (two halves of the mold), spacers and supports. The number of plate and components depends on the type of mold. Every mold is a type of its own and has its own unique manufacturing procedure. The figure below demonstrates a template process flow of production of mold.

[1] The organization chart and the data related to employees has been obtain ed from the human resources.

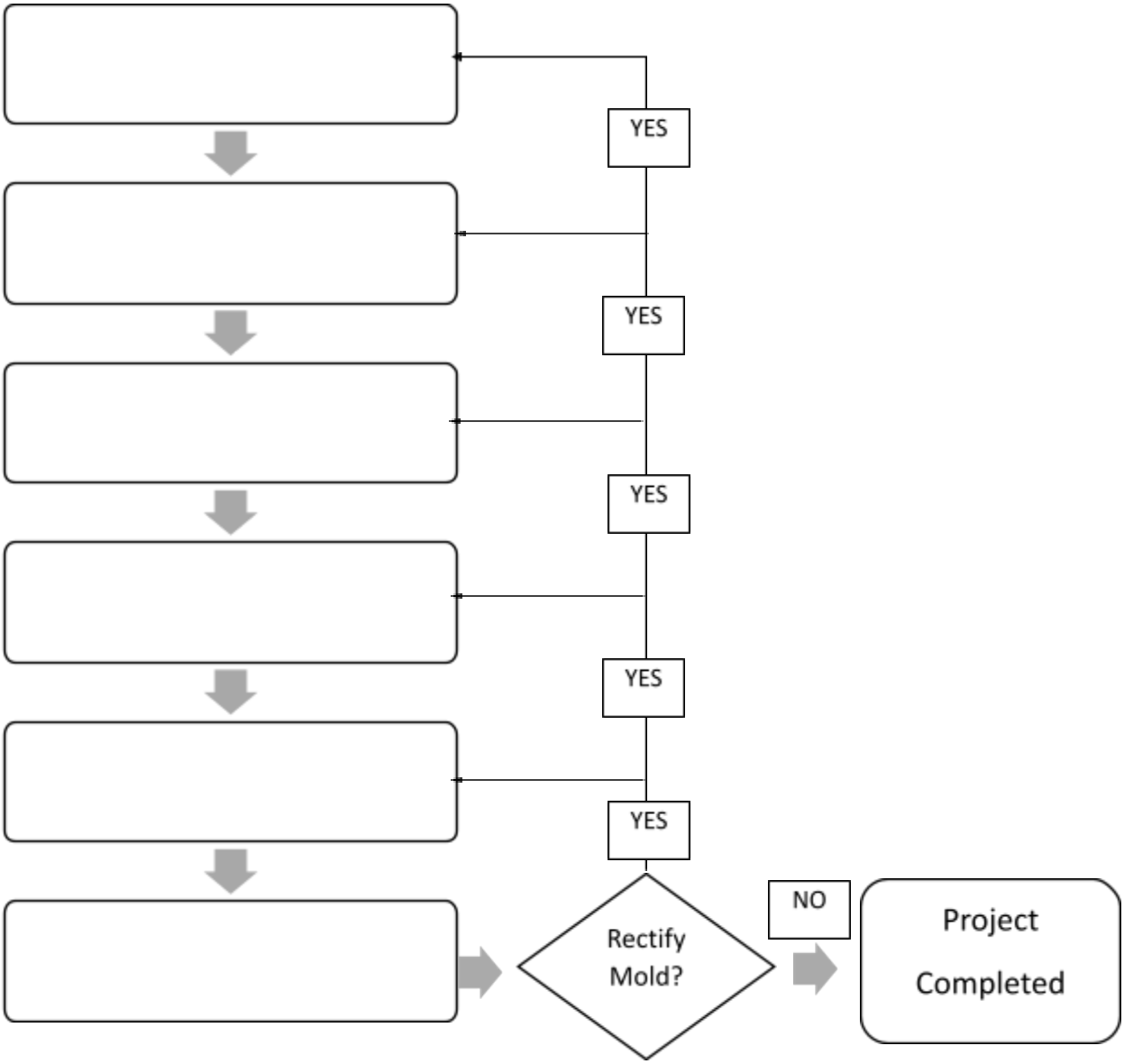


Figure 2: Process flow chart of manufacturing of an injection mold

1.3 IMPORTANCE OF PROJECT

The project *Data Validated Investigation for Enriching Workplace (D-VIEW)* was commenced to reduce the production cost and improve delivery time to customers. This can be achieved by through the elimination of Non-Value-Added (NVA) activities and minimization of Business Non-Value-Added (BNVA) activities.

Focus groups were created to discuss the opportunities of optimization of workplace and the following constraints were identified.

a. Defects in Products: There was lack of proper analysis of causes related to defects.
b. Repetitive Steps: Due to corrections, the steps of production were being repeated.
c. Waiting Time: In CNC machining, the machines would be waiting for programs or operators or the workpiece.
d. People Waste: Excessive dependency on responsible of section to make decisions. Lack of auto control.
e. Motion Waste: Workers searching for tools and accessories in the shop flow.
f. Lack of data collection system – There was no historic data available to know the actual state of the process.

A systematic implementation of **LEAN** would assist in dealing with the above-mentioned constraints thereby providing greater productivity, increased morale and therefore higher profits.

Adjustment and assembly of molds is a human extensive operation. As stated earlier in section 1.2 that each mold is kind of its own, the time consumed for this operation cannot be predetermined. However, it depends on the quality of CNC machine at the adjustment zones of two halves of a mold. The tools of **SIX SIGMA** methodology would help in optimizing the quality of CNC machined parts. The objective was to improve the CNC machining, depending upon the type of tools and workpiece, which would result in minimum deviation in final part relative to the design. This would assist in reducing the time taken for adjustment of mold and its components and thereby reducing the production cost and improving delivery times.

Moldetipo Group initiated the projects related to Lean Six Sigma with *READY (Reorganization, Enrichment and Analysis of Data to Yield)* lead by Engineer Tiago Santos, Production Director of Moldetipo. Under this project, the production and information management system were reviewed with help of 5S and the results were beneficial for the group (Santos, Simões, & Sousa, 2017). In the project report of *READY*, mentioned was the future objective of the company related to the cost analysis of non-conformities and improvement of OEE of the CNC machines. The project *D-VIEW* is a part of the continuous improvement journey that Moldetipo Group initiated in 2017.

For the project *D-VIEW*, the team consists of five elements (table 1). Engineer Rui Silva, CEO of Moldetipo Group, is the sponsor whose role is to define the financial resources and decision making for the project. Engineer Tiago Santos, Production Director and a Lean Six Sigma Black Belt, has deep knowledge of production process and the improvements needed; is the project champion. Engineer Anurag Venkat, R&D and Quality Director is the team lead with know-how of Lean and Six Sigma tools. Engineer Simao Ferreira, Quality Analyst, is a trainee in Lean tools to accompany the future projects and is a team member. Engineer Ricardo Lopes, external consultant, has an immense experience in Maintenance is a team member as well.

Table 1: Project Team

Role	Member	Function
Project Sponsor	Rui Silva	Internal team sponsor
Project Champion	Tiago Santos	Ensure team has necessary resources
Master Black Belt	Cristina Barros	Facilitator
Team Lead	Anurag Venkat	Project Manager
Team Member	Simao Ferreira	Trainee for future projects
Team Member	Ricardo Lopes	External Consultant

1.4 WORK METHODOLOGY AND REPORT STRUCTURE

The base of the *D-VIEW* project is DMAIC (Define, Measure, Analyze, Improve and Control). Define stage identifies the relevance of the project for the organization. In Measure phase, the data is collected to represent the process ‘as it is’ for establishing the Key Process Indicators (KPI). Data, once collected and validated, is examined in the Analyze phase and planned actions are carried out in the Improve stage. Finally, in the Control phase, the methodology for monitoring the KPIs is designed. The work is documented and submitted as a report to the project owner with a control plan for the interventions.

The project was carried out in three fronts to tackle the constraints mentioned in section 1.3.

- Management of Non-Conformities (NC): cause, occurrence and cost analysis of defects in products, cost related to repetitive work.
- Rentability of CNC Machines: people waste, waiting time, motion waste

- Optimization of CNC machining: reduction in time for adjustment of molds in bench area.

The DMAIC cycle is followed, as closely as possible, in the given sections. The final section discusses the conclusions drawn from the implementations on the shop floor for optimizing the process.

2. MANAGEMENT OF NON-CONFORMITIES

A NC report is a document to register a failure in the process that causes a defect in a product or a defective product. Majority of the NCs arise due to variation in component properties or dimensional failures. Conventional statistical techniques are ineffective in controlling mistakes. The distinction between mistake and a variation becomes utmost important when the target of NCs gets low as sustained by Motorola's experiment (Hinckley & Barkan). As the complexity in the process or product increases, the likelihood of occurrences of NCs also increase.

Having wised upon the importance of dealing with mistakes, Moldetipo initiated the registration of NCs since January 2018. The document is an adaption of 8D methodology and a sample report is shown in the Annexes-I.

2.1 DEFINE

The timeline for DMAIC stages of management of NCs was defined and steps along the implementations were registered.

Table 2: Timeline for Management of NCs.

Stages	Deadline	Actions
Define	March 2018	Establish a time plan, development of NC document, identify process of operation.
Measure and Analyze	September 2018	Diagnosis of the impact of problems and causes based on cost and occurrence.
Improve	December 2018	Implementation of the action plans
Control	March 2019	Evaluation of impact of action plans on the NCs and organize a document for management of KPIs

A process flow map (figure3) was established with the Production and Quality Department to organize the flow of information.

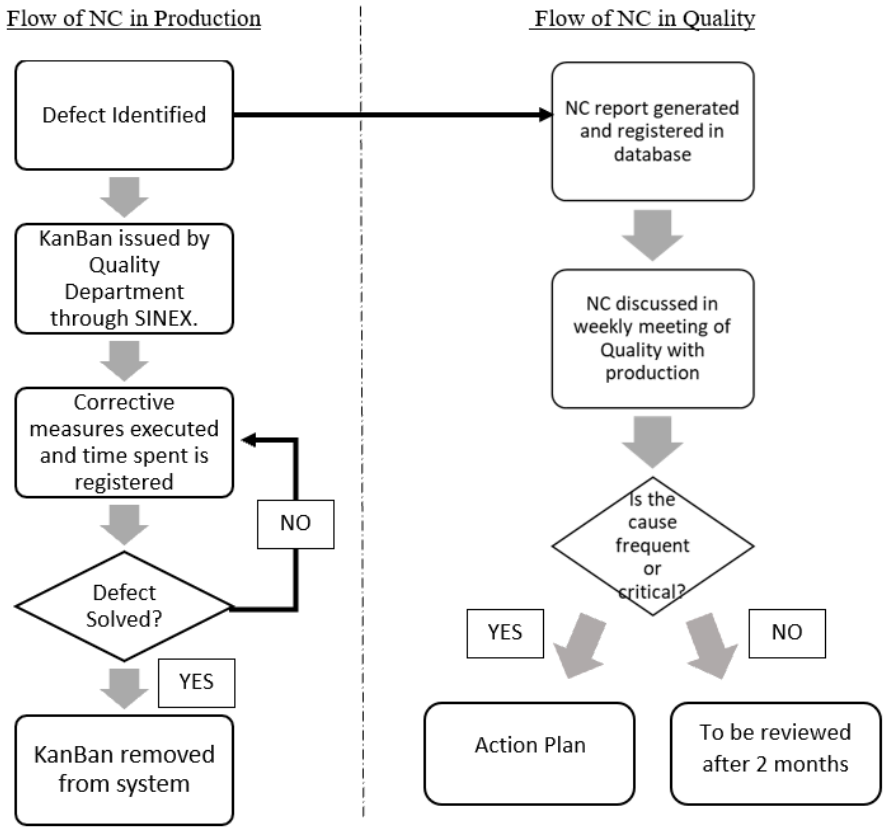


Figure 3: Process Flow of NC

Based on NCs registered in January and February 2018, the common modes of problem and causes were identified for each section which are shown in table 3.

Table 3: Identified Problems and Causes of Production

Problem	Cause
• Form and Dimensional errors • Holes and Screws incomplete/missing • Collision of parts • Tool breakage • Feature dislocation	• Fixation error • Misinterpretation of draws/programs • Insufficient information to execute the job • Lack of auto control • Lack of attention.

*****Based on the points shown in above table, the NC report was developed.*

Production management software SINEX was acquired by the company in June 2018. SINEX distinguishes the work based on the job order and each NC job is given a specific number which functions like a KANBAN. The time taken for corrections is recorded in this KANBAN which allows us to deduce the cost of the corrections. This value is doubled (opportunity cost) to obtain the cost of a NC.

2.2 MEASURE AND ANALYZE

The NCs from January 2018 to August 2018 were considered for analysis. A total of 125 occurrences were recorded costing 28,241.71€. Figures 4 and 5 below shows cost and occurrences of NCs as a percentage of contribution by each section.

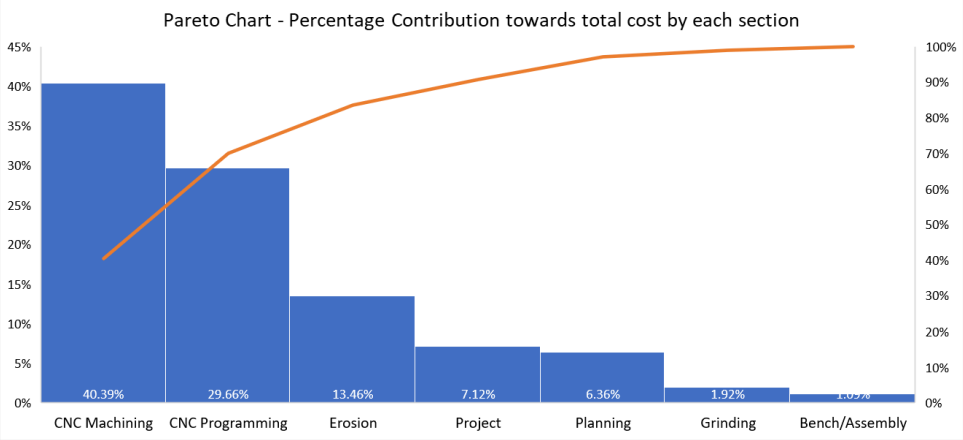


Figure 4: Pareto Chart - % Contribution by each section towards total NC cost

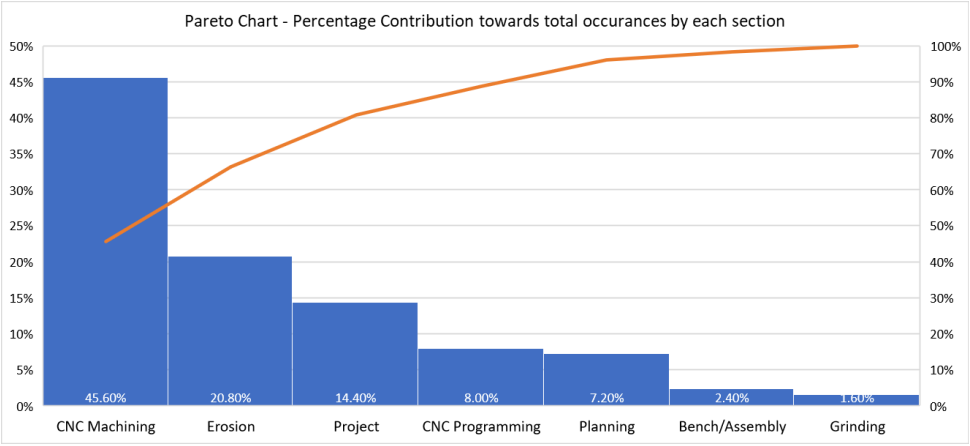


Figure 5: Pareto Chart - % Contribution by each section towards total NC occurrences

As we can see, CNC Machining and Programming have the highest cumulative impact on the occurrences and the cost. Due to failures in process in these sections, 19782.46€ was spent on solving 67 cases of defect or defective parts at an average of 295.26€ per NC. This prompted the management to decide that maximum attention is needed towards CNC section to find the causes to the problems and subsequently the solutions.

The KPI for this part of the project is average cost of NC related to a cause or a problem and is referred in the rest of the report as KPI-I. The objective was to reduce the KPI-I by 20% for each of the selected problems by March 2019. The improvements to be made were planned in two moves. The first one was to reduce the failures which have huge impact so that we bring down the cost for each NC rather than the number of NCs. In the second part, we would look to reduce the number of occurrences. This approach was considered as the attempts to bring down the huge impact NCs would undeniably be visible to the workers on the shop-floor. This would showcase the path that the company has selected and motivate the people to contribute towards reducing the occurrences of the NCs.

Figures 6 and 7, represent the cost and occurrences of NCs as a percentage of contribution by each problem.

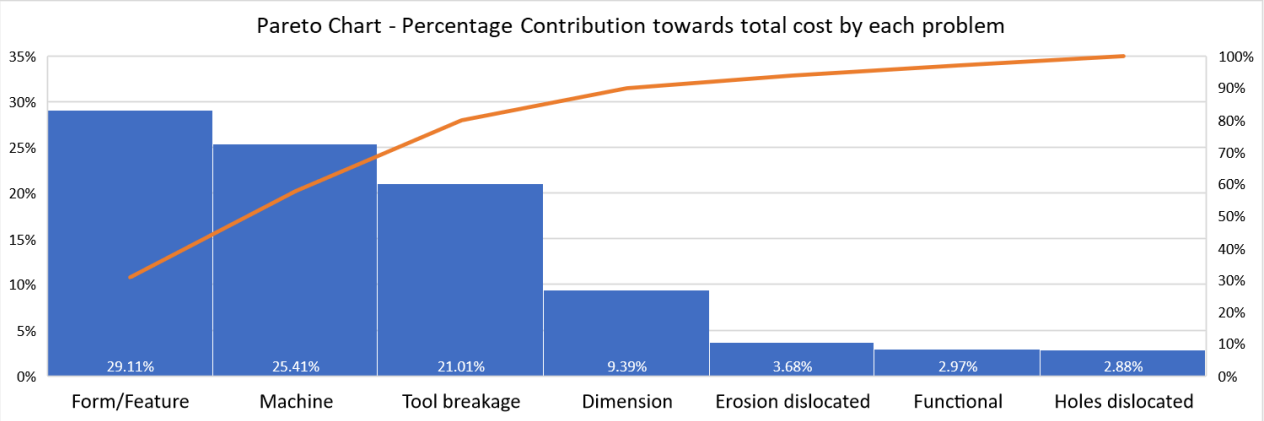


Figure 6: Pareto Chart - % Contribution by each problem towards total NC cost

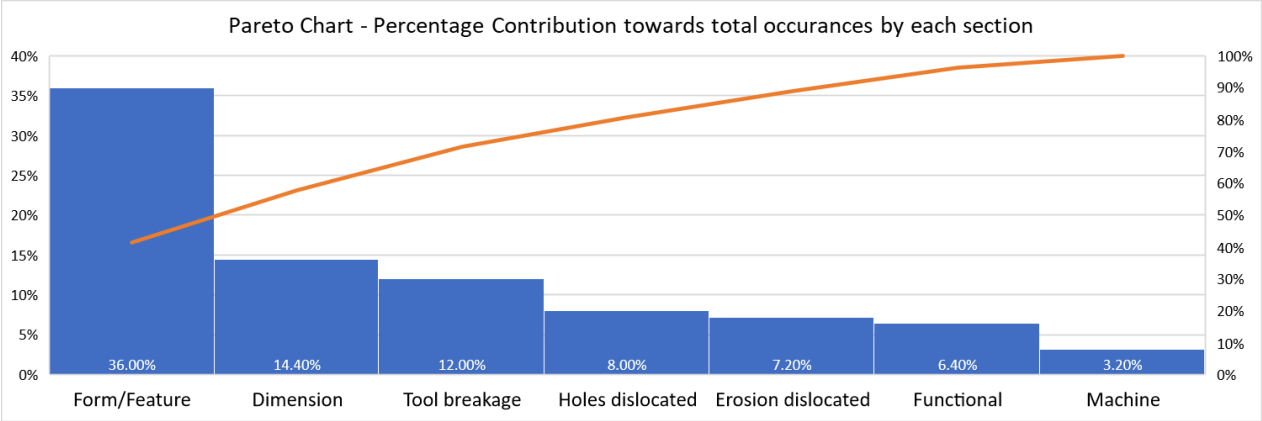


Figure 7: Pareto Chart - % Contribution by each problem towards total NC occurrences

From figure 6, we can see that the problems related to dimensional failures, form/feature failure, tool breakage and machine were contributing to 84.92% of total cost of NCs. The occurrences of NCs for form/feature failure, dimensional failure and tool breakage are significant according to figure 7. These problems were selected to be worked out.

The problems were discussed with different focus groups. The groups were comprised of the workers from different sections and the responsible of the sections. Table 4 demonstrates the identified causes, through brain storming, for each problem that were shortlisted based on the above shown Pareto charts.

Table 4: Cause for Process Failures

Problem	Cause
Dimensional Errors	No verification done after machining/erosion
Form/Feature	Lack of measurement system for verifying form of the part
Tool Breakage	No standard method of using tools for machining, Lack of attention by operators as they are always finding for tools or accessories.
Machine related problems.	Lack of maintenance.

Based on the cost of corrections of NCs and the occurrences, the KPI-I at the end of August 2018 was registered as follows (table 5).

Table 5: KPI-I before improvements

Problem	KPI-I (Average cost for each problem)
Dimensional Errors	147.32€/NC
Form/Feature	182.67€/NC
Tool Breakage	395.53€/NC
Machine related problems.	1793.75€/NC

2.3 IMPROVE

The causes determined in the previous section were discussed with the responsible of the department and Director of Production. Accordingly, the solutions were established.

Table 6: Solution to problems of NCs

Problem	Cause	Solution
Dimensional Errors	No verification done after machining/erosion	Creation of auto control system
Form/Feature	No measurement system for verifying form of the part	Acquire a software of measurement of steel
Tool Breakage	No standard method of using tools, Lack of attention as operators are always looking for tools.	5S
Machine related problems.	Lack of maintenance.	TPM

The solutions discussed were implemented.

a. Workers were provided training of design viewer software. Along with the part, they were given a checklist of dimensions to be verified and calipers were used for checking.



Figure 8: Auto Control Checklist and Calipers

b. The software for measuring form of the part would detail the deviations from the 3D. This helps in identifying the mistake before the part is delivered to assembly. The software was validated through MSA which is explained in section 4 of the report.

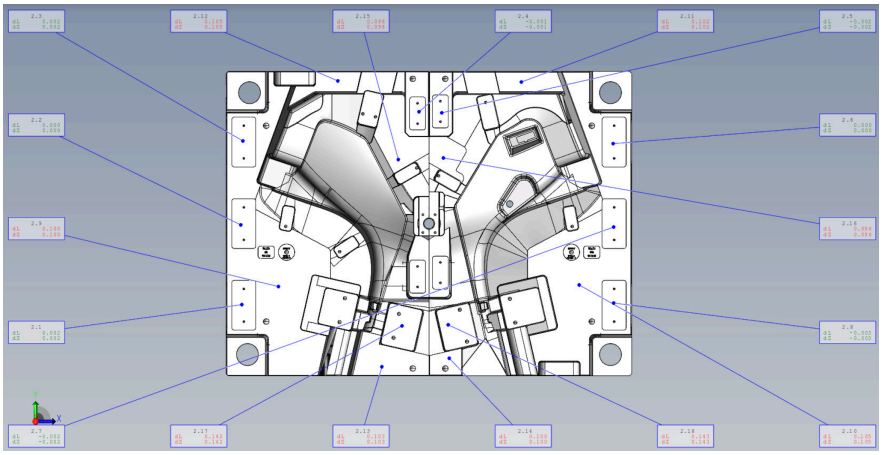


Figure 9: Auto Control Form/Feature

c. The tools and the cones were standardized in the carrousel of the CNC machine. The list of tools was prepared for each machine and programs were made according to the tools available in the machine rather than tools available in the production. To reduce the

movement of the operators, the workplace was organized with the required tools and accessories near the machines (5S is discussed in section 3 of the report).

moldetipo pr
from ideas to series

VTECH

Nº Ferramenta	Ferramenta	Raio	Cone	Altura da Ferramenta	Navalhas/Pastilha	Passo Lateral	Inc.	Rot.	Avanço	Ref.
1	APALPADOR									
2	TR25	1.8	SK.50.25.100	100	3P	13	0,35	2364	4255	SECO
3	TR20	0.8	SK.50.25.100	105	2P	10	0,3	2870	3000	SECO
4	TR16	0.8	SK.50.16.160	80	2P	8	0,2	3592	3000	SECO
5	TR10	0.5	SK50.10.160	60	N	5	0,14	4774	2673	
6	TR8	0.5	SK.50.8.160	30	N					
7	TR6	0.5	28.180	35	N	3	0,1	7427	2525	
8	TR4	0.5	SK.50 CP.28.140	20	N					
9	TR20	1	SK.50.20.120	130	1P	10	0,2	3200	2000	FRANKEN
10	TR16	1	SK.50.16.80	70	1P	8	0,15	4000	2200	FRANKEN
11	TR10	0.5	SK.50.10.160	60	N	5	0,1	6366	2800	
12	TR8	0.5	SK.50.8.160	40	N					
13	TR6	0.5	SK.50.6.160	35	N	3	0,09	7957	2400	
14	TR4	0.5	SK.50.6.120	30	N					
15	ESF16	8	SK.50.16.100	60	1P	0,16		4276	2400	FRANKEN
16	ESF10	5	SK.50.10.160	65	N	0,12		4800	2300	
17	ESF8	4	SK.50.8.160	60	N					
18	ESF6	3	SK.50.6.160	45	N	0,09		7957	2200	
19	ESF4	2	SK.50.6.80	10	N					
20	ESF3	1.5	SK50 CP.28.140	20	N	0,05		11950	1800	
21	ESF1,5	0.75	SK50 CP.28.140	6	N	0,03		11950	1100	

	DESBASTE		PRÉ-ACABAMENTO
	TOPO RASO ACABAMENTO		ESFÉRICAS ACABAMENTO

Figure 10: Standardization of Tools in the Machines

d. TPM is still being implemented and is expected to be in functioning by the end of July 2019.

All the above points, other than TPM were implemented by the end of Oct 2018 and the NCs were measured to look for impact of the improvement till May 2019. Figure11 demonstrating the improvements in the KPI-I.

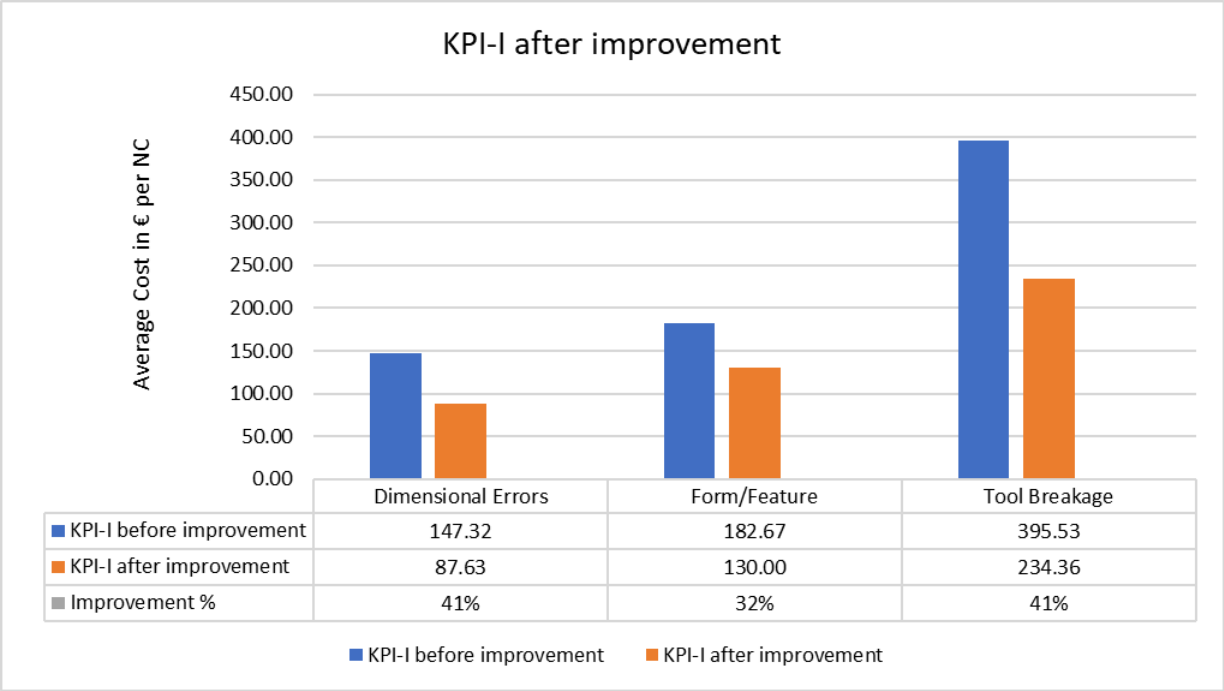


Figure 11: KPI-I before and after improvements.

With above improvements in place, for every 10 NCs of each problem, there will be a reduced production cost of approximately **2,726€.**

2.4 CONTROL

The NCs would be reviewed in the weekly meeting of production so that the responsible of the sections are notified to the problems occurring. The responsible would explain the cause and what measures to take if the problem is frequent. The format of the presentation is available in the Annexes-I.

A three-monthly audit would be conducted across the production for the NCs and review of the implementations. In this audit, the frequently occurring NCs or the NCs with huge impact would be discussed and action plans would be decided. The report would be documented as "Management of Improvements" which can be reviewed in the Annexes-I.

3. RENTABILITY OF CNC MACHINES

The process of mold making involves complex steps starting from design to shipping of mold. Generally, the maximum time of the process is spent in CNC machining and bench work (adjustment and assembly). In 2017, with the help of project *READY* (Santos, Simões, & Sousa, 2017), Moldetipo was able to reduce the setup and the operational time in the bench work. This area being manual centric, the scope of improvement after a certain point is dependent of the experience of the workers. Thus, the management decided to optimize the organization of the CNC machining department by increasing the capacity and the availability of the machines which would, in turn, raise the rentability of the section. As no two molds have similar parts, holding of stock is not a possibility in this industry. The time taken for release of mold parts from the CNC department is dependent on how lean the process is and how well is the shop floor managed. **LEAN** tools provide us an opportunity to have an optimized workplace and environment. This would shorten the cycle time for machining process, thereby, shortening the delivery time.

3.1 DEFINE

The timeline for the project was established based on DMAIC. This project was run parallel to the project of "Management of Non-Conformities" as problems and solutions were inter-related.

Table 7: Timeline for Rentability of CNC Machines

Stages	Deadline	Actions
Define	May 2018	Establish VOC, VOE and VOB, Create SIPOC
Measure and Analyze	November 2018	Quantify the problem Locate areas of improvement and create action plan
Improve	December 2018	Implementation the action plans
Control	March 2019	Evaluation of impact of action plans, create control method

The SIPOC map was created to understand the process in interest. This map was also used for identifying process failures in NCs.

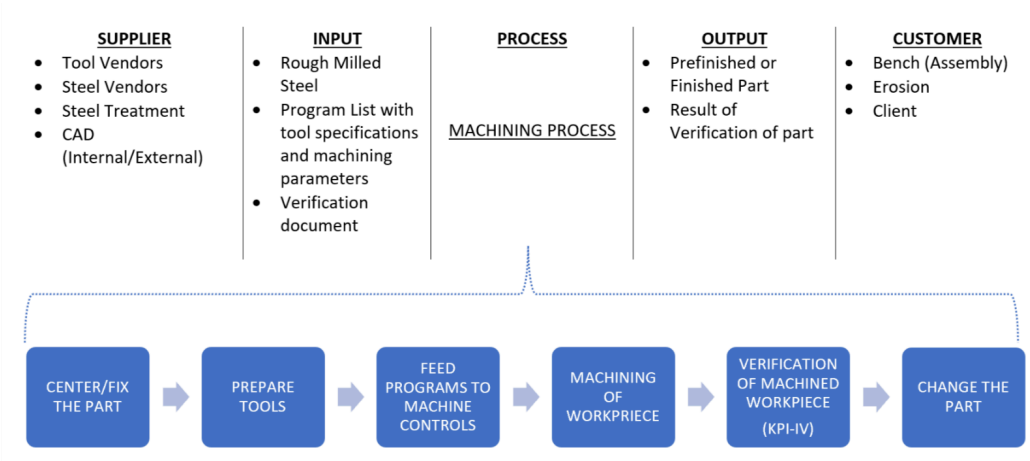


Figure 12: SIPOC of CNC Machining Department

3.2 MEASURE AND ANALYSE

The rentability of the machines is evaluated by the average machining hours of each machine per week. The hours of machining are derived from the counters of the machine. These values are robust without any human interference. Each machine was weighted based on their importance.

The KPI of percentage machining capacity of section per week was established. This is the KPI-II of the project. The objective of the project is to have the percentage capacity of section above 60% per week by May 2019. The KPI was measured from August 2018 to the end of September 2018. Figure13 shows the KPI-II for this duration.

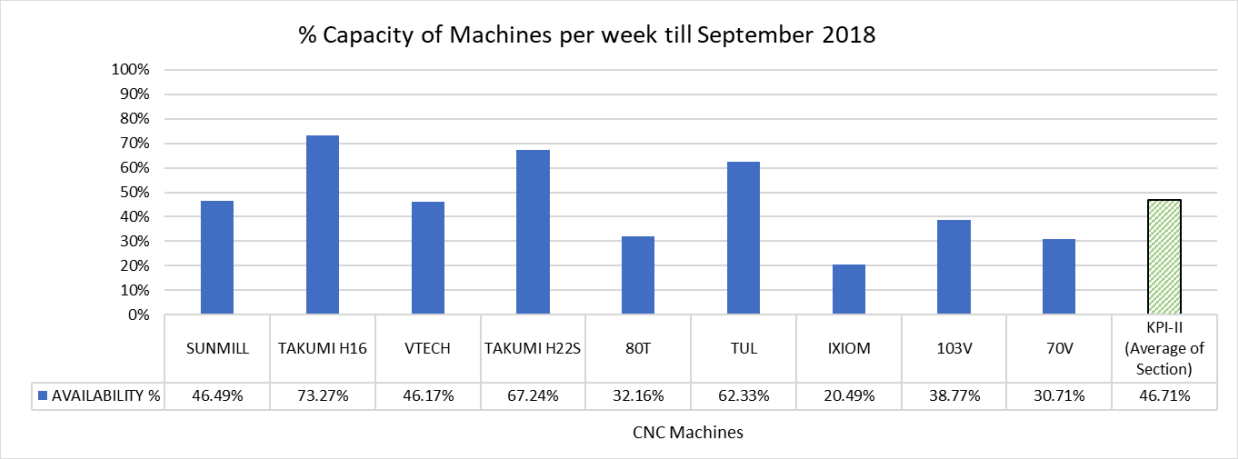


Figure 13: KPI-II before improvements

At the end of week 46, it was observed that the section of CNC machining was delivering at 46% of its capacity. To understand the reason for low machining capacity, a study was conducted for 3 weeks in September. Each hour, the state of the machine, when machine was not working, was noted. The study was conducted for 3 weeks to reduce the error of consideration that the machine would stay in the same state for the next hour from the moment the status was noted. The statuses of the machines were classified as shown in table 8 and the analysis of the study is represented in figure 14.

Table 8: Identified Statuses of CNC Machines

VA or NBVA	Machining (machine working), Verification of Part, Centering/Fixing part, preparing tools in machine, Feeding programs to the controller
Absence of Operator (when machine is stopped)	Preparing tools outside the machine, searching tools/supports, changing parts, working on other parts
Unplanned Stoppage	Maintenance related problems
Lack of Work	Waiting for sequence of work, waiting for programs/information

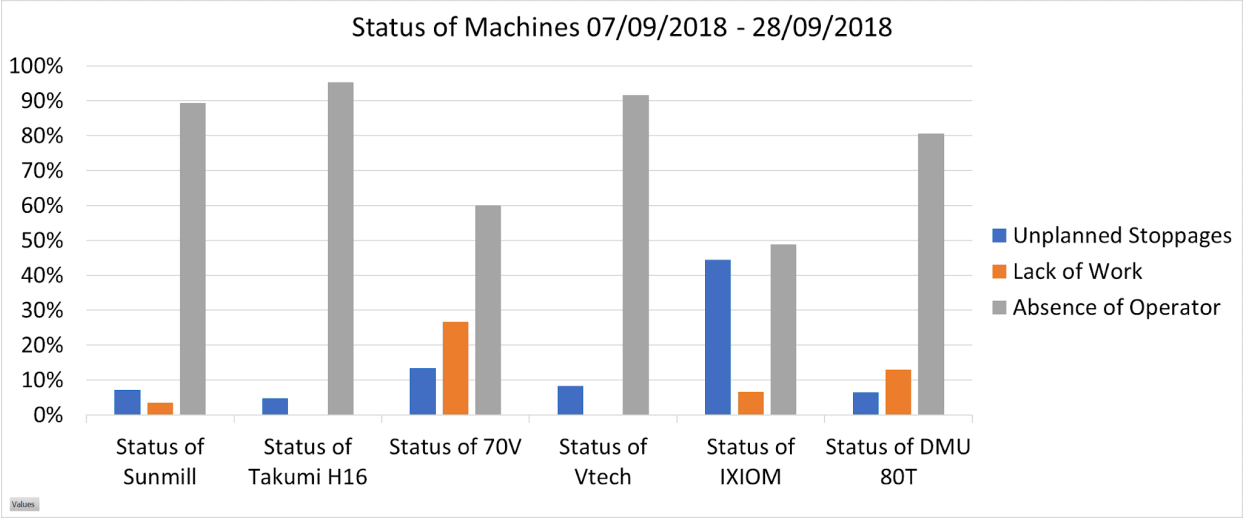


Figure 14: Status of Machines 07/09/2018 to 28/09/2018

The study of state of machines gave us first insights of the machining process. The absence of operator is the biggest contributors to the machine being stopped. A spaghetti analysis was made with operators to understand their movements when the machine was stopped.

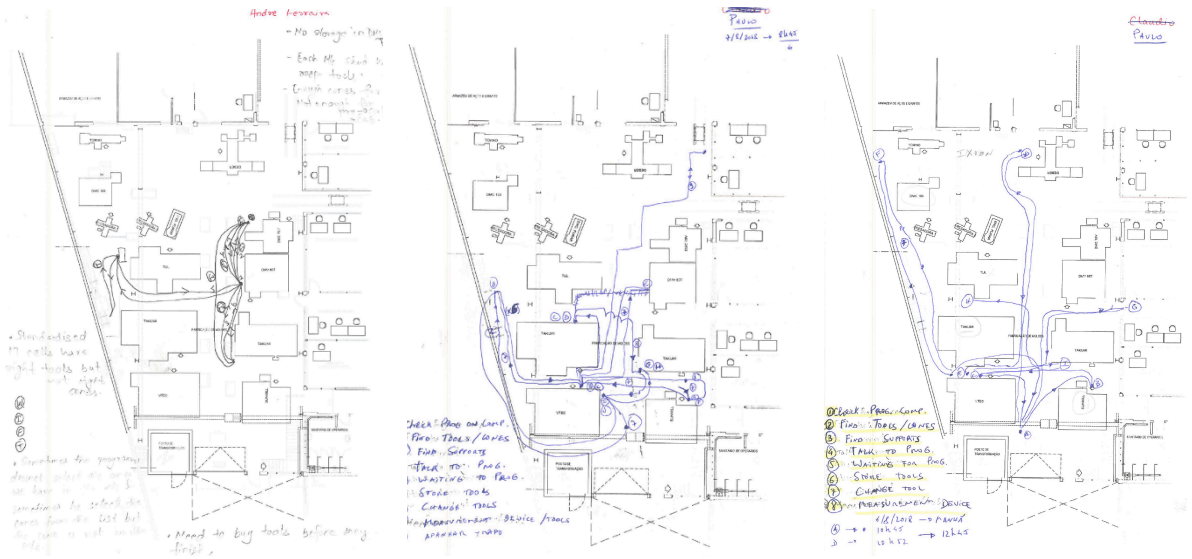


Figure 15 : Spaghetti Diagram of CNC Operators

The study of figure 15 showed that one operator either was working in another machine or was finding tools and accessories required for fixing the part. The above mentioned two studies concentrated more on the operators and not on the process itself. So, the first study was repeated but with more points to study.

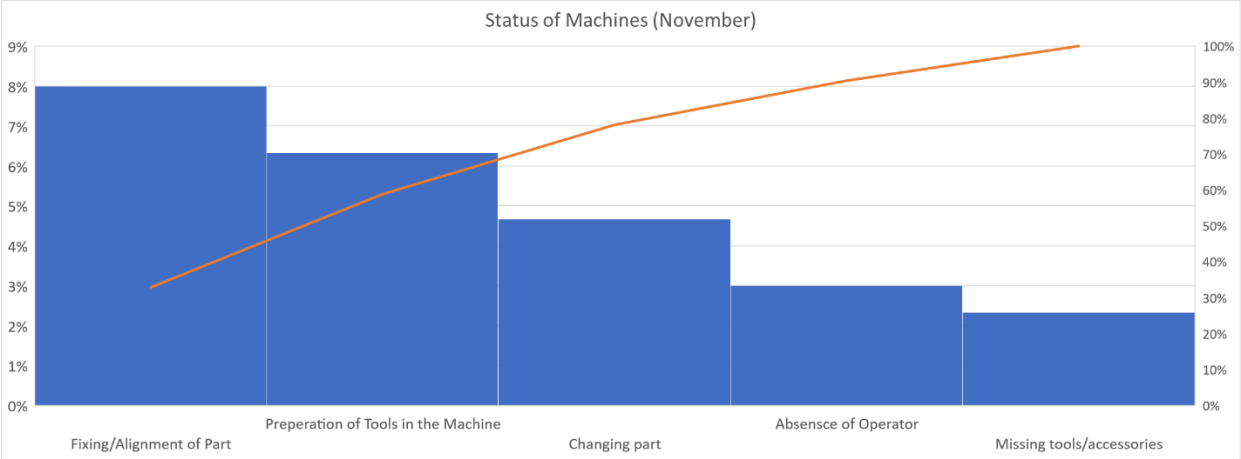


Figure 16: Status of Machines (November)

The graph in figure 16 clearly shows that BNVA tasks are the most time-consuming operations of the process, followed by the machine being stopped due to absence of operator and missing tools and accessories.

3.3 IMPROVE

Based on the studies of status of the machines and the spaghetti diagram, we concluded that the centering/fixing/aligning of parts, preparation of tools, waiting for operator and part changing consumes the maximum share of BNVA and NVA time. The following improvements were planned for reducing the cycle time.

Table 9: Improvements for NBVA and NVA in CNC Machining

NBVA or NVA	Improvements
Centering/Fixing/Aligning	SMED
Preparation of tools	Standardize tools in carousel. Programs to be made according to these tools.
Waiting for Operator and changing parts	5S

a. SMED – The implementation was made in Jan-Feb 2019. The SMED system was acquired to reduce setup time and to eliminate mistakes in fixing the parts which would reduce NCs.

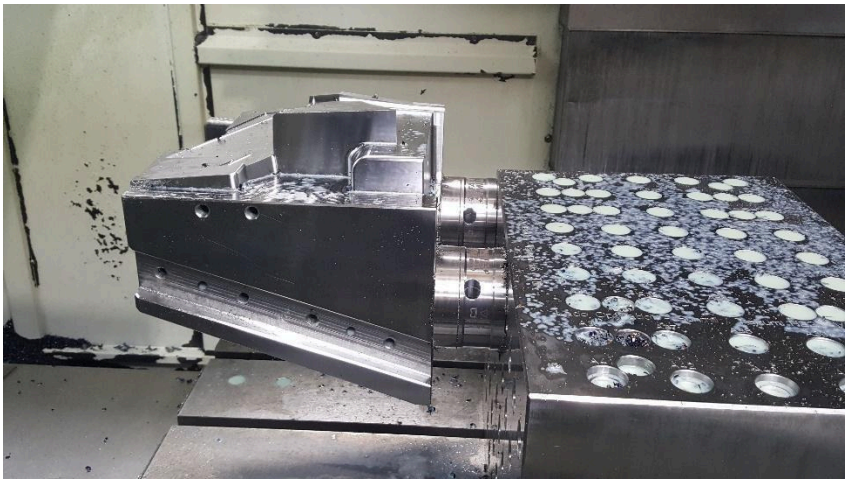


Figure 17: SMED

b. Standardization of tools in carousel – This point is already discussed in section 2.3 of this document.
c. 5S – It was built around the problems identified during analysis of NCs and absence of operators. The primary objective was to reduce miscommunications by creating teams of operator and programmer for the machines (shown in Annexes-II). The shop floor was redesigned, and the machines and tool placements were reorganized.

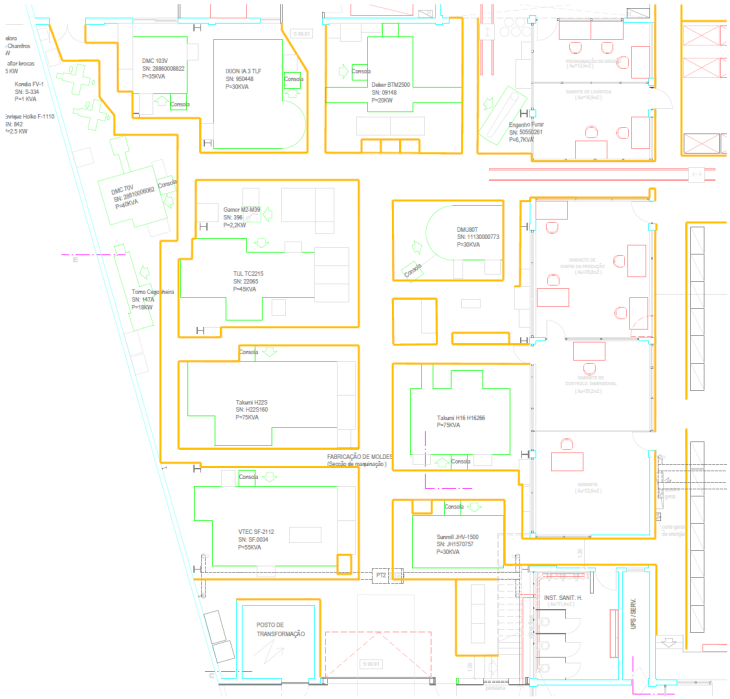


Figure 18: Shop floor after 5S

All the discussed points were implemented by February 2019. The KPI-II was being followed all through the process and significant changes were observed.

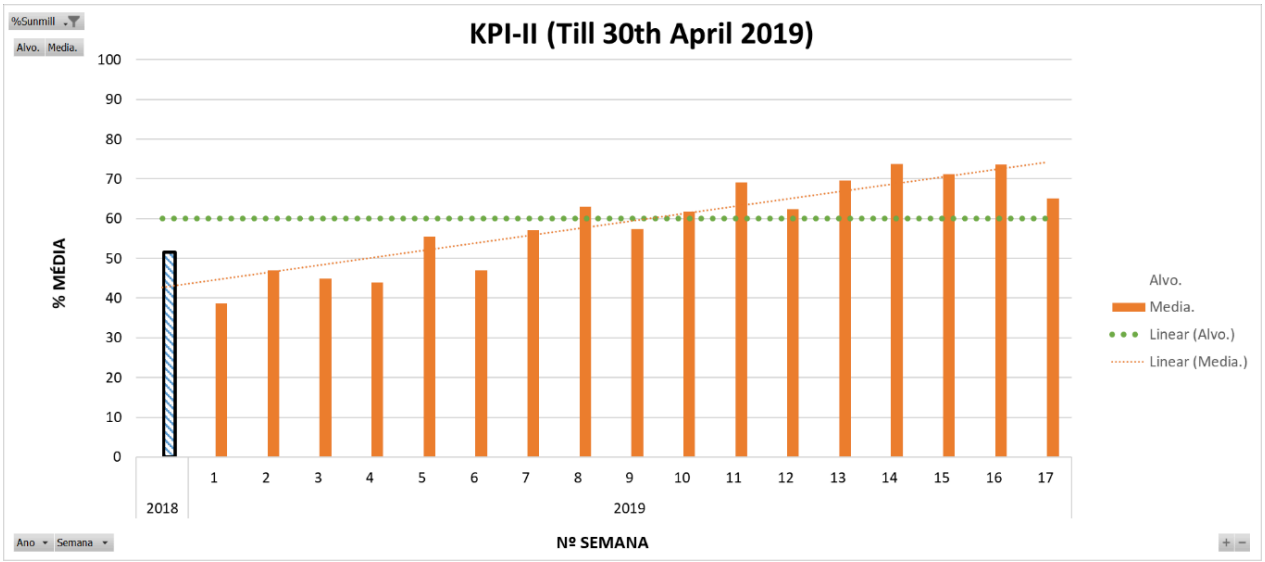


Figure 19: KPI-II until 30th April 2019

3.4 CONTROL

The goal of increasing the average percentage of machining capacity to 60% was achieved by March 2019. As of June 2019, the CNC section is operating at a capacity above 75%. This KPI is reviewed in the production meeting held every Friday the format of which is shown in Annexes II. The responsible of the section justifies the performance of the machines which is noted in the document shown below.

Data	Semana	Ano	Dia	Comentarios de Reunião	Ação a realizar	Prazo execução
21/1/19	4	2019	dom	realizado um teste de aperto rapido nas Secçoes de Produção; Também é discutido que se deve dar prioridade a trabalhos da "casa" e não a out-sources.		
22/1/19	4	2019	seg			
23/1/19	4	2019	ter			
24/1/19	4	2019	qua	VTEC continua a ter o mesmo problema no carrossel, descobrir porquê para que seja finalmente resolvido; Falou-se de trazer trabalhos de parceiros para cá para aumentar a rentabilidade das máquinas (CNC e Erosão); Estudar o aspirador nas robodrill's; O molde 3386 está em estado crítico (atrasado).		
25/1/19	5	2019	qui			
26/1/19	5	2019	sex			
27/1/19	5	2019	sáb			
28/1/19	5	2019	dom			
29/1/19	5	2019	seg			
30/1/19	5	2019	ter			
31/1/19	5	2019	qua			
1/2/19	6	2019	qui	Dados dizem que temos capacidade para trazer trabalho, para aumentar a rentabilidade; Começar a usar mais a ferramenta de alta pressão; IXION continua		
2/2/19	6	2019	sex			
3/2/19	6	2019	sáb			
4/2/19	6	2019	dom			

Figure 20 : Control document for KPI-II

4. OPTIMIZATION OF CNC MACHINING

Design and manufacturing of molds have a significant link in the final product production chain because nearly all mass-produced plastic parts are formed using a production process which involves molds. Thus, the quality and the lead time of molds effect the economics of producing large number of parts especially for the automotive industries (Altan, Lillg, & Yen). The quality of machining on the parting area of mold determines the time spend on adjustment of the two halves of the mold (explained in section 1.2). Sometimes, the mold halves had to be placed back in the CNC machine to repeat the process as steel was left over after the primary machine. This increases the production cost and delays the other projects. The company did not have a system which could indicate if the machined part falls inside the tolerance limits or not.

4.1 DEFINE AND MEASURE

The company decided to acquire a software for measuring the steel in the CNC machine after the machining process is executed to determine the deviations on the steel. Takumi H22S, a CNC machine, was the pilot for the project. ***The KPI for this part of the project is the range of machining which is established as KPI-III.*** The objective of the project is to achieve machining of the parts within the tolerance of ±0.02mm along the parting line. Six Sigma tools were used for the optimization of the machining. The timeline for the project is shown in the table below.

Table 10: Timeline for Optimization of CNC Machining.

Stages	Deadline	Actions
Define and Measure	June 2019	Plan the project an obtain necessary resources, MSA, Capability Analysis
Measure and Analyze	August 2019	Cause and Effect Matrix Hypothesis Testing, DOE
Improve	October 2019	Pilot Study
Control	December 2019	SPC, Control Plan

The software for measuring the deviations of steel was tested in Takumi H22S, a CNC machine, from May 2018 to December 2018 and was finally acquired in the end of January 2019. The software works with probes which measure the machined part and compares to the 3D file. The sample report generated by the software is shown below.

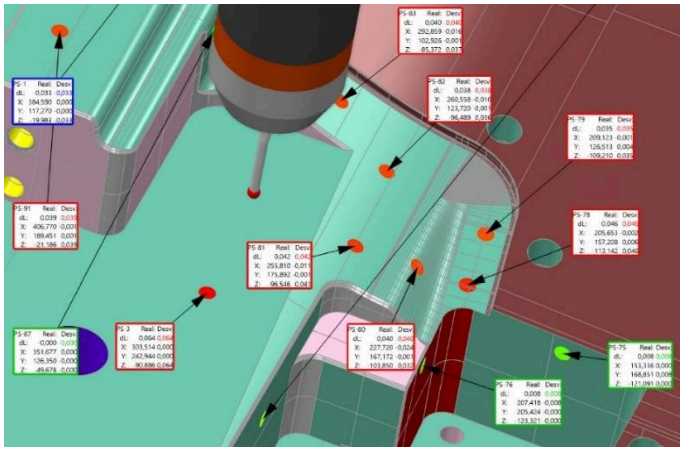


Figure 21: Sample report of measurement software

Probe, being a measuring device, was validated with a sphere of 12mm diameter which had 0.000mm as the reference value for deviation. Type 1 Gage Study in Minitab was used for analyzing the bias and repeatability of the system. The graph in figure22 shows the details of the analysis.

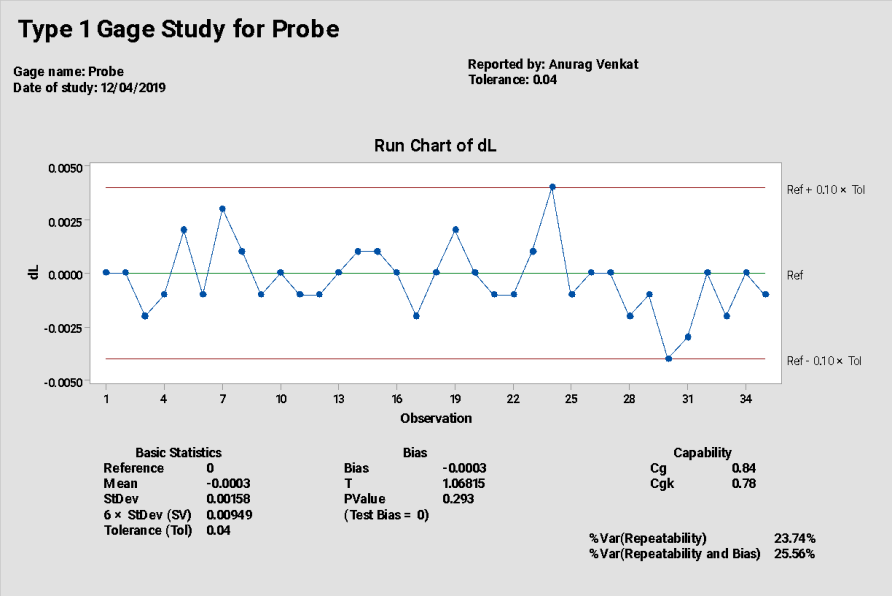


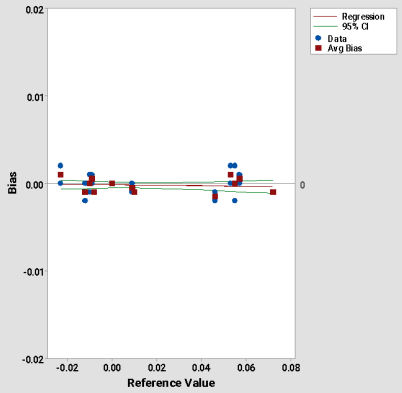
Figure 22:Type 1 Gage Study of Probe

For the study, a sample size of 35 random data points was considered, and all the deviations were measured in the normal direction to the surface (cumulative deviation of X, Y and Z axis). The mean bias in the system is -0.0003mm and the p-value of the test shows that the bias is not statistically significant. Cg and CgK values are not up to the benchmark value (automotive industry – 1.33) (Montgomery, 2013), the repeatability of the system in under control statistically.

The second MSA was made for the software that is used to measure the part with the probe. Having validated the probe, the results generated by the software would not be inducing the errors of the probe. A part (validated by a certified laboratory) was measured twice in the CNC machine and then Gage Linearity and Bias Study was conducted in Minitab. The data had a sample size of 20 measurements with deviations in X, Y and Z axis.

Gage Linearity and Bias Report for Deviations in X Axis

Gage name: BLUM Probe
Date of study: 12/04/2019



Gage Linearity

Predictor	Coef	SE Coef	P
Constant	-0.0001641	0.0001701	0.341
Slope	-0.002871	0.005737	0.620

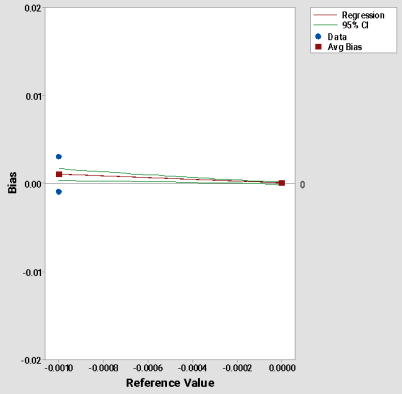
S 0.0009755 R-Sq 0.7%

Gage Bias

Reference	Bias	P
Average	-0.000	0.197
-0.023	0.0010	0.50
-0.012	-0.0010	0.50
-0.01	0.0000	1.000
-0.009	0.0005	0.50
-0.008	-0.0010	*
0	0.0000	*
0.009	-0.000	0.50
0.01	-0.0010	*
0.046	-0.0015	0.20
0.053	0.0010	0.50

Gage Linearity and Bias Report for Deviations in Y Axis

Gage name: BLUM Probe
Date of study: 12/04/2019



Gage Linearity

Predictor	Coef	SE Coef	P
Constant	0.00000000	0.00007443	1.000
Slope	-1.0000	0.3329	0.005

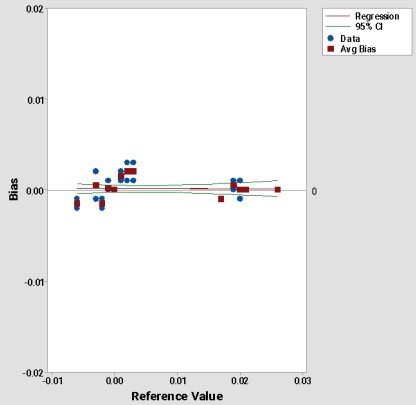
S 0.0004588 R-Sq 19.2%

Gage Bias

Reference	Bias	P
Average	0.00005	0.623
-0.001	0.00100	0.705
0	0.00000	*

Gage Linearity and Bias Report for Deviations in Z Axis

Gage name: BLUM Probe
Date of study: 12/04/2019



Gage Linearity

Predictor	Coef	SE Coef	P
Constant	0.0001507	0.0001928	0.439
Slope	-0.00014	0.01825	0.994

S 0.0010894 R-Sq 0.0%

Gage Bias

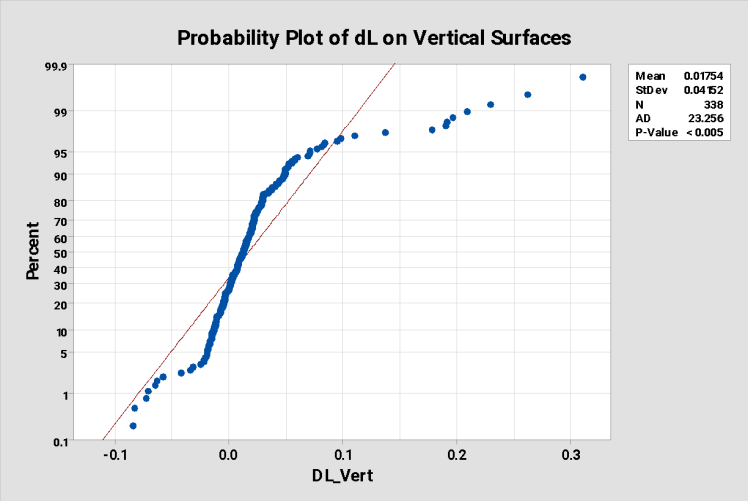
Reference	Bias	P
Average	0.0001500	0.253
-0.006	-0.0015000	0.205
-0.003	0.0005000	0.795
-0.002	-0.0015000	0.205
-0.001	0.0001667	0.391
0	0.0000000	*
0.001	0.0015000	0.205
0.002	0.0020000	0.295
0.003	0.0020000	0.295
0.017	-0.0010000	*
0.019	0.0005000	0.500

Figure 23: Gage and Linearity Study for Probe

The p-value for the linearity and bias test for X and Z axis is greater than 0.05 showing that the linearity and bias are not statistically significant in the system. However, for the test of deviations in Y axis, the slope of the linearity line is statistically significant. This is because of lack of variability in the data set. The Measurement System Analysis (MSA) validated the software and the probe for measurement of the deviation in steel. The error induced by the measurement probe and the software on to the deviation values of the process will not be significant.

The data of machining deviations collected during May-December 2018 was used to evaluate the process. For analysis, the deviation in normal direction (dL) of measurement was considered as it is the cumulative error of deviations in X (dX), Y (dY) and Z (dZ) axis. To simplify the analysis, the points obtained from each part were classified among the vertical, normal and the horizontal surfaces. This classification was made to eliminate the variability due to strategy of machining.

The data were sub-grouped according to the parts from which they were obtained, subgroups having unequal sample size. The normality test (figure24) shows that dL of each surface does not follow a normal distribution.



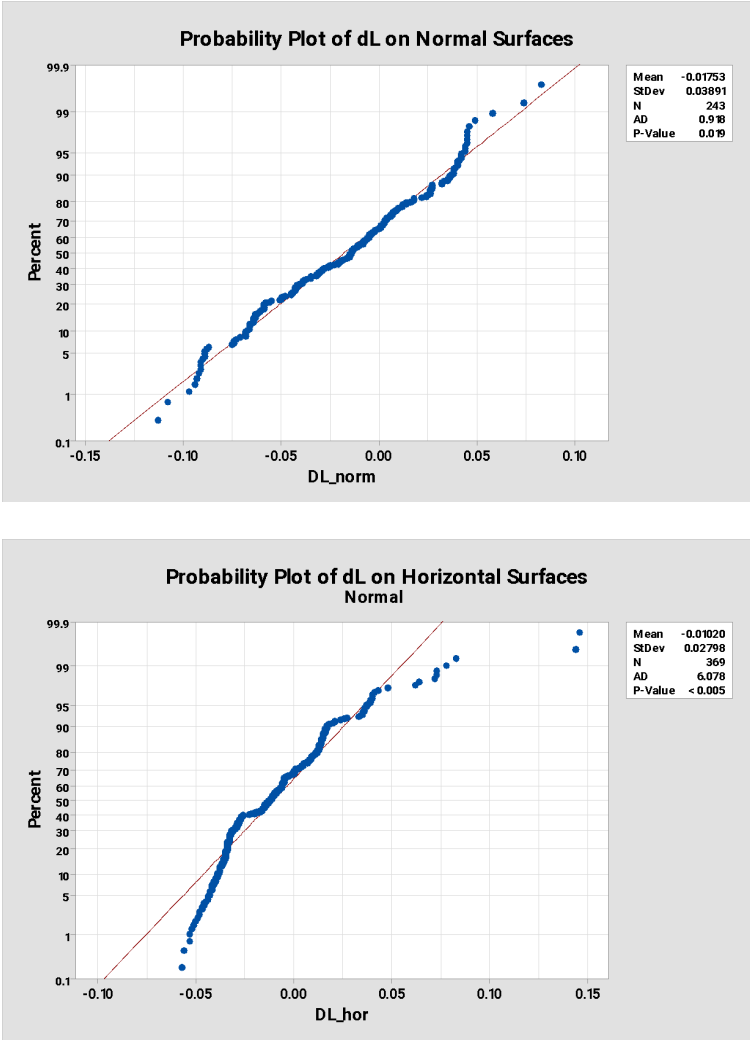


Figure 24: Probability Plot of dL on a) Vertical, b) Normal and c) Horizontal Surfaces

To visualize the spread of the data, below is shown the graphical summary of the distribution after the outliers were eliminated.

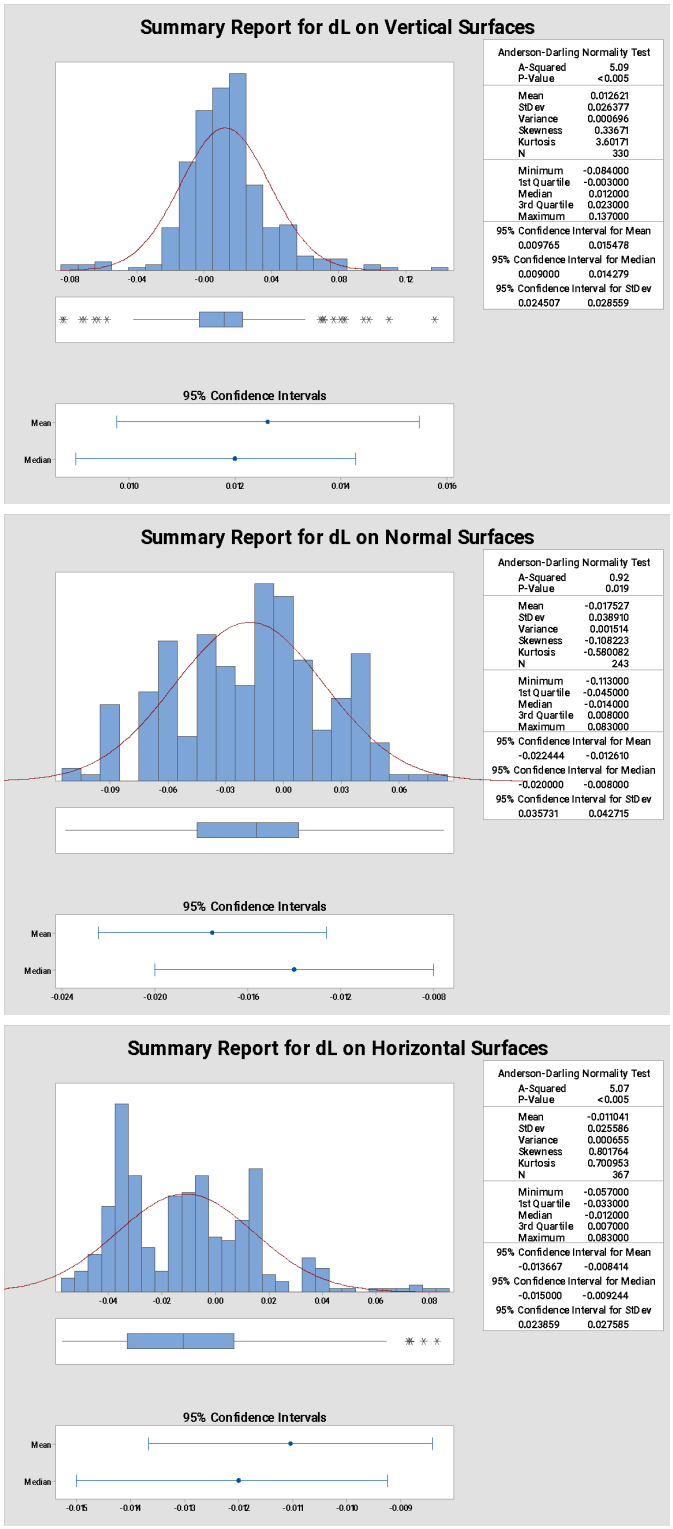
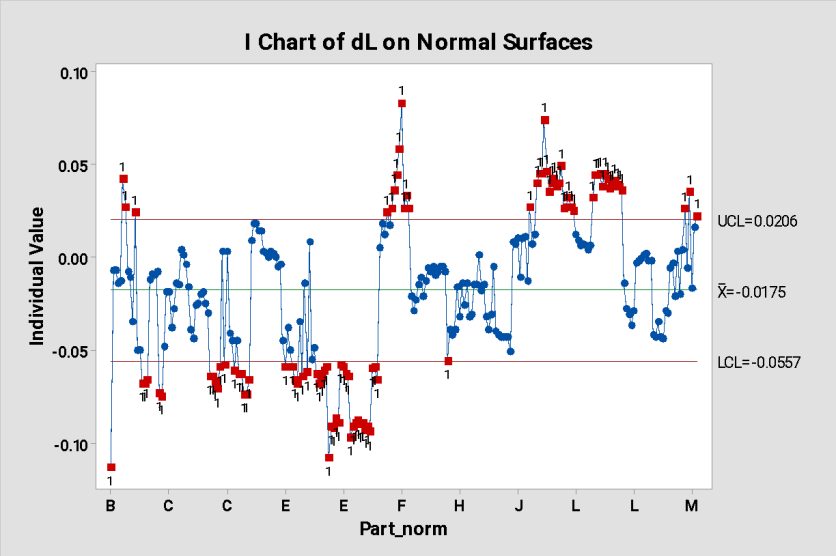
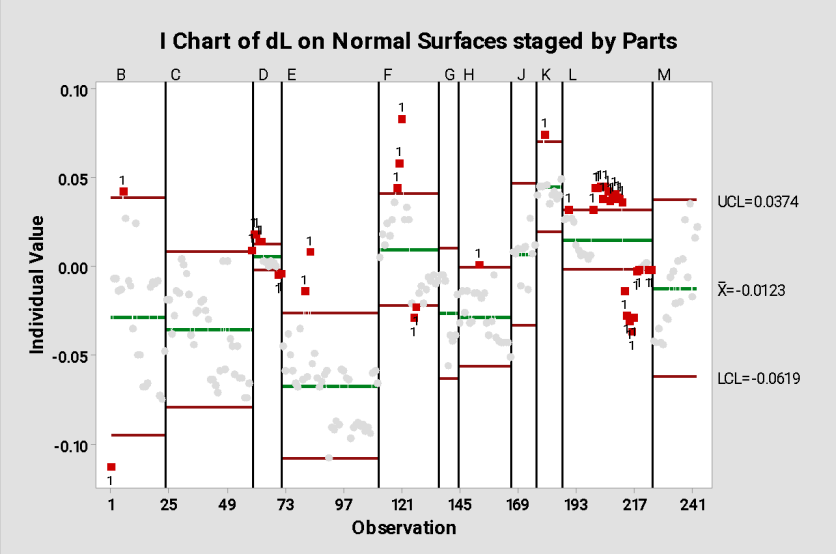


Figure 25: Graphical Summary of dL on a) Vertical, b) Normal and c) Horizontal Surfaces

The bimodal behavior in the spread of distributions on normal and horizontal surfaces is caused by the data from different subgroups. This can be understood by the Individual charts of dL shown below.



(a)

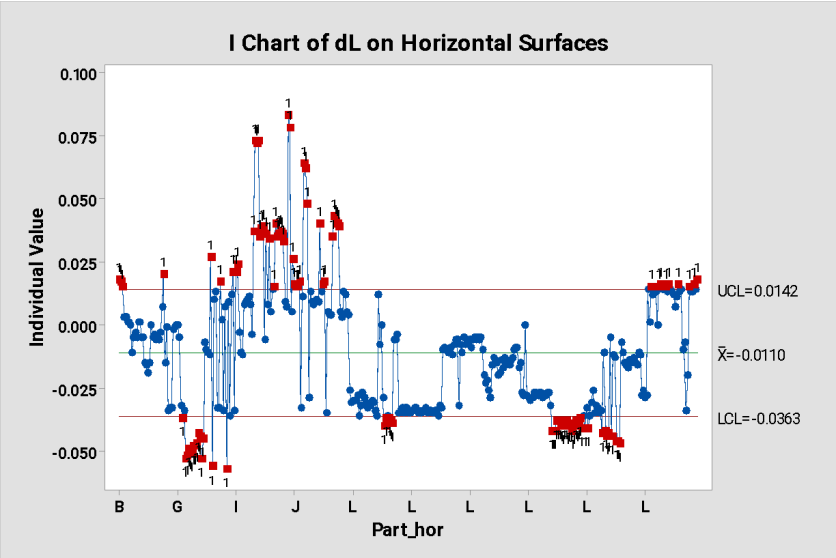


(b)

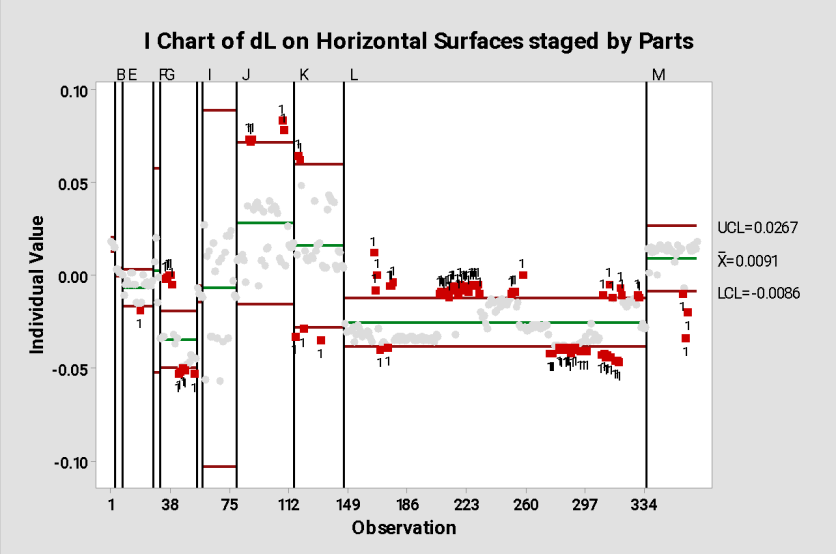
Figure 26:Individual Chart for dL on Normal Surfaces (a) for all subgroups (b)staged by subgroup

The figure 26(a) shows that the process is statistically out of control and the deviations on normal surfaces vary from part to part. Figure 26(b) displays this variation with changing means for each part. Since data from different parts were used for analysis, the deviations were affected

by variable causes for each situation. The variation between the parts is more significant than the deviation within the part. Even on horizontal surfaces, the variation between the parts is much significant than the deviation with in the part. ***Having said that, it is important to note that the subgroup size plays an important role in determining the width of the control limits.*** Figure 27 represents the information for deviations on horizontal surfaces.



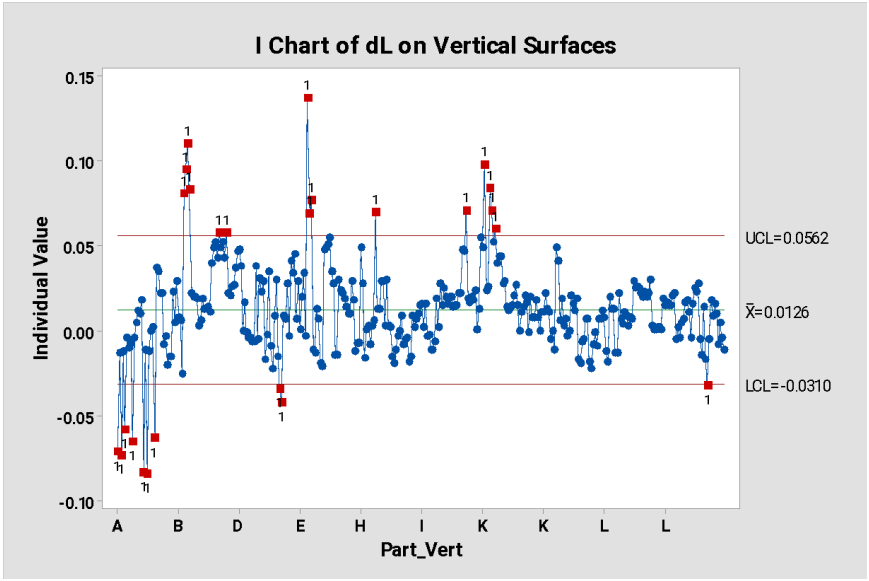
(a)



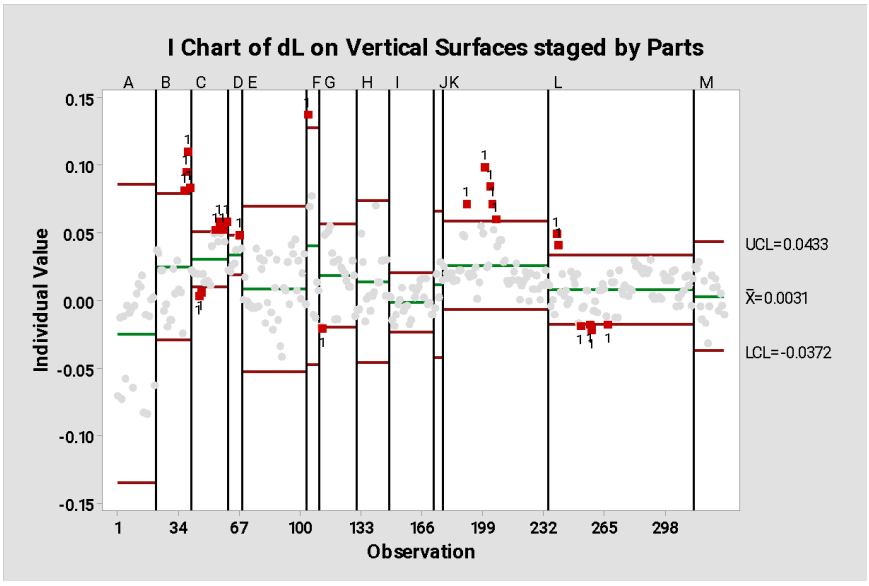
(b)

Figure 27: Individual Chart for dL on Horizontal Surfaces (a) for all subgroups (b)staged by subgroup

However, unlike the deviations on normal and horizontal surfaces, the figure 28 shows that the deviations on the vertical surfaces are not as signification between the parts. This can be observed from the following Individual Chart.



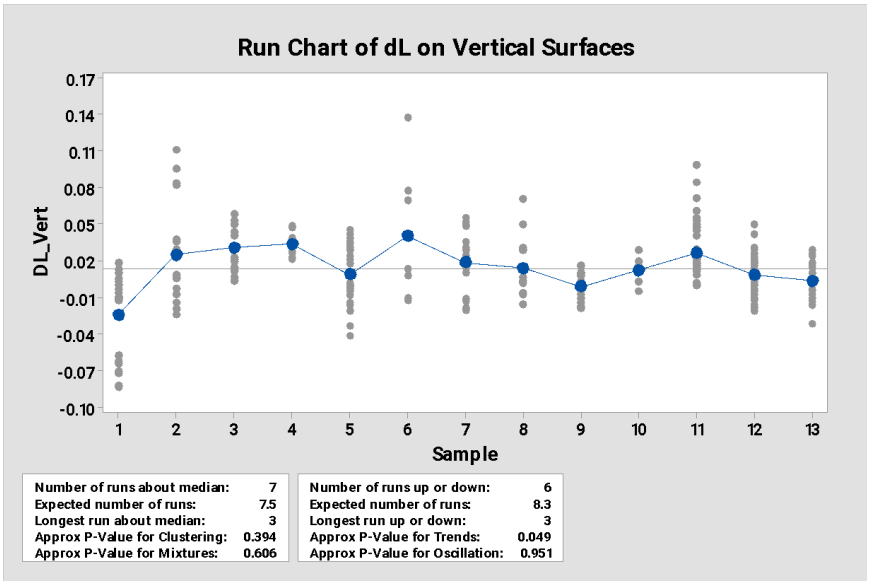
(a)



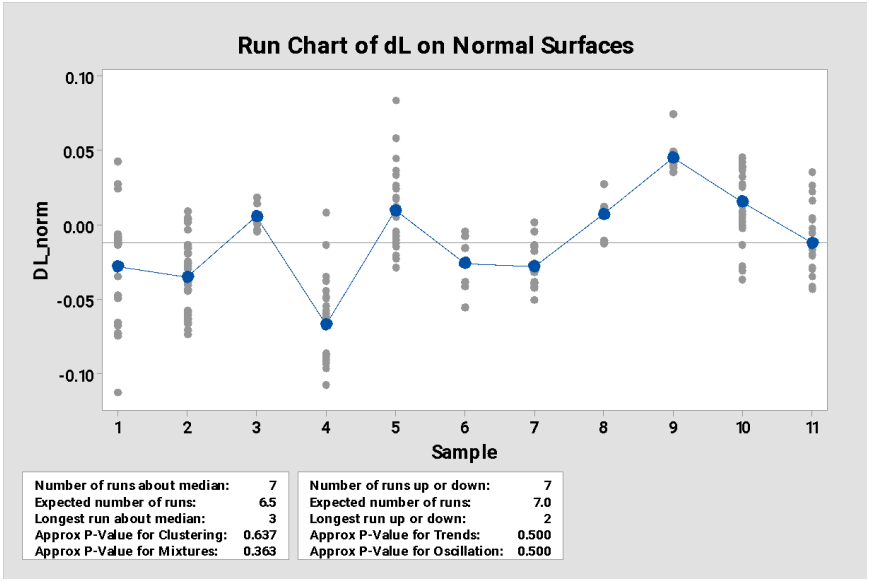
(b)

Figure 28: Individual Chart for dL on Vertical Surfaces (a) for all subgroups (b)staged by subgroup

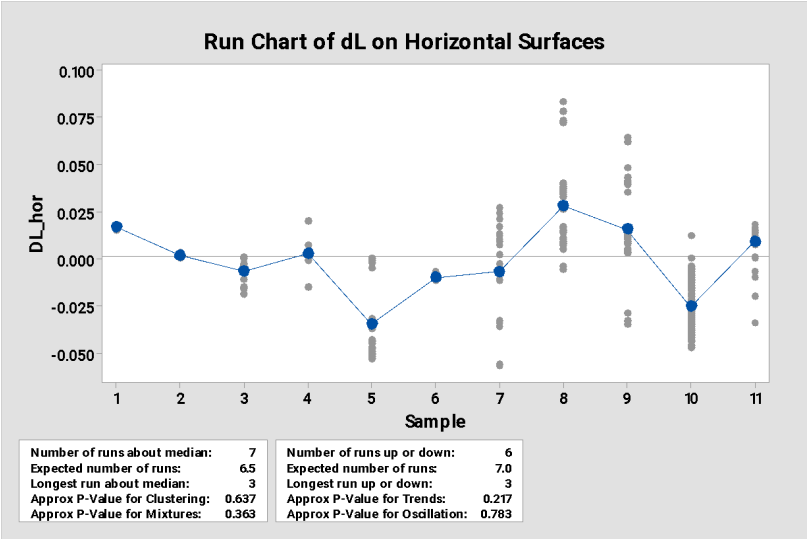
The Individual Charts do not provide detailed insights of the patterns in the data such as oscillations or trends which can cause variation due to special causes concerned with between parts (part to part) variation. For this purpose, the Run Chart analysis with subgroup mean was conducted for cumulative deviations on vertical, normal and horizontal surfaces. The Run Chart offers understanding of behavior of means of deviations between parts which help us to identify the probable problems.



(a)



(b)

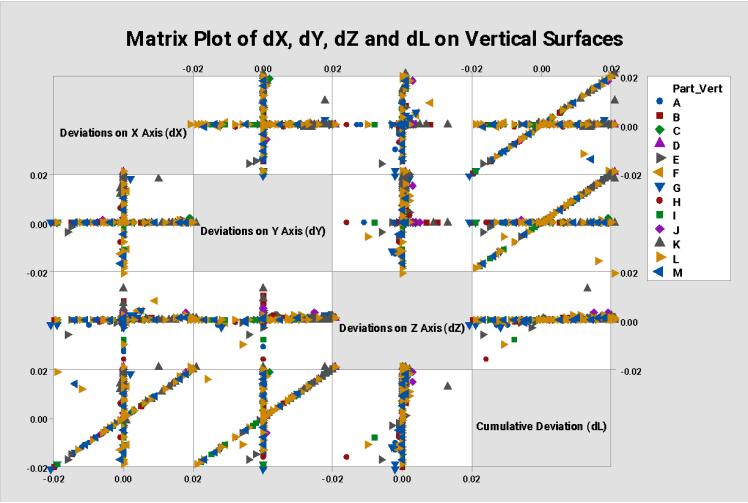


(c)

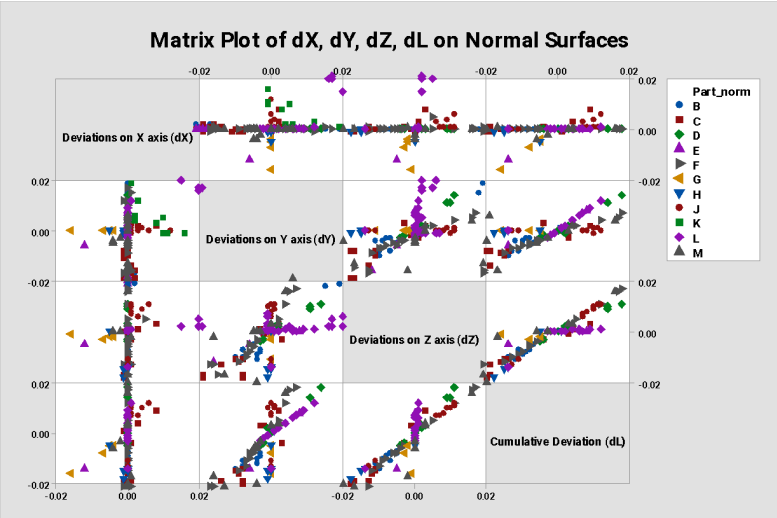
Figure 29: Run Chart of cumulative deviations on (a) Vertical, (b) Normal and (c) Horizontal Surfaces

The data of deviations on vertical, normal or horizontal surfaces do not show significant clustering, mixing or oscillation of data but the deviations on the vertical surfaces do exhibit tends. This deduction can be made by verifying the p-values of each hypothesis test made in the graphs above.

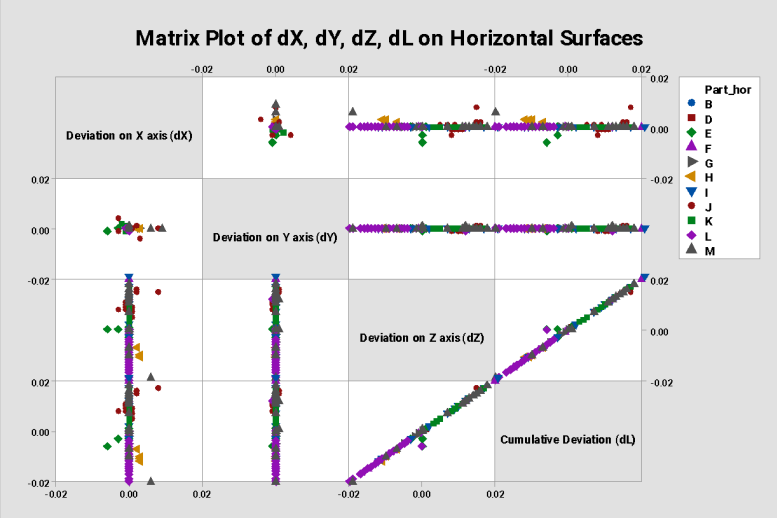
As mentioned earlier, the data used for the analysis is a cumulative deviation of X, Y and Z direction. It is important to study the relation between deviation in X direction (dX), deviation in Y direction (dY), deviation in Z direction (dZ) and cumulative deviation (dL) for vertical, normal and horizontal surfaces which can be best described by the matrix plot of Minitab.



(a)



(b)



(c)

Figure 30: Matrix Plot of dX, dY, dZ, dL for Vertical, Normal and Horizontal Surfaces

The following observations can be made from the matrix plot:-

- On the vertical surfaces, the deviations with respect to X, Y and Z axis are independent of each other and these deviations have a positive correlation with cumulative deviation (dL) which was analyzed in figure 30(a).

- On the normal surfaces, it can be noted that the deviations on Z axis has a linear positive correlation with the cumulative deviation (dL) and deviations on Z axis influence the deviations on X and Y axis. However, there is no correlation between the deviations of X and the Y axis.
- On the horizontal surfaces, there is no significant deviation on X and Y axis. The deviations on Z axis are linearly and positively corelated to the cumulative deviation (dL).

To summarize the investigation of Matrix Plot, the deviation on Z axis is the key contributor to the deviations on X or Y axis and subsequently to the cumulative deviation. Having said that, the trends observed in the Run Chart of vertical surfaces needs to be scrutinized and the cause of special variation must be identified. One of the possible causes of variation can be tool wear. Currently the height and radius (wear) of tools for machining is measured with a laser system which is sent to the control of CNC. Measurement System Analysis must be made for the laser system to ensure that the tools are being measured correctly.

5. CONCLUSION

The general aim of the project was to depict the importance of tools of Lean and Six Sigma for creating value for the mold making industries by specifying the relations between the business competitive factors and the key process indicators. Lack of historical data made it difficult to measure the actual process which was the concern of the production as well. However, along the time, with the help of focus groups and *gemba,* the actual state of the process was identified. The constraints realized in the define and measure phase were taken in control with the help of Lean and Six Sigma principles. The project was carried out in three fronts. The first two parts were related to implementations of Lean tools and for the later part, Six Sigma tools were used.

The management of non-conformities provided us the details about the ground reality of process failure and the causes for these failures. The objective of reduction of 20% cost of NCs was achieved but the effective evaluation can be guaranteed only in the long term after the three-monthly auditing to be done in July 2019 and November 2019 as explained in the control plan. New failures in the process would be identified along the time and remedial actions will be taken. The implementation of auto-control systems has responsibilized the workers to their job and they feel empowered with the decision-making trust that they have been designated.

The capacity of the CNC machines was increased from 46% to about 70% exceeding the set target of 60%. The approach of measuring the capacity was implemented in the section of erosion as well. The capacity of machines each week

are discussed in weekly meeting of productions which allows the departments to be informed about the capacity of the respective sections. The solutions of 5S and SMED reduced the cycle time of the machining process by lessening the NVA and BNVA activities

The optimization of CNC machining involved the treatment of data applying Six Sigma principles of statistical inference. The measurement probe and the software for the measurement of deviations of steel was validated by the Measurement System Analysis and was proved not to have significant bias or linearity. The actual process data is sub-grouped according to the parts which have variations in mean. Through run chart, the process is found to have special cause variations along the X and the Y axis. The matrix plot displayed a random yet positive correlation between the deviations between Y axis and Z axis; and a positive linear relation between Z axis and the cumulative deviation. It is suspected that the measurement of tools is not accurate. The laser system used for measurement of height and radius (wear) of tool needs to be validated through MSA.

RETURN ON INVESTMENT

Table 11: Return on Investment (yearly)

Investments	
Measurement device (Probe)	12,000€
Software	5,000€
SMED	20,000€
Organization of Shop floor	14,000€
New calipers for the Shop floor	3,000€
Training of employees on 5S	3,500€
Returns	

Reduction in Non-Conformity costs	15,250€
Increase in CNC Machining capacity	570,024€
Percentage of Return on Investment	
9.18%	

BIBLIOGRAPHY

- Altan, T., Lillg, B., & Yen, Y. (n.d.). Manufacturing of Dies and Molds. *CIRP Annals*.
- Hinckley, C. M., & Barkan, P. (n.d.). The Role of Variation, Mistakes, and Complexity in Producing Nonconformities. *Journal of Quality Technology*.
- Montgomery, D. C. (2013). *Statistical Quality Control.*
- Santos, T. M., Simões, P. M., & Sousa, J. P. (2017). *Reorganization, Enrichment and Analysis of Data to Yield (READY).*
- Schulz, B. (2018, 12 21). *State of Mold Manufacturing in Portugal*. Retrieved from Mold Making Technology: https://www.moldmakingtechnology.com/blog/post/state-of-mold-manufacturing-in-portugal

ANNEXES-I

Non-Conformity Report

moldetipo group

RELATORIO DE NÃO CONFORMIDADE

Nº DE NC	486	Nº DE NC Sinex	3538901	Validação de NC (Sim/Não):	Sim
DATA	20/05/2019	Nº MOLDE	3538	Nº PECA/S	200/201

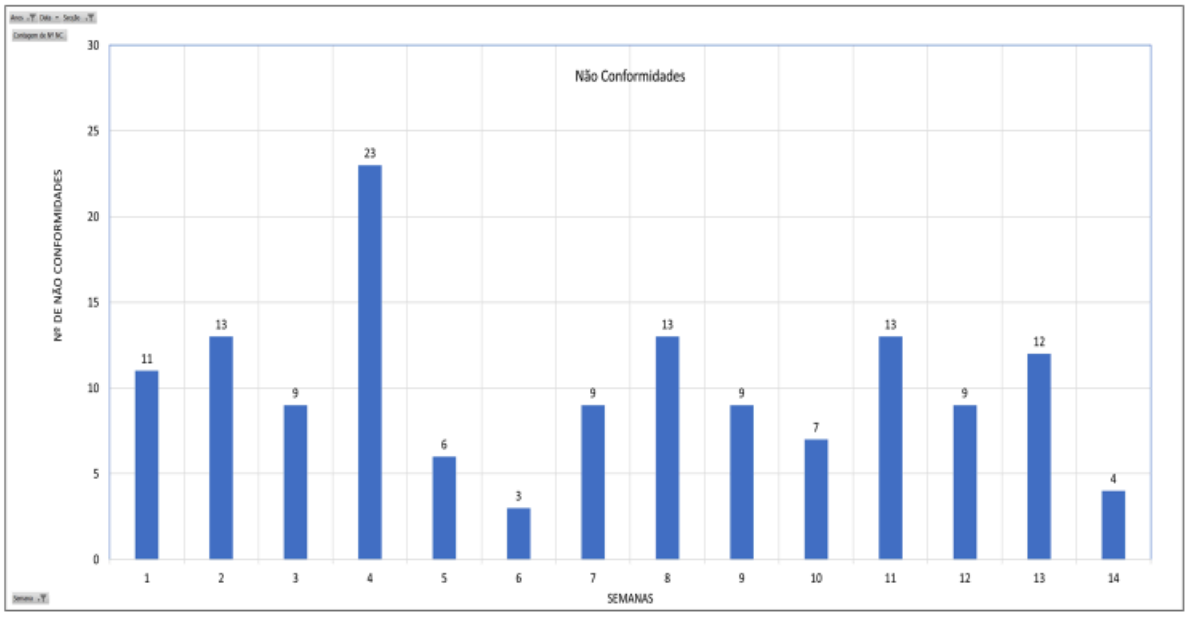
Tipo de Problema		Descrição de Problema
Forma		Cortou a mais na peça.
Dimensão		
Funcional		
Material		
OUTROS		

Origem	CNC	Trabalhador	Paulo Antonio de Sousa Carvalho
Tipo da Causa	Descrição da Causa		
Falta do AutoControlo	Operador usou o programa CHAMA errado, foi usado o de teste. Esse mesmo que tinha uma frese de maior raio do que o suposto.		

Plano de Contenção Provisória			
Recuperar		Sucata	Usar como está
Devolver			
Executado pelo Dir. Podução			

Ação Preventiva		
Nome		Data:

FORMAT OF PRESENTATION OF NCs

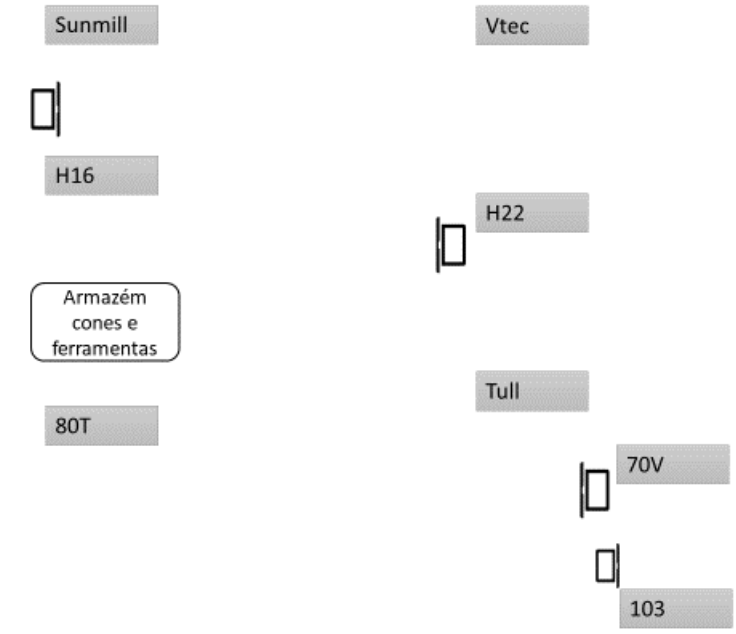


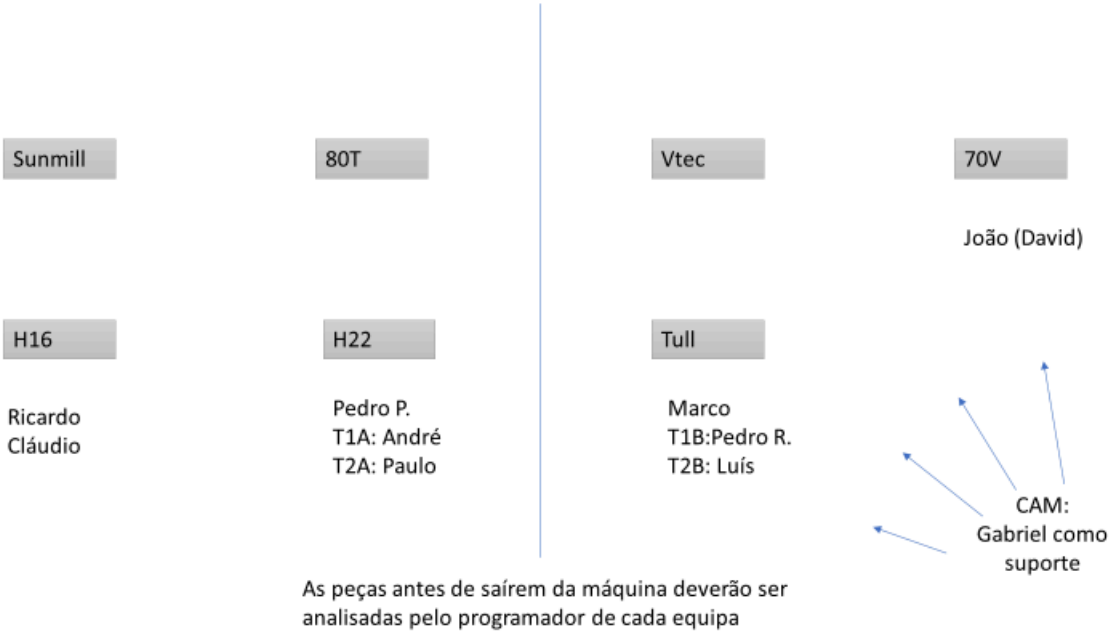
Data	Nº Mold	Peça	Secção	Custo	Resumo
26/3/19	3521	102	CNC		Peça deslocou no movimento
25/3/19	3487	56	CNC		Cortou a mais as barras de ajustamento
26/3/19	3514	201A1	CNC		Peça foi mal centrada
26/3/19	3521	101	CNC		Operador usou cone errado à folha de programas, criando mossa
26/3/19	3521	200	Planeamento		Alteração mal difinida
27/3/19	3503	2	CNC		Caixas ficaram com profundidade a mais.
27/3/19	3504	100	Projeto		Faltou desenhar roscas
27/3/19	3416	82/85	CNC	60.00 €	Peças com aço a menos, precisam de solda
29/3/19			CNC	150.00 €	Alongador de 20mm partiu
1/4/19	3518	P23/P24	Compras	30.00 €	Não foram requisitadas as roscas nas guias de extração
1/4/19	3487	1	Forencedor-CAD	145.00 €	Folga perto do olhal
1/4/19	3503	32	Fornecedor-CAD	71.00 €	Falta folga no anel para o Sistema de Injeção
1/4/19	3503	3	Fornecedor-CAD		Colisão das barras de movimento da cavidade com a chapa 3
2/4/19	-	Ponteira	CNC	60.00 €	Ponteira de Renishaw partida
3/4/19	3517	5/6	Fornecedor-Maq		Peças fornecidas vieram com 921 em vez de 946

MANAGEMENT OF IMPROVEMENTS

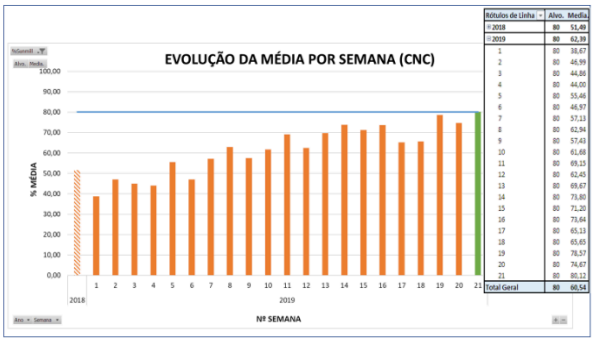
Origem	Risco (R) ou Oportunidade (O) ou Ocorrência (OC) ou Objetivo (OBJ)		Detalhes de R ou OC ou OBJ	Efeitos dos R ou OC ou OBJ	Causas (para OC)	KPI(s)	1º Verificação		
							Data	KPI	TOTAL €
PROJECT - PROJ	R	FORMA - I	CAIXA EM FALTA/DESLOCADA, FALTA FUGAS, PROBLEMA DE JUSTAMENTO OU APERTO		**ERRO DE PROJETO / FALTA INFORMAÇÃO**	MÉDIA DO CUSTO (TOTAL PROBLEMAS DE PROJETO)	1/2/2018	88 €	1,182.00 €
	R	DIMENSÃO - II	CAIXA MAIS FUNDA/LARGA, CABEÇAS MAIS FUNDAS,		**ERRO DE PROJETO / PROJETO ALTERADO E NÃO INFORMADO**	MÉDIA DO CUSTO (TOTAL PROBLEMAS DE PROJETO)	1/2/2018	144 €	1,081.50 €
	R	FUNCIONAL / COLISÃO - III	INTERFERÊNCIA, POUCA FOLGA		**FALTA DE VERIFICAÇÃO (AUTOCONTROLO)**	MÉDIA DO CUSTO (TOTAL PROBLEMAS DE PROJETO)	1/2/2018	236 €	1,896.00 €
CNC MAQ. - CNCMQ	R	FORMA - I	FACE SELECIONADA ERRADA, FIXAÇÃO INCORRETA, PEÇA MAL CALÇADA	PEÇA DANIFICADA, AÇO A MENOS, SUCATA	**DESEMPENO/ CENTRAMENTO/FIXAÇÃO**	MÉDIA DO CUSTO (% TOTAL CAUSAS DE FORMA)	1/2/2018	153 €	2,301.00 €
	R	FORMA - II	FACE SELECIONADA ERRADA, TROCA DA FERRAMENTA, CAIXA COM CALOS	AÇO A MENOS, AÇO A MAIS	**FALTA DE AUTOCONTROLO**	MÉDIA DO CUSTO (% TOTAL CAUSAS DE FORMA)	1/2/2018	121 €	1,632.00 €
	R	FRESE/CONE PARTIDO - III	Z MAL TIRADO, TROCA DA FERRAMENTA, FERRAMENTA COM ALTURA INCORRETA, FALTA DE ATENÇÃO	PEÇA DANIFICADA, SUCATA	**ERRO DE AFERIÇÃO**	MÉDIA DO CUSTO (% TOTAL CAUSAS DE FRESE/CONE PARTIDO)	1/2/2018	279 €	5,433.00 €
	R	DIMENSÃO / FURO/ROSCA/H7 DESLOCADA/INCOMPLETO - IV	FALTA VERIFICAÇÃO, FATA DE AUTOCONTROLO, FALTA DE ATENÇÃO	REMAQUINAÇÃO	**CORES MAL DEFINIDAS NO DESENHO / INTERPRETAÇÃO / INFORMAÇÃO**	MÉDIA DO CUSTO (% TOTAL (INTERPRETAÇÃO + INFORMAÇÃO) DE (FURO/ROSCA DESLOCADA + DIMENSÃO)	1/2/2018	205 €	1,050.00 €
	R	DIMENSÃO / FURO/ROSCA/H7 DESLOCADA/INCOMPLETO - V		REMAQUINAÇÃO	**FALTA DE VERIFICAÇÃO (AUTOCONTROLO)**	MÉDIA DO CUSTO (% TOTAL (VERIFICAÇÃO+AUTOCONTROLO) DE (FURO/ROSCA DESLOCADA + DIMENSÃO)	1/2/2018	111 €	615.00 €
	OBJ	AUMENTAR CAPACIDADE DE MAQUINAÇÃO DA SECÇÃO		MENOS SUBCONTRACTAÇÃO		CAPACIDADE DE PRODUÇÃO EM % - TRIMESTRAL	1/2/2018	49%	231,429 €
FORNECEDOR CAD - FCAD	R	COLISÃO - I	INTERFERÊNCIA	REMAQUINAÇÃO, CORREÇÃO		MÉDIA DO CUSTO (% TOTAL PROBLEMAS)	1/2/2018	89 €	2,130.00 €
	R	CHANFRO/RIO EM FALTA - II		MAQ. NA BANCADA, REMAQUINAÇÃO, COLISÃO		MÉDIA DO CUSTO (% TOTAL PROBLEMAS)	1/2/2018	179 €	1,608.00 €
	R	ZONA DE FOLGA INSUFICIENTE - III	POUCA FOLGA	JUST. NA BANCADA, REMAQUINAÇÃO		MÉDIA DO CUSTO (% TOTAL PROBLEMAS)	1/2/2018	53 €	240.00 €
	R	FORMA - IV	CAIXA EM FALTA/DESLOCADA, FALTA FUGAS, PROBLEMA DE JUSTAMENTO OU APERTO	REMAQUINAÇÃO, SUCATA		MÉDIA DO CUSTO (% TOTAL PROBLEMAS)	1/2/2018	1,080 €	6,480.00 €

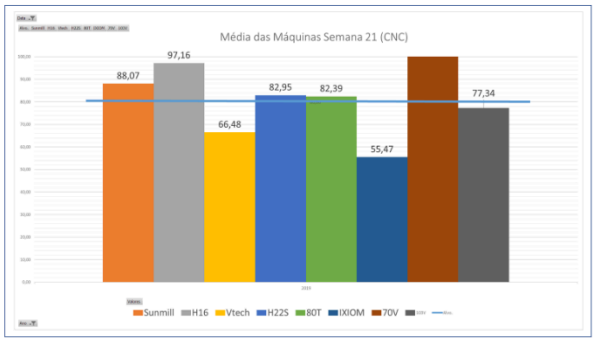
ANNEXES-II

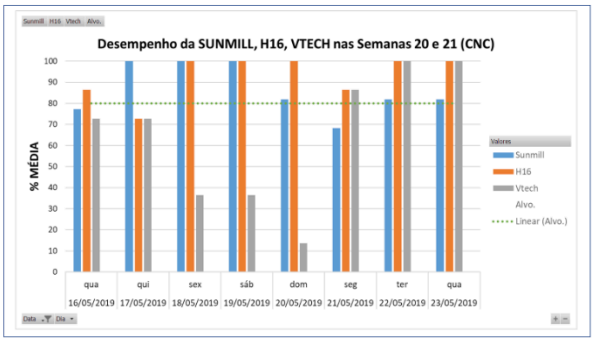


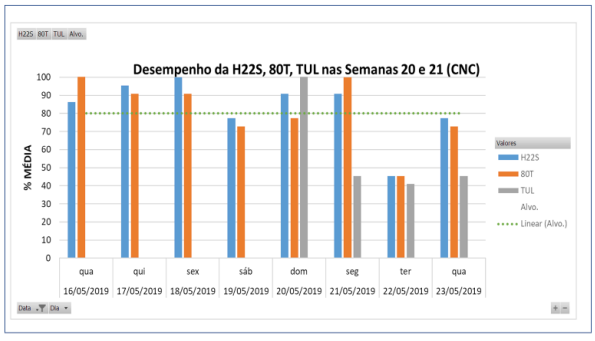


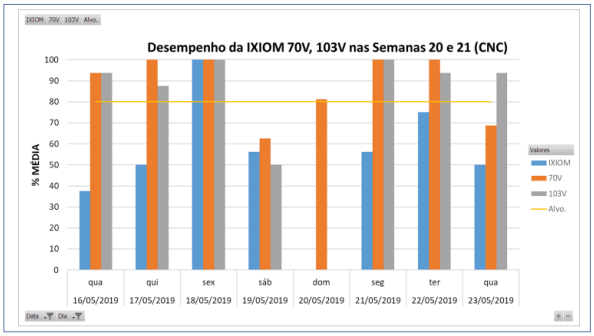
FORMAT OF PRESENTATION OF CAPACITY OF MACHINES


EVOLUÇÃO DA MÉDIA POR SEMANA (CNC)
% MÉDIA
Nº SEMANA
2018
2019
Rótulos de Linha
Alvo.
Média
2018 80 51,49
2019 80 62,39
1 80 38,67
2 80 46,99
3 80 44,86
4 80 44,00
5 80 55,46
6 80 46,97
7 80 57,13
8 80 61,94
9 80 57,43
10 80 61,68
11 80 69,15
12 80 62,40
13 80 69,67
14 80 73,80
15 80 71,20
16 80 73,64
17 80 65,13
18 80 65,65
19 80 78,57
20 80 74,67
21 80 80,12
Total Geral 80 60,54


Média das Máquinas Semana 21 (CNC)
88,07
97,16
66,48
82,95
82,39
55,47
77,34
Sunmill
H16
Vtech
H22S
80T
IXIOM
70V


Desempenho da SUNMILL, H16, VTECH nas Semanas 20 e 21 (CNC)
% MÉDIA
qua 16/05/2019
qui 17/05/2019
sex 18/05/2019
sáb 19/05/2019
dom 20/05/2019
seg 21/05/2019
ter 22/05/2019
qua 23/05/2019
Valores
Sunmill
H16
Vtech
Alvo.
Linear (Alvo.)


Desempenho da H22S, 80T, TUL nas Semanas 20 e 21 (CNC)
% MÉDIA
qua 16/05/2019
qui 17/05/2019
sex 18/05/2019
sáb 19/05/2019
dom 20/05/2019
seg 21/05/2019
ter 22/05/2019
qua 23/05/2019
Valores
H22S
80T
TUL
Alvo.
Linear (Alvo.)


Desempenho da IXIOM 70V, 103V nas Semanas 20 e 21 (CNC)
% MÉDIA
qua 16/05/2019
qui 17/05/2019
sex 18/05/2019
sáb 19/05/2019
dom 20/05/2019
seg 21/05/2019
ter 22/05/2019
qua 23/05/2019
Valores
IXIOM
70V
103V
Alvo.