

Drill Base Unit Quality Improvement Report

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Introduction

The following report will analyse surface defect data gathered over the period of a week for a pillar drill base that is being manufactured and using different quality improvement tools and research, produce a corrective action plan to reduce the quantity of the different types of defects. The production of the drill base is broken down into two operations as follows:

- Sand Casting (Operation 1)
- Machining, Milling, Drilling (Operation 2)

For each operation there are two workers, Workers A & B refer to Operation 1 and Workers C & D refer to Operation 2. I will be looking at the potential causes of the defects for both operations.

I will assume that in operation 1 they are using the 'Greensand Method' which is simply sand combined with a binder such as water and clay is packed around a pattern to form the mould (Shewmon). I will also assume in Operation 2 all the machining, milling and drilling is done manually by the workers and there is minimal or no automation.

Data Analysis – Operation 1

From the defect data provided by the company (Figure 1) a spreadsheet has been produced with graphs to help quantify and interpret the data. From looking at the pareto chart of Operation 1 (Figure 2) you can immediately determine that surface finish is the main defect accounting for 62% of all defects, Blowholes being the second highest defect at 27% and improper shape accounting for 11% of defects. This clearly shows that Surface finish defects must be the focus for defect reduction as it is the highest occurring defect that would lead to potential rejections or cause additional work to be undertaken in order to correct the defect.

When the defect data is split between the workers, we can see in Figure 3 that for surface finish, Worker A has almost half as many defects compared to Worker B but for blow hole defects and improper shape defects, they are marginally the same. This shows there's an underlying problem within the sand-casting process because both workers are producing an unacceptable number of defects however, there is a further cause for Worker B's defects that will need to be addressed.

Another observation that can be made in Figure 4 is that there are more defects occurring in the middle of the week by both workers as opposed to the beginning and end of the week.

To understand the sand-casting process better and help with identifying the root cause of defects a process flow diagram (Figure 5) was created using information from a technical website. (Techminy, 2016). Further to the process flow diagram an Ishikawa diagram (Figure 6) has been created highlighting possible causes for the casting defects. From this diagram we can pinpoint some of the potential causes for the defects.

Firstly, the quality of the materials being used may be poor and as this is the first step in the process after the design it would have a “knock on” effect causing issues at later stages. It has been determined that sand quality and the composition of the mould used greatly affect the quality (Custompart, 2019). The use of a lower grain sand would decrease permeability, and this has a direct result in improving the surface finish of the casting. If the sand is not stored as recommended by the supplier this also would have an adverse effect on the casting’s quality because things such as moisture content of the sand would be affected. It has also been determined that the type of mould also affects the surface finish as instead of using a Greensand mould; which is simply sand, water and clay mixed together; using a Skin-dried mould which has extra additives in the sand to increase mould strength which in turn, increases surface quality. (Custompart, 2019).

Quality of the materials isn’t the only determining factor however, the methods that are being used will also affect the outcome. As the data in Figure 3 indicates the workers must be following a very limited set of instructions on the method in which they should complete the casting. If there was a standard operating procedure in place you would see a similar number in defects between the workers, but currently this is not the case. There are numerous factors within the method such as how the mould is clamped, pouring speed/temperature of the molten metal and how the sand is packed which without set parameters would have a detrimental effect on the casting (DATAU S. G, 2012). This could also be attributed to a lack of, or poor-quality training. Other factors to consider for the disparity of defects between Worker A and B would be Worker A might have more experience and with that, a better judgement than Worker B or Worker B has a poor attitude towards his job and is very careless. If that is the case that would be attributed to numerous factors that were found in the Ishikawa diagram (Figure 6) such as a poor working environment and poor management. This could also be supported by Figure 4 as the workers could lose motivation and become complacent in their job which results in more defects as a direct result.

Data Analysis – Operation 2

Again, after looking at the defect data a pareto chart has been created for Operation 2 (Figure 7) and surface finish is also the most frequent defect which accounts for 66% of the total defects in this operation. Blow holes account for 12% of the defects, improper shape 9%, defective finishing 8% and other defects 5%. As in Operation 1 surface finish will need to be the focus for improvement in minimising these defects as they will cause the most rejections and reworks.

When the defect data is split between the workers in Figure 8, they show similar results which would indicate there is a common cause for the defects as opposed to one worker doing something differently to the other which is the case for Operation 1.

Figure 9 shows a similar pattern as Operation 1’s chart that more defects tend to occur in the middle of the week although the cause could potentially be different due to it being a different operation.

An Ishikawa diagram (Figure 10) has been created for this operation which focuses more on the actual operation as opposed to other factors in Figure 6 that we have previously discussed. The diagram has been created through information gained from an engineering website. (Custompart, 2019)

From the diagram a few potential causes of defects have been identified. The cutting tool that is being used will affect the surface finish of the machining depending on a few factors such as the material of the tool, whether its coated in another alloy to make it more durable and heat resistant and the wear on the cutting tool. The wear on the cutting tool must be checked routinely and changed if necessary, in order to keep the cutting precise. This may have a relation to Figure 9 and explain why there are more defects during the middle of the week, if they change the tool Thursday morning that explains the lowering of defects.

There are numerous actions that are controlled manually by the workers which would have a detrimental effect on the surface finish of the workpiece such as the rate in which the workpiece is fed into the machine, the speed of the cutting tool, depth and angle of the cut and what coolant (if any) is being used. If the worker hasn't had proper training, is careless or the parameters for cutting this workpiece haven't been set, the worker will have to use their own judgement and the change of these actions occurring are much higher. These parameters will also cause chipping if not controlled correctly which will affect the surface finish.

Other problems identified are vibration within the machine which is then transferred onto the workpiece which will affect the finish. Swarf that is being produced from cutting/drilling not being removed/controlled adequately which will affect the workpiece and cause it to be reworked to remove chips that have warped to the workpiece. (ChiragKulkarni, 2017). Another potential cause could be poor clamping of the workpiece or the cutting tool not being held tight enough, this causes chattering which affects the cutting tolerances.

Figure 11 shows an FMEA table identifying the RPN of some of the failures in the process. It highlights that most of the causes are from the feed rate and speed of cutting along with poor tightening of the workpiece and the cutting tool.

Conclusion

From analysing the data for Operation 1 the causes that were highlighted were the type of sand casting that was being used resulting in a poor surface finish along with human error which is due to a lack of training and having set instructions from standard operating procedures. It also highlighted the type of materials being used would influence the surface finish.

In Operation 2 the causes that were highlighted were cutting parameters such as the feed rate of the workpiece and the cutting speed of the tool. Poor cutting practices such as the non-removal/control of swarf produced from cutting and lack of coolant being used.

Most of the causes in both operations are from human error and can be minimised through automation of both operations, through automation you would minimise the casting defects through better control of things such as pouring temp and speed and the packing of the sand around the mould although this may not be an option currently. In Operation 2 if the process was automated through CNC machining defects would be minimised through having proper cutting parameters such as the speed of cutting and feed rate as these can be pre-set. The machine would automatically apply the correct amount of coolant and the swarf could be automatically blown away by compressed air. The workers can then be trained on how to control the machines were applicable.

Corrective Action Plan

Finding	Process	Corrective Action	Responsibility
Large grain sand being used in the casting process	Operation 1	Order and use smaller grain sand to increase surface finish quality	Purchasing Department
The use of 'Greensand' method when sand casting causes poor surface finish	Operation 1	Add bonding materials to the sand in order to create better mould strength to increase surface quality	Workers
Poor storage of sand leading to high moisture content	Operation 1	Store sand as recommended by supplier in order to minimise moisture content	Workers

Poor instructions for workers to follow during casting process	Operation 1	Implement standard working procedures for the casting process to minimise human error	Management
Poor packing of the sand around the mould	Operation 1	Automate the ramming procedure to remove human error	Workers/Management
High defect disparity between workers	Operation 1	Create proper training matrix for employees and new starters and ensure they get the correct support needed	Management
High defects during middle of the week suggesting carelessness and complacency	Operation 1&2	Renew the working environment to a better standard to increase moral	Management
High defects caused by manual machining	Operation 2	Implement a CNC machine for the cutting to reduce defect rate and remove most defects by human error	Management
Poor cutting parameters	Operation 2	Introduce new cutting parameters for the cutting process such as feed rate and cutting speed to ensure better quality finish	Management
Poor cutting methods through lack of coolant and swarf removal	Operation 2	Automate coolant application and swarf removal through compressed air	Management
Poor clamping of workpiece and cutting tool	Operation 2	Inspection clamping of workpiece and cutting tool on the new CNC machine prior to cutting	Workers

Management should implement the corrective actions as soon as possible seeking assistance from relevant engineers where possible. These actions will minimise the defective rate PPM and increase performance of the plant.

Appendices

Figure 1

DRILL BASE UNIT - PROCESS DEFECT DATA

Equipment	Worker	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
		am	pm	am	pm	am	pm	am	pm	am	pm	am	pm
Operation 1 (Sand Casting)	A	OOX●	OX	OOO	OX	OOOX XX●	OOOO XXX	OOOO XXX●	OX	OOOO	OO	O	XX●
	B	OOX●	OOOX XO	OOOO OOXX	OOOX X	OOOO OOXX ●●	OOOO OOX●	OOOO OX	OOOX ●●	OOOX ●	OOOO O	OOX	OOO●X OO
Operation 2 (Machining/ Milling/ Drilling)	C	OOX	OX	OO	●	OOOO	OOOO OOX	OO	O●	OO◆	OO□	◆O	□O
	D	OOX	OX	OO	OOO●	OOO● ◆	OOOO OX	O●O	OO◆	OO◆◆ □	O●●	□OOX	XXO

Legend:

O Surface Finish ◆ Defective Finishing X Blow Hole ● Improper Shape □ Others

Figure 2

Pareto Chart of Operation 1 Defects

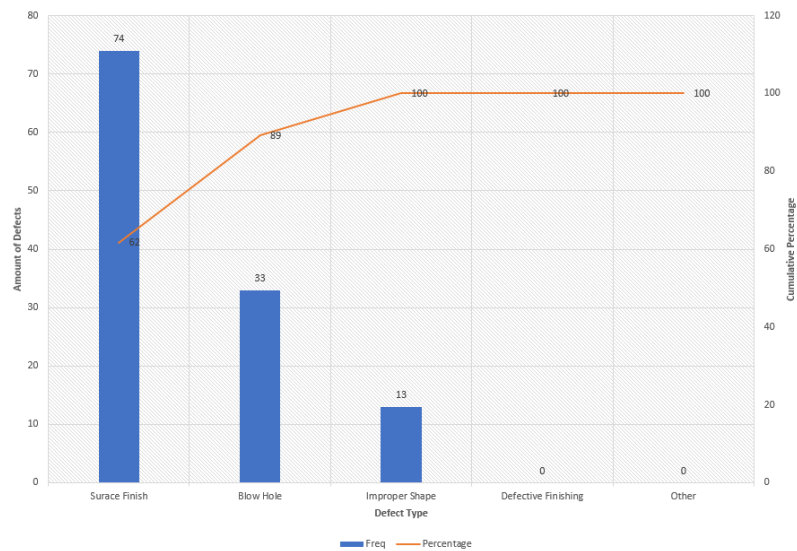


Figure 3

Comparison of Defects Between Worker A & B

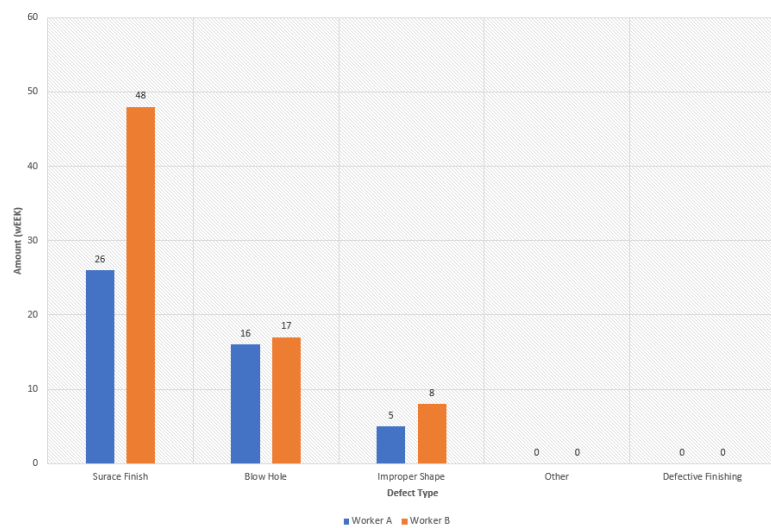


Figure 4

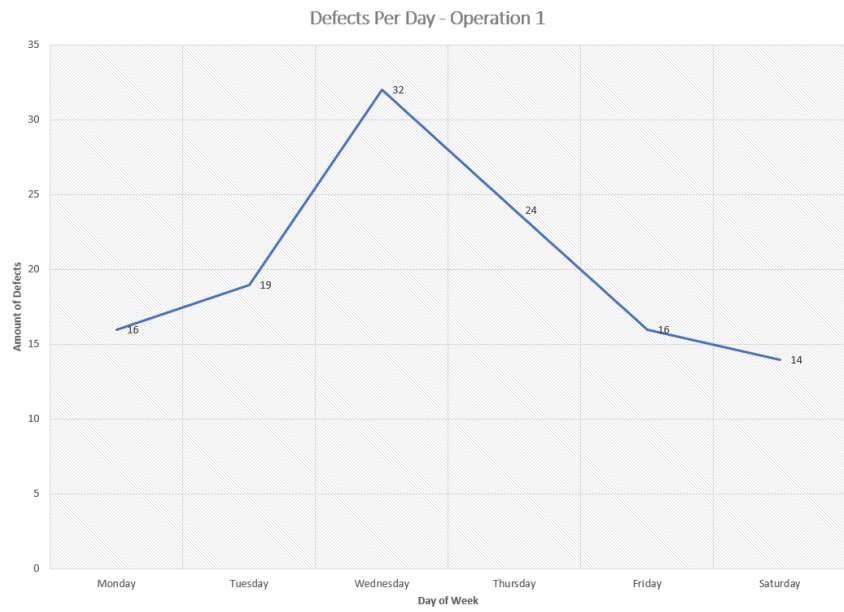


Figure 5

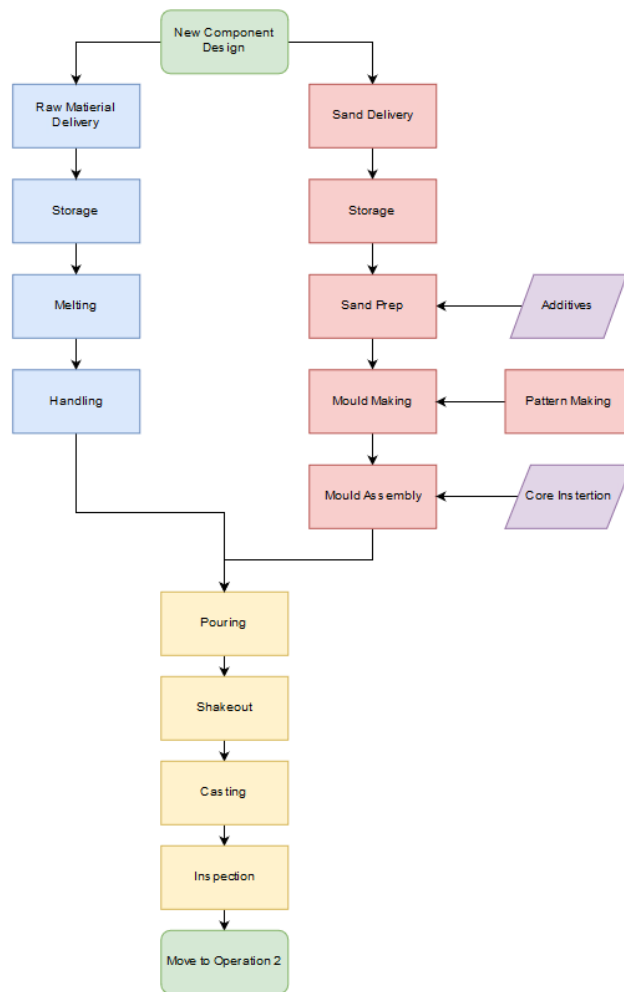


Figure 6

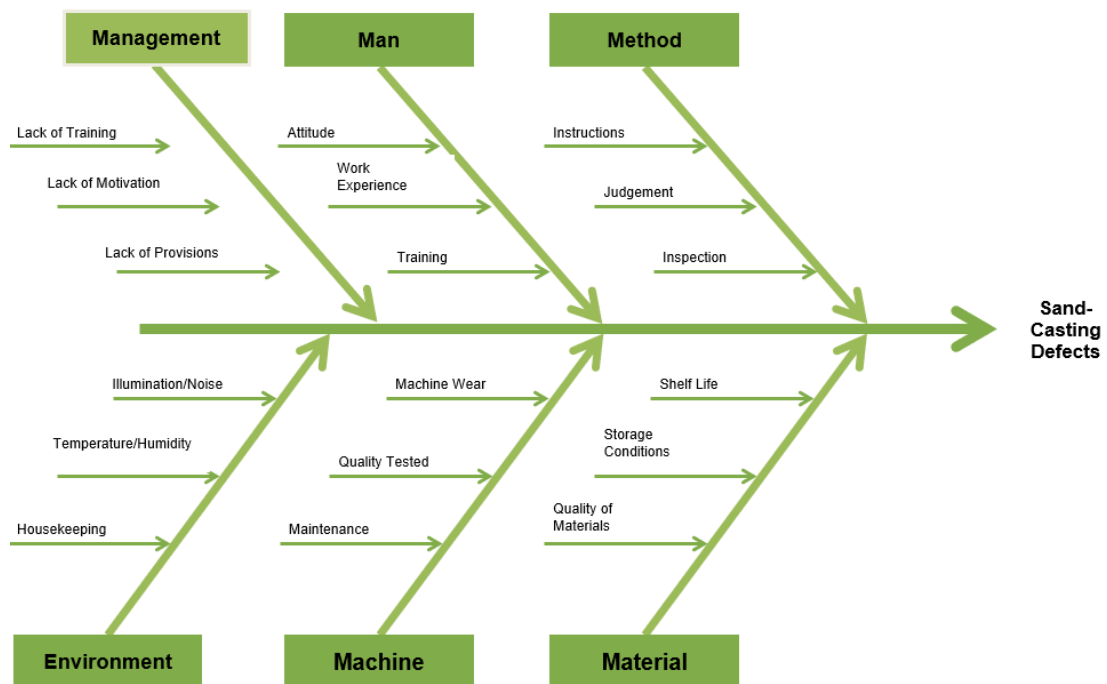


Figure 7

Pareto Chart of Operation 2 Defects

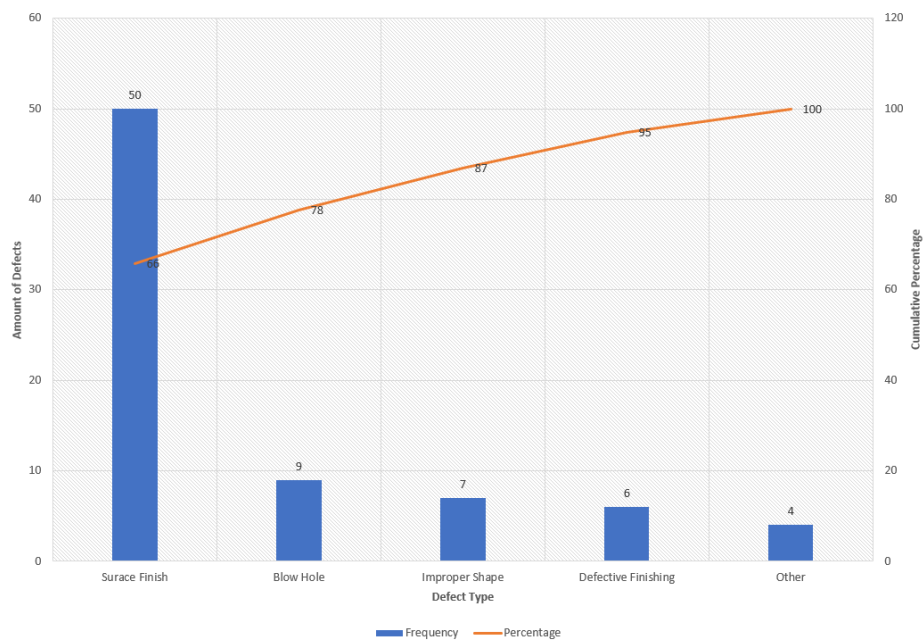


Figure 8

Comparison Between Workers C&D - Operation 2

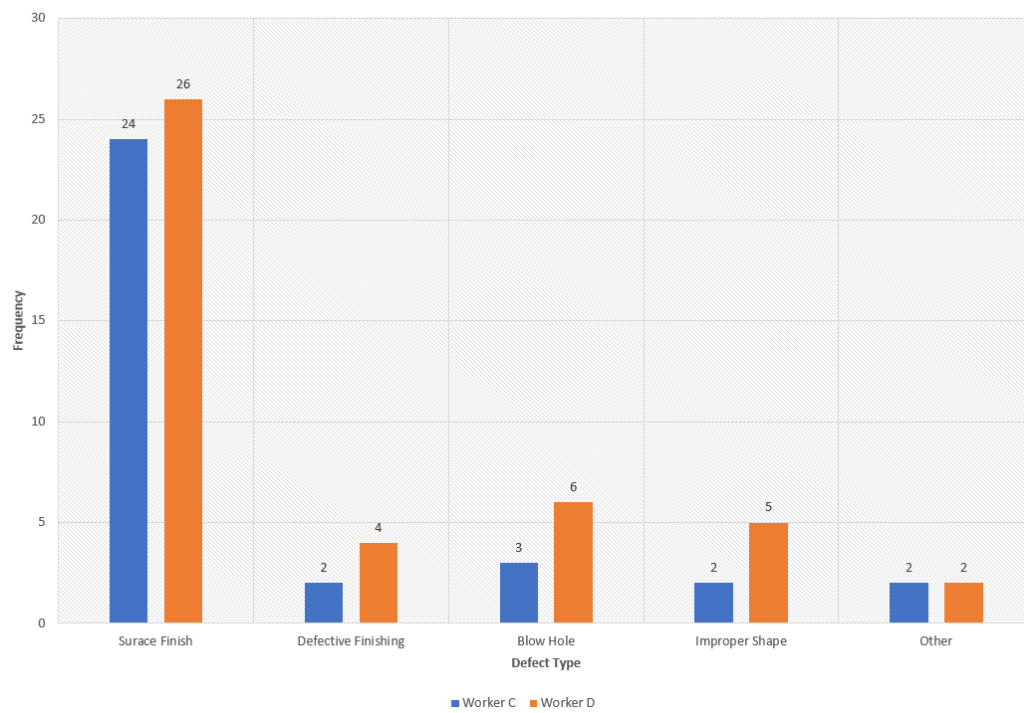


Figure 9

Defects Per Day - Operation 2

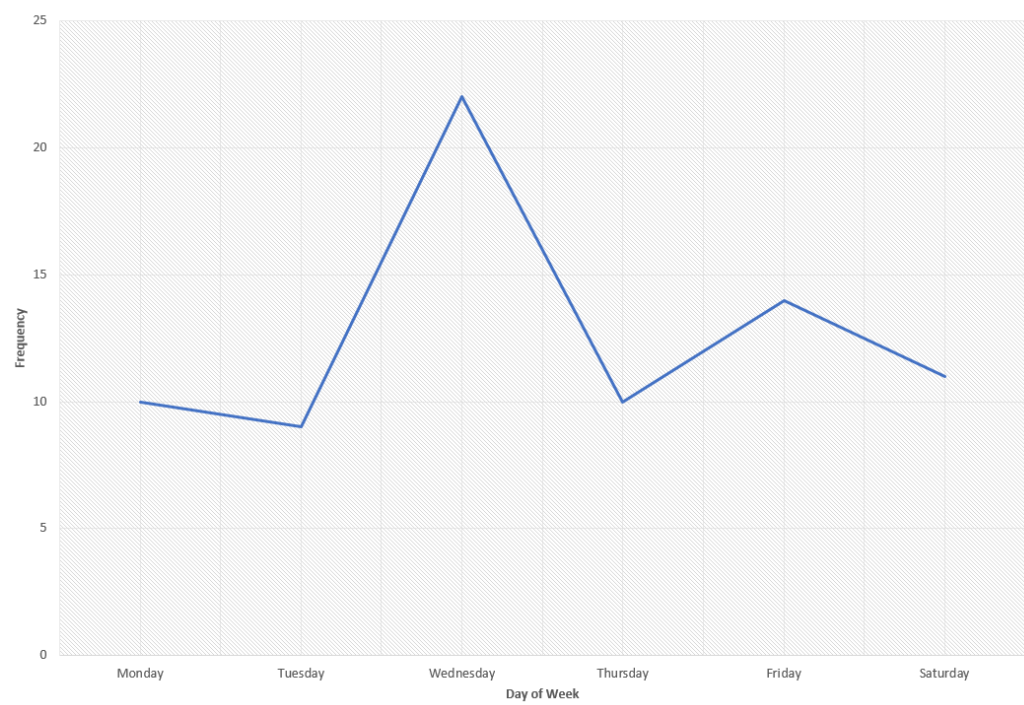


Figure 10

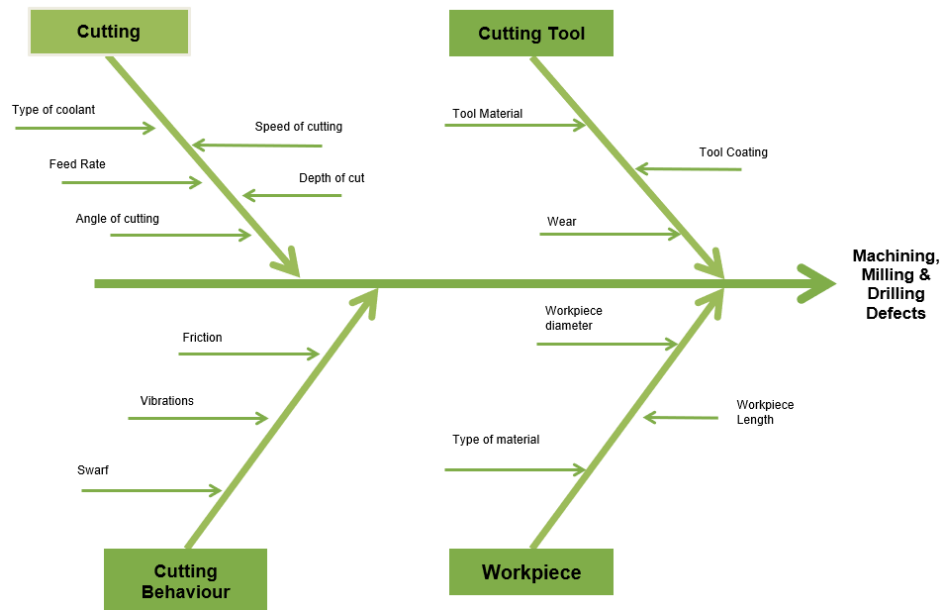


Figure 11

Function/ Process	Failure Mode	Effect of Failure	Severity ¹	Occurrence ¹	Detection ¹	Risk Priority Number ²	Recommended Action
Feed Rate	Feed too fast	Rough Surface Finish	2	4	3	24	Slow feed rate
Cutting Speed	Speed too slow	Rough Surface Finish	2	4	3	24	Increased cutting speed
Feed Rate	Feed too fast	Chipping/High Tool Wear	3	3	4	36	Slow feed rate
Clamping Workpiece	Loose clamping	Chipping	3	1	4	12	Inspect clamping before starting/Tighten if necessary
Tool holder	Loose cutting tool	Chipping	3	1	4	12	Tighten tool holder

1. Scale of 1-5 where 1 is low and 5 is high for severity and occurrence. 1 is easy to and 5 is hard for detection
2. Severity x Occurrence x Detection = RPN

References

- ChiragKulkarni, D. (2017). *Defect Identification in CNC Manufactured Products and their Control Measure*. International Journal of Innovative Research in Science, Engineering and Technology.
- Custompart. (2019). *Milling*. Retrieved from Custompart.Net: <https://www.custompartnet.com/wu/milling>
- Custompart. (2019). *Sand Casting Process*. Retrieved from Custompart.net: <https://www.custompartnet.com/wu/SandCasting>
- DATAU S. G, O. J. (2012). *THE EFFECT OF SAND CASTING PROCESS PARAMETERS ON MECHANICAL PROPERTIES OF ALUMINUM ALLOY CASTING* . National Agency for Science and Engineering Infrastructure (NASENI).
- Shewmon, P. G. (n.d.). Physical metallurgy. *Britannica*, 3.
- Techminy. (2016, November 2). *Sand Casting Process Basic Concept and Procedure*. Retrieved from Techminy: <https://techminy.com/sand-casting-process/>