Improving the Quality of Electric Bicycle Production During the Covid-19 Pandemic using the FMEA Method

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Abstract
In March 2020, WHO declared the coronavirus (COVID-19) a new world pandemic. Different countries have implemented different strategies to control the impact of the pandemic. For example, France and Germany implemented relatively strict lockdown policies and empowered people to work. In addition, public transport is advised to keep passenger levels low and avoid overcrowding, while people over the age of 70 are encouraged to abstain from public transport altogether. As a result, the use of bicycles as an active mode of transportation has increased and this mode is highlighted to overcome problems related to social distancing in the transportation domain. This is what underlies the bicycle industry to increase productivity and improve quality during the pandemic. This research is focused on analyzing the quality improvement of the electric bicycle production process using the FMEA method. This FMEA method is based on a simple DMAIC problem solving methodology, namely: Define (formulate), Measure (measure), Analyze (analyze), Improve (improve) and Control (control), which combines several statistical tools and other process improvements. The steps carried out using the FMEA method are identifying several types of problems, determining the severity rating value, occurrence rating value, detection value, and calculating the Risk Priority Number (RPN). After obtaining the RPN value from the FMEA method, then an analysis is carried out in determining the priority of problems in the bicycle production process. The result of the research is that there are three processes that must be prioritized.

Keywords
Bike, DMAIC, FMEA, RPN

1. Introduction
Various countries in the world have implemented different strategies to control the impact of the Covid-19 pandemic that occurred in early 2020. For example, France and Germany implemented relatively strict lock down policies and gave people authority to work (Pierre, 2020). In addition, public transport is advised to keep passenger levels low to avoid overcrowding, while people over the age of 70 are encouraged not to use public transport at all (Folkhalsomyndigheten, 2020).

The transport domain is an integral part of everyday life, and an in-depth understanding of the health and comfort of its users is very important, especially in the case of the Covid-19 pandemic. During the pandemic, social distancing has been introduced as a remedy to reduce human interaction, as some people may be infected with the virus but not aware that they should be quarantined (Wilder-Smith and Freedman, 2020). As a result, the use of bicycles as an active mode of transportation has increased and this mode is highlighted to overcome problems related to social distance in the transportation domain (De Vos, 2020). Cycling provides broad benefits for users and society, such as improved health and reduced CO2 emissions and fuel consumption (Hood et al., 2011).

Based on data from the Indonesian Cycling Industry Association (AIPI), that demand for bicycles in Indonesia for several brands such as Polygon, United, Pacific, and Element has increased in the range of 60% - 80% by reaching more than 8-9 million units/year, both for bicycles for adults and children (Adell & Hiselius, 2021). Sales of bicycles in Indonesia during the Covid-19 pandemic increased by 50% to 200% or it can be said that demand reached 2000 bicycles per day while production capacity was only 850 to 1000 bicycles per day. Therefore, bicycle companies are competing to increase production due to skyrocketing demand in the midst of the pandemic. Increased productivity can be pursued by using the lean manufacturing method so that in production it can minimize processing time.

Figure 1 shows that the number of customer requests and complaints in 2020, namely in the months before the pandemic and after the pandemic, showed an increase. In January to May the company had an average demand of 22056 units and the number of complaints was 23 customers. After the company experienced the impact of the pandemic, from June to October the average demand was 44045, a significant increase of 99.7% and the number of complaints by 73, an increase of 218%. Therefore, appropriate methods are needed to improve quality and productivity.

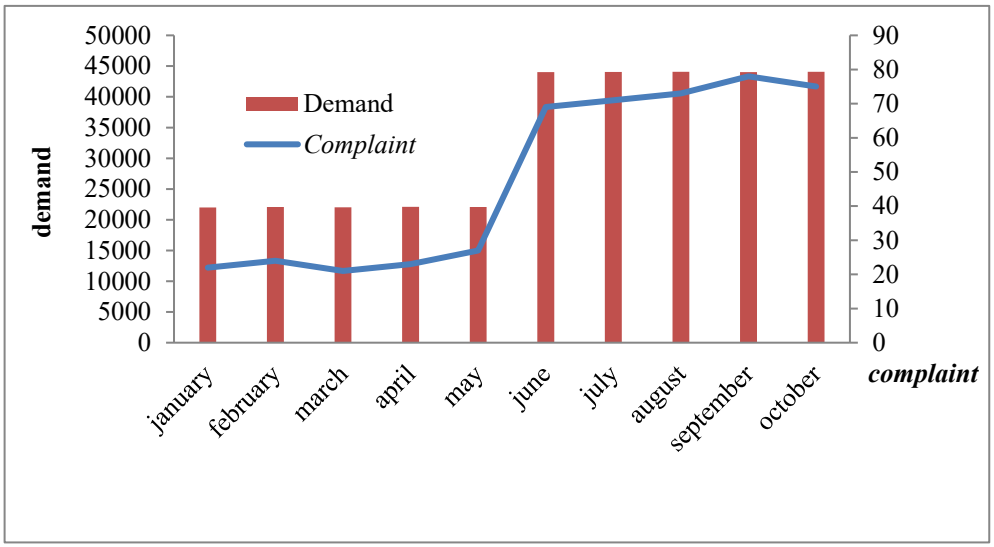


Figure 1. Number of customer demand and complaints in January – October 2020

The purpose of this study is to analyze the quality improvement of the electric bicycle production process using the FMEA method and recommend the proposed quality improvement in the electric bicycle production process based on the FMEA analysis approach.

2. Literature Review

One of the references used shows that the root cause of FMEA, can be applied to obtain solutions to reduce vehicle safety, and the analysis can be generalized to other products or manufacturing processes (Chi et al., 2020). Other journals show that FMEA can reduce the number of complaints and the application of this procedure has revealed about 1500 failure modes which are mapped and set to be filtered by 150 questions (Russo, Birolini, et al., 2016). The national journal used can reduce over time by 18% (Agung & Hasbullah, 2019). Other journals can result in the machine setup time in the insertion process being reduced from 145 seconds to 54 seconds (Azizi & Thulasi, 2015). A similar paper is to identify the factors causing the high changeover time of the model on the punching machine (Mulyana & Hasibuan, 2017). FMEA resulted in a 6% increase in productivity over a 6 month period and significantly reduced scrap rates (Ioana, Maria, et al., 2020). Another paper shows that the approach taken to prevent defects in the automotive industry, which considers maintenance to predict the condition of each component and assembly line using FMEA (Laseinde, 2021).

3. Methods

DMAIC

The first is Define: At this stage, process identification and SIPOC Diagram creation will be carried out. The SIPOC diagram is useful for providing an overview of the production process from the supplier to the customer. The second is Measure: At this stage, performance measurement is carried out based on each work station. The third is Analyze: At this stage the analysis process is carried out from the data and process maps that have been collected to find and determine the root cause of the process being studied, then it will be carried out with Pareto diagram analysis. Fourth, Improve: The improve stage is the stage where improvements will be implemented, namely FMEA which can generate priority problems and design creative solutions from proposed improvements to overcome and prevent problems faced in order to achieve the right and appropriate goals based on the results of the analysis on the research that has been done. . Fifth, namely Control: At this stage the researcher gives a limitation of the research, which is only to the improve stage in the form of recommendations for improvement for the bicycle industry. The improve stage relates to the determination and implementation of solutions based on the results of the analysis that has been carried out on each previous. One approach that can be used is Failure Mode and Effect Analysis (FMEA).

FMEA is a systematic approach used by engineers to identify potential failure modes and their effects (Yunanto et al., 2021; Simbolon & Hasibuan, 2018; Sultoni & Saroso, 2019). FMEA is an analytical tool that systematically identifies the consequences or consequences of system or process failures, and reduces or eliminates the chances of failure. Definition and ranking of various terminology in FMEA. The first stage, namely, the potential effect is the effect that is felt or experienced by the last user. Second, a potential failure mode is a failure or flaw in the design that causes the defect to not function properly. Third, the potential causes of failure are design flaws and changes in variables that will affect the process and result in product delays. Fourth, Occurrence (O) is an estimate of the probability or chance that the cause will occur and produce a failure mode that causes a certain effect. Fifth, Severity (S) is a subjective estimate or estimate of how badly the end user will feel as a result of the failure. Sixth, Detectability (D) is a subjective estimate of how effective and prevention methods are.

The data collection techniques used in this research are as follows, namely the first is a literature study which seeks and explores information or knowledge related to this research through scientific sources such as books, journals and others related to the research or problems encountered. Second, Observation is a data collection technique by conducting a direct review of every activity that occurs in the bicycle industry, especially in the conveyor line 1 section to identify the factors causing waste. Standard time, cycle, normal. At this stage using the observation sheet recording process time, observation analysis sheet. Research aids include writing instruments in the form of notebooks and pens, stopwatches, recorders, cameras, calculators. Third, the interview is an unstructured interview or often also referred to as an in-depth interview. This interview can be used to collect information that is not obtained from observations. To find out which Activity has more waiting time value. Regarding product quality. Fourth, Focus Group Discussion (FGD) is a data collection technique that is generally carried out in qualitative research with the aim of finding the meaning of a theme according to the understanding of a group. FGD is intended to avoid the wrong meaning of a researcher to the focus of the problem being studied. The FGD is a discussion group, not an interview. The forum group discussion (FGD) in this research was conducted with 5 or more related parties, namely from the QC department, R&D, production managers, and operators. For quantitative data, namely the observation sheet for recording processing time, the observation analysis sheet. Research aids include writing instruments in the form of notebooks, pens, stopwatches, recorders, cameras, calculators.

4. Data Collection

Picture 2 shows that there are several processes and work stations in the bicycle production process. There are 5 processes, first in the bicycle warehouse, namely the assembly of all bicycle spare parts from suppliers and will be recalculated according to demand and will be inspected by incoming QC. Next is welding which combines the bicycle frame connections from several parts such as the seat tube, top tube, and down tube. The third is the painting frame, which is carried out by the painting process on the frame and requires a fairly long drying time. Next is the assay wheel, which is the process of installing tires on bicycles and this process has quite a lot of work stations such as installing spokes, installing outer tires, pressing wheels, checking wheel torque, and others. The last is the assay line which includes com gear work stations, wheel stations, tensioners, brake levers, shifters, accessories, and packaging stations. From the seven work stations, Pareto diagram and FMEA analysis will be carried out.

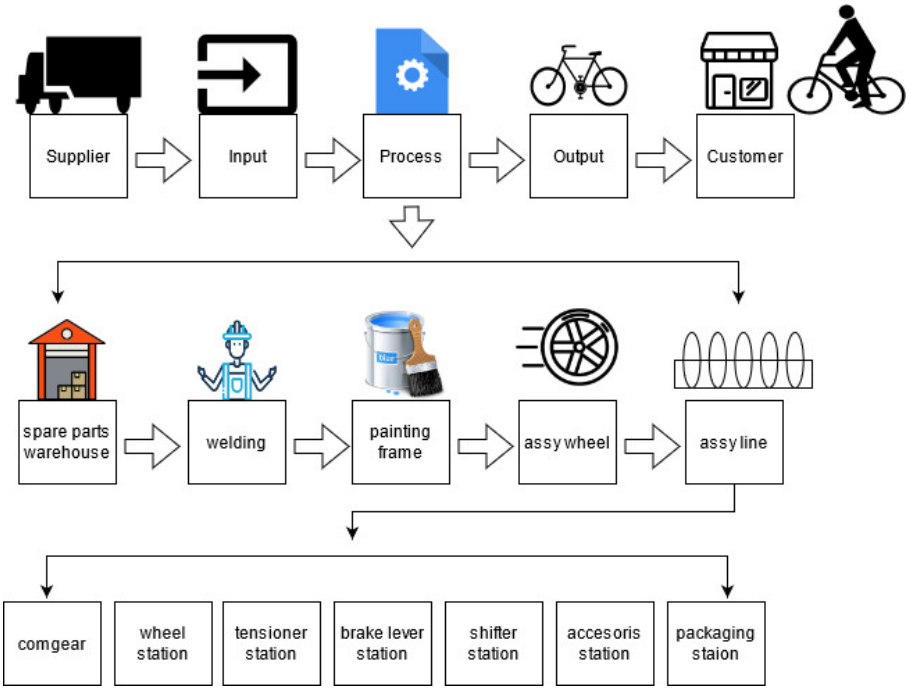


Figure 2. Flow process and work station

Table 1 shows that the types of defects found in the bicycle industry have 23 types and each type of defect has a varying number of defects. The types of defects such as the steam racer are not sturdy, the foam protector on the frame is damaged and cannot be fully closed, and the combination switch does not work and has the minimum number of defects, namely 3 and 4 units. The type of defect connector battery, frame with spots/smudges, display error, and loose wheel have a total defect of 11, 13, and 15 units.

Table 1. Type of defect

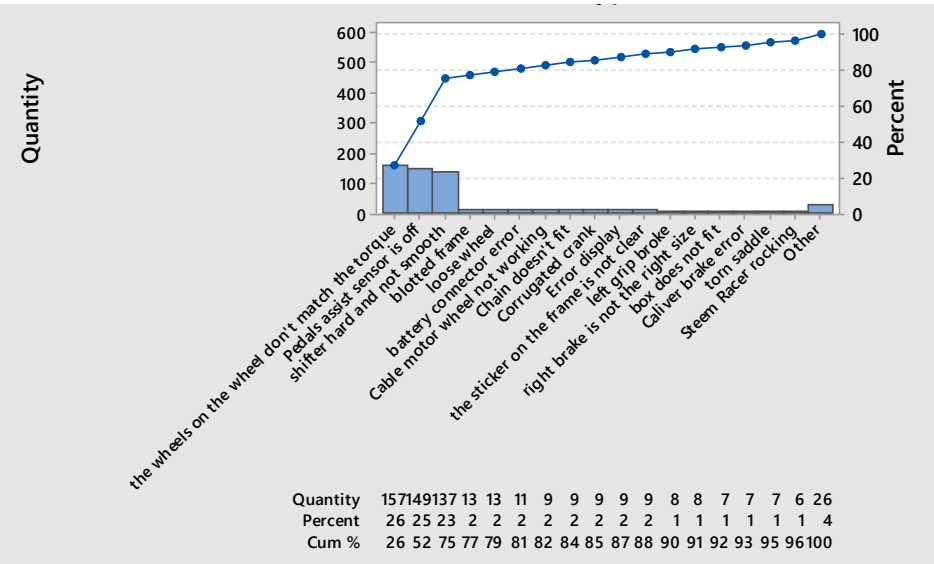
No	Defect Type	Quantity	No	Defect Type	Quantity
1	Battery connector error	11	13	Blotted frame	13
2	Corrugated crank	9	14	The handlebar is not straight and does not fit	6
3	Error display	9	15	Right brake is not the right size	8
4	Steam racer is not sturdy	3	16	Shifter hard and not smooth	137
5	Combination switch not working	4	17	Box does not fit	7
6	Cable motor wheel not working	9	18	The sticker on the frame is not clear	9
7	Pedals assist sensor is off	149	19	The barcode on the battery is not clear	5
8	Caliper brake error	7	20	The foam protector on the frame is broken and can't be fully closed	3
9	Chain doesn't fit	9	21	Left grip broke	8
10	Controller error	5	22	Torn saddle	7
11	Loose wheel	13	23	Steam racer rocking	6
12	The wheels on the wheel don't match the torque	157			

For the most types of defects, the wheels on the wheel do not match the torque, the shifter is hard and not smooth, and the pedal assist sensor is not active with the number of defects above 120. The three most types of defects are at different work stations, namely the wheel station and shifter work stations station, and accessories station (mudguard, handgrip, battery etc.).

5. Results and Discussion

5.1 Type of Defect

Picture 3 shows that there are 3 types of defects that have the most influence on the number of defects in the production process, namely the wheels on the wheel do not match the torque, the shifter is hard and not smooth, and the pedal assist sensor is not active with each having a number of defects of 157 units, 137 units, and 149 units. Of the three types of defects, 80% of the problems found in the production process and work stations that produce these defects will be prioritized for further FMEA analysis so that it can be seen which work stations have the most problems and are prioritized for repair in the near future.



Picture 3. Pareto chart from type of defect

5.2 FMEA Results

Table 2 shows that the rating value was obtained through a quantitative and objective assessment conducted through FGD with the R & D, QC, and operator departments on the known factors causing defects. FMEA analysis was made based on the results of brainstorming with supervisors, observations, and observations assisted by the R & D. FMEA analysis is devoted to the results of 80% of the total number of problems in accordance with the principle of the Pareto diagram to determine the priority of risk based on the effect of failure, the frequency of the number of events, and effectiveness in detecting process failures.

Table 2 FMEA

Make of Failure	Potential Failure	Severity	Cause of Failure	Occurance	Current Process Control	Detection	RPN
Comgear station	The result of the press pedals are not up to standard	3	Press tools / guns are old, the power cable is sometimes messy and hangs, disturbing workers	4	The operator only performs a visual check of the press results	3	36
wheel station	Freewheel is tough and can't turn back	8	The process is done manually and there are no work tools	8	The operator only performs a visual check	2	128
Tensioner station	Ceting installation is not up to standard	3	Installation of bolts with work tools and there is a manual process at several work stations	4	The operator only performs a visual check of the spot results and only focus on production target	2	24
Brake Lever station	The rear brake is still not up to standard and not gripping	3	Installation of bolts with work tools and there is a process with a screwdriver	3	The operator only performs a visual check	2	18
shifter station	Gear changes / when the transition is not smooth	5	Tools from suppliers are damaged and have errors	4	The operator only performs a visual check	2	80
Accessoris station (mudguard , handgrip, battry etc)	The nut when installing the mudguard does not match the torque	8	Old bolts and wrong accessories from the supplier	7	The operator only performs a visual check of the spot results and only focus on production target	3	112
packaging station	The results of packing are not neat and do not cover the critical parts (the frame is hit by a collision)	4	Operators do it in a hurry	3	The operator only performs a visual check of packaging process	3	36

5.3 Improvements

From the results of the FMEA analysis that has been carried out, it can be concluded that the RPN value contained in the welding & press process shows varying results. In the wheel station process, it ranks first with the highest RPN, which is 128. For the Accessories station process, it is in the second rank, which is 112. The third rank is occupied by the shifter station process with a value of 80. It can be seen that these 3 processes are the main problems that must be prioritized. in order to reduce the number of defects and improve the quality of the bicycle production process.

5.4 Validation (11 font)

The risk priority number (RPN) is obtained by means of RPN = severity x occurrence x detection. After the RPN value is known, then through ranking, the RPN value is sorted from the largest number to the smallest number. Based on the results of the calculations above, the RPN values contained in the process show varying results. In the wheel station process, it ranks first with the highest RPN of 128. For the Accessoris station process it is in the second rank, which is 112. The third rank is occupied by the shifter station process with a value of 80. For other processes the total

RPN value is very low even less than 40 after obtaining the top three rankings from the entire process, management should prioritize the three processes first and correct errors that result in large number of defects and improvements must be made to the three processes thoroughly and appropriately.

6. Conclusion

Based on the results of observations and observations that have been made, several conclusions have been obtained, namely that in the bicycle industry during the Covid-19 period there was a significant increase in production, namely with brands such as Polygon, United, Pacific, and Element, which increased from 60% to 80% by reaching more than 8-9 million units, both for bicycles for adults and children. From January to May, the company had an average request of 22056 and the number of complaints was 23. After the company experienced the impact of the pandemic, from June to October the average demand was 44045, a significant increase of 99.7% and the number of complaints was 73, which increased by 218. %. And from the results of the FMEA analysis that has been done, it can be concluded that the RPN value contained in the welding & press process shows varying results. In the wheel station process, it ranks first with the highest RPN, which is 128. For the Accessories station process, it is in the second rank, which is 112. The third rank is occupied by the shifter station process with a value of 80. It can be seen that these 3 processes are the main problems that must be prioritized in order to reduce the number of defects and improve the quality of the bicycle production process.

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