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Analysis of Product Quality Control Using FTA (Fault Tree Analysis) Method

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Abstract:

Shoes are one of the protectors of the human body as footwear used for daily activities. In addition to being a means of body protection, shoes are currently used as school uniforms. CV. Esa Kalen Jaya is a company that produces upper school shoes. But CV Essay Kalen Jaya experienced problems in the production, namely uncontrolled defective products produced by 1,542 pairs of upper shoes. So the need for analysis of the causes of defects and provide suggestions for quality improvement due to factors that cause product defects. To be able to determine the root cause of product defects used FTA (fault tree analysis) method. The result is that the cause of the occurrence of disability is caused by 9 factors. With improvement recommendations conduct training and evaluation on a regular basis to help improve the ability of workers in sewing so as to minimize errors.

Keywords: *Fault Tree Analysis, Defect, Upper, Shoes.*

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1. Introduction

According to (Wirawati, 2019) quality control is a process that must be carried out before the start of the production process, during the production process, until the end of the production process with the manufacture of the final product. Quality control is carried out not only to produce results in the form of products or services that meet the expected standards. But also improve the quality of products that have not met the established standards and maintain adequate quality.

CV. Esa Kalen Jaya is a subsidiary of manufacturing holding company PT. Esa Kalen Jaya which is a manufacturing company that produces upper school shoes located at Jl.Jombang Temuwulan District Perak Jombang Regency East Java 61461. The company was only established in 2022 by producing semi-finished goods, namely the production of shoe uppers with materials supplied by the parent company. Where the upper shoe production output produced will then be distributed to the parent company every week to be assembled with other parts in the parent company to become a

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finished shoe product that is ready to be marketed to consumers. It's a very young age for a company. CV. Esa Kalen Jaya currently still has many obstacles. one of the obstacles faced today is uncontrolled defective products or defects produced. This can be proven by finding product defects of 1,542 pairs of shoes out of a total production of 12,300 pairs. The damage of 1,542 pairs of shoes included 189 nempul defects, 1109 unstitched defects, 131 oblique band defects, and 113 defects in material damage. This disability is classified as very high because it exceeds the expectations of the company's desired standard of 9% while the disability generated by the company reaches 12.5%. Failure in production is classified as very high and needs to be improved to reduce the number of defective products in each production process. The quality control applied by the company today is to inspect the product and repair the product without knowing the cause of the product defect.

To overcome the above problems, an appropriate method is needed to find the root cause of the defect to reduce the level of product defects in the company. The method that can be used to overcome product defects and find out the root cause of defects is by using the FTA (fault tree analysis) method. The FTA (fault tree analysis) method is used because this method is an analysis method that can analyze system failures by analyzing the risks that play a role in the emergence of a major failure, and can find the cause of product defects in the production process (Wicaksono et al, 2022).

By using this method is expected to analyze and identify the causes of disability in order to be known and can be addressed as soon as possible. This method is also expected to provide suggestions for quality improvements due to factors that cause defects in shoe upper products that exist in CV. Esa Kalen Jaya. With the hope of CV. Esa Kalen Jaya can implement this method in production process activities. Until the CV. Esa Kalen Jaya can overcome defects and can reduce product defects as soon as possible.

Based on the background that has been described above, then the formulation of the problem in this study is how to analyze the factors that cause defects in school shoe upper products and provide suggestions for improvement.

The purpose of this study is to analyze the causes of defects in school shoes upper products in CV. Esa Kalen Jaya and provide suggestions for quality improvement due to factors causing product defects.

2. Theoretical Background

Quality

Quality is very important for a product, both in the form of goods and services. For manufacturers, quality, cost, and productivity are critical in producing a product. Quality is the ability of a product or service to consistently meet consumer expectations. So quality is the single most important thing for both sides. In many cases, the concept of quality differs between manufacturers/producers and customers/consumers. Quality is a measure of a product or service in terms of

subjective quality, quality is very important for the product to increase sales and compete with similar products from other companies. According to experts, the definition of quality is as follows:

According to Assauri in the study (Shiyamy et al., 2021), the activity that guarantees the reflection of the quality policy (standard) on the final result is quality control. Quality control involves a broad understanding, including aspects of policy, standardization, Control, Quality Assurance, Quality Development and legislation. Quality control is a management tool to improve product quality when necessary, maintain high quality and reduce the number of defective materials. Therefore, it can be concluded that quality control is an attempt to maintain the quality of purchased goods in such a way as to comply with product information determined based on company policy. In terms of quality control, it is necessary to check all products purchased according to standards and record and analyze deviations that occur, so that they can be used for production improvement activities in the future.

According to Nasution in research (Syarifah Nazia et al., 2023) states that quality is the dynamic state of products, people, work, processes and tasks, as well as the environment that meet or exceed customer or consumer expectations. According to fahmi in the study (Kiki et al., 2019) says that a product is considered to have quality if the product is in accordance with the expectations of various parties, especially producers and consumers.

Defect Product

According to Kotler in the study (Puspasari et al., 2019) says that "a product is everything that can be offered to the market to meet and satisfy the needs or desires of consumers". Defective products are products whose condition is damaged, or does not meet established quality standards, and cannot be repaired economically and produced into good quality products. Although technically it can be repaired and can be done, it can result in repair costs that will be higher than the increase in value or benefits of repairs. Defective products are finished products, but their condition does not meet the established standards.

According to Mulyadi in the study (Puspasari et al., 2019) defective products i.e. products that do not meet the established quality standards, which cannot be economically repaired into a good product and cannot be economically accounted for as a good product. Defective products are different from the rest of the materials because the rest of the materials are materials that have been damaged in the production process, so they have not yet had time to become products, while defective products are products that have absorbed material costs, labor costs and factory overhead costs.

Quality Control

Quality control is a control tool in the manufacturing process of a product or service produced in accordance with established quality standards so that the resulting product is able to meet the needs and customer satisfaction, increase company profits and

reduce production costs (Kiki et al., 2019). According to experts, quality control is defined as follows :

According to (Wirawati, 2019) quality control is a process that must be carried out before the start of the production process, during the production process, until the end of the production process with the manufacture of the final product. Quality control is carried out not only to produce results in the form of products or services that meet the expected standards. But also improve the quality of products that have not met the established standards and maintain adequate quality. According to pasaribu in the study (Kiki et al., 2019) quality control can be defined as a technique in manufacturing or factory management that will produce or manufacture goods of the same quality. Producing goods of the same quality can be explained that the goods produced in accordance with the same standards and quality.

The Relation of Quality Control with Product Quality Improvement
According to Wahyuni in the study (Kiki et al., 2019) says that in the process the quality must be integrated with all existing parts of the production at the enterprise. Quality cannot stand alone, because the availability of quality goods or services must be supported by a quality process from input to output. Therefore, by implementing optimal quality control activities, it can prevent problems or minimize deviations and non-conformities that can directly affect product quality.

FTA (Fault Tree Analysis)
According to (Markulik et al., 2021) Failure tree analysis (FTA) is a qualitative and quantitative analysis of a tree-shaped failure. It defines the relationship between the peak event-the failure-and the base event (root), which is a fault of the lowest element of the system or an external influence. The error tree is created in an understandable form, analyzed and modified if necessary to simplify the identification of failures. From the highest failure level-the top event-it is possible to proceed from the tree level to the base event. In this way, it is possible to investigate each dependency in its subsystem. In analyzing this method, a systematic approach is needed, because it is necessary to capture the functional linkages between the monitored system elements. The FTA method is carried out from top to bottom through the tree, in order to recognize the causal dependence of the peak event. FTAs are particularly suitable for the analysis of complex systems consisting of functionally dependent subsystems to fulfill a defined function. It is suitable for cases where the analysis process requires many different specialties.

According to Priyatna in the study (Iraz., et al, 2023) Fault tree analysis (FTA) is a technique used to identify risks that play a role in the occurrence of a failure. FTA can also identify relationships between causal factors and can be displayed in the form of a fault tree. Error tree analysis is one of the methods used to analyze the root cause of work failure with a top down approach, which begins with the assumption of failure from the top event and then details the cause of a top event to a basic failure (root cause).

Fault Tree Analysis (FTA) is a technique used in identifying risks that play a role in the emergence of a failure, this method is done with a top down approach, which begins with the assumption of failure from the top event (top event) and then details the causes of a top event to a basic failure (root cause). Fault Tree Analysis (FTA) identifies relationships between causal factors and displays them in the form of a fault tree. Fault tree analysis (fault tree analysis) is one of the methods that can be used to analyze the root causes of work accidents or work failures, Fault Tree Analysis (FTA) is a technique for classifying instrumental relationships that lead to certain failure modes (Wicaksono et al, 2022).

Fault tree analysis is a simple fault tree analysis technique that can be described in detail related to the causal relationship of events that occur in creating a fault tree model. FTA is more focused on damage that has a level of importance at the highest level (undesired top-level event).The analysis begins by defining the defect (undesired event) and then systematically will involve all possible events and errors that can lead to disability analysis conducted will identify all events along with their causes. FTA uses analysis to find the causal relationship of an event in the system (Suseno, 2022). FTA is a deductive analysis method for identifying damage to a system by describing alternative events in a structured block diagram. Deductive analysis can be performed on complex systems. The starting point of FTA analysis is the identification of failure modes at the top level of a system. The failure tree describes the state of a system component (Basic Event) and the relationship between the base event and the top event. Expressing this relationship is called a logic gate (Hariadi et al., 2023)

Cut Set Method

According to research (Nurfatha & Herwanto, 2023) The Cut set method is a series of system components that can cause system failure if failure occurs, while the minimum cut set is a series of minimal system components that can cause system failure. Furthermore, the FTA can be analyzed to obtain clear information about the condition of the system and determine the improvements that need to be made. Determining the minimum cut set is a qualitative analysis using boolean algebra. Boolean algebra is an algebra that can be used to simplify or decompose complex and complex logic circuits into simpler logic circuits .

According to (Clifton A Ericson, 2022) cut set is a tree-forming combination of errors if smeua occurs, it will lead to a peak event. It is also useful to check and evaluate the error diagram obtained by drawing a line through the blocks in the system to show the minimum of failures that can cause the entire system to fail

3. Methodology

This research was conducted at CV. Esa Kalen Jaya, located at JL. Jombang Temuwulan District Perak Jombang Regency East Java 61461. The research approach used is qualitative and quantitative. The use of both approaches is influenced by the use of FTA (fault tree analysis) method in data processing. The FTA method introduces qualitative inputs in the form of human perception, which then qualitative

values will be converted into quantitative values in order to be processed further. The method of data collection used in this study is using primary data and secondary data. Where the primary data obtained directly through interviews with the quality control, field observations and documentation. The data taken in the primary data is quality control data, the number of defective products, types of defective products and others. While secondary data is data that is available by the company. Secondary Data is sourced from company documents from each division. Secondary Data taken include data on the total production of upper shoes, disability data on production, data on the type of disability in one production, the factors causing disability.

4. Empirical Findings/Result

Production Quantity data

There are several defects that occur in shoe upper products where the products produced are not in accordance with predetermined standards. Here is a list of defect types.

Table 1. The Number Of Defects And Type Of Product Defects For The Period February 2023-January 2024

Bulan	Jumlah *Defect* Per Pasang				Jumlah
	Nyepul	Tidak Terjahit	Pita Miring	Kerusakan Bahan	
February	189	1109	131	113	1542
March	196	1124	132	87	1539
April	156	980	113	81	1330
May	187	899	112	95	1293
June	169	876	117	120	1282
July	198	892	145	98	1333
Agust	198	1241	178	101	1718
September	178	897	169	120	1364
October	169	895	188	96	1348
November	280	1109	156	121	1666
December	165	962	187	83	1397
January	288	1033	168	98	1587

Product defect identification

Based on the table above, it can be seen that the types of defects include nempul, unstitched, oblique tape and material damage so that the percentage of defects and cumulative percentage can be calculated. The following is a histogram table and pareto diagram for the identification of product defect data.

Figure 1. histogram of product defects

Figure 2. Pareto Of Product Defects

1. *Fault Tree Analysis* for each *Top Event*

After each defect has been identified related to the cause of the defect using a causal diagram will then proceed to create an FTA diagram for each defect.

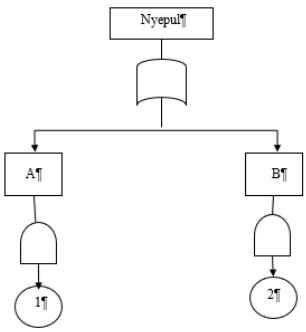

Figure 3. Diagram Fault Tree Analysis defect Nyepul

Description:

A : Human Error

B : Les Engine maintenance

1 : less meticulous tailors in sewing upper shoes

2 : sewing machine stuck

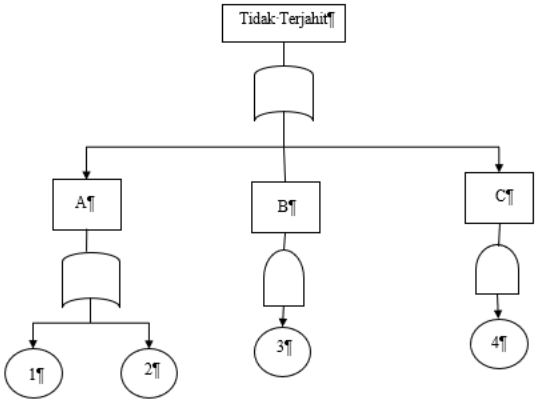

Figure 4. Diagram Fault Tree Analysis Defect Tidak Terjahit

Description :
A :Human Error
B : Material
C : Less machine maintenance
1 : Less meticulous tailors in sewing upper shoes
2 : not sewn according to the pattern
3 : Needle damage such as broken and bent
4 : sewing machine jam

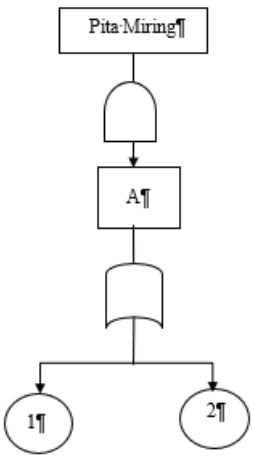

Figure 4. Diagram *Fault Tree Analysis* Cacat Pita Miring

Description:
A : *Human error*
1 : Lack of training
2 : Fatigue factors

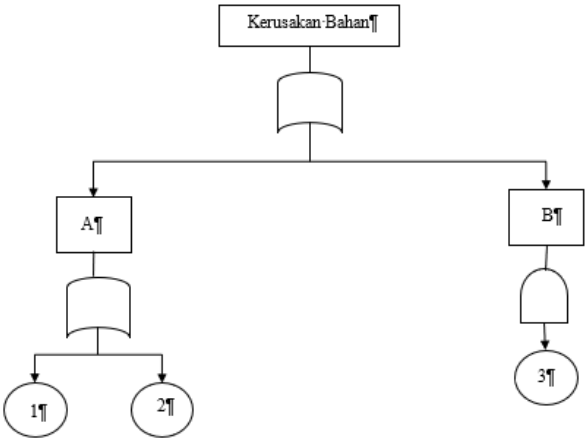

Figure 5. Diagram *Fault Tree Analysis* Cacat Kerusakan Bahan

Description :
A : *Human error*
B : *Material*
1 : errors during shipment
2 : the cut does not fit the pattern
3 : Supply of goods from the parent company has been disabled

2. Basic Event probability calculation

After identification of the root cause of disability or basic event, it can be seen that the root cause or basic event for 12 months. The following is the probability calculation data of each basic event.

Tabel 2. Probability Of A Root Cause Or Basic Event

No	Root cause *(basic event)*	Average frequency of occurrence	Average total production	probability of occurrence
1	less meticulous tailors in sewing upper shoes	7,61	10.576,02	0,0007192
2	Sewing machine stuck	3,89	10.572,3	0,00367736
3	Needle demage such as broken and bent	3,49	10.571,91	0,000330157
4	Not sewn according to the pattern	3,84	10.572,25	0,000362887
5	Lack of training of employees	6,18	10.574,6	0,000584674
6	Fetigue factors	15,96	10.584,38	0,00150833
7	Supply of goods from the parent company has been disable	1,96	10.570,38	0,000185266
8	Errors during shipment	0,95	10.569,37	8,9611
9	Cutting does not fit the pattern	0,96	10.569,37	9,0367

3. Calculation *Cut Set Method*

In the calculation of the cut set method, the following results are obtained:

a. Defact nyepul
   The probability result calculated before evaluating is 0.0043939 or 0.4393% for 12 months of production process. While the probability generated after the evaluation of.0.00439656 or 0.4396%.
b. Defect tidak terjahit
   The probability result calculated before evaluating is 0.0047 or 0.47% for 12 months of production process. While the probability generated after the evaluation of.0.00475 or equal to 0.475%
c. Defect pita miring
   The probability result calculated before evaluating is 0.002092122 or 0.209% for 12 months of production process. While the probability generated after the evaluation of.0.002093004 or equal to 0.2%
d. Defect kerusakan bahan
   The probability result calculated before evaluating is 0.000365968 or 0.03% for 12 months of production process. While the probability generated after the evaluation of.0.000366001 or 0.03%.

So it can be interpreted that the calculation before evaluating and before evaluating the calculation of the cut set has changed. And it was found that the probability of occurrence of the highest defects in the defect is not sewn by 0.475% and the probability of occurrence of the lowest defects in defects of material damage by 0.03%Hasil probabilitas yang dihitung sebelum melakukan evaluasi adalah sebesar 0,000365968 atau 0,03% selama 12 bulan proses produksi. Sedangkan probabilitas yang dihasilkan setelah dilakukan evaluasi sebesar.0,000366001 atau sebesar 0,03%.

Repair Recomendation

After the calculation for the value of the probability of disability that will occur based on the top event, it will be continued by providing improvement recommendations for each basic event or the root cause of disability sebauh presented in the following table:

Tabel 3. Repair recomendation

No.	*Basic Event*	Recomendation
1	less meticulous tailors in sewing upper shoes	Conduct regular training and evaluation to help improve the ability of workers in sewing so as to minimize errors.
2	Sewing machine stuck	We recommend that tailors perform maintenance on the sewing machine periodically, tailors pay more attention to the tension on the thread. And the tailor adjusts between the sewing thread, needle and the thickness of the upper of the shoe.
3	less meticulous tailors in sewing upper shoes	Conduct regular training and evaluation to help improve the ability of workers in sewing so as to minimize errors.
4	Sewing machine stuck	We recommend that tailors perform maintenance on the sewing machine periodically, tailors pay more attention to the tension on the thread. And the tailor adjusts between the sewing thread, needle and the thickness of the upper of the shoe.

5	Needle demage such as broken and bent	It is best for the tailor to change the needle periodically and choose a sharp needle with a certain thickness so that it does not break easily.
6	Not sewn according to the pattern	Before sewing better seamstress to analyze the pattern.
7	Lack of training of employees	Provide training related to sewing on the ribbon to comply with established standards.
8	Fetigue factors	This fatigue can be minimized by reducing very high production targets or increasing the number of existing employees. And provide adequate rest to employees.
9	Supply of goods from the parent company has been disable	We recommend that the parent company further develop an effective supervision system to monitor the quality of raw materials to be received by the branch company. It can detect defects early on and stop the delivery of raw materials that do not meet quality standards. Branch companies are developing better quality control systems to ensure that the raw materials received meet quality standards .
10	Errors during shipment	Optimize supervision procedures for workers so that workers are more focused on work.
11	Cutting does not fit the pattern	Conduct regular training and evaluation to improve workers ' ability to cut materials according to predetermined patterns. Provide information evenly on each worker in order to understand well how to cut the material according to a predetermined pattern, so as to minimize errors.

5. Conclusions

Based on research that has been done on CV. Esa Kalen Jaya then it can be concluded that there are 9 causes of defects in the upper shoe production process that is less meticulous tailors in sewing upper shoes. The sewing machine is stuck. Needle damage such as broken and bent. Not sewn according to the pattern. Lack of training in employees. Fatigue factor. Supply of goods from the parent company has suffered a defect. Errors at the time of delivery. Cutting does not fit the pattern.

So that the proposed improvements that can be given to CV Esa Kalen Jaya is to conduct regular training and evaluation to help improve the ability of workers in sewing so as to minimize errors, tailors perform maintenance on the sewing machine periodically, tailors pay attention to the tension in the thread, and adjust between the sewing thread, needle and thickness of the upper, Before sewing taylor better to analyze the pattern first, preferably CV. Esa Kalen Jaya reduce very high production targets or increase the number of existing employees to get better quality production results, preferably CV. Esa Kalen Jaya provides adequate rest time for employees to minimize the occurrence of fatigue, the parent company should further develop an effective supervision system to monitor the quality of raw materials to be received by branch companies. It can detect defects early on and stop the delivery of raw materials that do not meet quality standards. Branch companies are developing better quality

control systems to ensure that the raw materials received meet quality standards, optimizing supervision procedures for workers to focus more on work, providing information evenly to each worker in order to understand well how to cut materials according to a predetermined pattern, so as to minimize errors.

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