Analysis of the Causes of Thread Cone Products Below the Tensile Strength Index Value

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Abstract

Yarn spinning is an important aspect of the world of textiles. This is because spinning is the main focus of the textile industry sub-sector. Therefore, when yarn products are not suitable, this can have an impact on consumers and companies. This research then aims to look at the problem of the non-standard strength index of 30 TR 65/35 process cone threads using a problem-solving method through the PDCA concept. This research will be carried out using semi-quantitative methods. The analysis method used incorporates concepts from FTA (Fault Tree Analysis) and PDCA. The results of this research then found that the case study at PT X identified the main cause of non-standard tensile strength of 30 TR yarn as a combination of material suitability, machine condition, and environmental factors which had the most significant impact. The use of SFX brand polyester fiber and SPV brand rayon as raw materials, as well as an appropriate waste reuse sorting process, has been proven to increase the quality of the tensile strength of the yarn. Errors in twist values and suboptimal machine maintenance were also found to contribute to a decrease in yarn tensile strength. Production environmental conditions, such as high humidity, have a negative effect on yarn strength. An effective solution to this problem was found by adding wax to the thread, increasing its tensile strength by 7%.

Keywords: *Yarn, Tensile Strength, Spinning, Machine.*

A. INTRODUCTION

In the world of textiles, several sub-fields are the main focus of the textile industry, one of which is yarn spinning. Spinning is the process of processing the initial product in the form of lumps of fiber, both natural and artificial fibers, which are processed in such a way using high-tech machines through the concept of reducing the material (drafting) into small fiber strands called yarn (Ruckdashel et al., 2021). One of the yarn-spinning companies is PT X. The vision and mission of this company are to produce high-quality products supported by the application of the latest technology, especially Ring Spinning and Winding machines, which both adopt robot doffing technology in the hope that they will be accepted by the market. However, meeting market and consumer needs, cannot be separated from the existence of inappropriate product quality due to several problems in the production process (Yin et al., 2021).

On the Winding machine, as the final gate of the yarn production process, several products are usually found that are not suitable as a result of the previous process. The winding machine used is under the Saurer Schlaforst brand and is of the Autoconer 6 type which has the advantage of automatic doffing and is also equipped with Uster Quantum 3 as a component for assessing yarn quality (Ali et al., 2021). One of them is a cone yarn product that has an inappropriate level of tensile strength. Many factors cause this problem, especially as a result of previous processes, such as the main process of forming yarn in Ring Spinning. Products that do not meet the criteria or can be said to be defective are the result of errors that occur during the production process (Prasad et al., 2020).

The existence of inappropriate products will have an impact on consumers and companies. The results of this coness yarn product will usually be a problem when processed in further processing (weaving), yarn with a non-standard strength index, either lower or higher than the tolerance limit, will result in a bad end to the process (Schmutz & Som, 2022). If the quality of the thread produced is not optimal, it will become a low-grade product or even unusable. Therefore, follow-up action is needed to resolve the problems that occur and find the root cause of the non-standard products produced (Cooper & Claxton, 2022).

Judging from the background of the problem and observation of thread quality data, it was found that there were non-standard deviations in the tensile strength values in the 30 TR 65/35 process thread cone products. This research then aims to find out and understand the problem and obtain answers to cases of non-standard cone thread strength index for the 30 TR 65/35 process using the problem-solving method through the PDCA concept.

B. LITERATURE REVIEW

1. Spinning

Spinning is the process of turning fiber into yarn. This process is included in the dry process so that the waste produced is in the form of dust originating from short fibers and noise generated from machines where the waste produced depends on the type of fiber being processed. The theoretical basis of this research is based on matters that discuss yarn quality which focuses on the yarn tensile strength index (Raian et al., 2023).

The yarn spinning process is a process where raw fiber is processed in such a way using certain machines. The fiber, which is initially in the form of a large box bearing, is broken down and cleaned using a blowing machine, then goes to the next process, namely separation and further cleaning which is carried out in a carding machine. After the fibers are separated and then formed into long strands called slivers, the resulting sliver carding will be further processed in the drawing machine to combine several slivers into one (Uddin & Uddin, 2023). Then the sliver from the drawing machine is used as feed material for the flyer machine. In this machine the sliver will undergo shrinkage and stretching (drafting) and then be rolled on a tube-shaped medium called a bobbin. This bobbin is the forerunner of the thread in the Ring Spinning machine (Jalil et al., 2021).

Figure 1. LMW AX9 Spinning Ring

Ring Spinning Machine is a machine used in the process of making yarn, usually for fabric-making materials. The process involves spinning the fiber into yarn by rotating the fiber through a series of elements, including take-up rollers, wire rollers, and the main machine, called a ring frame. The process of making yarn begins with taking raw fibers from materials such as cotton, wool, or synthetic fibers. These fibers are then processed through various stages, including cleaning, winding, and spinning (Abdkader & Hossain, 2023).

With this machine, the raw fiber is fed into the machine by a forklift. The fiber then passes through a series of take-up rollers that continuously rotate to pull the fiber into the machine. After passing through the take-up roll, the fibers pass through the screen roll, where they are guided in the desired direction and flattened (Müller et al., 2020). After passing through the wire rollers, the fiber enters the main machine, or ring frame, where the fiber is spun into yarn. The main machine uses a series of bobbins rotating at high speed to spin the fiber continuously, forming a consistent and strong thread (Jiang et al., 2023).

Ring Spinning Machines are very important in the textile industry because they can be used to produce yarn with high quality and cost efficiency. This machine is widely used throughout the world to produce yarn used in making various types of fabric. On the Ring Spinning machine, the output is the thread that is still rolled in the cop and then carried out the winding process in the Winding machine (Mahmood, 2020).

2. **Winding Machine**

A thread winding machine is a machine used to wind thread on cheese. These machines are commonly used in the textile industry to produce yarn used in various applications, such as clothing, fabrics, and technical textiles. The process of using a winding machine, namely passing the thread through several control machines, including cleaning machines, winding machines, and binding machines. The thread is then directed to the Winding machine, where the sorted thread is put into a magazine and arranged to produce neat spools of thread following production specifications (Azeem et al., 2022).

The Saurer Schlaforst Autoconer machine is application-based in carrying out its production and has 60 spindles. The function of the Schlaforst Winding machine is as follows:

a. Sorting and cutting threads that are out of standard.
b. Improve thread quality (thin, thick, hairiness, neps).
c. Connecting thread.
d. Change the shape of the cop roll to a cone (Gramsch et al., 2022).

According to Wicaksono, Winding Machine parts include:

a. Machine Head
   At the head of the machine, there is a monitor that can control or regulate all the parameters of the Winding machine. One Winding machine line consists of 60 spindles, this part functions to regulate the 60 spindles.
b. Spindle
   The spindle is the part that regulates the thread-winding process.
c. Cones Winder
   Functions as a winder for the thread from the machine to the spool (cones), if the spool is at the desired length then the winding process will stop, equipped with a sensor that can read the length of the thread.
d. Sensing head
   This is the part of the machine that detects thread quality. If the sensor reads that the thread quality does not comply with QC, it will automatically be cut by a knife (cutting device).
e. Splicers
   Functions as an automatic thread connector using air assistance from the compressor. The threads from the section arm and gripper arm are combined in this splicer. The wind is blown as if to provide a twist so that the thread reconnects.
f. Section Arm and Gripper Arm
   The section arm and gripper arm are suction arms that function to suck and pull the thread. In the section arm, there is an up-end sensor that functions to read whether there is a thread passing through the section arm. If there is, thread winding will continue, but if there is none, the sensor sends a command to the spindle so that the spindle stops and there is a sign/parameter that states that there is no thread passing through the section arm.
g. Upper Tube Holder
   The upper tube holder functions as a tube holder at the top where the thread will later be rolled up and moved the tube to the tube holder below.

h. Lower Tube Holder
The function is to catch/receive the tube from the top tube and if it is felt that the thread on the cop has run out, it will be thrown away and replaced with a new tube.

i. Conveyor belt
In this part of the machine, there are two places for placing the running belt according to their respective functions. At the bottom front of the machine, the conveyor belt functions to move the empty tubes to the storage area. Meanwhile, at the top and rear of the machine, the conveyor belt functions to move full cones from all splicers to the back of the machine head.

j. Engine Tail
The tail of the machine is at the very end of the machine. In this section there is an emergency button that functions to turn off the machine in one line, there is also a container for empty tubes (Selema et al., 2022).

Yarn Winding Machines are available in various sizes and capacities and can be controlled automatically or manually. Some yarn winding machines are also equipped with sensors and monitoring systems to ensure the quality of the yarn produced, such as thickness, fineness, and tensile strength. Yarn Winding Machines are an important part of the modern textile industry, enabling manufacturers to produce yarn more efficiently and consistently, with shorter production times and lower costs. The final result of the winding machine is thread cones that are ready for marketing. However, it is not uncommon for this yarn to have several specifications and quality inadequacies (Pereira et al., 2023).

3. Yarn Quality

Quality is the level of goodness or badness, the level, or what can also be called the degree of something. Yarn is a regular arrangement of fibers in a longitudinal direction with a diameter and number of twists obtained from a process called spinning. It can be concluded that yarn quality is a level and quality value that indicates the condition, appearance, and suitability of the yarn product to be processed in the next stage (Haleem et al., 2021). Yarn quality itself consists of many aspects, starting from the IPI (Imperfection Index), thread properties, and thread construction. In the world of the manufacturing industry, especially in textile threads, product quality is of great concern, this is related to efforts to control production quality to produce a final product that is high quality and useful (Hoque et al., 2022). One of the qualities of thread is in terms of the strength of the thread relative to the weight of the thread itself, thread strength is the ability of the thread to withstand tensile force or tension without breaking. So, thread strength testing needs to be carried out to determine the quality produced (Liu et al., 2023). Some commonly used yarn strength testing tools are:

a. Universal Testing Machine (UTM): UTM is a strength testing tool that is often used to measure the tensile strength of yarn. The thread is placed between two handles and then pulled at a constant speed until it breaks. The pulling speed and maximum load applied to the thread will be recorded. This data is used to calculate the tensile strength and mechanical properties of the thread (Saritha et al., 2023).

b. Yarn Tension Meter: This tool is used to measure yarn tension during the textile manufacturing process. Yarn Tension Meter measures the tensile strength of thread on a spinning or weaving machine and provides feedback to regulate the speed and tension of the thread so that it remains stable during the production process (Genene Abay & Ayele, 2023).

c. Single Yarn Strength Tester (Uster): This tool is used to measure the tensile strength of a single yarn. The thread is fed into the machine and pulled until it breaks. The maximum pulling speed and load are recorded and used to calculate the tensile strength of the thread (Penava et al., 2021).

d. Twist Tester: This tool is used to measure the amount of twist in a thread and the associated tensile strength. The thread is stretched and clamped at both ends, then pulled manually to measure the tensile strength and check the number of thread twists (Liu et al., 2023).

e. Abrasion Tester: This tool is used to measure the abrasion resistance of threads to friction. The thread is placed on a machine and spun at a certain speed while being subjected to friction. The abrasion resistance of a thread is measured by determining how long the thread can last before it breaks or breaks (Miao et al., 2023).

C. METHOD

According to Sugiyono, research methods are a scientific way to obtain data with specific purposes and uses. From this statement, it can be concluded that several aspects need to be emphasized in research, namely scientific methods, data, objectives, and uses. Then, according to Subagyo, research methods are a way or way to find solutions to all the problems posed. It can be concluded that research methods are a set of rules, activities, and procedures used by practitioners of a scientific discipline. The type of research used in this report is semi-quantitative because the preparation of the final project report requires data processing in numerical/number form with test variables that can be measured (quantification). The data is in the form of test results of yarn quality samples which show the magnitude of b-force (gF), elongation, and Rkm (Kilometer Resistance). The main focus of this report discusses the Rkm values of threads that do not comply with standards which are then analyzed to find out the causes and solutions to these problems. The analysis method used incorporates concepts from FTA (Fault Tree Analysis) and PDCA. The reason the author uses this method is to determine problem factors and as a form of solution and to see the effectiveness of production process management on product results.

D. RESULT AND DISCUSSION

1. Root Problem

In the yarn production process at PT X, it was found that there were discrepancies in the quality of the yarn, namely the quality of the strength or durability of the yarn did not meet the established standards. This was discovered after testing the 30 TR cones thread resulting from the winding process. For this reason, there is a need to resolve these problems through the PDCA (Plan, Do, Check, Action) method and find the root causes with FTA (Fault Tree Analysis). Based on the inspection results, it was found that there are three thread quality parameters, including breaking force (b-force), which is a measure of the strength needed to break one strand of thread. Then elongation is the percentage of elongation of the thread before it breaks. Then, tenacity (in RKm) is the length of the thread (in kilometers) at which the thread breaks due to supporting its weight. The table above focuses on RKm data from cone threads that have not been treated with wax and it can be seen that the test results have not reached the standard, namely ≥ 27.0. Defects in the quality of thread strength can have an impact on subsequent processes, especially during the weaving process. For this reason, efforts need to be made to address and solve this problem.

Searching for the root of the problem is important and is included in the research stage as a first step before carrying out further analysis to find out what and why the problem occurred. Many methods and tools can be used to find factors that cause a nonconformity. However, in this section, it can be done by applying the FTA method. In this case, the use of FTA is seen by analyzing the possible errors that can occur and are interconnected with each other. Through this FTA, it will be easier to find root causes that have a direct or indirect impact on the problem.

From the research results, it can be analyzed that several possible main factors influence the quality of thread strength, namely:

a. Material factors, and differences in the use of raw materials (brands, specifications) also have an impact on the quality of the yarn obtained. Raw material specifications, especially fiber strength, are important to review further. If the fiber strength value obtained is appropriate and falls within the criteria, it will be directly proportional to the results of the yarn process using that fiber. Then a waste processing system is used (reuse) of waste/remnants of material that was discarded during the production process. The use of processing waste where it is mixed with new material has an impact on the quality of the yarn because there is fiber damage (damaged fibers), which mostly comes from waste. When processed it will cause the yarn to be defective.

b. Environmental factors, the condition of the production area or room which is always clean and orderly is the key to the success of a production process, conversely if the production location is not suitable it will have an impact on future production results. In this case, the conditions in the yarn production room must be carefully regulated, and the temperature and humidity must be regulated in such a way that the production process on the machine runs smoothly. If not, the incidents of thread breaking and lapping on the machine will be more frequent. The more thread breaks (end breaks), the more connections there will be, which can have an impact on the quality of the thread, the thread will become more brittle and break. The abundance of fly waste that flies and sticks when the yarn is spun will cause the yarn to be defective and its strength will decrease.

c. Machine Factor, machines have an important role in the production process, capable machines can produce products efficiently. This factor has more complexity in influencing production results. It is important to pay attention to how the machine is set, especially the twist on the thread must be appropriate because the influence of thread strength depends on the twist given. If the twist is too weak, the resulting thread will be brittle. Then maintenance, use, and checking of components used such as travelers, ring flange, snail wire on ring spinning machines, and splicers on winding machines must be carried out regularly.
d. Method factors, in the production process the flow or steps or stages are important to pay attention to so that they comply with existing SOPs. Applying good methods will produce products of good quality as well as create harmony and comfort in working. In this case, the wrong method in yarn production is usually in the spinning process in ring spinning, the number of operators who apply the joining method sideways or pass the end of the yarn through the back of the top roll, which greatly affects the quality of the yarn product; namely the emergence of thick, thin threads that are irregular (thick, thin) which will affect the physical properties of the thread and when processed in winding causes the frequency of yarn breaks to be high. The number of connections will affect the strength of the thread when a tensile test is carried out, the thread will easily break and the thread will become brittle because the cross-section is not uniform. The reason why using the side connection method is considered more efficient is because operators are required to work quickly and chase targets. However, this method will have a serious impact on the quality of the thread, especially its strength.

Through the test results, it was found that there was a deviation from the non-standard strength value (Rkm) of 30 TR cones thread. Then, looking at the results of the problem factor search chart using FTA, there was a correlation between several sub-factors which were the main actors causing the non-conformity. Therefore, it is necessary to improve and overcome problems using the PDCA method. The first phase of improvement efforts is the plan or planning stage.

2. Plan Stage (Planning) and Do Stage (Implementation)

This stage is the earliest stage in which the author classifies and defines the problems to be analyzed. The purpose of this stage is to deepen the problem by the researcher and then carry out a structural plan to find out the causes and ways to solve the problems that occur. After classifying the possible causal factors through FTA and the root causes of the 5 WHYs. An action plan table can be obtained containing efforts to prevent incidents of inappropriate thread strength quality from occurring. The following is Table 1 action plan that can be carried out.

Table 1. Action Plan

No	Action Plan	Executor
1	Sort process materials and waste reuse and check the actual blending ratio	Blowing Area and Quality Control Section
2	Trial modification of the use of traveler type, size, and brand	Quality Control and Maintenance
3	Setting the twist on the ring-spinning machine	Maintenance and Operators
4	Trial of adding wax to the thread for the winding process	Production and Quality Control

At this planning stage, the causal factors are looked at to then identify possible steps and precautions that can be taken. Implementation of this stage requires several parties who contribute/are directly related to the production process. After preparing the action plan, the next stage is a form of implementation of the plan that has been mapped. The form of realization of the "Plan" stage is as follows:

a. Process Materials and Raw Materials
b. Traveler Use Trial
c. Engine Tuning (Twist)
d. Trial Material Addition (Wax)

3. **Check Stage (Review)**

The checking or review stage is carried out after the plan at the "Do" stage is completed. The key to the successful realization of the plan is follow-up from the parties concerned to overcome the problems that occur. The following are the results of the review from the previous stage, including:

a. Process Material Readiness

The quality value of thread strength is greatly influenced by the raw materials used, especially their condition and specifications. PT X itself uses two brands of polyester and rayon fiber, namely Indorama Polyester and SFX (San Fang Xiang) and for Rayon it uses South Pacific Viscose (Lenzing) and Asia Pacific Rayon with almost the same fiber characteristics. In this case, the comparison results obtained are the use of fiber which is shown in the table above. It can be concluded that the use of fiber raw materials has a critical effect on product quality, in this case selecting fibers that have optimal conditions and specifications to obtain good quality yarn is important. Moreover, during the production process, waste material is added that can be reused, such as fine bonda waste and pneuma, which can affect yarn production results because waste is susceptible to fiber damage and roof fiber damage. The physical properties in the form of fiber strength of artificial fibers (polyester) are considered stronger than natural fibers (rayon, cotton), therefore the blending ratio stages of the yarn must be considered in more detail.

The results of the comparison of material types based on data and consultation with the company's quality control showed that the PE SFX material tends to produce better thread quality than PE Indorama, however, the machine settings used to process SFX must be more optimal. On the other hand, for the two types of viscose rayon, there is almost no difference when processed. The use of SFX and SPV (South Pacific Viscose) fibers is preferred.

b. Traveler Use Trial

Based on the test results, imperfections in the cone thread were found where the thread rolled in the shape of the cone came from the production of spinning in ring spinning (cop/tube thread) using a 1/0 kanai type traveller. It can be seen that the thin, thick, and neps parameters as well as the hairiness show quite good numbers. The total existing IPI is 59 IPI. It can be concluded that the influence of using a traveler in spinning yarn does not directly have an impact on the strength quality (RKm) of yarn, many factors influence it, one of which is seen from the IPI results. However, this index value is not always a benchmark, it is only used as data reinforcement. Yarn with a good IPI does not necessarily mean that the RKm produced will also be good, whereas, for yarn with a high IPI, the strength of the yarn will decrease. Threads with a high IPI, especially in the thick and thin parts, and the level of hairiness affect the appearance of the thread size cross-section, where the thread cross-section is very crucial for the quality of the strength produced. This can be seen from the visible diameter of the thread, a thread diameter that is too small can cause the thread strength to be low. This is because the smaller the diameter of the thread, the less fiber is used to form the thread, so its strength is also lower. In this case research, the thread IPI did not contribute to the non-standard thread strength that occurred as seen from the existing test data.

c. Machine Tuning (Twist and Thread Construction)

Yarn twist strength refers to the minimum amount of twist required to provide optimal strength to the yarn. It is important to twist the thread correctly to ensure optimal thread strength when used in finished products. Yarn twist itself can affect the physical and mechanical properties of yarn, including strength, fineness, absorbency, and elasticity. The twist setting can be adjusted by adjusting the machine speed and reel rotation to produce yarn with the desired properties. Too few twists in the thread can cause weakness and brittleness in the thread, while too many twists can cause stiffness and hardness in the thread. Therefore, the twist strength of the thread must be selected carefully to ensure ideal thread strength and suit the desired application.

To measure the twist strength of the thread, a tensile test can be carried out on the thread, and measurements are taken at the maximum tensile load and length of the thread at break. The twist strength of the yarn can then be calculated by dividing the maximum tensile load by the cross-sectional area of the yarn. In this case, the twist of 30 TR yarn on the ring spinning machine was found to be 18.60 TPI. This figure shows that there is 18.6 times the twist given to the yarn to form a strong yarn construction. Please note that the greater the thread number, the higher the twist given. Twist greatly affects the texture and diameter of the thread, threads with a greater twist will have a texture that tends to be rough and the number of twisted fibers increases, causing the diameter to increase.

Based on the table of yarn twist test results, it can be seen that there are yarns with quite low twist values and some that are too high. This shows that the possibility of errors occurring in the twisting process on machine components is also supported by the material being processed. It should be emphasized that a twist that does not match the machine settings will have an impact on the quality of the thread, especially its strength. It is known that the actual twist is 18.60 but it has a lower tolerance limit of (n-1) from the actual value and an upper tolerance limit of (n+1) from the actual value. Yarn with an inappropriate twist causes the RKm value of the cone thread processed on the winding machine to be non-standard.

d. Trial Material Addition (Wax)

In the realization of this planned step, the results of the trial/testing of adding wax to the 30 TR cone thread winding process were obtained, which was assessed as being able to improve the quality of adding wax to the thread using Yoe Sin Castle Ring Wax brand wax. This brand is considered to have good quality for improving thread quality.

After testing the addition of wax to the thread winding process, it can be concluded that adding wax can increase the strength of the thread as seen in the test results where the RKm value has increased significantly from the initial data before the wax was added.

Table 2. Percentage Increase in RKm

Percentage of Wax Test Results 30 TR				
Test Sample	**RKm Before Wax**	**RKm After Wax**	**Percentage**	**Standard**
A	25.52	27.11	6.2%	27.00
B	24.72	26.93	8.9%	27.00
C	24.73	26.22	6.0%	27.00
D	24.60	26.61	8.2%	27.00
E	25.91	26.10	0.7%	27.00
F	25.31	27.38	8.2%	27.00
G	24.30	26.85	10.5%	27.00
H	24.77	26.18	5.7%	27.00
Mean	24.98	26.67	7%	

The table above is the result of the percentage increase in the RKm of the thread after the wax process. It can be seen that the thread has increased on average by 7% from the initial strength (RKm). However, most of the threads still have tensile strength below the established standards. Thus, the process of applying wax to the thread during the winding process on the winding machine is effective in improving the strength quality of the thread. Regarding whether the strength value resulting from the wax process is permanent or not, it is necessary to pay attention because, in the subsequent processing in the weaving section, the yarn undergoes a sizzing (starch) and desizzing (starch removal) process. This process greatly influences the physical properties of the thread, such as the strength and stability of the thread when it is woven into a fabric product.

4. **Action Stage**

The action (follow-up) stage is the final stage after carrying out the three steps above. This stage contains 'decision' and 'conclusion' from the results of the plan that has been carried out, whether it is necessary to decide on a new standard or procedure to prevent and avoid the occurrence of the same problem in the future or to set a new target for further improvement. Steps that can be taken are to maintain quality and improve existing quality and as much as possible minimize the occurrence of products that do not comply with standards. The case study in this analysis was carried out by applying the 5W1H concept to provide action and improvement efforts that can be carried out by the company.

Referring to the data from the 5W1H analysis shows that there are dominant factors that cause non-standardization of thread strength, namely material factors, machine factors, and environmental conditions. Regarding the material/raw material factor, the results of the analysis obtained are carrying out further checks on the material and optimizing the sorting of waste reuse that will be processed to prevent damage and roof fiber from being processed. Then regarding engine factors, two analysis results have been obtained to obtain quality product results, carry out periodic checks optimize engine settings, and replace worn or damaged engine parts/components. Finally, environmental factors are the results of an analysis where there is a relationship between the condition of the area and the role of humans in it.

Regularly check the condition of relative humidity (RH) and room temperature, because if the room is too humid or dry, the yarn being produced and the condition of existing machines will experience problems/damage, then the importance of maintaining the production area environment cannot be separated from the behavior of the human resources implemented. Therefore, it is important to implement 5R, especially cleanliness, to reduce the opportunity for thread contamination to occur which has an impact on its quality, as well as implement Quality Improvement utilizing Countless Products and Quality Improvement.

The steps or actions that can be taken to overcome problems and improve quality in continuous process performance can be seen as follows:

a. Material factors
    1). Sorting and managing raw materials and processes as well as checking more specifically regarding the condition and production capacity of materials as well as optimizing waste reuse sorting.

2). Continuing and harmonizing the FIFO (First In First Out) material usage system, then the bale management section is arranged consistently and appropriately so that there are no errors in material input when it is processed.
3). Using superior material specifications by reducing costs, and following the quality obtained

b. Machine Factor
   1) Carry out routine and periodic adjustments and maintenance, carefully schedule scouring and cleaning of machines, and replace machine parts/components that are worn out or approaching their lifetime. Machine settings, especially yarn twist and roll stretch settings (related to the level of fiber evenness) are adjusted to the material being processed and the yarn process.

c. Environmental Factors
   1) Monitor and promptly check the normal range of relative humidity (RH) and optimal temperature of the production work area, communicate, and coordinate with the company's utility department to ensure the room and machine air pressure supply is stable.
   2) Implementing clean conditions around the production room, not throwing waste carelessly, and applying a deft attitude for operators when they notice lapping material in the machine to prevent lapping waste from scattering and flying due to the blowing of the OHTC (Overhead Traveling Cleaner) blower.

d. Method Factors
   1) Provide regular understanding and information by trainers for production operators, especially ring spinning machine parts, provide teaching and always supervise operators who are working, provide skill ups for operators to find out their ability to connect broken threads according to the company's SOP; namely from the front by joining the base end of the thread with the fibers coming out of the drafting area.

E. CONCLUSION

Based on the results of the case study of the problem of finding a 30 TR yarn product whose strength was not standard through the application of the PDCA (Plan, Do, Check, Action) and FTA (Fault Tree Analysis) concepts at PT X, the conclusion was obtained; namely, the most common cause of finding cases of inappropriate tensile strength quality in terms of FTA analysis is influenced by three dominant factors which include material suitability factors, machine factors, and environmental condition factors, all three of which have the greatest influence than other factors. Looking at the material factor, based on field observations checks, and comparisons of material use, it was found that the SFX brand polyester fiber raw material combined with SPV brand rayon was considered more feasible and showed results during processing and the final product had quality yarn; especially the tensile strength is better than other brands. In addition, reprocessing reuse waste that is not properly sorted can damage other fibers and result in inappropriate final yarn quality. Then, looking at the machine factor, the machine has a very vital role in the production process. It was found that in the case above there was quite a big influence on the quality of the tensile strength of the thread, an inappropriate twist value causes the thread to become brittle and break easily, which is directly proportional to its weak mechanical properties. Then, in terms of maintenance and machine condition, it also contributes to the quality of thread strength, it is necessary to optimize maintenance and replace spare parts according to lifetime. Finally, looking at environmental factors, the RH and temperature conditions in the production area influence the yarn being processed. If the room is too humid, the yarn will absorb more water vapor, this can cause the yarn to be damaged and its strength to decrease. Referring to the PDCA stage, the problem, in this case, study found a fairly effective solution to overcome the low RKm strength of the thread through the addition of wax to the thread. This is proven by the change in the RKm value of the thread which has increased by 7% from the average initial tensile strength.

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