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ANALYZE AND IMPROVE PROCESS CAPABILITY USING CONTROL CHART AND FISH BONE DIAGRAM

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Abstract
The research aims to To improve the process's ability to achieve the required design specifications and meet customer requirements in a company of the Iraqi Ministry of Industry and Minerals, the research is based on the research problem of the existence of deviations in the air filter manufacturing process and the exit of some operations from statistical control , as the research method was based on the case study (Case Study) and is represented in observation, personal interviews, field experience and the use of the inspection list with the intention of Access to scientific facts that help in comprehensive and realistic analysis to reach scientific facts The research results showed that the company's quality control department lacks qualified personnel to use quality management tools, including the fishbone test, which helps in identifying the roots of problems, defects, and failures in production lines.

Keywords: Process capability, fishbone, control panels.

Introduction

At a time when organizations in general and industrial organizations in particular are seeking to reach advanced levels In production processes to increase customer satisfaction with the quality of products and services provided to them, the role of statistical control techniques has emerged as a contributing factor in helping officials monitor production processes and control the variance and deviation of the process shown by statistical control charts, which give an indication of the average and deviation of process variables. However, the processes that Its outputs fall within the limits of statistical control. Products or services may not be produced according to the specified design specifications , because the control limits are built on the rates and variances of the sample distribution, not the product specifications . One of the important tools used in analyzing process variance and deviation related to product requirements or specifications is the process capability , a statistical measure associated with process variability and defined as the time interval of a normally distributed process.

Chapter One / Research Methodology and Previous Studies

Chapter One: Research Methodology

First: The research problem

The production process has a role Vital and important in achieving design specifications and meeting customer requirements, therefore, any deficiency or inability to achieve a percentage of conformity between the specified design specifications and the achieved product

specifications will lead to an increase in the amount of defects in the outputs, which leads to a negative impact. To satisfy the customer and manage the organization Therefore , process capability analysis is one of the important techniques for improving conformance quality and reducing the amount of defective production. And this is what It constitutes a case worthy of research, study and testing in industrial organizations. After it became clear that the research problem is the presence of deviations in the air filter manufacturing process and the exit of some processes from statistical control, the following questions can be raised to express the study problem:

1. what Critical processes in the air filter manufacturing process . Are there process deviations? What are the causes of deviations?
2. Are the air filter manufacturing processes (clip manufacturing , cap manufacturing, gasket casting , paper crushing) capable of achieving high levels of conformity to design specifications or is there variation?

Second: Research objectives

The research objectives can be summarized as follows:

1. Improving process capability In the air filter factory, using a number of statistical control tools, during the technological process of manufacturing the air filter Identify critical processes and identify deviations if any.
2. Knowing the extent of application of the researched processes (manufacturing Clip , manufacturing Covers , pouring Gasket , breaking Paper) for design specifications using a number of special indicators to measure the process capability.

Third: The importance of research

And it can embodiment The importance of the following :

1. Improving process capability will help the company and the plant meet design specifications and keep the process under control and within specification limits to improve quality.
2. Providing factory management with information on how to benefit from the results of the process capability analysis, which may lead to motivating employees to initiate new ideas to improve product quality.

Research methodology

research adopted the case study approach because it is the most appropriate approach to achieve its goals , because it is distinguished by its accurate and detailed description of the data and because it combines more than one method (personal interviews, field experience, obtaining real data from records), which leads to an actual diagnosis of the problem to reach realistic solutions that can be applied.

Fifth : Study methodology

The current study will adopt the case study approach , because it is an approach that aims to collect data related to the phenomenon being studied. Through direct observation, field experience and direct meetings with the aim of arriving at scientific facts.

Sixth : Limits of the study

The study's limitations were as follows:

1. Timeframe : From 10/15/2022 to 12/1/2022
2. Iraqi Ministry of Industry and Minerals was selected.
3. Human boundaries : represented by a sample of the company's employees.

Chapter Two : Some Previous Studies

This section includes a presentation of previous theoretical , cognitive and applied efforts related to the research topic. Current , According to their chronological sequence , as follows: table (1) and (2)

Some previous studies of process capability

study MARYANI & ETAL , 2020) :	
Improving process capability through DMAIC stages for casting aluminum wheels .	Study title
rejection cases for the products provided by the company during production, which were identified as (leakage , perforation of porosity, ovality) . All of this leads to an increase in production costs .	Study problem
This research aims to reduce defects in the casting process using DMAIC methodology and to identify the root causes of the main problem in aluminum castings using fishbone diagram.	Study objectives
Product performance increased from Cp = 0.81 to Cp = 1.4 , and sigma level = 2.9 to sigma level = 4.0. The impact on the company was that the defect rate decreased , ultimately resulting in production cost savings of IDR 417,550,000 per month. Therefore, implementing the DMAIC method can significantly improve product quality and have an impact on production cost savings .	The most important results of the study

study Negrón , 2022):	
Implement lean manufacturing to improve process capacity and performance .	Study title
The research problem is summarized by identifying some of the factors that affect production floor output, such as ineffective layout design, all of which leads to increased production costs due to the high defect rates that the process generates.	Study problem
This research aims to reduce waste and losses such as movement, inventory, transportation and waiting, reduce defects by at least 40% and increase productivity by 15%.	Study objectives
At the end of the project, a 15% improvement in productivity was observed; in addition, the defect rate was reduced by 33% .	The most important results of the study

Chapter Two / Theoretical Aspect

Section One: Operational Ability

Firstly Definition of process capability

Today, the customer has an important and powerful role in product design. And its development, therefore, the need to understand and control processes has increased to be more clear and specific to meet its requirements. Given the increasing complexity of the technical systems used in industry, the role of applying quality management tools to assess

the production process's ability to meet or exceed pre-determined specifications has emerged. In the early 1980s, In the past, process capability analysis has become one of the important tools used to improve process efficiency and reduce variations resulting from non-conformity to specifications, which prompted interested parties and researchers to pay great attention to process capability through their writings and they concluded by setting different definitions according to their vision of it (Abbas, 2018: p. 16)

Table (3) The concept of process capability according to the opinions of some writers and researchers

Definition	Source	T
It is the ability to combine equipment to produce a product that consistently meets design requirements and customer expectations.	Erameh & et.al,2016:80	1
The ability of the process to meet design specifications as determined by engineering design or customer requirements. The variation should be small enough that production is consistent and within specifications.	Heizer,et.al,2017:26	2
It is the ability of a process to meet customer expectations expressed in terms of specification limits.	Parchami & et.al,2017:702	3
It is the variation of the process outputs relative to the .variation allowed by the design specifications	Stevenson,2018:442	4
Minimize process variations by focusing on critical properties that work when the process is statistically controlled and normally distributed.	Abbas, 2018: 17	5
It is the ability to collect, interpret and synthesize information in the context of organizational decision-making.	Lia & et.al, 2019:2	6

Source : Prepared by the researcher Based on the sources mentioned in the table.

The researcher knows the capacity of the process. It is a (Description Graphically , it shows the performance of the process and helps the process employees to know the differences or variations in the production process and interpret them so that decision makers can make a decision.

Second: The objectives of the process capability

The process of analyzing the process capability aims to (Jablaq, 2021: 189):

1. Determine the spread of variance
2. Find the effect of time on both the mean and the spread.
3. The management, analysis, and use of process capability studies should be an integral part of the quality engineering function.
4. Use the results in new design applications, inspection planning, and evaluation techniques.
5. It is a kind of tool that can be used to prevent defects during the production cycle through better designs, through realistic knowledge of process constraints and through knowledge of process factors that can or cannot be controlled.

6. Identifying variances with objectives and benefits of reducing them in the manufacturing process is the main activity of process management.
7. evaluation bezel Fulfillment The process For specifications or capacity The process on production parts Compatible with Specifications Engineering
8. evaluation stability The process Over time the time or capacity The process on Preservation on condition monitoring Statistics Good

Third: Steps to analyze the process capability

To analyze the process's ability to produce products within the tolerance limits, the following steps are followed (Abbas, 2018:19) (Wooluru & et.al, 2014; 402-403)

1. Understand the basic concepts of process capability analysis and its metrics.
2. Data collection process It is best to collect at least 60 data values for each critical parameter.
3. Calculating the required statistics, i.e. calculating the process performance indicators, as well as estimating the process mean and standard deviation, which are obtained from the collected data.
4. Verify the validity of important assumptions. These important assumptions include the following:

A. Verify its validity before estimating the process capability for a tedious process.
B. The process must be under statistical control.
C. The quality property has a normal distribution.
D. In the case of two-sided specifications, the process average is concentrated between the lower and upper specification limits.
E. Observations should be random and independent of each other.

5. Process capability results analysis.
6. If the process is unable to meet specifications, the dominant factor affecting the process capability is investigated.
7. Take necessary actions to improve process performance.
8. Estimating confidence intervals and conducting a hypothesis test

The steps of process capability analysis according to Deming's methodology can be expressed in the following form (1)

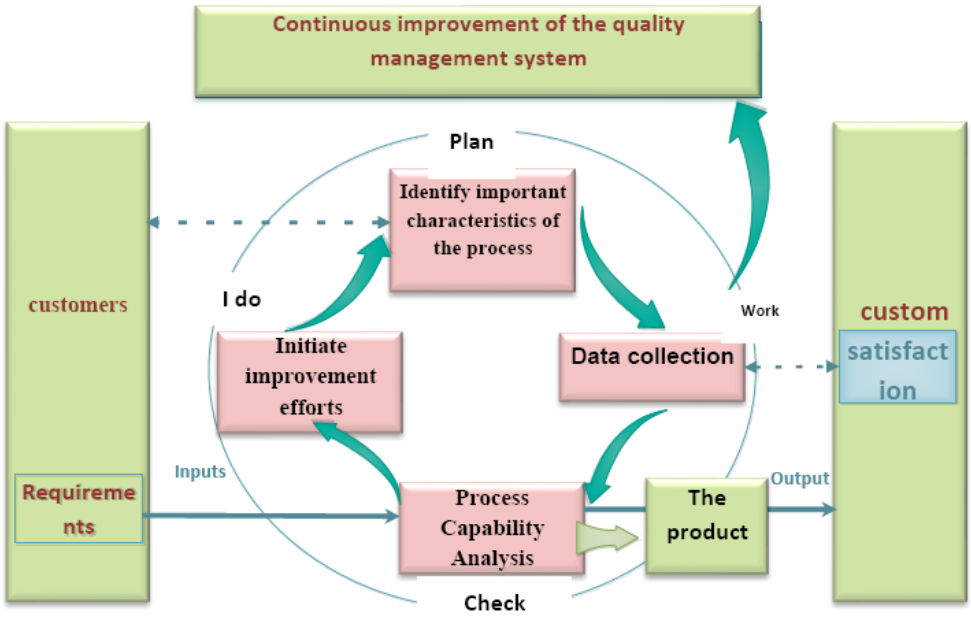


Figure (1) Steps for analyzing process capability according to Deming's methodology
Source: Prepared by the researcher based on the quality management system model in ISO 9001:2015 ISO

Section Two / Control Panels

First: Control panels

Control charts are the most sophisticated statistical tools for quality management. It is also called a chart . Do not control by Shewhart)) by its developer Walter Shewhart Walter A. Shewhart) who used it in his Bell Telephone Laboratories. It is one of the graphs that shows the amount of variation in a process according to the order of time , as well as showing how the process proceeds statistically , It indicates whether or not there is a quality problem through the presence of a center line for the average, with the upper line indicating the upper control limit and the lower line indicating the lower control limit. When samples fall outside the upper or lower limits, the process warns of a deviation and a departure from control. Therefore, the primary goal of control charts is to prevent defects in the process by detecting them early (Abdelhaleem , 2019: 416 & Abdel-Hamid.)

Second: Types of control panels

There are two basic types of quality control maps, including: (Jab Laq, 2021: 171-178)

1. Trait monitoring maps .
2. Monitoring maps for variables.

1. Trait monitoring maps Control charts for attributes

These are the attributes related to quality and can be described as being present or absent in the product. These maps are used to classify products as conforming or non-conforming, damaged or valid, good or bad. The attribute control maps include two basic types of maps:

A. percentage Defective Control chart

)P-Chart) for short. This map is used to measure the quality of products on the basis that they are good, bad, acceptable, or rejected. An example of this is electric lights, which may light up or not. This map is calculated according to the following equations:

$$\text{Central line} = \bar{p} = \frac{\text{Number of defective units}}{\text{Total units subject to control}}$$

UCL upper limit control:

$$= \text{Central line} \bar{p} = \frac{\text{Total units subject to control}}{\text{UCL : upper limit control}}$$

$$UCL = \bar{P} + 3\sqrt{\frac{\bar{P}(1-\bar{P})}{n}}$$

Minimum control limit LCL :

$$LCL = \bar{P} - 3\sqrt{\frac{\bar{P}(1-\bar{P})}{n}}$$

$\bar{P}$ =percentage of defective units

n = sample size

B. Count of Defective Control chart

Called the C-Chart for short , this chart is appropriate when organizations are concerned about the number of defects that are likely to occur, and the sample size can be large enough to identify at least one defect in a unit of product. The three lines of this chart are determined according to the following equations:

$$\text{Central line CL} = \bar{C} = \frac{\text{Number of defective units in samples}}{\text{Number of samples}}$$

UCL upper limit control :

$$UCL = \bar{C} + 3\sqrt{\bar{C}}$$

Minimum control limit LCL :

$$LCL = \bar{C} - 3\sqrt{\bar{C}}$$

Control charts for variables

A variable is a quality characteristic that can be measured and expressed numerically. Its value can change, which is why it is called a variable. Variables can be represented by length, weight, days of delay, volume, or temperature. They are of two types:

X- Chart

$$\overline{X}=\frac{Xi}{n}$$

$$R = \text{largest value} - \text{smallest value}$$

$$\overline{R} = \frac{\sum Ri}{N}$$

$$\text{Central line } \overline{\overline{X}} = \frac{\text{Sum of sample means } \overline{X}}{\text{Number of samples}}$$

UCL upper limit control :

$$UCL=\overline{\overline{X}} + A2\ \overline{R}$$

Minimum control limit LCL :

$$LCL=\overline{\overline{X}} - A2\ \overline{R}$$

R- chart

UCL upper limit control:

$$UCL = D4*\overline{R}$$

Minimum control limit LCL :

$$LCL=D3*\overline{R}$$

Section Three / Fishbone Diagram

First: The concept of fishbone diagram

basic quality tools , also known as the Ishikawa Method after its developer, Dr. Kaoru Ishikawa (1943). It is known as an important tool used to identify the root causes of a problem. In this technique, all possible causes of the problem are considered and an attempt is made to identify the cause of each cause that led to the problem (Muhammad, 2015:33) .

It is also called a cause-and-effect diagram, as it illustrates the relationship between all factors. Additionally, it is called a fishbone diagram because of its resemblance to a fish skeleton. It systematically identifies the main causes and divides them into sub-causes and further subdivisions in order to investigate, analyze, and resolve the root causes that initially led to the problem. This tool helps an organization manage and address the potential causes of the problem. This tool bridges the gap between the organization and the most influential causes, allowing for a complete understanding of the problem and helping to study each cause (Abdel-Hamid & et.al, 2019: 415)

Second: Steps for preparing a fishbone diagram

The steps for preparing this plan include : (Al-Alaq, 2021: 177)

The first step : Write the problem whose causes you want to investigate inside a rectangle or triangle on the right side, then draw a thick arrow from left to right in the direction of the problem. This arrow is the axis of the diagram and represents the direction of the operations.
Step two: Identify the main reasons and write their titles inside rectangles in a symmetrical and consistent manner above and below the thick arrow, with arrows drawn from those rectangles connected to the thick arrow drawn in the first step.
Step 3: Identify the sub-causes for each main cause and write them by drawing sub-arrows near each main cause in the direction of the thick arrow drawn in the first step. Figure (5) shows the fishbone diagram.

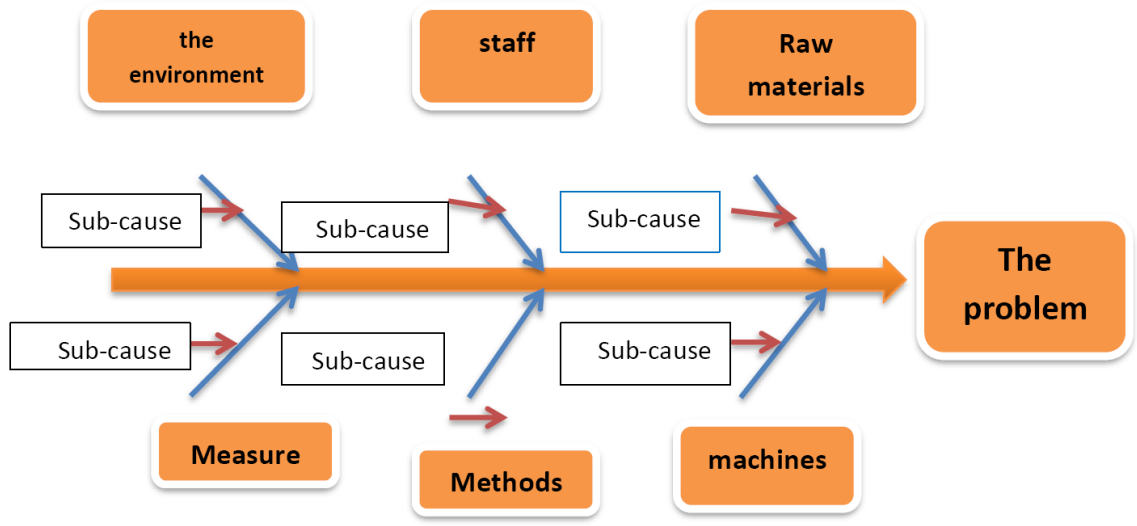


Figure (2) Fishbone diagram
Source: Hial, Alaa Farhan, (2020), " Identifying the factors affecting product quality using the Failure Mode and Effect Analysis (FMEA) tool / A case study in Al-Zawraa General Company ", Master's thesis, Administrative Technical College - Baghdad, Middle Technical University.

Third: Benefits of fishbone diagram
A cause-effect diagram is very useful because it depicts information in an organized and understandable way. There are five main benefits of a fishbone diagram . 2014 : 260 , Goetsch & David(
1. Display relationships clearly and logically: A fishbone diagram brings together the links and relationships between the possible causes and effects shown in the diagram.
2. Show all reasons at once: A fishbone diagram shows every possible cause in one diagram, which is useful for in-depth analysis.
3. Facilitate brainstorming: The fishbone diagram is a great way to enhance and simplify brainstorming about the causes of a particular outcome because it captures all the causes.
4. Motivate problem solving :Seeing the causes in the diagram and exploring the root cause may motivate the team to discover possible solutions to the problems.

5. Help keep the team focused: A fishbone diagram can keep a team focused while discussing what needs to be done to solve a problem or achieve a common goal. It helps analyze all stakeholders .

Section Three: The Practical Aspect

It is clear table Number (4) Cases non Matching that Done Note it In (26) samples Sequence From (100) air filters . Note that it For reasons Facilitation Then lonliness Examination to get to know With (100) panels . So it will be prepared. C - Chart of this Data and assume that Specifications (20.50 and 18.50) in The problem . And capacity Process (S = 0.38)

Number of samples	Number of matching units	Number of samples	Number of non-conforming units
1	21	14	19
2	24	15	10
3	16	16	17
4	12	17	13
5	15	18	22
6	5	19	18
7	28	20	39
8	20	21	30
9	31	22	24
10	25	23	16
11	20	24	19
12	24	25	17
13	16	26	15
27	16	37	18
28	18	38	21
29	12	39	16
30	15	40	22
31	24	41	19
32	21	42	12
33	28	43	14
34	20	44	9
35	25	45	16
36	19	46	21

Given because Samples 26 contains On 516 cases non agree Total , We We estimate (c) by

$$\bar{C} = \frac{516}{26} = 19.85$$

The lower and upper limits of the average number of samples c-chart

$$UCL = \bar{c} + 3\sqrt{\bar{c}} = 19.85 + 3\sqrt{19.85} = 33.22$$

$$CL = \bar{C} = 19.85$$

$$LCL = \bar{c} - 3\sqrt{\bar{c}} = 19.85 - 3\sqrt{19.85} = 6.85$$

c-chart control panels are shown in Figure (). The number of non-conformities from the initial samples is plotted in this chart

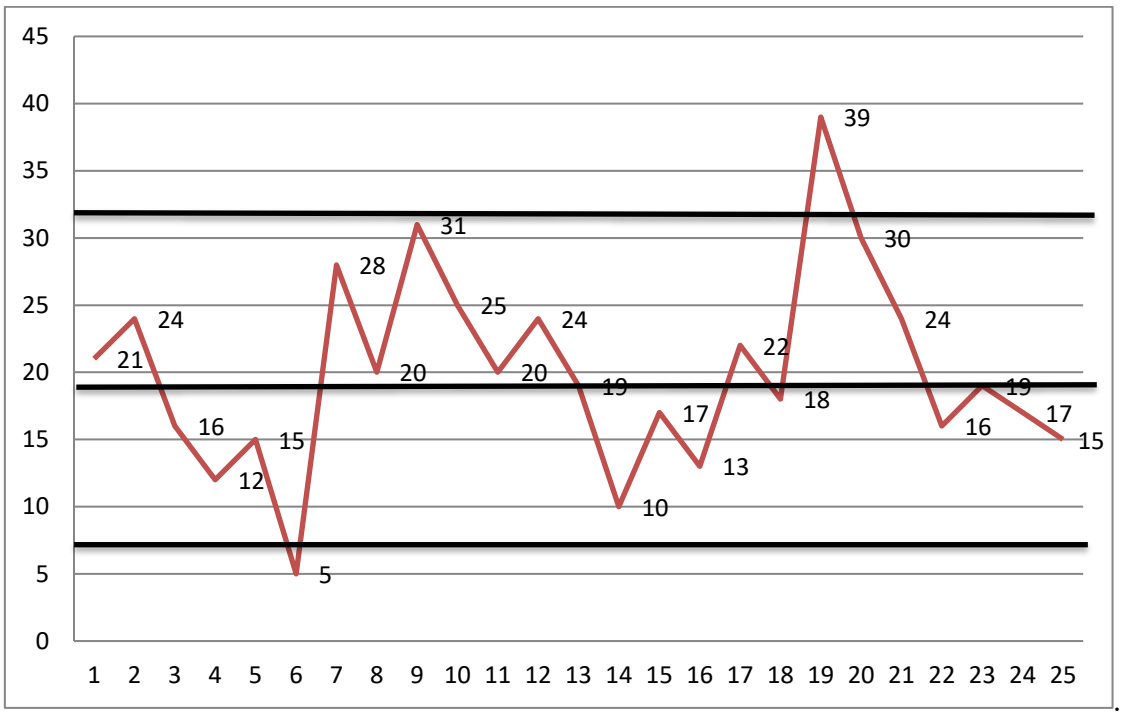


Figure (3) Control panels in cases of non-conformity

We note from Figure (3) that the sample (6 and 20) is outside the control limits. Examination of Sample 6 revealed that many of the possible nonconformities were not identified. Furthermore, the unexpectedly large number of nonconformities in Sample 20 resulted from a temperature control problem in the welding process during the clamp manufacturing stage , which was subsequently corrected. Therefore, it seems reasonable to exclude these two samples and review the experimental control limits. An estimate of c is now being calculated

.

$$\bar{C} = \frac{472}{24} = 19.67$$

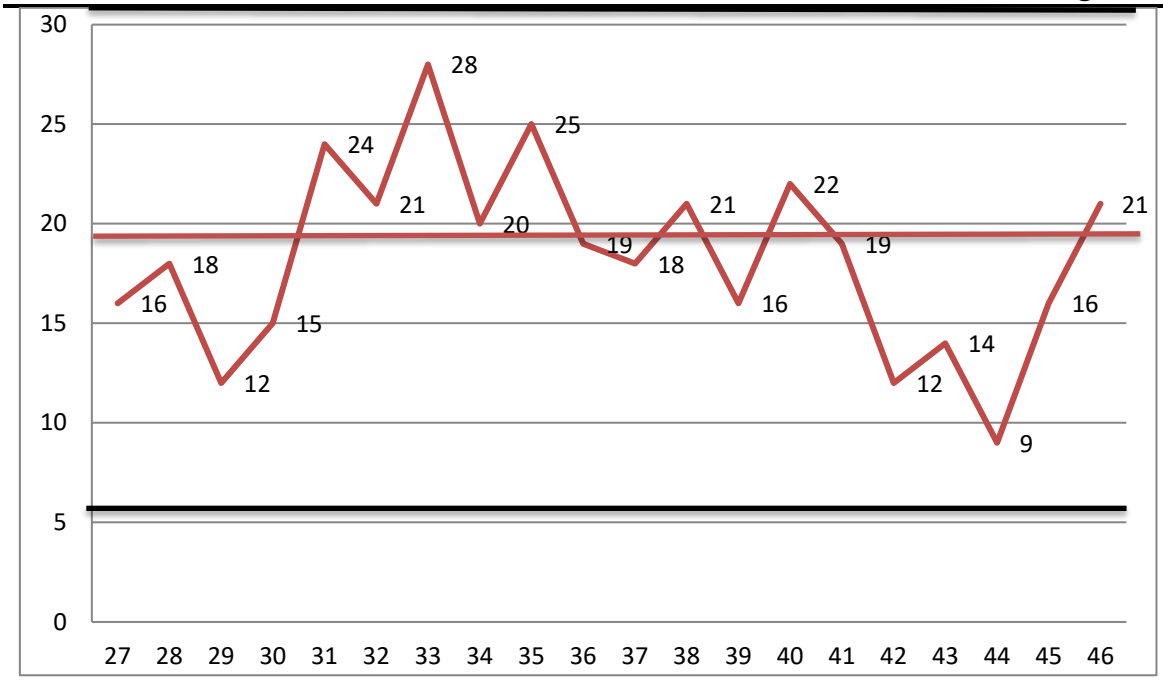
$$UCL = \bar{c} + 3\sqrt{\bar{c}} = 19.67 + 3\sqrt{19.67} = 32.97$$

$$CL = \bar{C} = 19.67$$

$$LCL = \bar{c} - 3\sqrt{\bar{c}} = 19.67 - 3\sqrt{19.67} = 6.36$$

As you become This is amazing values Standard that maybe comparison Production With it in period Next

.



Another useful technique for further analysis of nonconformities is the fishbone diagram . A cause-and-effect diagram is used to illustrate the various sources of nonconformities in products and their interrelationships. It is useful in focusing the attention of operators, manufacturing engineers, and managers on quality problems. Developing a good cause-and-effect diagram typically improves the technological understanding of the process.

A cause-and-effect diagram for the air filter manufacturing process is shown in Figure (4). Since most of the defects in this example were related to the manufacturing stages , a cause-and-effect diagram can help in selecting variables for an experiment designed to improve the filter manufacturing process.

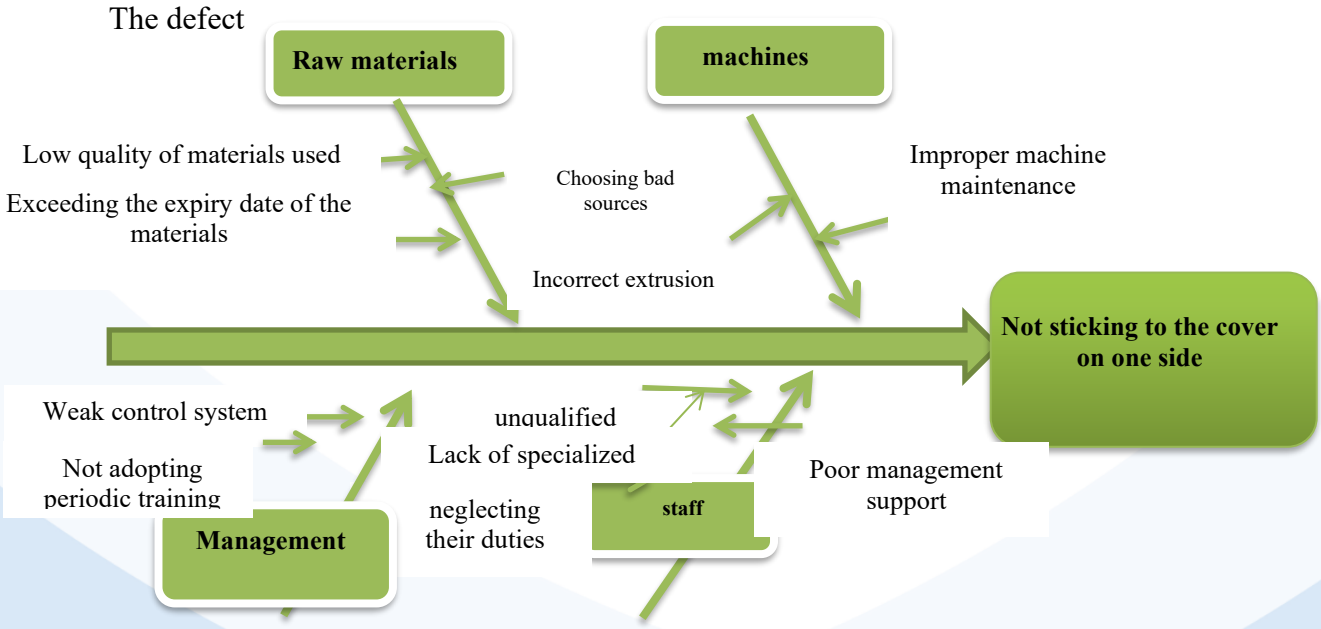
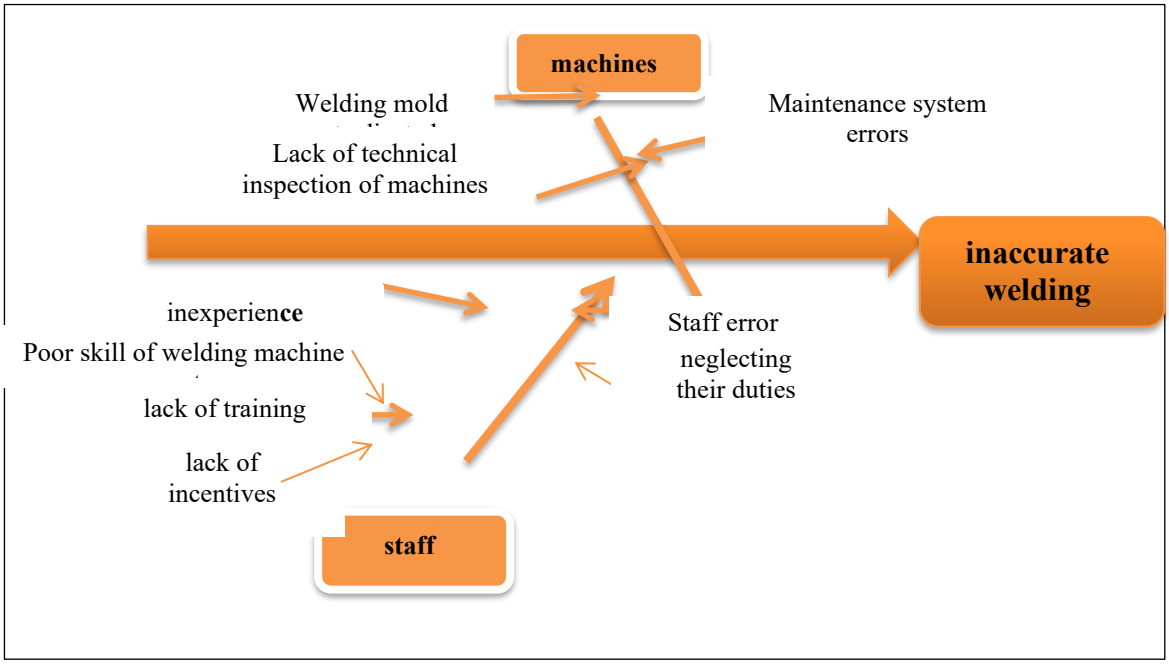


Figure 4 Fishbone diagram of non-adherence to the cover from one side

Figure (5) below shows the presence of two main factors that affect welding accuracy, which are:
Machines and workers each have secondary causes that led to this defect.



.Source: Prepared by the researcher
By calculating the control panels for the C-chart and drawing a fishbone diagram for some of the defects that appear in the air filter manufacturing process, the process capacity will be calculated as follows:

$$\mathbf{Cp} = \frac{USL-LSL}{6\sigma} = \frac{20.50-18.50}{6\ (0.38)}$$

Cp= 0.877

Chapter Four / Conclusions and Recommendations
Chapter One / Conclusions
Will cover this The topic an offer Conclusions that Connect To her in a light What came in the theoretical and practical aspects Analysis Quantitative and statistical For data Extracted from Records The company is as follows:

1. The absence of statistical control panels has caused most operations to deviate from technical specifications, leading to numerous defects and persistent failures without any action taken.
2. The company's quality control department lacks qualified personnel to use quality management tools, including the fishbone test, which helps identify the root causes of problems, defects, and failures in production lines.
3. Calculating the process capacity and its indicators using control panel and cause and effect analysis resulted in higher values of the process capacity indicators , which indicates

that the accuracy of the control panel and cause and effect is better than the traditional method of calculating the process capacity.

4. It was found by calculating the process capability indicators that they are low in the traditional method, due to the large number of deviations in the production processes.

5. Calculating process performance indicators is important because it leads to knowing what The extent to which organizations are able to produce within the limits of design specifications.

Section Two / Recommendations

1. Using statistical control panels to monitor processes to predict the quality of outputs and ensure they do not deviate from the specified specifications, using the Excel program used in this research or any other program to obtain accurate results in less time.
2. The necessity of measuring the process capacity and its indicators in order for production to be in accordance with the established design specifications, identifying process deviations early, and reducing deviations in operations.
3. on to divide Maintenance numbers Programs maintenance Preventive For machines and equipment that she has role big in to improve ability The process.
4. necessity interest In the environment Factory from heat and moisture And systems health And safety Professional from Okay more efficiency Its operations.

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