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Graduation Project I

Improving Productivity in Vehicle Maintenance Shop

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SUMMARY OR ABSTRACT

Work on this research and did studies on determining the appropriate inventory and control system, also decided to train mechanics and did high-cost analysis for various types of tires to choose the optimal tire.

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Chapter 1

Introduction

1.1 Problem Statement

Productivity in A Digital World The consequences of knowledge acceleration indicate an enormous need for companies to be adaptable and flexible to change. Industries are facing ever-changing environments marked by increased globalization, new competitors, and diversified consumer demand. Incorporating industry progress faster to stay relevant and competitive. Businesses that assimilate digital innovation into the corporate culture from senior management down to lower-level employees will be industry leaders. This new way of thinking will be even more critical as the adoption of new technology rate increases. Innovation is a continual cycle of discovery, development, and implementation that enables businesses to invest in the next generation of industry progress. Laggards who are slow to enter into the process of continual improvement become outdated with nowadays, as the improvement in our world became fast so in industrial we must have improved to keep in whit avolition. we con tin on improving productivity so we starting to analyze date and where we are late then we try to use some strategy. For example, kaizen and how it is the effect. [1]

1.2 Project Objective:

To take Al Mulhem Marble Co's vehicle garage as a case study and improve its productivity. Every possible factor will be studied to find the major causes that are decreasing the facilities' productivity.

1.3 Constraints

Al Mulhem Marble Co. is a building materials store located in Jeddah, Saudi Arabia.

The only issue about choosing this workshop is that they don't have an actual production line. The only thing to be considered as a production line would be fixing the vehicles but we don't have enough data to make a research on it nor they are facing major problems with it.

Based on the information gathered from the engineer in charge, their main issues are the huge demand for vehicle parts, tires specifically. Data will be gathered and analyzed to justify the problem and to suggest solutions that will increase the productivity.

1.4 Methodology

The workshop's data was received from the engineer in charge. It got analyzed to first, sort out the causes of low productivity and then to suggest applicable solutions based on it. Kaizen is the main approach for the analysis. Statistics were taken from the workshop which allowed us to create a Pareto Chart which justified the very high demand of maintenance requests. Also, the process flow chart shows the steps that are taken from the moment the maintenance was required until the problem was resolved which allowed us to assess the inputs and outputs of each step. Finally, a fishbone diagram was created and justified from the workshop's management department which allowed us to make possible reasonable solutions

Chapter 2

Literature Review

2.1 Productivity

Productivity is commonly defined as a ratio between the output volume and the volume of inputs. In other words, it measures how efficiently production inputs, such as labor and capital, are being used in an economy to produce a given level of output.

Productivity is considered a key source of economic growth and competitiveness and, as such, is basic statistical information for many international comparisons and country performance assessments. For example, productivity data are used to investigate the impact of product and labor market regulations on economic performance. [2]

> Productivity is the key source of economic growth and competitiveness. A country's ability to improve its standard of living depends almost entirely on its ability to raise its output per worker, i.e., producing more goods and services for a given number of hours of work.
>
> Economists use productivity growth to model the productive capacity of economies and determine their capacity utilization rates. This, in turn, is used to forecast business cycles and predict future levels of GDP growth. In addition, production capacity and utilization are used to assess demand and inflationary pressures. [3]
>
> **Productivity Formula**
>
> With this in mind, the formula for calculating productivity is the quotient between output and resources used.
>
> **Productivity = Output / factor used**
>
> For a company, an industry or a country, productivity is a determinant factor in economic growth, since it involves:
>
> **Saving costs**: by allowing you to get rid of what is unnecessary for the achievement of the objectives.
>
> **Saving time**: because it allows performing a greater number of tasks in a shorter time and dedicating that "saved" time to continue to grow through other tasks. [4]

2.2 Measuring Productivity

In principle, productivity is a rather straightforward indicator. It describes the relationship between output and the inputs that are required to generate that output. Despite its apparent simplicity, several problems arise when measuring productivity. These issues are particularly important for comparing productivity growth across countries, whether for the entire economy or for different industries, and for comparing productivity levels internationally. Some of these measurement difficulties are closely related to technological developments – currently of great interest.

In general, productivity measures can be divided into 2 parts:

1. Partial Productivity.

   Partial Productivity: It is concerned with the relationship between single production factor (input) and its production result (output). It focuses on productivity measures for smaller areas, functions or sub-sections of the company.

2. Multifactor Productivity.

   Multifactor Productivity: Also known as the total factor productivity indicates the ratio of output relative to its input factors. It allows productivity measures of upper levels in the company. It does not focus the same as that of partial productivity. On one hand, partial productivity will focus on the small sections only while multifactor productivity will deal with almost the whole company. That is why, both of them are vital for the organization.

   Multifactor productivity can be measured as follows:

   Multifactor Productivity = Labor + Capital + Energy + Material + Miscellaneous. [4]

2.3 Improving Productivity

Key Factors for Improving Productivity

There are many aspects to consider when it comes to improving productivity:

- people and manpower structure
- attitudes and values
- skills and education
- Control (Purchasing, overproduction, total quality, location, finance, administration, planning, cost and articles)
- Resources (Organization, efficiency, work methods, motivations, new technology, losses and downtime, scheduling, absenteeism
- Processes (Lead times, bottlenecks, wastes, cycle times, material flow, volumes)
- Products (Design for assembly, product variants, development)
- Market. [5]

Guide-lines for a good strategic approach were given by Stephen Moss as follows:

1. Translate competitive requirements into specific goals for operations in the light of the present and potential operating strengths and weaknesses of the company and its competitors.
2. Review and rethink the entire operating system from product design through service after sale. Consider the full range of inputs, and do not be constrained by conventional wisdom, always keep in mind the interdependencies within the system.
3. Assume ongoing change is both inevitable and desirable. New technologies become available, market requirements and resources change, and competitors act and react. Therefore, the system must be innovative and flexible so it can improve and adapt continually.

   Thus, productivity strategy is the pattern of decisions in the enterprise that determine its objectives, procedures and principal policies and plans for achieving long-term productivity improvement goals. A good productivity improvement strategy should, as a minimum:

- develop a clear and easily communicated definition of the productivity improvement concept;
  - explain why organizational improvement is important;
  - evaluate current operating status and the reasons for the current status;
  - develop models of excellence;
  - develop improvement policies and plans.

- Some of the objectives could be broad; for example, to improve the organization's productivity by 8 per cent in two years, with detailed objectives for individual units in the organization.

- Organizations with clear productivity concepts should identify clear goals and objectives.

- Some of the objectives could be broad; for example, to improve the organization's productivity by 8 per cent in two years, with detailed objectives for individual units in the organization.

- The overall goals and objectives should be supplemented by detailed action plans on how to improve productivity. In this connection it is useful to set the objectives for identifiable smaller groups so that performance can be assessed. [6]

There are various ways to enhance productivity in an organization:

a. **Follow up**

- Employers often set targets and feel their job is done.

- No, every target or milestone set needs to be followed up as well, to see if the progress is sufficient and if not, whether any interim measures can be taken before it is too late to salvage a situation.

- It also keeps the employee on track, ensuring there is consistent effort throughout the lifetime of the project

b. **Encourage, motivate, reward and recognize**

- The employer must ensure that on his part he always has words of encouragement for his staff. Encouraging them helps them move forward and do even better, and makes the worker feel happy. Innovative ways of motivating them spurs them even more. For example, holidays or conferences paid for by the company have been found to motivate employees immensely.

c. **Team work**

- Team work always helps in increasing workplace productivity since there is more input in the form of more ideas and minds at work. Working alone is not always the happiest situation either, especially in the field. Successful team building and working together is bound to bring out the best out of the employees who may also then compete with each other ensuring the business is the winner.

d. **Courses and improvement options**

- Employees are delighted when they can enhance their skills and get additional learning opportunities sponsored by the employer. This helps them learn, feel indebted for the money being spent on them, which also adds to their resume, and are obliged to perform better by applying all the knowledge gained in these courses.

e. **Spend less time on meetings and more on action**

- The current trend to have more meetings and discussion rather than spending more time working to achieve results, leads to precious productive time loss.
- Meetings for reviews and sharing of ideas can be limited and kept short.
- Employees should have more time to show results. [7]

Chapter 3.0

Continuous Improvement

Continuous improvement is a never-ending strive for perfection in everything you do. It is an ongoing effort to improve products, services, or processes. These efforts can seek "incremental" improvement over time or "breakthrough" improvement all at once.

Continuous improvement seeks to improve every process in your company by focusing on enhancing the activities that generate the most value for your customer while removing as many waste activities as possible.

Facilities that focus on improving continuously become more competitive over time and can maintain their advantages in their industry, but only if the improvement efforts are done correctly. Taking good baseline measurements and taking ongoing measurements will help identify the effectiveness of the efforts being made.

3.1 Continuous Improvement Benefits

i. Streamline workflows: The Lean way of working enables efficient workflows that save time and money, allowing you to reduce wasted time and effort. For example, projects that involve shifting deadlines, changing priorities and other complexities are usually filled with opportunities to improve.

ii. Reduce project costs and prevent overages: It's important for a project manager to know the cost of completing a body of work. For this reason, most project management offices benefit from knowing the amount of time it takes to get certain types of work done. Project managers can reduce project cost and prevent overages using Forecasting Software. [8]

3.2 Continuous Improvement Principles and Methods

3.2.1 6 principles of the continuous improvement model:

- Principle 1 – Improvements are based on small changes, not only on major paradigm shifts or new inventions
- Principle 2 – Employee ideas are valuable
- Principle 3 – Incremental improvements are typically inexpensive to implement
- Principle 4 – Employees take ownership and are involved in improvement
- Principle 5 – Improvement is reflective
- Principle 6 – Improvement is measurable and potentially repeatable. [8]

3.2.2 Continuous Improvement Tools :

There are various continuous improvement tools available to use such as:

a) PDCA

b) DMAIC

c) Gemba Walks

d) Kanban

e) The 5 Whys

f) Value Stream Mapping (VSM)

g) Kaizen

PDCA

Among the most widely used tools for the continuous improvement model is a four-step quality assurance method—the plan-do-check-act (PDCA) cycle:

1. **Plan:** Identify an opportunity and plan for change.
2. **Do:** Implement the change on a small scale.
3. **Check:** Use data to analyze the results of the change and determine whether it made a difference.
4. **Act:** If the change was successful, implement it on a wider scale and continuously assess your results. If the change did not work, begin the cycle again.

DMAIC

DMAIC is a project methodology with five phases; define, measure, analyze, improve, control. These steps are used to help ensure that improvements are data-driven, measurable, and repeatable. The DMAIC improvement cycle is an effective technique for structured change management. The emphasis on measurement and analysis helps ensure that opportunities for improvement are executed in a way that ensures the most positive impact.

Define: The purpose of this step is to clearly pronounce the business problem, goal, potential resources, project scope and high-level project timeline. Seek to clarify facts, set objectives and form the project team. Define the following:

- A problem
- The customer(s), SIPOC
- Voice of the customer (VOC) and Critical to Quality (CTQs) — what are the critical process outputs?

Measure: The purpose of this step is to measure the specification of problem/goal. This is a data collection step, the purpose of which is to establish process performance baselines. The performance metric baseline(s) from the Measure phase will be compared to the performance metric at the conclusion of the project to determine objectively whether significant improvement has been made. The team decides on what should be measured and how to measure it. It is usual for teams to invest a lot of effort into assessing the suitability of the proposed measurement systems. Good data is at the heart of the DMAIC process.

Analyze: The purpose of this step is to identify, validate and select root cause for elimination via root cause analysis (for example a fishbone diagram). A data collection plan is created and data are collected to establish the relative contribution of each root causes to the project metricPrioritize the root causes (key process inputs) to pursue in the Improve step.

Identify how the process inputs (Xs) affect the process outputs (Ys). Use Statistical tests using p-values accompanied by Histograms, Pareto charts, and line plots are often used to do this.

Improve: The purpose of this step is to identify, test and implement a solution to the problem; in part or in free of all whole

- Create
- Focus on the simplest and easiest solutions

- Test solutions using Plan-Do-Check-Act (PDCA) cycle
- Based on PDCA results, attempt to anticipate any avoidable risks associated with the "improvement" using the Failure mode and effects analysis (FMEA)
- Create a detailed implementation plan
- Deploy improvements

Control: The purpose of this step is to embed the changes and ensure sustainability, this is sometimes referred to as making the change 'stick'. Control is the final stage within the DMAIC improvement method..[2]

- A Control chart can be useful during the Control stage to assess the stability of the improvements over time by serving as 1. a guide to continue monitoring the process and 2. provide a response plan for each of the measures being monitored in case the process becomes unstable. [9]

Gemba Walks

Gemba walks denote the action of going to see the actual process, understand the work, ask questions, and learn.

Taiichi Ohno,[6] an executive at Toyota, led the development of the concept of the Gemba Walk. The Gemba Walk is an opportunity for staff to stand back from their day-to-day tasks to walk the floor of their workplace to identify wasteful activities.[7] The objective of Gemba Walk is to understand the value stream and its problems rather than review results or make superficial comments. [9]

Kanban

Kanban is a lean method to manage and improve work across human systems. This approach aims to manage work by balancing demands with available capacity, and by improving the handling of system-level bottlenecks.

Toyota developed this system to make the production process more efficient. Kanban has a been adopted by a number of businesses today. It involves six main practices:

1. Visualize your workflow
2. Manage flow
3. Eliminate interruptions
4. Make policies explicit
5. Improve collaboratively
6. Create feedback loops. [9]

The 5 Whys

> **Five whys** is an iterative interrogative technique used to explore the cause-and-effect relationships underlying a particular problem.[1] The primary goal of the technique is to determine the root cause of a defect or problem by repeating the question "Why?". Each answer forms the basis of the next question. The "five" in the name derives from an anecdotal observation on the number of iterations needed to resolve the problem. [9]

Chapter 4

Kaizen

One approach to continuous, incremental improvement is called **kaizen**. It originated in Japan and the word translates to mean change (*kai*) for the good (*zen*). [10]

Kaizen is based on the philosophical belief that *everything* can be improved: some organizations look at a process and see that it's running fine; organizations that follow the principle of Kaizen see a process that can be improved. This means that nothing is ever seen as a status quo – there are continuous efforts to improve which result in small, often imperceptible, changes over time. These incremental changes add up to substantial changes over the longer term, without having to go through any radical innovation. It can be a much gentler and employee-friendly way to institute the changes that must occur as a business grows and adapts to its changing environment. [11]

Because Kaizen is more a philosophy than a specific tool, its approach is found in many different process improvement methods ranging from Total Quality Management (TQM), to the use of employee suggestion boxes. Under kaizen, all employees are responsible for identifying the gaps

and inefficiencies and everyone, at every level in the organization, suggests where improvement can take place. [12]

The Kaizen improvement focuses on the use of(13) :

1. Value-added and non-value-added work activities.

    - A **non**-**value**-**added** activity is an action taken that does not increase the worth of what is delivered to the customer.
    - To be a value-added action, the action must meet all three of the following criteria: The customer is willing to pay for this activity.
    - It must be done right the first time.
    - The action must somehow change the product or service in some manner.

2. *Muda*, which refers to the seven classes of waste—over-production, delay, transportation, processing, inventory, wasted motion, and defective parts.

    - Over Production: Based on Engineering, a lot more cars are getting fixed in the workshop than the actual amount of cars of the company.
    - Delay: When a vehicle stops working, a lot of time would be wasted because the loading and unloading of a shipment is delayed until it is fixed or another vehicle if possible arrives.
    - Transportation: There is a lot of transportation time in the facility to get the shipments.
    - Processes: It was invalid for us to find waste in the processes due to not enough data and our low lever of expertise in the actual processes.
    - Inventory: A lot of materials get ordered that they are rarely used and are stored for years in the inventory while we can use the space for materials that are frequently used.
    - Wasted motion: There is no optimum cycle time for the workers but it should be examined to try and reduce it as much as possible.
    - Defective Parts: Some vehicles that get fixed become defective after a shorter period of time that it should.

3. Principles of motion study and the use of cell technology.

4. Principles of materials handling and use of one-piece flow

   - **Material handling** is the movement, protection, storage and control of **materials** and products throughout manufacturing, warehousing, distribution, consumption and disposal.
   - Material handling is not audited as it's supposed to. For example, for the workshop, they order tires more than they should yet they are always short on tires.
   - Tires should be changed after a certain amount of mileage or a certain period of time but it is often changed before that.
   - Materials don't get properly documented so they sometimes lose track of the materials that they have.

5. Documentation of standard operating procedures.

   - It is one of the most important tasks in any facility because it used to control every aspect done in the facility.
   - With documentation, we can control wasted materials, wasted time, reduce costs.
   - With proper documentation, we can prevent or at least decrease incoming defects. For example, in the workshop there are many vehicles that keep breaking down even after getting fixed and it would be prevented if we had historical data.

6. The five S's for workplace organization, which are five Japanese words that mean proper arrangement (*seiko*), orderliness (*seiton*), personal cleanliness (*seiketso*), cleanup (*seiso*), and discipline (*shitsuke*).

   - Sort: In the work place, the environment was messy. A lot of time was wasted to get the tools. So every tool should have its specific place to maintain an organized environment.
   - Set in Order: it is almost implemented already in the workplace as for example, each type of vehicle has it's a specific place to be worked in because each vehicle (Cars, Trucks, forklifts, etc..) has its own machinery and tools.
   - Shine: it's used to keep the environment clean. For example, in the workplace, oil gets spilled on the floor, a lot of mess occurs due to the process. So based on a cost analysis study, but at least 1 or 2 workers should be hired to maintain a clean workplace to avoid any hazards from oils and for health reasons.
   - Standardize: Setting up standards for a neat, clean, workplace. Standardizing procedures will ensure the first three phases are maintained and the facility doesn't go back to the way it was before 5S.
   - Sustain: It is making sure that the facility is still using the 5s method. Can be achieved through motivation of the workers and getting everyone involved in the process or through auditing from the management.

- Safety: It is a very important aspect to maintain a safe environment to avoid health issues for the workers and to avoid numerous hazards in the workplace such as fire. Can be done through making precise emergency exits, or a fire fighting system, Ventilation, First aid kit and a doctor and a lot more.

7. Visual management by means of visual displays that everyone in the plant can use for be tter communications.

8. Just in
   ime principles to produce only the units in the right quantities, at the right time, and wit h the right resources.

9. *Poka-yoke* to prevent or detect errors.

   - **Poka**-**yoke** is a Japanese term that means "mistake-proofing“
   - Its purpose is to eliminate product defects by preventing, correcting, or drawing attention to human errors as they occur.
   - Poka- yoke should be implemented on the workers that fix the cars by giving them proper training when needed to avoid “over production”, where a vehicle goes back to the garage after getting fixed and the drivers themselves where they should stop driving recklessly.

10. Team dynamics, which include problem solving, communication skills, and conflict resolution. [13]

Chapter 5.0

Research

5.1 Company

Al Mulhem Marble Co is a marble and granite company in Jeddah, Saudi Arabia. They have a garage to fix their vehicles which the study will be implemented on.

The engineer who manages the workshop was contacted and he was very cooperative and responsive.

Data is available since approximately two years ago.

They are really looking forward to cut down their costs.

As they informed, their main issue is the huge demand on parts because of the high maintenance requests.

Chapter 5.2 Research

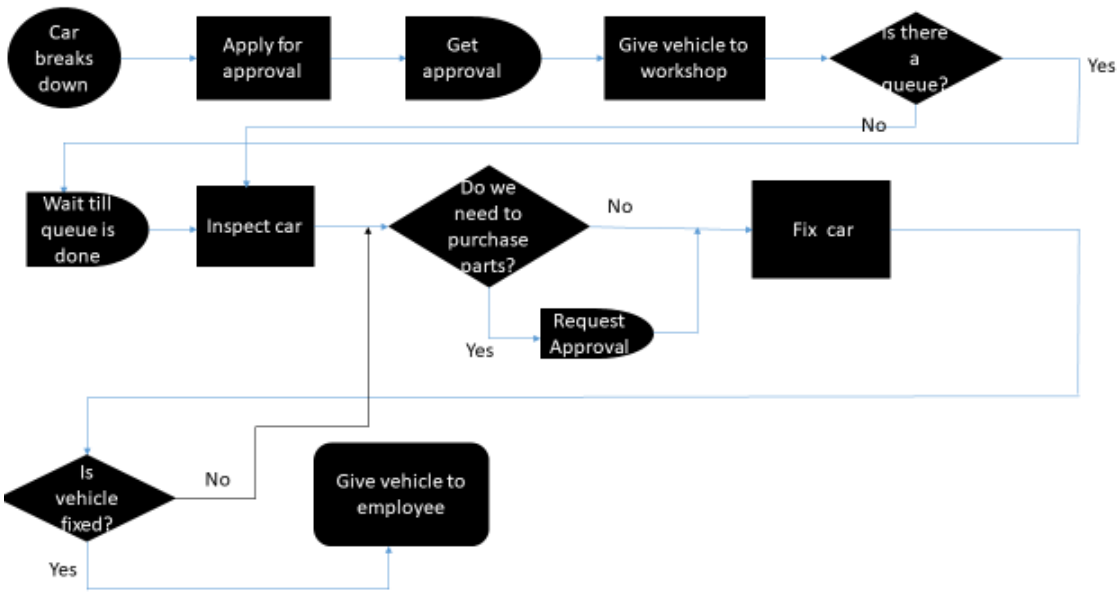

Figure 1 process flow Diagram

Table 1 Input/Output Table

Car breaks down	Employee/Random error
Apply for approval	Mohammad Ramez Al Hakimi
Get approval	Employee
Give vehicle to workshop	Employee
Is there a queue?	Dawood Al Jaze'ry
Wait till queue is done	Dawood Al Jaze'ry
Inspect car	For cars: Ama'ar Al halabi For trucks: أحمد علي الدريس
Do we need to purchase parts?	Depends on the case
Request Approval	Mohammad Ramez Al Hakimi
Fix car	
Is vehicle fixed?	
Give vehicle to employee	Dawood Al Jaze'ry

Pareto Chart

- Based on the data provided from the workshop's management from 19/03/2019 until 15/12/2020, a Pareto Chart was conducted.
- As it shows, there is a very high amount of maintenance requests and tires are the most changed part.

Table 2 Maintenance frequency Table

Issue	Frequency
Tire	1692
Oil Change	1033
AC Repair	1013
Battery	407
Tie rods balance	337
Suspension	303
Light bulbs	277
صیانه شامله	273
Gearbox	145
Electrical issues	107
Motor	15
Breaks	14
Air Filter	13
Road repair of a car	12
Motor fix	6
Handbrake	5
Fix the requirements of the periodic examination	5
Trailer lock installation	
Diesel pump repair	2

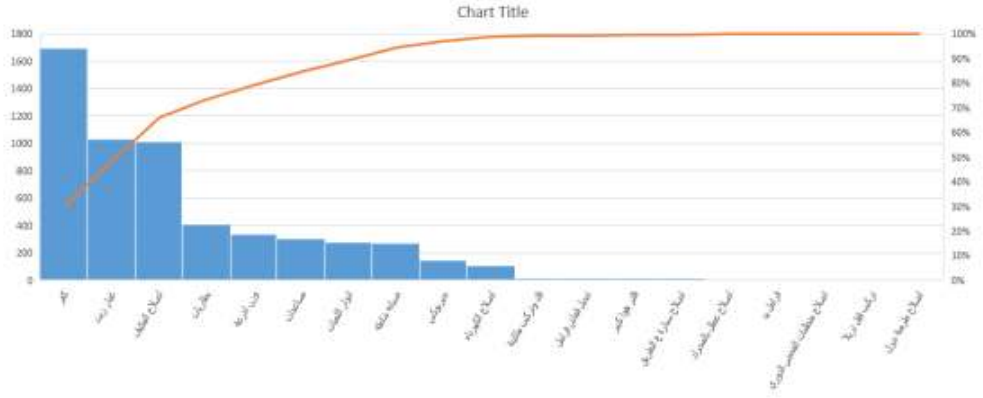

Figure 2 Pareto Chart

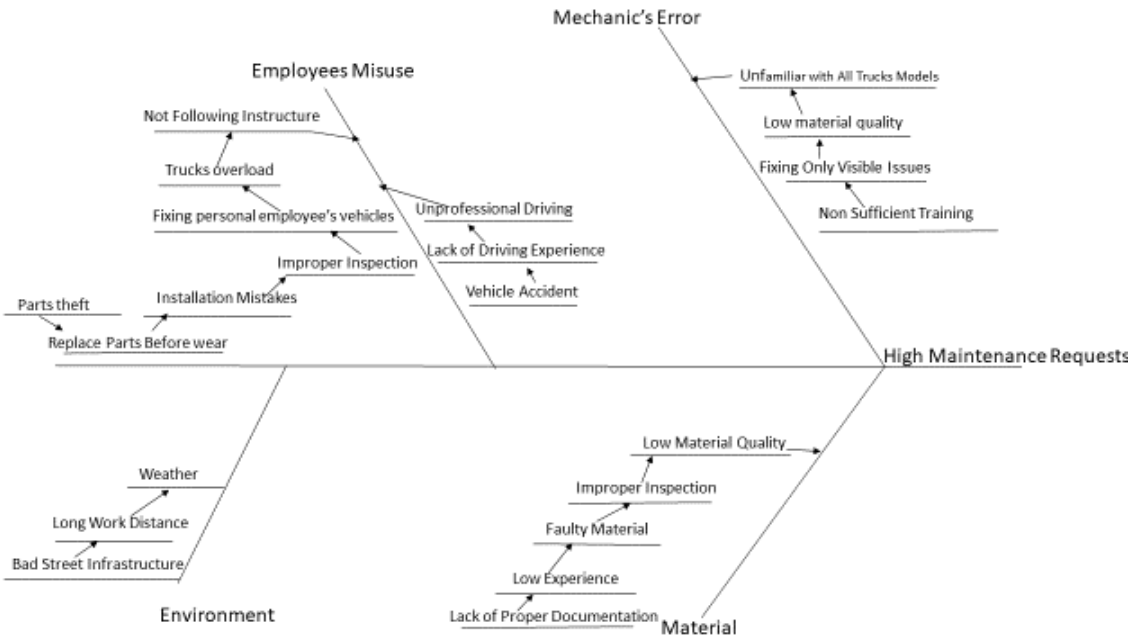

Figure 3 Fish Bone Diagram

5.3 Research Analysis

For the general high maintenance requests there are multiple reasons which are as follows:

1)Mechanic's fault

2)Not the optimal tires

3)Personal vehicle fix

The charts above justify that there is a huge demand on the parts and this could be due to multiple reasons:

1. Driver Misuse
2. Overload of trucks
3. Change before wear
4. Low quality

5. High distance traveled
6. Faulty tire

5.4 Suggested Solutions

Multiple solutions were given to the administration of the workshop and are as follows:

1)Assigning a proper inventory and surveillance system.

2)Training the mechanics

3)Doing a cost analysis for multiple tire types to choose the optimal tire

Chapter 6.0

Conclusion

On this research, productivity, how to measure productivity, types of productivity, and how to increase productivity are all explained in details as well.

Then, continuous improvement and its importance are clarified. There are multiple approaches for continuous improvement and how they are done that are explained in the research above.

Kaizen, one of the approaches of continuous improvement is described in details since it was the approach used in our study which is on Al Mulhem's Marble Co's workshop.

Al Mulhem Marble Co's workshop were facing low productivity and high wastes and are looking for solutions which this research suggests.

Through Kaizen's approach, a Pareto chart, a Process Flow Chart and a fishbone diagram are presented to find out their main issues which is the very high maintenance requests and to help resolve the issues.

This research shows the suggested solutions which are:

1)Assigning a proper inventory and surveillance system.

2)Training the mechanics

3)Doing a cost analysis for multiple tire types to choose the optimal tire

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