Dust extractor solution
Preface

This study is a result of master’s thesis in mechanical engineering at Halmstad University in collaboration with HGF rubber factory during spring term 2017.

The main contribution of the present work focusses on the development of significant approach to eliminate the dust from the contaminated product to improve the quality of the product. The aim of the thesis was to work on the product which is contaminated by the dust or its own scrap particles, eliminating that dust and obtaining the best quality and to motivate the most promising solution.

We would like to emphasize our thanks professor Dr. Aron Chibba for his support and guidance, opportunely posed questions that raised new lines of thought and motive to get good work on the thesis.

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______________________________  ________________________________
Rushik Patel                                                    Ajay Kumar
Abstract

The following report conducted with the collaboration of the University of Halmstad and HGF rubber company (Halmstad).

The focus on the project is eliminating the dust particles from the inner surface of the EPDM based rubber module.

As a part of improving knowledge about the quality and surface finishing and understanding the material’s characteristics. This project initiated in February 2018 and end date was set to August 2018.

The methodology used in this project is based on the Six-Sigma tools which is widely appreciated globally to obtain the Zero-defect production.

The implementations of this method and other tools are efficient and beneficial to reduce the defects in the production without compromising the initial quality of the product.

This thesis resulted in a quality improvement approach for eliminating the dust using methods such as Six-Sigma and 5 why’s.

**Keywords**: Six-sigma, DMAIC, 5 why’s, EPDM rubber, electrostatic electricity, high pressure vacuum cleaning and Adeline solvent.
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Symbols and Abbreviations

EMI: Electromagnetic Interface
EMP: Electromagnetic pulses
DMEDI: Define Measure Explore Develop Implement
DMAIC: Define measure analyze improve control
CTQ: Critical to Quality
DFMEA: Design failure mode effect analysis
EPDM: Ethylene propylene diene M-class
SBR: Styrene butadiene rubber
NBR: Nitrile Butadiene Rubber
PDCA: Plan Do Check Act
HEPA: High efficiency participate arresting
1. INTRODUCTION

Introduction

Surface quality of product is one of the important factor to be measured. The surface of the product is considerable by various aspects. One of them is the product should be appeared finished and the other is the product should be in such a condition that it can be proceed to the customer for further application. As, it is a fact that customer satisfaction is must for any organization to maintain the relationship with customer and to stabilize the organization’s value and reputation. The significant presence of dust can adversely affect the performance of the sealing system. Strategies are to be adopted to achieve a balance between performance efficiency and cleaning costs. Sealing rubber is play vital role in some places where air tight seal needed such as: - Marine, power station, manufacturing industry, offshore oil and gas etcetera. Whereas, the main application of this rubber is to provide sealing against water, air, EMI (electromagnetic interference) and EMP (electromagnetic pulses). The seals are approved by all major classification societies and used in many demanding industries and applications. This product is produced by HGF (rubber factory) Halmstad, Sweden. The HGF company located in Halmstad is producing rubber products which are used in several parts and equipment in machinery. The shape of one of the rubber part is Semi-circled. These rubber parts are manufactured by using machinery. After the manufacturing is done of these parts, dust is being removed by spraying water and hot air. Despite, the dust is not completely cleaned, and minor dust particles are available. But it does not stick properly if there are dust present on its inner surface because inner surface is significant itself for providing tight bond. So, it should be clean and tidy so that gum can work properly if there is needed to add thin layer between cable and sealing rubber. So, this book based on the methodology to extract the dust from the rubber surface. During the grinding process there are some small grinding particles coming by abrasive action on rubber. This small dust like particles remains on the rubber’s inner and outer surface. Thereafter, when this product leaving grinding area to wash and cleaning by normal water and air, So, this cleaning process successfully clean the dust from the outer surface, but still little bit dust particle remains from inner surface that need to clean by doing some extra work on it so that it could not be make hinderance in the quality of rubber when glue or other adhesive solution apply on inner surface. There are different sizes of rubber sealing product according to wire cable size.

1.2 Aim of the study

The main objective or the purpose of this study is to determine the dust or any other particles affecting the on the materials surface. The dust seen of the surface is improvise in two categories such as:

➢ Dust from the environment
   • Which is the main aspect considered as the environmental effect responsible making the object uncleaned?
   • What is the ambience in the company where the machine is placed?
Dust particles or machine scrap from machine itself
- How the process is operated in the machine?
- Whether the dust particles or scrap is removed properly or not?
- Is the dust measurable or visible?

1.2.1 Problem definition
In the first meeting with the supervisor of the HGF, the authors conducted a visual inspection regarding the process where the dust has been cleaned after it is driven from the manufacturing procedure. Tasks were assigned, and authors started to investigate about the material affected by dust. An appropriate method was needed to overcome this cause and sustain the quality of the product which is supposed to be given to the customer.

Authors believed in one of the best methods to get a precise definition of the problem was the 5-w’s method. This method works by asking several questions such as
- Who does the problem affect?
- What impact is the issue causing?
- When does the issue occur?
- Where is the issue occurring?
- Why is it important to fix the problem?

1.3 Limitations
Due to the limitation of measuring tool, the dust measuring tool was unavailable. Uncleaned dust was only measured by visual inspection. There were some limitations such as
- Results can be achieved by implementing few methodologies for finding the root cause.
- Practical tests or experiments were extremely recommended to execute the best consequences.

1.4 Individual responsibility and efforts during the project
Both authors have put the equal amount of efforts in the thesis. The amount of time spent for the experiments, analyzing the methods and gathering the information regarding the project. Visits were conducted to test the methodologies. The presentation with the HGF AB including research and writing the report.
1.5 Study environment
Both authors have worked on the thesis at different locations, practical and theoretical framework of the thesis including writing report at the Halmstad University.

2. Method

Six-sigma
This study is based on how to implement a method in which better result can be achieved in terms of quality by eliminating the uncleaned dust. The product is ingoing in production and as the customer is facing issues in further applications, the product needs improvement. We researched and gone through many articles. Eventually, “SIX-SIGMA” methodology was the relevant and most convincing method we realized. Six Sigma began as a manufacturing focus to reduce defect levels to only a few parts per million. It has evolved into a formal business strategy designed to accelerate improvements in every facet of an organization (Evans, 8th Edition). Six Sigma methodology consists various tools which can be used as per their requirements Such as DMEDI (Define, Measure, Explore, Develop, Implement) is the tool used to develop a new product. DMAIC (Define, Measure, Analyze, Improve, Control) is the tool used for improving existing products (Evans, 8th Edition).

![Six Sigma Methodologies](image)

Figure 2.1 Six Sigma Methodology

Above from these number of tools we went for DMAIC, to improve quality of the product and remove the defect or issue the customer is facing. DMAIC is considered as one of the best principle for problem solving. DMAIC- Define, measure, analyze, improve, and control is the flow process in which a problem can be defined precisely. We implemented this method in our project and it worked to identify the real problem and to overcome that.
**DEFINE**

The first stage of DMAIC is to define the problem. This activity is significantly different from project selection such as one must describe the problem in operational terms that facilitates further analysis. We implemented this in our project such as shown in Figure 2.3, an organization in making a multidiameter module is facing the issue of having dust on the surface of the product. The application of this product is to seal or cover the outer surface of the heavy loaded electric wires and for that they need to stick the two semi-circled modules in such a way that it makes a sealed tube. Due to the uncleaned dust the customer is facing difficulties in gluing the two modules.

**MEASURE**

This phase of the DMAIC focuses on how to measure the internal processes. It requires understanding of the casual relationships between process performance and customer value. It is very important to understand this customer’s relationship. However, once they are understood, procedures for gathering facts such as collecting good data, observation must be defined and implemented. Data form the existing production processes and practices often provide important
information such as feedback from the supervisors, workers, customers, and field employees (Evans, 8th Edition). For example, in our case the measurement of the uncleaned dust was very crucial. Measurements can play an important role in comparing the results. It gives a vision of how much the dust has been eliminated and how much it needs to be more. We inspected the dust and consulted the supervisor and workers. However, there was not any equipment or tool to measure the dust as it was visibly inspected. We can simplify it with having “Dust” or “No dust”. As shown in the figure 2.3, there are some of the area which is affected by the dust rather than entire product.

**ANALYZE**

A major flow in many problem-solving approaches is a lack of emphasis on rigorous analysis. Too often it happens, we want to jump to a solution without fully understanding the nature of the problem and identifying the source of the problem. The analyze phase of DMAIC focuses on why-defects, errors, or excessive variation occur, which often result from one or more than one (Evans, 8th Edition). To find the answers one requires identifying the key variables, that are most likely to create errors and excessive variation stating it as “root cause”. Root cause can be defined such as the condition form which the problem originated or initiated. For example, in medical analogy eliminating symptoms of problems usually provides only temporary relief whereas eliminating root cause provides long-term relief (Evans, 8th Edition). In our case we came across that we rather than jumping directly to solution will not be appropriate so considering this theory we decided to analyze the problem and to find the root cause of that error. We implemented the “5 Why” methodology,

As seen in the above figure this 5 WHY method can be used to find out the root cause by asking WHY several times. For example, in our case this method can be applied such as,

1. Why the module doesn’t stick to each other?
2. Why there is dust?
3. Why the dust is being not cleaned?
4. Why it is not cleaned efficiently?
5. What is the material remains uncleaned?
By asking such questions and communicating with the supervisor and the employees we came to know about the actual problem.

**IMPROVE**

Once the root cause of a problem is understood, the analyst or the team needs to generate ideas of removing or resolving the problem and improve the performance measures and CTOs. This idea-gathering phase is a highly creative activity because many solutions are not obvious. Once the different in the difficulties in this task is an instinct to prejudge ideas before thoroughly evaluating them. However, such ideas may form the basis for a creative and useful solution. Effective problem solvers must learn to defer judge the predefined situation of the results which is been gained by analyzing the values. Several processes and tools to facilitate idea generation can be used. One of the most popular method is brainstorming, it is used to generate ideas for problem solving. This method is proposed by Alex Osborn. After a set of ideas have been proposed, it is necessary to evaluate them and select the most promising. This process incudes confirming that the proposed solution will positively impact the key process variables and the CTQs and identifying the maximum acceptable ranges of these variables. (Evans, 8th Edition). To implement the solution effectively, responsibility must be assigned to a person or a group who will follow through on what must be done, where it will be done, when it will be done, and how it will be done. Project management techniques are helpful in implementing planning.

**CONTROL**

The control phase focuses on how to maintain the improvements, which includes putting tools in place to ensure that the key variables remain within the maximum acceptable ranges under the modified process. These improvements might include establishing the new standards and procedures, training the workforce, and insulting controls to make sure that improvements do not die over time. Controls might be as simple as using checklists of periodic status review to ensure that proper procedures are followed or employing statistical process control charts to monitor the performance of key measures. (Evans, 8th Edition).

The DMAIC process basically focuses on the following matters such as:

- Defining the processes.
- Measuring the current performance of business process.
- Finding the root cause of the problem.
- Making the improvements needs to eliminate the defects.
- Implementing the controls to alert leadership when the process is no longer in control.
2.1 ALTERNATIVE METHODS
There are various other methodologies used and mentioned for problem solving. Every method or process has its own criteria and principles on how to work. After referring articles and literatures we came across many other methods such as DMEDI, DMADV, DFMEA and many more. We would like to explain these methodologies in detail as following

DMEDI
DMEDI (define, measure, explore, develop and implement), it is data and statistical driven, but instead of a purely analytical approach, this approach entails application or creativity in using data to design new robust processes, products and services. The aim of this method is to secure a quantum leap year over existing processes, products or services, and seeks a competitive advantage. (Nayab, 2013)

DMEDI process helps in establishing new processes or changing processes after defining customer needs relative to a product or service. It also gives an aid in Existing processes, products or services remain broken or dysfunctional to that extent that starting from scratch becomes the best option. Secondly, the gap between the desired objectives and the current performance remains huge. Moreover, it also helps the situation demands a quantum leap in performance. (Nayab, 2013)

the “measure” phase in DMEDI places critical importance to define customers and their needs. While in DMAIC it works on the existing definitions of critical customers’ requirements and baseline outputs, DMAIC applies tools such as voice of the customer to determine CCR afresh. (Nayab, 2013)

The “explore” phase in DMEDI entails analysis of business processes. It approaches explores various options to provide a conceptual design of new process that satisfies customer needs and specification in the best way. In DMAIC this stage is tangible whereas DMEDI this stage is conceptual. (Nayab, 2013)

The “develop” phase in DMEDI is after exploring the various design options for the new processes, product, or service, delivers the most optimal design based on customer preferences. (Nayab, 2013)

The “implement” phase in DMEDI is the stage which entails putting the adopted business model through simulation tests to verify its efficiency in meeting customers’ needs and specifications and seeks to prevent potential losses. (Nayab, 2013)
The DMEDI process basically focuses on following matters such as:

- Defining the process or the flow
- Measuring the find the customer’s needs and requirements.
- Exploring the conceptual design satisfying customer’s needs and specifications.
- Developing the new options for process, product or service.
- Implement the simulations and the test. (Graves, 2014)

**DMADV**

DMADV (*define, measure, analyze, develop and verify*) in this methodology is used when an organization is creating new processes to achieve their customer’s needs.

The “define” stage in this phase the Six-Sigma team will define the project’s goals and deliverables. Whereas in DMAIC in this stage the team will define the projects problem in an outline for themselves and the organization’s leaders.

The “measure” stage in this phase the team measures the project’s factors that are critical to its deliverables. Whereas in DMAIC the project team maps the current process, gathers data, and identifies and understands the root cause of the process. Working in the conjunction with the measure phase is the analyze phase, when the team analyze the process options that will meet the customer’s requirement deliverables.

The “design” stage in this phase the team will document the detailed process that meet the customer’s deliverables.

The “verify” is the final stage of this process, in this phase the team will verify that the customer’s needs are met using the newly designed process.
3. THEORY:

3.1 Summary of the literature study and state of the art:

Rubber is a material around us that everybody is using in their daily lives. It can be seen more than 40,000 different kind of product medical devices, tire, gloves, rubber seal and so many other engineering products. Now a day, it has been become an important part of our lives and many engineering sectors. Its resilience, resistance to abrasion, impact, and efficient heat dispersion makes it ideal for use in for instance airplane tires and truck tires that are exposed to enormous stress. Its elasticity and temperature tolerance make it use for medical assistance. So far, no synthetic rubber has been made that can compete with natural rubber in these areas (Oscarsson, 2015-01-28). Roxtec proudly introduces the innovative Roxtec SPM™ seal – a patented sealing solution that helps you ensure safety and operational reliability without any downtime or cost related to welding. The seal is made of highly elastic EPDM rubber and fittings of acid-proof stainless steel. It is quick and easy to install from only one side of steel decks or bulkheads. The structure may range in thickness from 6 to 15 mm. The Roxtec SPM™ seal maintains a tight seal around the metal pipe as well as sealing inside any uneven or irregular opening.

The indicators that show when full compression is achieved are just one example of its safe and user-friendly design. (Roxtec SPM™ seal, n.d.)

The seal is made of highly elastic EPDM rubber and fittings of acid-proof stainless steel. It is quick and easy to install from only one side of steel decks or bulkheads. The structure may range in thickness from 6 to 15 mm. The Roxtec SPM™ seal maintains a tight seal around the metal pipe as well as sealing inside any uneven or irregular opening.

What is EPDM material:

The EPDM elastomer is one of the more interesting types of rubber. Chemically known as ethylene propylene diene monomer rubber, it possesses many traits that are characteristic of conventional elastomers, such as tear resistance, a high tensile strength, and a low compression set. Of course, this doesn’t set EPDM products apart from other elastomers like SBR or NBR that also have similar physical properties.

About Roxtec rubber: Roxtec is a world leading company provide sealing for pipe transit and cables. It was founded in 1990 by Mikael Blomquist in his residential garage in Karlskrona Sweden. It was very efficient invention of multidiameter solution that improve the process of improvement the sealing cable and penetration. It is growing vastly in worldwide. Now a day, Roxtec provide complete sealing for number of application in industrial field. It can work efficiently on land, at sea and underground. Roxtec RS X is non-welding seal with sleeve for single cables and pipes. The sleeve has rubber gasket on the outside and expand in the hole to firm attachment as a bolt are tightened.it comes in adaptable to cable and pipes of different sizes through removal layers.

• Fire rated
• Water tight
Why use the Roxtec SPM™ seal?

**Protect against fire, gas and water**
The Roxtec SPM™ seal is developed for the marine and offshore industries and can be used to seal metal pipes against multiple risk factors.

**Save time and money**
The seal is light and does not require welding – which helps you ensure cost-efficiency and productivity.

**Speed up installation**
It is quick and simple to install from only one side of decks or bulkheads, and its design is both safe and user-friendly. (Roxtec SPM™ seal, n.d.)

**Agents of deterioration and recommendations for their control:**

**Radiations:** This rubber is not good and affected by ultraviolet rays. For some plastics and rubbers, visible light also causes deterioration. The higher intensity of job faster the deterioration. (Lafontaine R. H., 1984)

**Humidity and temperature:** The effect of humidity and temperature are not matter. However, it does promote the damaging action of acidic atmospheric pollutants and acidic by-products of deterioration. (Lafontaine R. H., 1982.)

**Pollutants:** there are a lot of things such as sulphur dioxide and nitrogen dioxide. These kinds of gasses are acidotic may cause Harmful effect especially in humid condition. Ozon which may be damaging the rubber. Ozone, which might be produced by ultraviolet radiation that is catastrophic.

**Stress and other physical forces:** some time degraded plastic and rubbers surprisingly brittle. Stress, such as that created by stretching rubber, can increase the rate of its chemical (oxidative)
deterioration. Cracks will tend to appear at right angles to the direction of the applied stress. For example, cracks may develop along a fold. (Care of Objects Made from Rubber and Plastic, 2018)

There are some problems in this sealing product that the availability of dust or powder after grinding. Customers and companies both are facing problems by this because company issues that they need to remove this remaining dust manually with hand that takes more time and manpower even they have machine, but it does not work properly. On the other hand, buyers face problem that if there are dust available on the rubber surface then glue does not work properly if they need to put other layers.

Six sigma is a very efficient and renowned methodology for elimination defects from any manufacturing system. This process must not produce more than 3-4 defects per million opportunities. The Six Sigma DMAIC process (define, measure, analyses, improve, control) is an improvement system for existing processes falling below specification and looking for incremental improvement. It was initiated at Motorola in 1980s since than it comes in popularity among the organization. Six sigma methodology helps to get significance performance in manufacturing process. (Goh, 2002). The sigma’s name oriented from Greek alphabet and in quality control terms sigma (σ) has been traditionally used to measure the variation in a process or its output. (Omachonu, 2004). In this six-sigma methodology the “sigma level” represents the level of organization. Particularly, a Six Sigma level refers to 3.4 DPMO (Stamatis, 2004), or in other words, to have a process which only produces 3.4 defects per every one million products produced. Six Sigma is also a management philosophy and strategy that helps organizations to get lower cost, as well as a problem solving and improvement methodology that can be applied to every type of process to eliminate the root cause of defects.

The main processing goal of six sigma is to identifies and eliminate the defects that may affects to the system (Bailey, 2001). It has the highest record to effectiveness and it can bring the performance up of any organization if organization follow it good wise. Therefore some authors believe that if we get six sigma that means we can get cost reduction in manufacturing process, defect elimination, cycle time improvement, increase the satisfaction of customers, improve quality standard of product and organization and raise the profits. (Pyzdek, 2010).

On the other hand, by using this methodology an organization can get improvement in other areas such as in logistic area purchasing legal and human resources. Furthermore, (Kumar, 2008) argues that six-sigma only use in defect reduction. It can also be applied in business processes and to develop new business models.

(Banuelas, 2005) believe other benefits of six sigma DMAIC such as:

*An increase in process knowledge.
*participation of employees in Six Sigma projects; and
*problem solving by using the concept of statistical thinking can also be gained from the application of Six Sigma.
As a reason, not only does an organization itself gain benefits from implementing Six Sigma in terms of cost savings, productivity enhancement and process improvement, but individuals involved also increase their statistical knowledge and problem-solving skills by conducting a Six Sigma project. DMAIC resembles the Deming's (1993) continuous learning and process improvement model PDCA (plan, do, check, act). Within the Six Sigma's approach, the DMAIC model refers, step by step, how problems should be addressed, grouping quality tools, while establishing a standardized routine to solve problems.

Considering this situation and evaluating we came up with several possibilities to eliminate the dust. Researching and reading various authors and scientific articles we came to know that there are various method or processes are there which can be used to remove from rubber. We would like to discuss first about the static electricity. It is one of the used process to obtain the best surface quality from a product using Electrostatic force. Static electricity is a stationary electric charge typically produced by friction, that causes sparks or crackling or the attraction of dust or hair. (Slinker, 2014). The process of static electricity works on the basic principle of electric current exchange. It creates an imbalance of positive and negative charges in objects. Inside any product there is atoms such as protons, electrons and neutrons. In this stage the process work as the protons are positively charged, the electrons are negatively charged, and the neutron are neutral. After this the materials are rubbed with each other to transfer negative charges or electrons.

Taking about the history of static electricity is such as it is created by Wilhelm Beth, Lubek.

The basic formulation of dust removal and static electricity is such as that the dust particles are charged with electrostatic induction. When the dust particles are charged and active and separated, it is collected by due to the coulomb force generated by the alternate current field. Then the dust particles are transported due to the gradient force induced by electric curtain of non-uniform travelling-wave electric field (Slinker, 2014). This system is basically used in the large industries who faces this dust problem affecting their environment and products. So, using this procedure to eliminate dust is one of the trusted one. As, the dust is being captured and conveyed by duct never settles in the duct. Finally, the dust is collected using a variety of things such as basic pass-through filter, or in case of static electricity, electrostatic precipitator. We gone through a literature by (Fraunhofer-Gesellschaft, 2009), it is being mentioned there that this little thing that count in industrial manufacturing process. The particles that has less than the half of the diameter of a hair in the size can significantly impair quality in production. For instance, there should be no particles
larger than 5 micrometers on any of the product, as these could contaminate the products. The static electricity can also affect the product such as when this process is performed on removing dust using electrostatic force, sometimes the surface or the whole of the product can also be affected. These types of processes can create static current and this can also may damage or defect a product.

As, we worked on a EPDM based rubber product and basically it consists the rubber characteristics, so this process may defect the product and can also harm the surface of the product. Eventually, the following customer will also face difficulties in sticking or binding the two rubber modules with each other.

Vacuum cleaning is one of the easiest and efficient cleaning methods using the compatible vacuum cleaners. This vacuum cleaning methods are used on the commercial basis such as cleaning floor, sofa, and more home appliances. There is one more process which is the advanced and précised one which is generally used by the industries. Many industrial products, or machines are so delicate and small that one should take care while doing this process. These industries used the brush vacuuming to clean such products or machines. (BRUSH VACUUMING TECHNIQUES, 2017). The basic principle of vacuuming is that it creates a negative air flow. For example, when one takes a sip a drink through a straw, the action of sucking creates a negative air flow inside the straw. This pressure is lower than that of atmospheric pressure, such the vacuum cleaner creates a negative air pressure inside and such the air inside. (Zovoilis, 2017).

The vacuum machine uses an electric motor that spins a fan, sucking in air- and any small particles caught up in it and pushing it out the other side, into a bag or a canister, to create the negative pressure. The reason of having the exhaust port since the air is confined space that vents the air out in the atmosphere, allowing the motor to continue functioning normally. The air, however does not pass through and get ejected out the other side. Since all these trapped particles are trapped by the bag or the container, the vacuum cleaner passes the air through at least one filter and often a HEPA (high efficiency particulate arresting) to remove all the dust almost. (Zovoilis, 2017)

As, vacuuming cleaning could be a better option to clean the dust efficiently. However, to perform this task on our project we should test a prototype of this procedure in the industry. The machine which is used to cut or remove the outer edges of the rubber module and to clean the product is in ongoing condition. To perform test, we need the machine should be completely shut down for an amount of time. The other aspect we must consider is the cost. If we would approach this procedure to the company, they must install a high-pressure vacuum pump to that machine and it would raise the cost in every single step. They would have to maintain the vacuum pump and process, electricity is also one of the factor they must considered. These all aspects would directly affect the eventual rate of the product and the customer will also have to face this.

Compressed air is used for many places for cleaning. We have also considered this method in our thesis report because it is widely used in industries. Several industries make use this source as
energy and great number of workers also use this for cleaning by different way according to product. It is also used for many other places such as maintaining machinery, workshop, floor, walls and ceiling. But most of the industries use this for dust cleaning or debris.

Me and my colleague have this possibility that the process we are thinking about the dust cleaning from the rubber product through the high-pressure air during its side cutting process. Because during its cutting and grinding process some fine cut material like powder stick to the rubber product so if there will be the pressure of air simultaneously grinding then the possibility is that powder cannot stick on product. Moreover, brushing method also can be used during flowing high pressurized air on the specimen.

**Regulation concerning compressed air**

*Air pressure limit:* The pressure of compressed air is used to clean the machine and product shall be less than 200 kilopascals. unless cleaning is carried out in an enclosure specially designed for abrasive air blasting and equipped with a vacuum system.

*Inspection and maintenance:* - Hand tools and portable tools and all air cleaner devices shall be inspected and maintained timely and if there are any defect found then it should be repaired or fixed so that it can work efficiently.

*Electric wires and flexible hose:* - if the air compressor left on the ground, be protected so as not to be damaged and be aware and secured so that eliminate the risk of failing. When suspended be at sufficient height to ensure clearance but at least at 2 meters.

*Piping for compressed air:* - Piping in which compressed air flows it should be protected from at the impact and be clearly identified as to the nature of its content. (Rouleau, 2004)

**Safety equipment:**

*pre- set pressure regulator:* - This is the device that use for regulating the air pressure to set standards. This device should be installed directly on the air piping that cannot be removed easily. It is used to control the pressure of air and here the maximum outlet pressure should be 200 kilopascals. (Rouleau, 2004)

*Pneumatic quick fitting:* - This device prevents the hose whiplash. It is airtight, reliable and very easy to use.

*Safety air gun:* - This type of air gun is used to increase the pressure of air while limiting the static pressure under 200 kilopascals. so this is the integral part of air compressor cleaning system. A nozzle is mounted on the end so that we can achieve the desired angle to flow the air pressure.

In this system, nozzle and air gun should be crack less and trigger should be operating freely and there is no air should be out when trigger is released. End peace should be free from distortion and if there is any kind of defect detect then it should be fixed on time. (Rouleau, 2004)

We can also use some liquid solvent in water for remaining dust clean. There are a lot of detergent and cleanser available in market that can be used for cleaning rubber material. But the thing is we need to care about it should not be spirit or petroleum based because no any industry wants to take
any kind of risk by using flammable cleanser for their product. So brushing and any cleanser can be used with water pressure on product. And after cleaning it with the water and cleanser solution then it should be arrangement of its dryness before exit the product out. because if wet product directly get in touch with outer environment then it attracts more dust from surrounding. So, we can add some cleanser such as quick break-D cleanser, cleans all, super SC etc. Quick Break D is an excellent water soluble, non-flammable with medium foaming characteristics making it suitable for use through hand pumps and high-pressure equipment.

3.2 Chosen topic

Considering all the methods and the processes we have searched from various literatures and articles, we came up with many of the possibilities such as vacuuming cleaning, adding solvent with water, high pressurize air and performing static electricity. As, the company is recently using this high pressurize air technique, but they are not capable to clean it efficiently. The process they are doing for cleaning the product is using water, spraying and blowing air on the product. This process is being carried out after the product is been grinded, it is then send to the cleaning belt where the pressurize air is been applied to eliminate the dust. However, the process is working, and the product also gets cleaned but not “efficiently”. Focusing on the other methods and process, we believe that they may affect the cost of the product. Such as, if we will go for vacuuming cleaning, it is very complicated process. For instance, in our project the machine which is making the product and manufacturing and cleaning is the ongoing machine. As, the machine is confidential it is packed form the outer atmosphere and one cannot easily understand the process neither can view the process which is being conducted inside the machine. So, this would be a challenge for us as well as for the company. We must install the vacuum pump and the following parts to make the process possible. For this, the machine should be redesigned including the vacuum pump and its parts and this process will cost the company and the client as well.

Static electricity is also a better concept and it will be efficient than any other methods. In this process the dust should be collected by performing the static electricity with the help of electrostatic plate which should be placed on the machine. It should be in such position that when the product is conveyed on the belt to the cleaning process. For this process the machine should be placed in such a condition where there is low change of conducting electricity or any other conducting influences. To do this process the proper study should be carried out of the machine by consulting the company making the machine. The electricity which is used to operate the machine, it should be examined whether it is obtaining three phases current or two-phase current. A segment must be placed to carry out this process where the dust is being attracted by the plate and then collected to a bag such as it should not be stick again to the product.

Adding any chemical solvent to the water which is used to spray to the product is also an aiding concept. There are different types of chemicals which is used widely to clean the dust or any other dust particles from a product. Considering our project and the contaminated product by the dust one of the chemical is Acetone or mineral spirits. These chemical is compatible with the EPDM rubber and non-react solvents. As, every individual chemical has its own characteristics and thinking to use this solvent will be somehow harmful for the product. The EPDM rubber product
is used in the heavy industries and marine applications. So, this process is useful and its own pros and cons.

Moreover, the most promising concept to us is using the high pressurize air spraying on the product. After studying the situation and the cleaning process we came up with this process. As for now, the company is using this process, but it is not efficient. There are many factors that are affecting this process such as the air which is blown is not at the right place neither at right time. Considering the process from our perspective we virtually simulated the process in a different way.
RESULT

After doing a lot of study and research for the product and every possible solution considering the aspects of company and the client, we decided to go with the most promising solution from our perspective which is using the High pressurize air including water. Air is the most and the old process which is used for cleaning the dust or any other particle. This process can be used on every single product and has no other drawbacks. There many types of air pumps and compressors which is used to blow air with high pressure with the help of nozzle. In this case, after consulting and examining the cleaning process done by the machine we decided to experiment or to test the same process of cleaning but with different concept. The concept is such as when the EPDM based rubber modules are placed for cleaning after manufacturing in the machine. The modules are placed in such a way that the outer surface is placed in upward position and the inner surface is placed in downward position. In this position the outer edges of the modules which remains uncut or in technical language we can say that material as scrap as shown in the below figure 4.1

![Figure 4.1 (HGF)](image)

This material is being grinded, such as the modules are placed in between and on the both sides there are two grinding motors are placed. These motors make the grinding plates work in clockwise and anti-clockwise direction respectively. The materials which is being grinded separates from the materials and it sticks to the product again in the powder form. As this is a rubber material there is more friction between the product and the powder particles. Then the product is conveyed by the conveyer belt to the cleaning sections where blowing air and spraying water takes place.

So, we decided that to improve this process we would like to introduce a concept such as when the grinding takes place, high pressurize air should be blown simultaneously so that it may lower the chances of sticking the grinded powder to the product. Surveying the supervisor of the technical department about the air blown to the product is not sufficient. We examined the pressure gauge
which was mounted to the compressor to check the air flow from the compressor to air gun nozzle was not working. But the supervisor admitted that the air which is blown was about 10bar(approximately). Unfortunately, we were not able to test this method practically as the machine is in working condition. To implement this concept, we need to install the air guns nozzles into the machine where the grinding process takes place. As, the machine is confidential we cannot display it, but we would to explain this phenomenon with a help of diagram. The figure is as follow;

![Diagram](image)

**Figure 4.2**

As you can see in the above diagram the multidiameter is placed in between the two grinding belts, based on the conveyer belt. As, the product is available in multi diameter, so the machine adjusts the grinding belts according to the size of a module. Our approach was to install the air blowing guns inside the machine. According to survey, the recent pressure of air blown to the product was approximately 10bar or (145.038psi), we suggested the company to increase the air pressure from 145psi to 155psi (10.6bar). The company is using one Air blow gun, we suggested to install one more Air blow gun using nozzles. One nozzle should be places in such a position such as it should blow the air on the outer surface of the product, other nozzle should be placed in such a position that it should blow air in the inner surface of the module. The aim of installing these nozzles is to prevent the powder released through the grinding process. This process may lower the chance of sticking the powder of rubber to the module.

The perspective of approaching this concept has many pros such as;

- The company can clean the product on the same machine, no need of mounting or installing a new machine
- The machine can use the same compressor for this process, no need of installing a new compressor.
- This process will not cost the company to invest much in the equipment, this will maintain the cost of the product.

There are few aspects which should be considered as drawbacks such as;
• This process should only be carried out by the machine, no manual presence.
• Output of the air is high; fittings and connections should be done precisely and under proper supervision.
CONCLUSIONS

3.1 CONCLUSIONS

The aspects describing the various types of methodologies or processes or tools are important to considered.

- There are many methodologies including scientific and non-scientific methods to improve the quality of the existing products.

- Six-Sigma is one of the proven and widely used methodology used by many, large and small-scale industries. Consisting several tools such as DMAIC, DMADV, DMEDI, 5 why, brainstorming and many more.

- Implementing the DMAIC methodology in our project helped us finding the root cause of the problem and Ways to improve the quality by eliminating the issues.

- Considering the fact and the possibility we preferred the High pressurize air to clean the dust or dust particles and maintain the initial quality of the product.

- We approached to the company with this concept if the client will accept the concept than we would to design the system in the existing machine and implement this process.

- Unfortunately, we were not able to test the solution. We are admitting this process as the most promising solution considering the facts and literature study about the materials and methods.

3.1.1 Recommendation to future activities

There are few factors that we would like to recommend to client for the betterment of the quality of the product.

- We suggest the client to re-design the existing machine if possible, that would lead to the improvement of the quality and process of cleaning.

- Maintenance and periodic replacement of grinding belts is necessary to stabilize the particles released by the grinding material.

- Pressure gauge mounted on the compressor should be checked and calibrated, so that one can check the pressure and regulate it as per need.
**Critical review:**

This critical review is based on the self-experienced. Explained following:

**What kind of factors affect the work been done differently**

This project has no connection to environment because it has no effect on environment and environment has no any affect on the project. There are so many kinds of articles and reports from the university library from Emerald that helps, guide and give the direction regarding project. In this project, there was some problems to how to find the causes and solutions that can helps to get rid unwanted dust. So, after reading so many literatures and with suggestion from the professor it has been decided that we need to use six sigma DMAIC and 5 whys. It successfully works. With the help of 5whys and DMAIC can find out the root cause of problem then it also indicates how to solve the problems. As in this project the root cause of dust is occurred in the grinding section that need to fix.

**Environmental and sustainable development**

Initially it has been decided that for removing the dust we will use the vacuumed and electrostatic plate that attracts the dust. But here it takes a lot of cost for its installing, operating and maintaining.so the solution should no be taken so much cost moreover it should be reliable and sustainable. That is why high pressurised air and brushing consider the good and cheapest solution for this.

**Health and safety**

Health and safety are a crucial matter in company. It can not be skipped.it is the field concerned with the health and safety of people at work. In the rubber factory there are many kinds of harmful gasses emits to the environment that is hazardous for human life and fluids and solvent are using in the industry that should be use very carefully otherwise there are so many kinds of illness occur with the people at work such as skin related problems and breath related problem.

**Economy**

Cost is also the significant matter in every organisation. Every organisation wants to reduction the cost in production so that their product cost can be less as much as possible. In this project cost should also take care that is why some possible solution cannot be continued such as electrostatic plates for attracting dust and other hand vacuuming. So, it will take a lot cost. That is why it is better to find its alternate solution that is cheap.

**Ethical aspect**

Ethical aspect is the crucial factor in human life not only on work. So, every worker should be honest and careful regarding their work. Workers need to understand their own responsibility. No one organisation can get success if their workers do not follow ethics and rule and if they do not care about work. So, honesty is the best policy in life. It is the key success for business.
References
(n.d.).


