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Reduction of Plastic Film Waste Using Quality Control Tools

تقليل فاقد البلاستيك باستخدام ادوات الجودة

A Thesis Submitted In Partial Fulfillment of the Degree of M.Sc in Plastic Engineering

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September 2017

المستخلص

حدثت الكثير من التغيرات المهمة في مجال الجودة التي انعكست بتغير التعريف، التقنيات، ومجال التطبيق. كما صاحبه تغيرات في توقعات العميل. الذي بدوره أدى لاهتمام خاص بالجوانب الهندسية للجودة.

الهدف من هذا العمل هو تقليل نسبة التالف اثناء الإنتاج في مصنع ماكس كدراسة حالة وذلك بتحديد المشاكل الأساسية التي تؤدى للتلف وإيجاد الحلول المناسبة باستخدام أدوات الجودة. في هذا العمل تم تطبيق خرائط السريان وذلك لتقديم صورة واضحة للعملية المراد التركيز عليها. أيضا تم استخدام مخطط ايشكاوا لتحديد أسباب مشاكل المواد الخام، الماكينات، الطرق المستخدمة، الخ. مخططات التحكم استخدمت لتقييم وتلخيص النتائج.

بعد تطبيق أدوات الجودة تدنت النسبة المئوية لتالف الإنتاج من 25% الى 8.6%. مما يعتبر تدنياً ملحوظاً في وقت قصير. وذلك يؤكد ان استخدام أدوات الجودة ساعد في حساب، وتحليل عمليات التصنيع والتحكم فيها وتقليل تالف الناتج اثناء عملية الإنتاج.

Abstract

The field of quality undergoes significant changes as reflected by changes in its definition, approaches, techniques, and scope of application. Changes in customer expectation. This also calls for special attention to the engineering aspects of quality. The aims of this work is to reduce plastic waste at Max Plastic Factory by identifying major causes of the defect problem and to adopt solutions by using quality techniques. In this work flow chart was applied to provide a diagrammatic picture of the focused process, Ishikawa Diagram was also used to determine the breakdown of the potential causes of the material problems, machine, method, etc. While control charts were used to evaluate and summarize the results.

After applying quality tools, the percentage of plastic waste is reduced from 25% to 8.6%, which is considered a huge reduction in shorter time. Thus using quality tools had helped to evaluate, analyze and control the production process and reduce waste during production cycle.

Acknowledgments

I am very grateful for the assistance of everyone who was involved in this work. I would like to thank the individuals from Max Plastic factory who allowed me to apply my work on their factory for their cooperation, enthusiasm, and time. Without their generosity, this work would not have been possible. I would like to thank Professor Ahmed Ibrahim Seedahmed for his patience, help and for the opportunity to guide me in this work.

I am grateful to Plastic Department teachers and staff for the diligent efforts supporting and giving me feedback during this work.

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Chapter I

Introduction

1.1 Background

Plastic have undoubtedly been the wonder materials of the last century. It has fundamentally revolutionized the manner in which it is conceptualized, and implements new products. It is ubiquitous in today's environment, appearing in ways that range from mundane to high-tech, from indispensable to completely wasteful. The manner in which this material has shaped our impressions of plastic as a miracle material.

Many of the negative impressions have come from the fact that the world was not prepared for materials of such complexity. In many ways, inability to understand plastic affected the manner in which have been used or misused them. Before the appearance of plastic, most materials were relatively simple, or if complex, natural. In both cases, either by the application of existing science or by long historical knowledge of their use, it was possible to use these materials in an effective manner. In the case of plastics, the converse occurred. The discovery of plastic is the most comprehensive periods of discovery in material science. The very nature of plastics has demanded significant advances in the ability to understand polymers, analyze their composition, and characterize this behavior. These technologies, collectively termed plastic analysis techniques, have come a long way in helping to design novel materials for a better tomorrow.

The world production of plastic in 1900 was about 30,000 t – in the year 2010 it had reached 265 Mt, with thermoplastics contributing about 90 % of this amount, while the rest was thermosets. For the last 20 years, plastic production has increased at the rate of about 5 % per year, with no saturation in sight. In 2010, China accounted for 23.5 % of plastic production, whereas Europe and the North American (NAFTA) region contributed 21.5 % and 20.5 %, respectively. Global plastic consumption in 2015 reaches 297.5 Mt. According to a report by Global Industry Analysts Inc.,

One of the most outstanding features of plastic is the ease with which they can processed. In some cases, semi-finished articles such as sheets or rods are produced, and subsequently fabricated into shape using conventional methods such as welding or machining. In the majority of cases, however, the finished article, which may be quite complex in shape, it can be produced in a single operation. The processing stages of heating, shaping and cooling may be continuous (eg production of pipe by extrusion) or a repeated cycle of events (eg production of a telephone housing by injection moulding) but in most cases the processes may be automated and so are particularly suitable for mass production. There is a wide range of processing methods may be used for plastic. In most cases, the choice of method it is based on the shape of the component and whether it is thermoplastic or thermosetting. It is important therefore that throughout the design process, the designer must have a basic understanding of the range of processing methods for plastic since an ill-conceived shape or design detail may limit the choice of moulding methods.

The most common methods of processing plastics films is Extrusion Blow Molding using a screw inside a barrel. The plastic, usually in the form of granules or powder, is fed from a hopper on to the screw. Then it is conveyed along the barrel where it is heated by conduction from the barrel heaters and shear due to its movement along the screw flights. The depth of the screw channel reduced along the length of the screw to compact the material. At the end of the extruder, the melt passes through a die to produce an extrudate of the desired shape.

Since the film is drawn upward. Moreover, expanded radially by air pressure. A biaxially oriented film is produced. Most plastic bags and wrapping films made this way. The die is similar to that used for making pipes or tubing. The melt polymer forced upward through the spin annular slit, emerging into the atmosphere as a thin-walled continuous tube. The tube then very rapidly hauled upwards by the pull rolls. Expanded by internal pressure, and at the same time acted upon by cooling air jets, which cause it to solidify at some tens of centimeters above the shaper lips. The bubble collapsed and the film rolled onto a wind-up roll. The stability of the bubble is crucial, resulting in a biaxially oriented film.

Blow molding is a very complex process because a large number of properties are balanced and interdependent. It seems simple to melt some plastic, make a bubble shape, and inflate a hollow object, but consistency is the whole key to blow molding at production speeds. Achieving consistency is a matter of paying attention to all of the details involved in running the Blow molding machine. The primary input variables in this process include material temperature, condition, die temperature and design, extrusion rate of the melt, injection air temperature, die temperature and design, cooling rate and time. All of these variables affect the outcome of the part and must be carefully control.

Advantages of Blow Molding Some of the obvious advantages of the Blow molding process are its ability to make hollow films with high productivity, no subsequent finishing, and high surface quality. Since it is a low-pressure process, products have low residual stresses, which provide adequate environmental stress-cracking resistance. Because of the stretching that accompanies internal blowup of the film, biaxial orientation is easily achieved, and with modification, uniaxial orientation, if preferred. Control over orientation gives better mechanical strength. The improvements to the blow molding process have also inspired the development of high quality products.

Material selection for Blow molding applications based on the end use of the product. In general, Blow molding requires that plastic have high stiffness, good impact properties; good environmental stress cracking resistance, and process consistently. Containers designed to carry reactive chemicals or other active liquids will require the use of a material with high chemical resistivity. The material used in Blow molding must also have sufficient strength to allow the formation of film bubble.

Packaging film is very thin plastic and the basic component of plastic and elastomer materials. Generally, films have used as barriers; they keep dirt, germs, liquids or gases on one side of the film. Nearly any plastic can made in film form; it has many advantages a trend toward conversion to biodegradable, sustainable, and recyclable flexible packaging materials to improve the environmental footprint of packaging. Flexible packaging films have being made thinner to reduce costs and minimize waste after use, which also drives the need for higher performing materials. Flexible packaging products will replace bottles and containers for a range of food and beverage products.

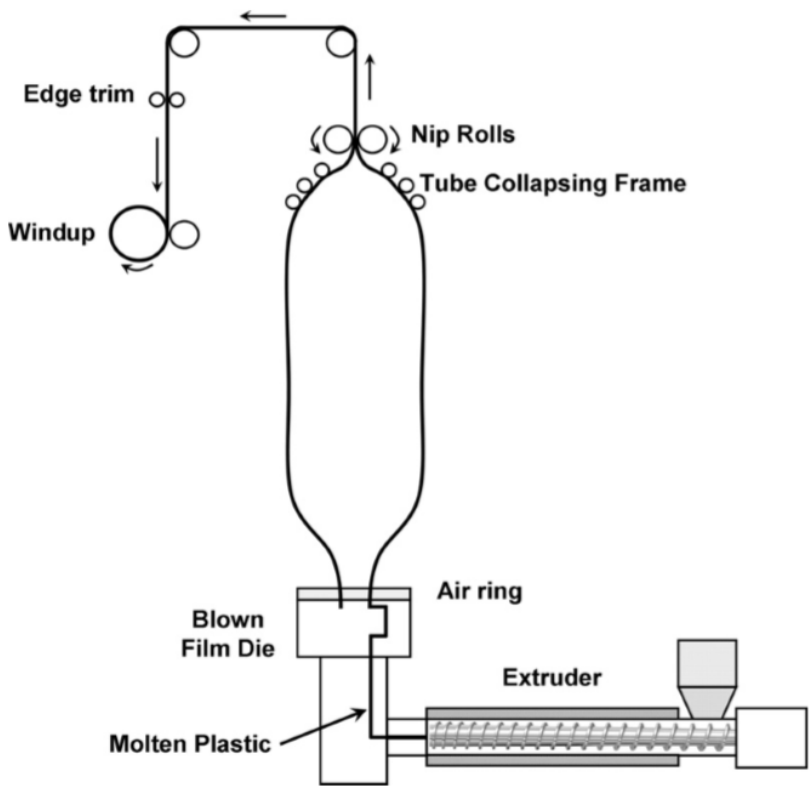

Figure 1.1 Schematic of a blown film process.

1.2 Statement of Problem

Max Plastic factory in Khartoum produce packaging plastic films and it has excessive plastic waste and defects during production cycle approaches 200 to 300 kg per ton.(20 to 30% of the input raw material). They do not have Quality control standards which have caused non-stable production cycle time and quality issues that include poor quality for the products, high waste percentage.

1.3 Purpose of the Study

The purpose of this study is to reduce plastic waste during production by improving manufacturing efficiency by implementing continuous improvement methods such as quality tools for analyzing the current process and redesign the clamping apparatus for the company.

1.4 Objective of this Study

1. Study the work environment as to specify major causes of plastic waste.
2. Gather and analyze the data to determine the factory current performance.
3. Apply the methodology (Quality tools) to reduce plastic waste.
4. Make recommendations to improve product quality and processing.

Chapter II

Literature Review

2.1 Introduction

The interest of the current work is to reduce plastic film waste that generally occur during film manufacturing. These defects often spoil the aesthetics and even the intended use of the film. Plastic film produced by long screw pumps known as extruders. Defects in manufactured film are normally associated with contaminant particles in the polymer melt are being extruded. They may originate from the polymer feed or may create during the extrusion process. Industrial attempts to prevent such defects involve ways of first detecting them and then diagnosing their origin. Traditionally, visual inspection of film followed by trial and error procedures to eradicate them have been common place.

The quality of plastic film is very sensitive to foreign particles in the polymer melt. A visual defect transmits light differently from the rest of the material in the film and spoils the appearance, as well as possibly the functioning of the film. Types of defects vary from one manufacturing field to another depending on the materials, processing conditions, and processing steps. Generally, defect appearance depends on its source and processing conditions. Defects appear in different forms such as holes, black specks, and bubbles. Areas with different surface texture, lumps, discolorations, and scratches.

In film manufacturing, some defects caused by problems in the manufacturing line or malfunctioning parts. For example, any scratches or sharp points on the film die, rollers, or winders will result in a film defect. Any non-uniformity in extrusion flow rate and roller or winder pulling rate will result in film thickness and width variations. In most cases, it is possible to readily determine the source of these types of defects and resolve the problem.

In addition, plastic film quality is investigated by off-line measurement of different film properties. Among these, visual quality control is conducted by placing a piece of film sample against the light and counting the number of visible defects or defects in a predefined size range in a specified area. This number is then compared with established standards for overall appearance quality.

The off-line approach is time consuming and does not provide real-time feedback to prevent defect generation. It can only monitor a small part of the product. In addition, personal judgment and opinion may be involved leading to variability in results. As will be seen in the next section, over the years, fast and reliable automated real-time film inspection systems have developed. [1]

To study the quality of resin or master batch in plastic compounding, Dominey described in 2003 a technique for producing sample film on a continuous basis and analyzing the film in real time. This system utilized a line scan camera and a high frequency fluorescent light source. All defect images were recorded and processed using image processing software. Defects were classified and counted based on their size and intensity. [4]

In polymer compound, particles or fibers are incorporated with polymer resins in different ways to create new materials with significantly improved properties. Properties of the resulting composite depend on the properties of its individual components, their size and shape distributions, and orientation. The most widely used mineral fillers (or reinforcements) are calcium carbonate, talc, clay, silica, mica, master patch and glass. Some of the important properties of fillers that affect the properties of the final material are density, particle size, particle shape, hardness, thermal expansion coefficient, melting temperature, and surface tension. Addition of filler particles to polymers in molding and extrusion applications is common. However, in clear film manufacturing, only very low concentrations of filler can be added to the polymer if clarity is to be retained. [7]

The in-line melt monitoring research at the University of Toronto, serving as a precursor to this work, was begun by Desa. Desa et al. Focused on monitoring the quality of recycled plastic waste during extrusion. The main goal was to detect particles and microgels inside the melt. The developed system was able to detect particles near the extruder wall, however image quality was poor. [3]

Mehra and Vujnovic also used a similar system to monitor contaminants during extrusion. Based on the results of this previous work and with the advances made in the lighting and CCD camera technology, a new and powerful in-line melt monitoring system was developed by Ing et al. This system is capable of scanning through the melt channel, hence called the Scanning Particle Monitor (SPM). The SPM can monitor low concentrations of dispersed phases across a translucent polymer melt. This system provides quantitative information on particle properties, velocity and concentration profiles. [1]

2.2 Quality control

Everyone want quality products or services, or a high level of quality. However, what do they really mean? Is it possible to have too much quality? Without a clear definition of quality, it cannot even begin to measure and evaluate it. In the following sections, the definition of quality in customer-oriented and statistical terms.

Quality control is a critical concept in every industry and profession. As globalization continues and the world becomes smaller, making it possible for consumers to select from the best products worldwide, the survival of the job and of the company depends on the ability to produce a quality product or service. In this chapter, it will define the term “quality,” with introduce some important quality control concepts and methods.

What does the word quality mean? For most people, quality is associated with the idea of a product or service that is well done, looks good, and does its job well. It is easy to think of a quality product as one that lasts, holds up well under use, and does not require constant repair. A quality product or service should meet a high standard in many areas, such as form, features, fit and finish, reliability, and usability.

Most people use the word quality to mean “having a high degree of excellence,” but like beauty, quality is in the eye of the beholder. If a consumer’s desire were to have basic transportation at a low price, he would buy a Toyota rather than a Lexus. The Toyota may be a lesser grade of car, but is it of lower quality than the Lexus? That is up to the consumer to decide.

To complicate matters, the definition of quality changes over time. The Ford Model T was once thought of as a quality product, but if a dealership sold it today, it would be in the same quality class as the Yugo. Consumers’ quality standards for cars have changed over time, just as they have for other products. As products and services evolve, consumer expectations tend to increase so that yesterday’s quality product becomes tomorrow’s junk.

What do these facts mean to business? Quality, in the eyes of a business, revolves around meeting customer expectations expectations that may be stated or implied. One action that sums up quality from a business perspective is when the customer returns after the sale and the product does not. Repeat business is probably the most basic measure of quality, because customers vote on the quality of the product or service with their pocketbooks. However, unlike political elections, customers vote daily, and new opposing candidates appear just as often to try to win customers' votes.

The statistical definition of quality is a little more precise than other definitions, such as the customer-based concept, and based on mathematics. When measure quality statistically, look for variation in a measurement between what the customers asks for and what produce. The less variation it have, the higher the quality of the product or service.

All processes have some natural variation; use statistics to detect abnormal variation that could cause to produce a bad product or service. It can also use statistics to avoid testing every item that produce. By testing a sample of what have made or deliver, it can use statistics to measure its quality and find out whether it meets customer requirements.

Almost every industry has an association or trade group that sets quality standards against which companies can measure the quality of their products or services. Industries also have their own government- or business supported standards bodies for products important to them. The International Organization for Standardization (ISO) is an international body made up of the national standards organizations for almost every country.

Quality standards provide a common language and measurement system for describing the quality attributes of the products or services that sell. The term standards describes things such as specifications, metrics, or statements about a process. Quality standards are designed to help the document what making or doing (specifications) so that can prove followed and made exactly what company would.

Quality management standards deal with the training, quality assessment, and quality management needs of the organization. These standards are designed to ensure that ther process is capable of creating a quality product or service.

Quality standards allow companies to focus on their roles in the production process instead of spending valuable time and resources inspecting incoming materials and parts. Imagine the cost involved in inspecting every part or material that a vendor sends. Multiply that over the entire production process, and can see how individual inspections don't give companies an efficient way to ensure quality. [12]

2.2.1 Quality Assurance

In the 1980s, companies around the world discovered that if they wanted to compete in the marketplace, they had to improve quality while reducing costs. Companies who survived accomplished this by shifting how they managed their quality processes. Instead of relying on inspection alone to identify and correct problems, they moved toward a focus on preventing problems before they occurred. Quality control programs evolved into a more comprehensive quality assurance process. Quality control changed from being a post-manufacturing step performed at the end of each process to being part of the process itself.

The International Organization for Standardization (ISO) defines quality assurance as “providing confidence that requirements will be met.” To meet the goal of the quality assurance process, a company has to look not only at the product or service that’s the output of its production process, but also at activities such as design, development, production, installation, service after the sale, and documentation. In other words, quality assurance is more than just checking to see that the product or service meets the customers’ expectations; also have to look at the process involved in creating the product or service to see if the company is capable of producing a quality product or service each time. Part of this is verifying that the materials or parts receive are correct before they go into whatever product or service company makes or provide, And ensuring that the specifications for the product or service are clear.

Quality assurance is more effective the earlier it occurs in the process. In fact, quality assurance should begin before the product is assembled or the service is designed. How is this possible? It all starts with the suppliers. [12]

2.2.2 The Role of Inspection in Quality Control

In a perfect world, the product or service would always come out just right, but sometimes mistakes happen, and the only way to catch these mistakes is to inspect items before it ship them to consumers.

No matter the product have created or service that provided, it should have to complete a series of steps before it can deliver to the customers. Errors can occur at any one of these steps, causing the product or service to fall short of company customers’ expectations. How do they catch these errors before they reach the customer? Inspect the product or service at key points between major steps in production and remove or repair any bad items along the way.

Inspection is the analysis or examination of an item carried out to determine whether it's defective. Expert's use the terms conforming to say that an item meets customer specifications and nonconforming if it fails.

2.2.3 Quality Management

Quality management stage is the highest level involving the application of quality management principles to all aspects of the business. Typical of an organization going through a total quality process would be a clear and unambiguous vision, few interdepartmental barriers, time spent on training, excellent supplier and customer relations and the realization that quality is not just product quality but also the quality of the whole organization including sales, finance, personnel and other non-manufacturing functions.

Quality control managers use two approaches to determine if a product conforms: Examine the item or the results of the service and compare it to some standard description or image, And measure some physical property of the item or service and compare the measurement with a customer specification. [2]

2.2.4 Quality Engineering

Parallel to quality management, quality engineering has developed. A research done by V. A. Feigenbaum shows that prevention of quality defects and quality costs actually start with the engineering designs of products. These designs determine the material and often the machines, processes and skills required to manufacture a product for the marketplace. It is necessary to provide a distinction between quality management (soft aspects of quality) and quality engineering (technical aspects of quality) for setting the focus and the direction for further development. This is also necessary to gain better understanding on issues affecting each aspect. Putting everything under the quality management banner may be proper when addressing quality issues from integration and conceptual perspectives. Quality management and quality engineering may be addressing similar quality issues but their treatment is normally different in terms of depth and breadth. [2]

2.2.5 The definition of defect

A defect is a glitch that prevents the product or service from being acceptable to the customer. Nonconformance means that it did not match the customer or product specifications. They are not exactly the same. The bottom line is that every defect means the product does not conform to specifications, but not every nonconformance is a defect.

A defect may prevent the product from working 100 percent, or it may simply be a cosmetic blemish. If the hard drive in the laptop fails, it has a defect because the laptop is unusable. If the laptop has a scratch, it has a defect that makes the machine look less impressive, even though it still functions.

If the manufacturer of the laptop installs the wrong hard drive, but it has the same or larger capacity, the machine would not have a defect. The laptop is perfectly usable, and may not even notice the difference. However, the laptop does not conform to specifications because the manufacturer did not build it as planned in other words, the laptop is nonconforming. [12]

2.2.6 Process Focus

Basic functions that must be carried out to convert raw materials into finished product are processing, assembly, material handling and storage, inspection and test, and control. The first four are the physical activities that “touch” the product as it is being made. Processing and assembly add value to the product. The other functions do not add value to the product.

A process can be defined as sequence of operations that are performed during conversion process to convert a set of inputs (labor, material, knowledge, information, supplies, equipment, money, and time, etc.) to produce required output through value addition at intermittent stages. Every organization will have a network of processes that will need to be identified, evaluated and improved, on a regular basis.

At every supplier-customer, interface, there resides a transformation process and every single task throughout an organization must be viewed as a process in this way. Many processes are easily understood and relate to known procedures, e.g. drilling a hole, compressing tablets, filling cans with paint, polymerizing a chemical etc.

Others are less easily identified, e.g. servicing a customer, delivering a lecture, storing a product, inputting to a computer, etc. In some situations, it can be difficult to define the process. For example, if the process is making a sales call, it is vital to know if the scope of the process includes obtaining access to the potential customer or client. Defining the scope of a process is vital, since it will determine both the required inputs and the resultant outputs. The key to success is to align the employees of the business, their roles and responsibilities, with the organization and its processes. Many outstanding organizations have achieved and maintained their leadership through process improvement.

2.2.7 Activities of quality

In the manufacturing industry, activities concerned with quality can be divided into six stages:

1. Product planning: planning for the function, price, life cycle, etc. of the product concerned.

2. Product design: designing the product to have the functions decided in product planning.

3. Process design: designing the manufacturing process to have the functions decided in the product design.

4. Production: the process of actually making the product so that it is of the designed quality.

5. Sales: activities to sell the manufactured product.

6. After-sales service: customer service activities such as maintenance and product services.

It is important to note that company-wide activities are necessary to improve quality and productivity at each of the six stages mentioned above. A company needs to build an overall quality system in which all activities interact to produce products of designed quality with minimum costs.

Note that there are three different characteristics of quality in an overall quality system in the manufacturing industry:

1. Quality of design: quality of product planning, product design and process design.
2. Quality of conformance: quality of production.
3. Quality of service: quality of sales and after-sales services.

Nowadays, these three aspects of quality are equally important in the manufacturing company. If any one of them is not up to the mark, then the overall quality system is unbalanced, and the company will face serious problems. Although these definitions are somewhat different, some common ideas run through them. Quality involves developing specifications to meet customer needs (quality of design), manufacturing products which satisfy those specifications (quality of conformance), and then providing after-sales services. However, Taguchi’s definition of product quality is unusual. The loss he refers to may be caused by variability of function, or by harmful side-effects. Hence, if a product costs society no loss, the product is of the best quality, and the poorer the product's quality is, the greater the cost of the product to the society. [12]

2.2.8 Quality Tools

Quality control tools are seven, some developed by quality engineers, and some adapted from other applications. They provide the means for making quality management decisions based on facts. No particular tool is mandatory; any one may be helpful, depending on circumstances. A number of software programs are available as aids to the application of some of these tools.

Total Quality Management (TQM) and Total Quality Control (TQC) literature make frequent mention of seven basic tools. Kaoru Ishikawa contends that 95% of a company's problems can be solved using these seven tools. The tools are designed for simplicity. Only one, control charts require any significant training. The tools are:

- **Flow Charts**

A flow chart shows the steps in a process i.e., actions which transform an input to an output for the next step. This is a significant help in analyzing a process but it must reflect the actual process used rather than what the process owner thinks it is or wants it to be. The differences between the actual and the intended process are often surprising and provide many ideas for improvements. Measurements could be taken at each step to find the most significant causes of delays; these may then be flagged for improvement.

- **Ishikawa Diagrams**

Ishikawa diagrams are named after their inventor, Kaoru Ishikawa. They are also called fishbone charts, after their appearance, or cause and effect diagrams after their function. Their function is to identify the factors that are causing an undesired effect (e.g., defects) for improvement action, or to identify the factors needed to bring about a desired result (e.g., a winning proposal). The factors are identified by people familiar with the process involved. As a starting point, major factors could be designated using the "four M's": Method, Manpower, Material, and Machinery; or the "four P's": Policies, Procedures, People, and Plant. Factors can be subdivided, if useful, and the identification of significant factors is often a prelude to the statistical design of experiments.

- **Checklists**

Checklists are a simple way of gathering data so that decisions can be based on facts, rather than anecdotal evidence. Table 2.1 shows a checklist used to determine the causes of defects in a hypothetical assembly process. It indicates that "not-to-print" is the biggest cause of defects, and hence, a good subject for improvement. Checklist items should be selected to be mutually exclusive and to cover all reasonable categories. If too many checks are made in the "other" category, a new set of categories is needed.

Table 2.1 Checklist for Detects Found

Defect	Monday	Tuesday	Wednesday	Thursday	Friday	Total
Solder	I	II		I		4
Part	II		I	II	I	6
Not-to-Print	III	II	I	III	II	11
Timing		I	I		I	3
Other		I				1

Table 2.1 could also be used to relate the number of defects to the day of the week to see if there is any significant difference in the number of defects between workdays. Other possible column or row entries could be production line, shift, product type, machine used, operator, etc., depending on what factors are considered useful to examine. So long as each factor can be considered mutually exclusive, the chart can provide useful data. An Ishikwa Diagram may be helpful in selecting factors to consider. The data gathered in a checklist can be used as input to a Pareto chart for ease of analysis. Note that the data does not directly provide solutions. Knowing that "not-to-print" is the biggest cause of defects only starts the search for the root cause of "notto-print" situations

- **Control Charts**

This tool shows a moving picture of the variation in a process. In any production process, regardless of how well designed or carefully maintained it is, a certain amount of inherent or natural variability will always exist. This natural variability or "background noise" is the cumulative effect of many small, essentially unavoidable causes. In the framework of statistical quality control, this natural variability is often called a "stable system of chance causes." A process that is operating with only chance causes of variation present is said to be in statistical control. In other words, the chance causes are an inherent part of the process.

Other kinds of variability may occasionally be present in the output of a process. This variability in key quality characteristics usually arises from three sources: improperly adjusted or controlled machines, operators' errors, and/or defective raw material. Such variability is generally large when compared to the background noise, and it usually represents an unacceptable level of process performance. These sources of variability that are not part of the chance cause pattern are referred as "assignable cause." A process that is operating in the presence of assignable causes is said to be out of control.

Control charts can be used to analyze, stabilize and improve the process. It tells how a process is doing currently, what its capabilities are, and how those capabilities are affected by changes in the process. Control charts visibly track variation in a process over time; a process must be in statistical control before it can be improved. A process is statistically controlled when measurements from the process vary randomly within limits.

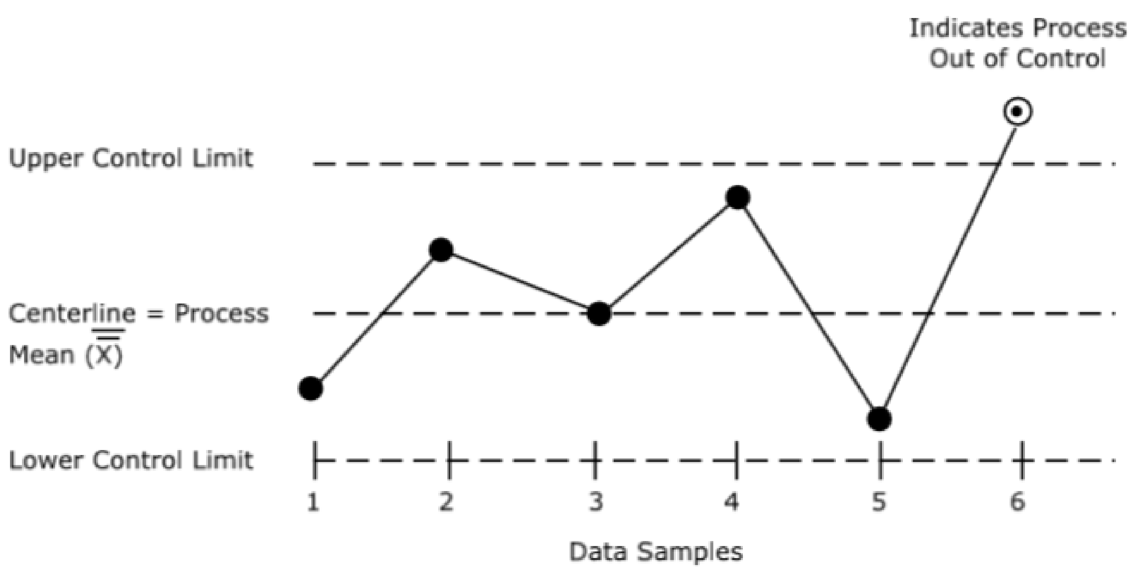

Figure 2.1 Control Chart

- **Pareto Charts**

Alfredo Pareto was an economist who noted that a few people controlled most of a nation's wealth. "Pareto's Law" has also been applied to many other areas, including defects, where a few causes are responsible for most of the problems. Separating the "vital few" from the "trivial many" can be done using a diagram known as a Pareto chart. Figure 2.2 shows the data from the checklist shown in Table 2.1 organized into a Pareto chart.

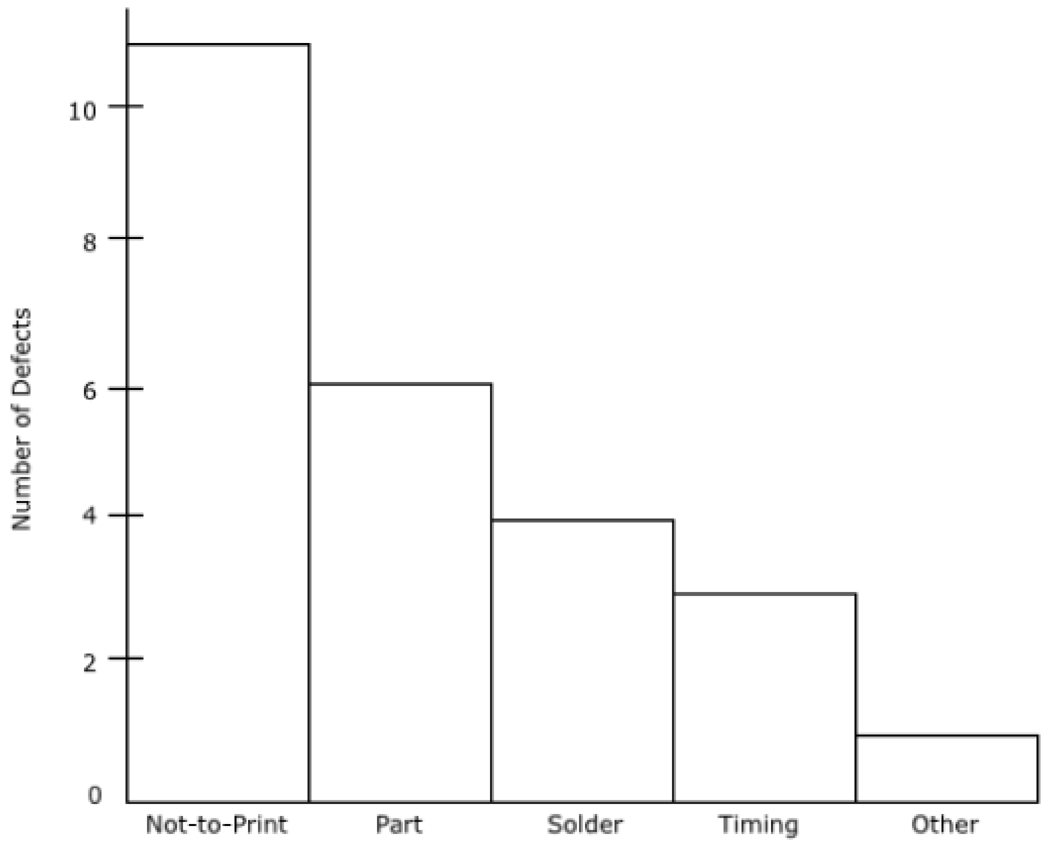

Figure 2.2 Pareto Chart

- **Histograms**

Histograms are another form of bar chart in which measurements are grouped into bins; in this case each bin representing a range of values of some parameter. For example, in Figure 2.3, X could represent the length of a rod in inches. The figure shows that most rods measure between 0.9 and 1.1 inches. If the target value is 1.0 inches, this could be good news. However, the chart also shows a wide variance, with the measured values falling between 0.5 and 1.5 inches. This wide a range is generally a most unsatisfactory situation.

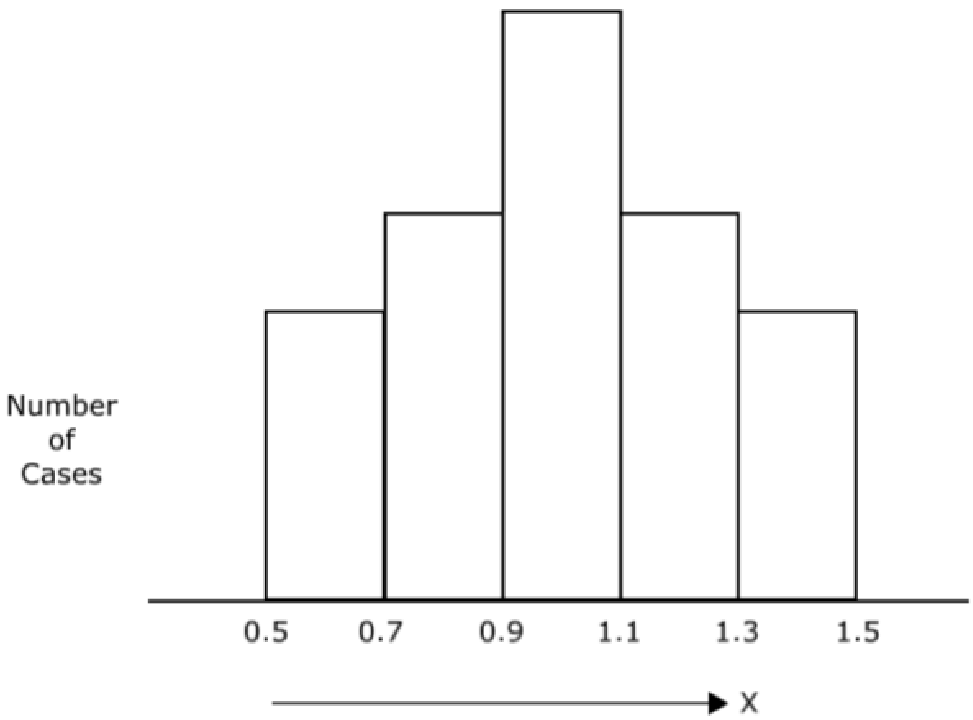

Figure 2.3 Histogram

- **Scattergrams**

Scattergrams are a graphical, rather than statistical, means of examining whether or not two parameters are related to each other. It is simply the plotting of each point of data on a chart with one parameter as the x-axis and the other as the y-axis. If the points form a narrow "cloud" the parameters are closely related and one may be used as a predictor of the other. A wide "cloud" indicates poor correlation. Figure 2.4 shows a plot of defect rate vs. temperature with a strong positive correlation.

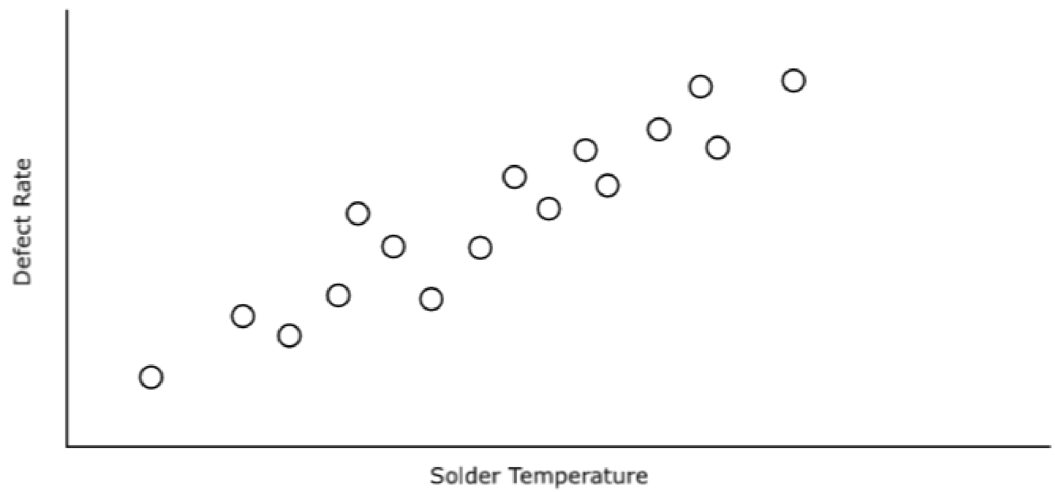

Figure 2.4 Scattergram Showing Strong Correlation

2.3 Max Plastic Factory

Max plastic factory is a new factory establish its work in the early of 2017, based on family owned business, small enough to provide the market with personal service and large enough to handle key accounts and manufacture large product runs. Their sales team is knowledgeable, helpful and experienced. their products include plastic films for packaging. It has May sizes and colors according to the market demands and customer requirements. Polyethylene is used as main material to produce plastic films, because of its good properties, which have been found satisfactory.

They have been successful in accomplishing the goals set in the beginning days of their production. In Max factory, they have combined cutting-edge with a highly skilled work force to produce a superior line of stretch film. They built customer satisfaction and trust in both the product line and their level of service. Moreover, they have maintained a competitive edge in product performance and value, as well as establishing a leadership role in the industry for new product development and technical innovation. Max plastic factory products are fully committed to strive for excellence and provide leadership in finding packaging solutions.

Their current working procedures includes buying the raw materials (High Density Polyethylene, Low Density Polyethylene, and pigments) from the suppliers and storage. Then the workers toke raw material and put it in the machine after mixing HDPE, LDPE and pigments together to give good physical properties for plastic films. After that they produce plastic films in rolls have a different weight and put it down randomly. The second stage is to take the rolls and put it in the cutter to cut it into specific length. The final stage to open the bags as to become useable using hydraulic press, now it is ready for packaging and deliver to their customers.

2.4 Previous Studies

Jutatip etal in 2010 studied the Defect of reduction in plastic packaging industry, the study aimed to identify root causes of the defect problem and generating a solution to reduce the percentage of defect by using quality techniques and continuous improvement. The methodology used in this study composed of five steps: quality problem definition, root causes identification, problem-solving generation, selection of alternative application, and evaluation. Along with these steps, the employed different quality tools like: brainstorming, process flowchart, graph, scatter diagram Key performances indicators of this study were the defect quantity. The Results indicated that the applied quality improvement process together with quality techniques could increase the effectiveness of gravure printing process, which reduced the quantity of defective products, and processing time. Moreover, the result from this study developed a system of continuous improvement for the company including a holistic process flowchart, a detail work instruction for defect reduction, a set of quality team, and a criteria standard to control the product quality. [11]

Ephrem Gidey in 2010 in his research Analysis of Quality and Productivity Relationship Based on Measurements in Ethiopian Plastic Industries, Said Quality and productivity are the two most important concepts, which are commonly used to express the level of excellence of industries in their continuous drive for improvement. Quality is a measure of excellence from the customer’s perspective and productivity is a measure of excellence from the producer’s perspective. Even if they have many aspects in common, they have also distinctions in their definitions, objectives, and measurements. As a response to their significance, commonalities, and distinctions, numerous studies have been conducted to determine their conceptual and analytical measurements and relationship. However, the relationship between quality and productivity has not been clearly determined until recently. Thus, studies tried to relate quality and productivity through measurements of posterior variables such as profitability, total profit, and unit profit as mediators.

In any continuous quality or productivity improvement initiatives, the focus is the elimination of wastes and variations. These undesirable factors reduce the levels of quality and productivity. The main objective of his research is to examine the existing measurement and relationship models of quality and productivity and to introduce a new mediator variable that negatively affects both quality and productivity. In his research, ‘ineffective input’ is taken as the sum of wastes and variations and as a mediator to study the measurement and relationship of quality and productivity. The new approach of examining quality and productivity measurement and relationship can advance the existing quality-productivity relationship models in two ways: 1) irrespective of the posterior variables which were used to study the relationship; 2) management philosophies are being practiced in industries mainly to eliminate wastes and variations.

Accordingly, in his research, a nonparametric statistics was adapted to study the analytical relationship that quality and productivity have with ineffective inputs. Both the measurement and relationship models are statistically and theoretically validated in Ethiopian Plastic Industries. The analytical findings showed that ineffective inputs have significant negative relationship with quality and insignificant positive relationship with the new productivity measure in one of the selected plastic industry. On the other hand, productivity has shown a significant but negative relationship with ineffective inputs. [6]

Chapter III

Methodology

3.1 Materials

In Max plastic factory, they use High Density Polyethylene mixed with Liner Low Density Polyethylene.

Polyethylene (Polythene) is one of the world's most popular plastics. It is an enormously versatile polymer, which is suited to a wide range of applications from heavy-duty damp proof membrane for new buildings to light, flexible bags and films.

Two major types of PE are in use in the films and flexible packaging sector – LDPE (Low Density) used generally for trays and heavier duty film such as long-life bags and sacks, poly tunnels, protective sheeting, food bags etc and HDPE (High Density) 0.951 g/cm^3 which is used for most thin gauge carrier bags, fresh produce bags and some bottles and caps.

Linear Low Density PE (LLDPE). Its density 0.918 g/cm^3, it is a substantially linear polymer, with significant numbers of short branches, commonly made by copolymerization of ethylene with longer-chain olefins. LLDPE has higher tensile strength than LDPE. It exhibits higher affect and puncture resistance than LDPE. Liner Low Density Polyethylene used with HDPE to increase its flexibility, thickness control, assure the quality of cutting in cutter and gives weld its strength. [See Appendix]

Table 3.1 Product blend

Type	PPH
HDPE	100
LLDPE	8
Waste	8
Pigment	4

3.2 Sampling:

It is important to determine the methodology of taking sample because testing every product produced at every stage of the production process can get very expensive and very slowly. The testing process can be destructive, so you cannot test every product produced.

For most processes and situations, using a sample can tell just as much as an exhaustive testing system. If 2 percent of the million items made have a problem, have a good chance of finding one or two bad ones by testing 100 or less. Then can figure out why those items are bad to try to prevent the problem from occurring again.

For the sake of the quality, control process, the samples taken randomly. Because Random sampling also avoids influence by people involved in the process.

All samples size in this work have been taken according to the equation below:

$$n = \frac{N}{1 + N(0.5)^2}$$

n= Sample size.

N= Population.

After the sample size determined, then the samples picked randomly. The randomness due to systemic randomness, which a number between 1 – 10 chosen randomly and then sample size divided over population to find the sequence number to follow starting from the number chosen before and adding the sequence number to it to find the others samples. [5]

3.3 Work Procedure

In a perfect world, factory products would always come out just right, but sometimes mistakes happen, and the only way to catch these mistakes is to inspect items before you ship them to consumers.

The aim of this work is to help to identify the main causes of waste during production cycle; Errors can occur at any one of these steps, causing product to fall short of the customers' expectation, Work is started with study the current work procedure used in Max plastic factory. Inspection is the analysis or examination of an item carried out to determine whether it is defective or not. Writing notes of wrong, incorrect, and non-available procedures during manufacturing process happened from either workers or technicians. Although all this inspection stuff may look good on paper, it can be difficult to implement in practice. An effective inspection process requires a change in how the factory normally manufactures a product.

The goal is for the product to meet customers' requirements each and every time, with a minimum of variation between individual units. Achieving this goal lowers the cost to both the producer and the customer.

To inspect for quality, first decide what product characteristics wanted to inspect, and then determined what values will signify that the product conforms to customer specifications. The following present two types of data used to measure an item's quality:

Attribute data: Qualitative information about the product, such as "the label is in the correct place" or "the color is yellow." Attribute data clearly defines whether the product achieves conformance.

Variable data: Measures some physical characteristic such as length, width, temperature, and time. Variable data is great when you have a desired target value and you can determine the amount of variation from the target.

Tables have been made to record production data for each shift, in order to maintain productivity.

Furthermore, the 5S is a method approach to eliminating waste in time and materials. Its philosophy is that a simplified work area operates more efficiently, cheaply, and safely.

The 5S stands for Sort, Straighten, Shine, Standardize, and Sustain. 5S's mantra is "only what is needed, in its proper place, clean and ready for use."

This method used to organized work environment Simple processes are the easiest to complete with the fewest errors. Cleaning and organizing a work area with 5S simplifies activities because it have fewer chances for errors.

5S simplifies processes. By examining workflows in the factory, by removing the need to work around, and making needed material easy to find.

The raw material is now always located in the same marked places. The materials stockman can see when materials are running low and address the situation before you run out. Therefore, 5S increases materials visibility.

The working areas organized, and decided what stays and goes; the result is cleaner, more efficient workspaces.

The locations of processes and materials have been planned and marked their locations on the floor, which reduces confusion and improves product quality.

3.4 Melt Flow Index

MFI is measured using the procedure used to determine the melt flow rate (MFR) of a thermoplastic material. The units of measure are grams of material/10 minutes (g/10 min). It is based on the measurement of the mass of material that extrudes from the die over a given period. It is generally used for materials having melt flow rates that fall between 0.15 and 50 g/10 min.

3.4.1 Procedure

Standard conditions of test are given in Table 3.2. Test conditions will be shown as: Condition _ _ _ / _ _ _, where the temperature in degrees Celsius is shown first, followed by the weight in kilograms. For example: Condition 190/2.16.

The conditions of temperature and load has selected in accordance with material specifications. Where multiple test conditions exist, test conditions shall be agreed upon by the cooperating laboratories.

The extrusion plastometer have inspected for cleanliness. All surfaces of the cylinder bore die and piston should be free of any residue from previous tests.

The die bore diameter at frequent intervals with appropriately sized go/no-go gauges (checked with die at 23 ± 5°C) have been checked to verify that the die is within the tolerances. Visually examine the die bore to verify that it is not scratched or damaged. Also visually inspect the land of the piston foot to verify that it is not scratched or damaged and use a calibrated micrometer to verify that the dimensions are within the tolerances. Then set the temperature in accordance with the manufacturer's instructions.

The die and the piston Inserted into the bore. Allow the temperature of the cylinder, with the piston and die in place, to stabilize within 190°C of the selected test temperature for at least 15 min before starting a test.

The piston removed from the bore. Within 60 seconds, charge the cylinder with a weighed portion of the sample in accordance with the expected flow rate reinsert the piston and add the weight 2.16 kg. The charging weights are merely suggestions, and the actual charging weight for a specific sample. Adjust the charge weight so that the piston is in the proper position at the end of the pre-heat period.

The test started by initiating the timing device that monitors the pre-heat period, which is a period of time that allows the material to soften and begin to melt. The pre-heat period shall last for 6 min from the completion of the charge.

Fig 3.1 Melt Flow tester

At the end of the pre-heat period and when the top scribe mark on the piston is visible above the cylinder (or top of the guide sleeve) and the lower scribe mark is in the cylinder (o-r below the top of the guide sleeve) indicating that the piston land, reset the timer to zero then simultaneously make the initial cut-off. The extrudate discarded from the pre-heat period. The final made cut-off exactly when the time interval selected is reached. The extrudate specimen collected and weighted. If the extrudate specimen contains visible bubbles, discard it and begin the test again. [10]

TABLE 3.2 Maximum Allowable Variation in Temperature with Distance and Time Throughout the Test

Test temperature set point T °C	Temperature tolerance, °C	
	At 75 ± 1 mm above the die surface (°C)^A	At 10 ± 1 mm above the die surface (°C)^A
$125 \leq T < 250$	±2.0	±0.2
$250 \leq T < 300$	±2.5	±0.5
$300 \leq T$	±3.0	±1.0

3.3 Density of Plastics

Standard Test Method for Density of Plastics by the Density Gradient Technique Designation: D 1505 according to American Society for Testing and Materials, This test method covers the determination of the density of solid plastics. This test method is based on observing the level to which a test specimen sinks in a liquid column exhibiting a density gradient, in comparison with standards of known density.

Density of plastics is define as the weight per unit volume of material at 23°C, expressed as follows: g/cm^3.

3.3.1 Apparatus

1. Density-Gradient Tube a suitable graduate with ground-glass stopper.
2. Constant Temperature Bath, means of controlling the temperature of the liquid in the tube at 23 ± 0.1°C. A thermostatted water jacket around the tube is a satisfactory and convenient method of achieving this.
3. Glass Floats, number of calibrated glass floats covering the density range to be studied and approximately evenly distributed throughout this range.

4. Pycnometer, for use in determining the densities of the standard floats.
5. Liquids, suitable for the preparation of a density gradient.

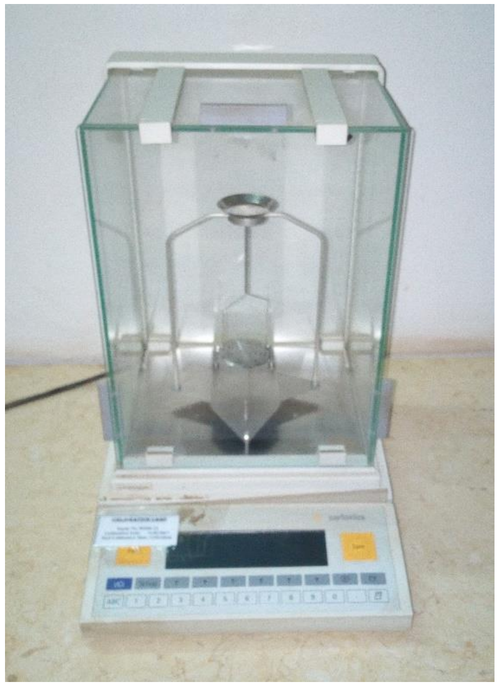

Fig 3.2 Density-Gradient Tube

3.3.2 Test Specimen

The test specimen is from the material under test. The test specimen pieces are granules from HDPE and LLDPE.

3.3.5 Procedure

Three representative test specimens have been weighted and wet with the less dense of the two liquids used in the tube and gently place them in the tube. Allow the tube and specimens to reach equilibrium, which will require 10 min or more. A line through the individual center of volume and averaging the three values has read the height of each float and each specimen. Finally, the volume calculated, and the weight divided over the volume to obtain the density. [9]

3.4 Tensile test

This is standard test method for tensile properties of Thin Plastic Sheeting; this standard is issued under the American Society for Testing and Materials designation D 882.

This test method covers the determination of tensile properties of plastics in the form of thin sheeting, including film (less than 1.0 mm (0.04 in.) in thickness), this test method may be used to test all plastics within the thickness range described and the capacity of the machine employed.

Static weighing, constant rate of grip Separation Test, This test method employs a constant rate of separation of the grips holding the ends of the test specimen. Specimen extension may be measured in these test methods by grip separation, extension indicators, or displacement of gage marks. A procedure for determining the tensile modulus of elasticity is included at one strain rate.

Test data obtained by this test method is relevant and appropriate for use in engineering design. [8]

3.4.1 Significance and Use

1. Tensile properties determined by this test method are of value for the identification and characterization of materials for control and specification purposes. Tensile properties may vary with specimen thickness, method of preparation, speed of testing, type of grips used, and manner of measuring extension. Consequently, where precise comparative results are desired, these factors must be carefully controlled. This test method shall be used for referee purposes, unless otherwise indicated in particular material specifications. For many materials, there may be a specification that requires the use of this test method, but with some procedural modifications that take precedence when adhering to the specification. Therefore, it is advisable to refer to that material specification before using this test method.
2. Tensile properties may be utilized to provide data for research and development and engineering design as well as quality control and specification. However, data from such tests cannot be considered significant for applications differing widely from the load-time scale of the test employed.
3. The tensile modulus of elasticity is an index of the stiffness of thin plastic sheeting. The reproducibility of test results is good when precise control is maintained over all test conditions. When different materials are being compared for stiffness, specimens of identical dimensions must be employed.
4. The tensile energy to break (TEB) is the total energy absorbed per unit volume of the specimen up to the point of rupture. In some texts this

property has been referred to as toughness. It is used to evaluate materials that may be subjected to heavy abuse or that might stall web transport equipment in the event of a machine malfunction in end-use applications. However, the rate of strain, specimen parameters, and especially flaws may cause large variations in the results. In that sense, caution is advised in utilizing TEB test results for end-use design applications.

5. Materials that fail by tearing give anomalous data, which cannot be compared with those from normal failure.

3.4.2 Apparatus

1. Testing Machine, A testing machine of the constant rate of crosshead movement type.
2. Extensometer, A suitable instrument may used for determining the distance between two designated points on the test specimen as the specimen is stretched Vernier Caliper used.
3. Width Measuring Devices, meter used.
4. Specimen Cutter, for the apparatus and techniques for cutting film and sheeting.

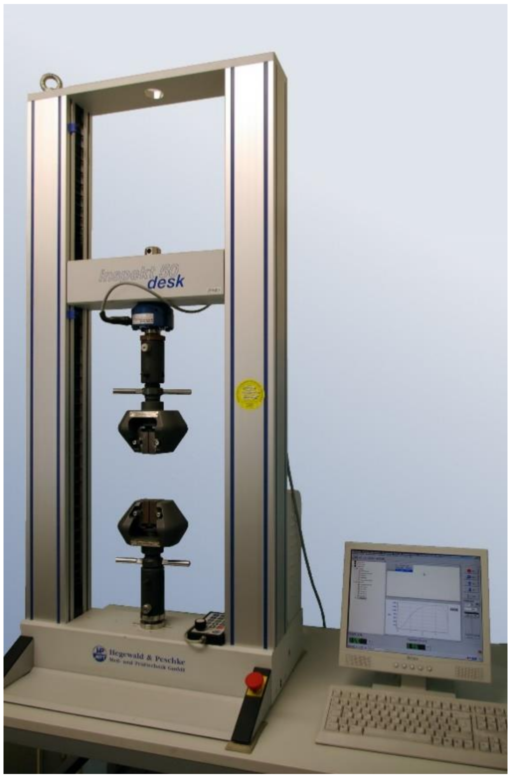

Fig 3.3 Tensile tester

3.4.3 Test Specimens

1. The test specimens shall consist of strips of uniform width and thickness at least 40 mm longer than the grip separation used.
2. The most care have taken in cutting specimens to prevent nicks and tears, which are likely to cause premature failures. The edges are parallel to within 5 % of the width over the length of the specimen between the grips.
3. The test specimens selected so that thickness is uniform to within 10 % of the thickness over the length of the specimen between the grips.

3.4.4 Test Conditions

The condition of the test specimens at 23 ± 2°C and 50 ± 5 % relative humidity , test speed 50 m/s, capacity 5 kg.

3.4.5 Number of Test Specimens

In the case of isotropic materials, which is the material tested six specimens are tested from each sample. Specimens that fail at some obvious flaw or that fail outside the gage length have been discarded and retests made.

3.4.6 Procedure

1. A load range selected such that specimen failure occurs within its upper two thirds. A few trial runs to select a proper combination of load range and specimen width.
2. The cross-sectional area of the specimen measured at several points along its length. The thickness is 0.020 mm.
3. The initial grip separation set in accordance and Set the rate of grip separation to give the desired strain rate, based on the initial distance between the grips. Zero the calibrated load weighing system, extension indicator(s) and recording system.
4. The test specimen placed in the grips of the testing machine, taking care to align the long axis of the specimen with an imaginary line joining the points of attachment of the grips to the machine. Tighten the grips evenly and firmly to the degree necessary to minimize slipping of the specimen during test.
5. The machine and record load versus extension has been wrote it down.
6. The tensile strength have been determined.

Chapter IV

Results and Discussion

4.1 Introduction

After studying work environment, data has been gathered and several tests have been done in order to check process efficiency. Then some quality control tools applied to investigate and determine the main problems and to find solutions to control the production cycle and reduce plastic waste.

4.2 Flow Charts

The flow chart of the production process has been found satisfactory with a little change in the storage of film rolls after production process before it goes to the cutter; it was storage randomly in the ground without any kind of sorting. Which, led to defect the quality of the film because of long storage time in the ground make the rolls handle dust and began to defect. The new process of handling the rolls is cleaning the ground, cover it with clean film, make specific place to storage them and toke the earliest production first to the cutter before the newest one.

Otherwise, the rest of the production process have no over production due to delay base on fast process and the next one is slow. There is over cycle time or long distance transportation from the production line and the other process.

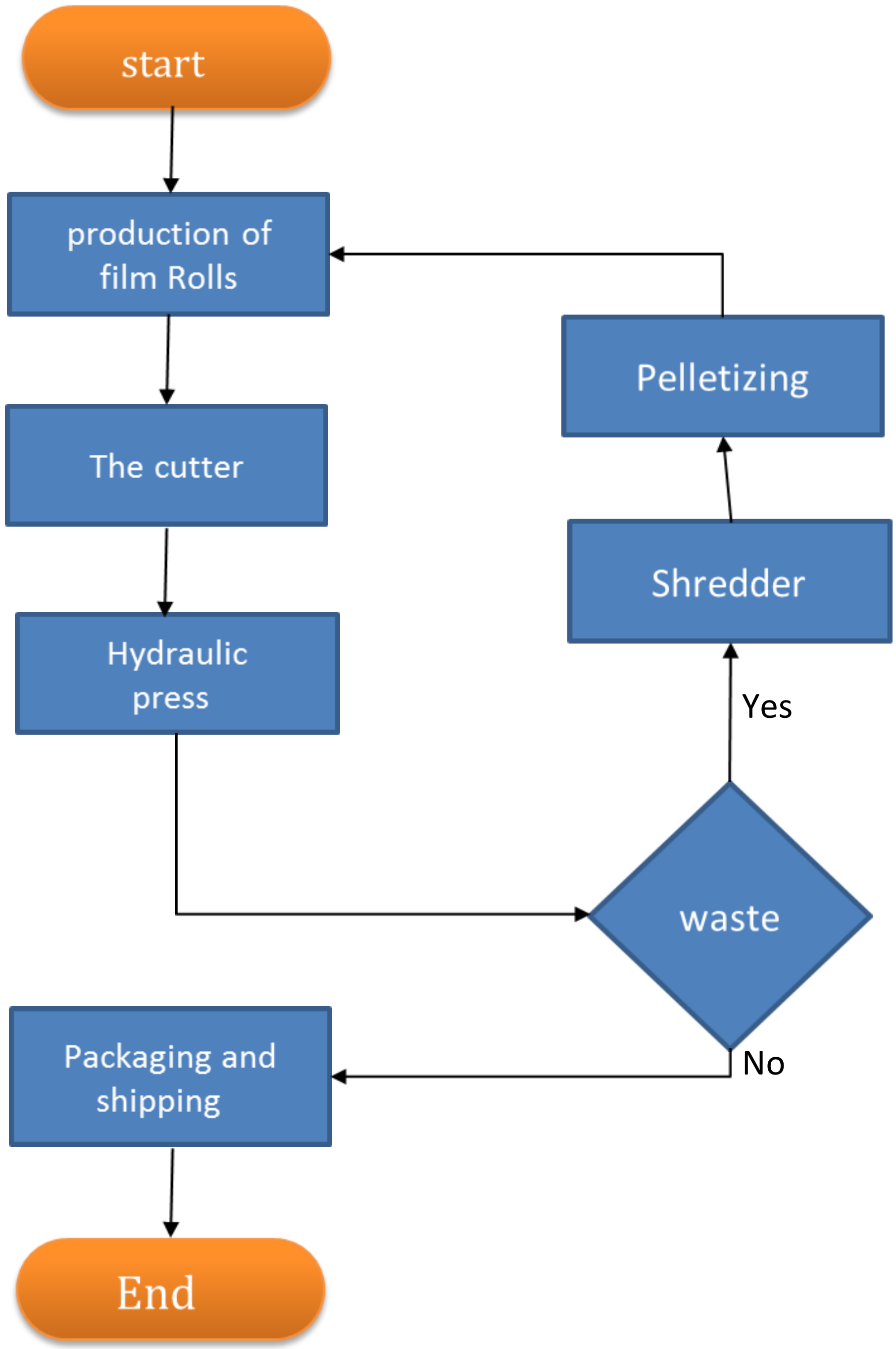

Fig. 4.1 Flow chart of the production cycle in Max plastic factory

4.3 Ishikawa Diagram

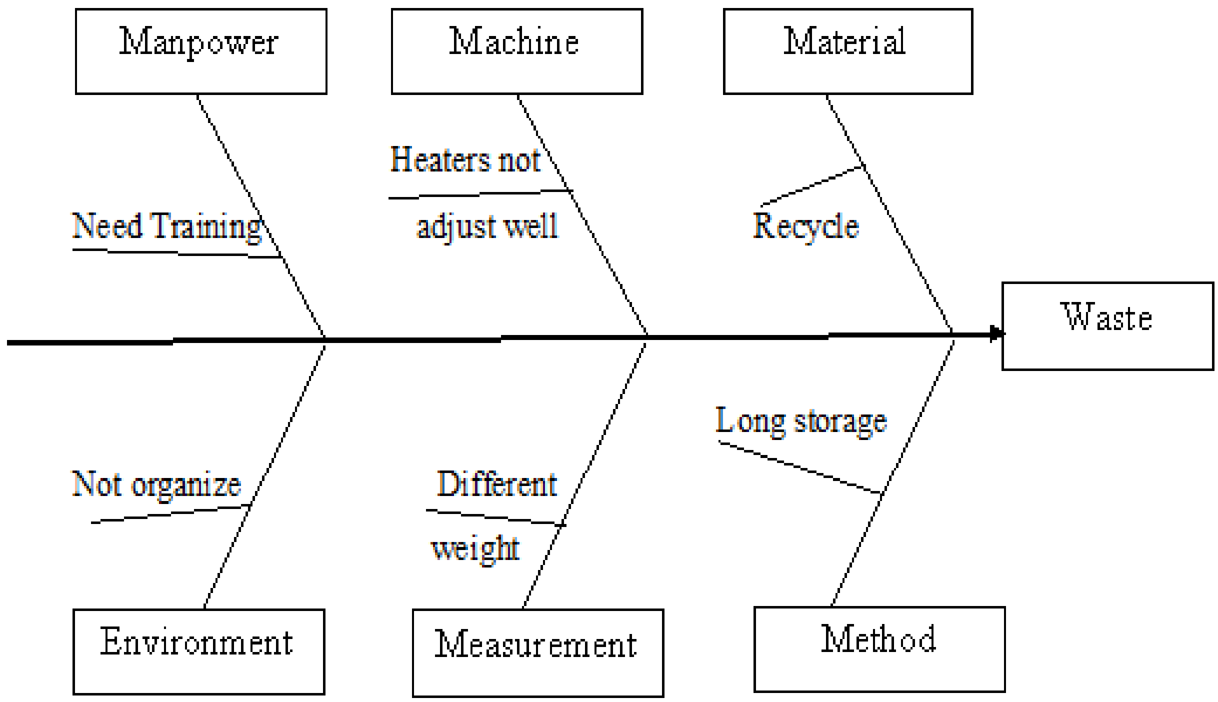

Fig. 4.2 Ishikawa Diagram

Ishikawa Diagram have been applied, and filled after studying the factors that can led to the problem, which is Plastic waste.

In the felid of Manpower it was noticed that they need more time to use the machines in a proper way, to solve this problem they have given a short training in how to use the machine without affecting products quality. It is preferable to give them more training.

For Machines the heater was not adjust according to materials datasheet, after materials datasheet given the heaters adjust in order to maintain satisfactory results, which have been recorded.

In Material case as has been, mentioned datasheet obtained and several tests have been made such as (MFI and Density test) it has found the material is the same material ordered by the factory, and it is suitable for the application. It will be discussed in details in 4.4 and 4.5.

The most important one is Environment. Unfortunately, it was not organized which affect products quality and increase defect during production. Serious steps have been made to organize the work environment by applying 5S system. Defining the problems there was not work tool location, Raw materials storage was not in the right place, Plastic film rolls was drop randomly after production, And finished products was storage on the floor near to plastic film rolls. These entire problems solved by sort all tools in one place, Specific place for raw materials storage, Plastic films rolls organize near to the cutter over each other and some cover made on the floor to prevent them from dust.

Measurement applied to measure film thickness is micrometer, which is digital one and more accuracy than the normal one. In the other side weight of final package is little different from each other due to stop and start because of defects during production but it is in acceptable range and can neglected.

Methodology of production as general it is correct by in details there is several mistakes, like after production film rolls it is storage in bad way and the worker from cutter toke the newest rolls instead of the old one, which, may cause defect on the rolls surface and led to product damage in the cutter stage. The problem solved by training the workers to handle rolls production in a correct way begging with right storage ending by taking the previous production before the newest.

4.4 Melt Flow index Results

First the main material which is High Density Polyethylene (HDPE).

Table 4.1 Melt flow rate of HDPE

Condition 190/2.16

Sample No.	MFI (g/10min)
1	0.05
2	0.052
3	0.05
4	0.05

The MFI of HDPE according to material datasheet is 0.05 g/10 min, the results obtained from MFI test has found identical with the material datasheet. That mean it is the right material to the application.

Secondly the sub material which is Linear Low Density Polyethylene (LLDPE).

Table 4.2 Melt flow rate of LLDPE

Condition 190/2.16

Sample No.	MFI (g/10min)
1	1.9
2	2
3	2

The MFI of LLDPE according to material datasheet is 2 g/10 min, the results obtained from MFI test has found identical with the material datasheet. That is mean it is the right material to the application.

4.5 Density of Plastics

First the main material which is High Density Polyethylene (HDPE).

Table 4.3 Density of HDPE

Sample No.	Density (Kg/m^3)
1	951
2	951
3	951
4	951

The Density of HDPE according to material datasheet is 951 Kg/m^3, the results obtained from MFI test has found identical with the material datasheet. That mean it is the right material to the application.

Secondly the sub material which is Linear Low Density Polyethylene (LLDPE).

Table 4.4 Density of LLDPE

Sample No.	Density (Kg/m^3)
1	920
2	920
3	920

The Density of LDPE according to material datasheet is 918 Kg/m^3, the results obtained from MFI test has found semi-identical with the material datasheet. That mean it is the right material to the application.

It is obviously from 4.3 and 4.4 that the raw material is the same martial ordered by the factory from the supplier and nearly same results to material datasheet obtained. These tests was helpful in Ishikawa Diagram to determine if the raw material caused any problems in production.

4.6 Control Charts

It used to show the response to problems solving, and the process in under control or not. It used to investigate about the productivity.

As shown in Fig4.3 below the productivity started to increase as days moved which means the problems solved using previous Ishikawa Diagram and started to show it is benefits.

Upper control limits (UCL), control limits (CL), and Lower control limits (LCL) determined according to acceptable valve that needed to achieve.

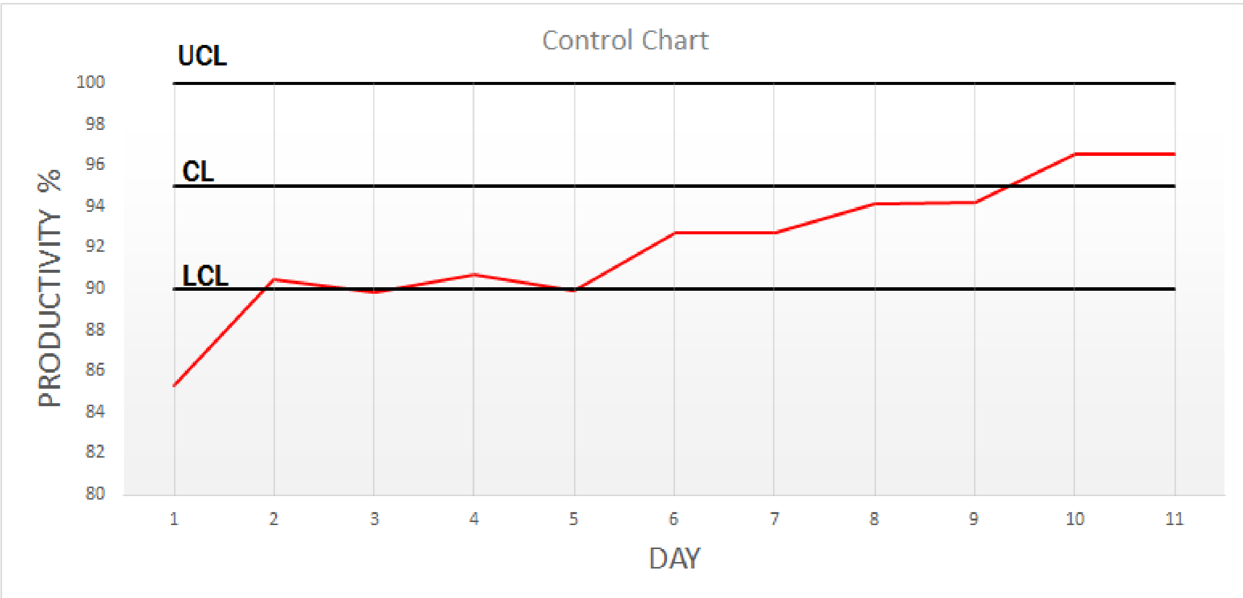

Fig. 4.3 Control charts of Productivity

In day 1, 3 and 5 the productivity is out of range, it is below the LCL which means there is still some problems occurs. Investigation have been made and the problems founded. The workers just started to get familiar to use the new system of production.

These data from those days have been eliminated after figuring out the root causes of the problems and it is solved, to produce the final control charts as appears in fig4.4 below.

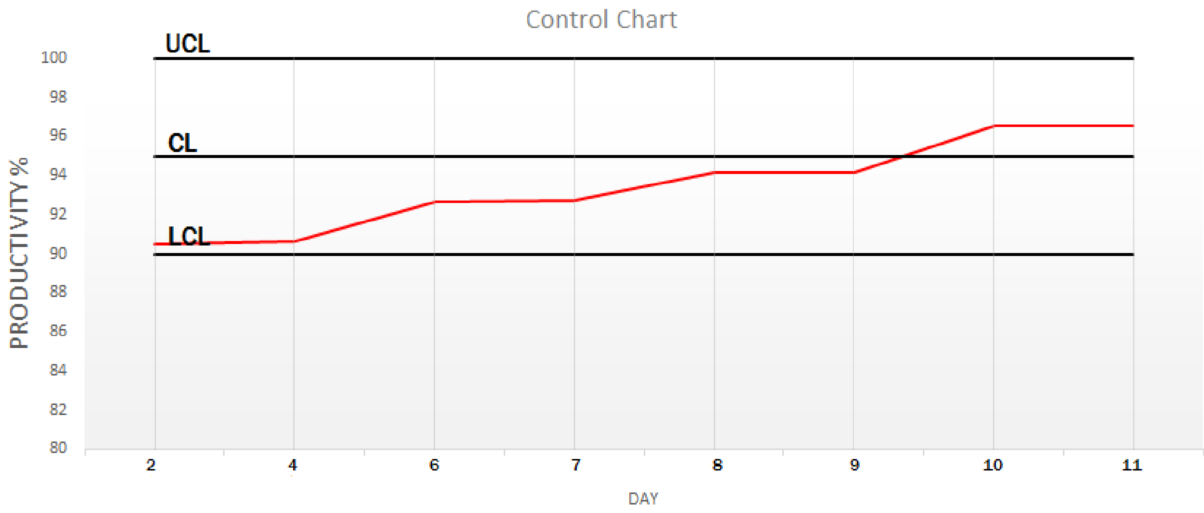

Fig. 4.4 Final Control charts of Productivity

A point to consider is the productivity increased due to reduce in waste during production, according to Max plastic factory data their waste was 200 - 250 kg that is around 20 - 25% per ton. Right now the waste decrease into 86 kg that is around 8.6% per ton. This data obtain from producing 3555 kg and the waste recorded 306 kg.

4.7 Tensile test

It is one of important tests to identify the product strength, because in this the product itself s under test.

Table 4.5 Tensile Strength

Sample	Force (kg_f)	Strength (MPa)
I	0.29	72.5
II	0.28	70

Film thickness 20 μm

These results are acceptable as quality indicators for the product which is plastic film. Adding LLDPE to HDPE was helpful to small increase in tensile strength.

Chapter V

Conclusion and Recommendations

5.1 Conclusion

Using Quality tools have good impact on manufacturing process in Max Plastic Factory, they influence in reducing plastic film waste though increase productivity. The waste decreases to 8.6% per ton, which means applying quality tools system was effective.

5.2 Recommendations

- It is recommended to use six sigma to control production process and study it is effect on waste.
- Work study on the effect of environmental (heat, sound, cloth), and psychological (behavior, awareness) of workers and it effect on productivity.
- Study the impact of adding waste to the virgin material as to reduce the cost. Moreover, how it could affect the physical properties of the final product.

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Appendix

شركة رابغ للتكرير والبتروكيماويات
Rabigh Refining & Petrochemical Co.

بتـــرو رابـــغ
Petro Rabigh

POLYETHYLENE

F0554

Bimodal High Density Polyethylene for film application

Description

F0554 is a high molecular weight high density polyethylene resin designed for blown film applications. This resin has broad molecular weight distribution that makes it easier to process. Films made from this resin

Exhibit high stiffness, excellent impact and toughness characteristics.

Applications

- Shopping bag
  Garbage bag
- Industrial liner

Resin Properties		Unit	Test Method	Typical Value	
MFR (190ºC/2.16Kg)		g/10min	ASTM D1238	0.05	
MFR (190ºC/21.6Kg)		g/10min	ASTM D1238	9.3	
Density		g/cm^3	ASTM D792 Method A	0.951	
Film Properties*				**Without Stabilizer**	**With Stabilizer**
Tensile Strength at Yield	MD	MPa	ASTM D882	35	35
	TD			30	30
Tensile Strength at Break	MD	MPa	ASTM D882	70	75
	TD			65	55
Tensile Elongation at Break	MD	%	ASTM D882	560	520
	TD			550	560
1% Secant Modulus	MD	MPa	ASTM D882	930	990
	TD			1030	1140
Elmendorf Tear Strength	MD	gf	ASTM D1922	17	11
	TD			39	78
Dart Drop Impact		g	ASTM D1709	340	280
Thermal Properties*					
Vicat Softening Temperature @10N		ºC	ASTM D1525	126	

*Blown film processing conditions: Extruder Φ50 mm, Die Φ120 mm, Die lip gap 1.35 mm, Temperature 200 °C, Output rate 50 kg/h, BUR 4.0, Film thickness 20 µm, Neck height 840 mm.

Processing conditions: Typical processing conditions: 180-230 ºC

Storage and handling: F0554 should be stored in a dry cool place with adequate ventilation and protected from UV-light at temperatures below 50°C. It is advisable to process polyethylene resins within 6 months after delivery.

218 Series

Linear Low Density Polyethylene for Blown Film

Product Description

218 series resins are Linear Low Density Polyethylene grades suitable for general purpose packaging. They are easy to process giving good tensile properties, impact strength and optical properties.

218 Series includes following grades:

218N: No Slip & No Antiblock

218W: 1500 ppm Slip & 3500 ppm Antiblock

Typical Applications

Lamination film, thin liners, shopping bags, carrier bags, garbage bags, coextruded films, consumer packaging etc.

Typical data

Properties	Unit	Value (1)	ASTM Method
Resin Properties			
Melt Flow Rate @ 190°C & 2.16 kg load	g/10 min.	2	D 1238
Density @ 23°C	kg/m³	918	D 1505
Mechanical Properties(2)			
Tensile Strength @ break, MD	MPa	35	D 882
TD		29	
Tensile Elongation @ break, MD	%	700	D 882
TD		750	
Tensile Strength @ yield, MD	MPa	12	D 882
TD		10	
1% Secant Modulus, MD	MPa	220	D 882
TD		260	
Puncture Resistance	J/mm	63	SABIC Method
Dart Impact Strength	g	85	D 1709

Elmendorf Tear Strength, MD TD	g	130 320	D 1922
Optical Properties(2)			
Haze Gloss @ 60°	% -	13 80	D 1003 D 2457
Thermal Properties			
Vicat Softening Point	°C	98	D 1525

(1) Typical values; not to be construed as specification limits.
(2) Properties have been measured by producing 30 μ film with 2.5 BUR using 100% 218N.

Processing Conditions

Typical processing conditions for 218 are:

Melt temperature: 185 - 205°C

Blow up ratio: 2 - 3

022009

Food Regulation

218 series resins are suitable for Food contact application. Detailed information is provided in relevant Material Safety Datasheet and for additional specific information please contact SABIC local representative for certificate.

Storage and Handling

Polyethylene resin should be stored in a manner to prevent a direct exposure to sunlight and/or heat. The storage area should also be dry and preferably don't exceed 50°C. SABIC would not give warranty to bad storage conditions which may lead to quality deterioration such as color change, bad smell and inadequate product performance. It is advisable to process PE resin within 6 months after delivery.