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Modeling lean six sigma in the small packaging industry in India

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M.S. DEGREE THESIS

The M.S. degree thesis of

Robin Patel

has been examined and approved

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Introducing Lean Six Sigma Green Belt's DMAIC methodology to the small scale Indian packaging industry where education level of worker is low or moderate.

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DEDICATION

This thesis is dedicated to my Father Mr. Vikrambhai Dahyalal Patel & Mother Mrs. Ramilabahen Vikrambhai Patel who have made many sacrifices while I have pursued this goal. I thank them for instilling the importance of hard work and higher education and taught me that even the largest task can be accomplished if it is done one step at a time. I am honored to have you as my parents. Thank you for giving me a chance to prove and improve myself through all my walks of life.

Also, my wife Kruti Desai, who has been a great source of motivation and inspiration.

Finally, this thesis is dedicated to my brother Krutarth Vikrambhai Patel, family and friends who believe in the richness of learning.

ABSTRACT

This thesis is a result of my interest in implementing Lean Six Sigma into Indian packaging companies because the Indian industry is growing at 18-20% annually (Samal, 2010). This growth rate is expected to triple in the next five years. With USA outsourcing to foreign nations this substantial growth, as I envision the USA companies who are seeking India packaging materials will benefit from my original approach for converting the Indian packaging industry using Lean Six Sigma.

I have a strong personal and professional desire to improve the manufacturing within India. It is the country in which I grew up and where my family currently lives and works.

The main objective of this research is to accomplish several major tasks: 1) Introduce a Lean Six Sigma Green Belt DMAIC methodology to an India packaging company and 2) Show how a Lean Six Sigma Green Belt would implement the DMAIC approach in a small Indian packaging company that plans to do business within the USA boundaries and 3) Utilize this packaging company as a model for other India packaging companies to follow if their plans are to sell quality packaging materials to the USA companies.

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INTRODUCTION

Abstract: The thesis statement shows how to implement a Lean Six Sigma green belt's DMAIC methodology within a small scale India packaging company, named Kishan Plastics, and to use it as model for other Indian packaging companies to follow. Considering the growth potential of doing more business with USA companies due to Kishan Plastics improving the quality of packaging product and within the Indian packaging industry based on manufacturing process improvements from implementing Lean Six Sigma tools. Kishan Plastics represents the small-scale India industries sector which plays a vital role in the growth of the country. It contributes almost 40% of the gross industrial value added in the Indian economy (Small & Medium Enterprises, n.d.).

Literature Review: In this section, research will reveal that the Six Sigma, Lean, Lean Six Sigma are crucial to the growth of a company. The literature review also provides the evidence that this thesis is original including identifying the needs within the Indian culture, government stats and industry movements within India. Literature review also reveals that one of the challenges in implementing Lean Six Sigma is based on the educational level of the employees is quite low: between 5th and 8th grade level. Due to the lack of education close attention will be paid to customizing the Lean Six Sigma green belt to the manufacturing process. Literature review further exposes other challenges a Green Belt will face.

Methodology: This section will clearly show the educational process necessary for transforming the current state of the India packaging production process by using the DMAIC tools. This section will begin with a brief tutorial on the major components of Lean Six Sigma. This section will take on a lesson plan approach where each phase of the DMAIC will be identified and illustrate how to use the many tools of the DMAIC. It will also show Kishan's

president the comparison between the current manufacturing conditions and a future state of the manufacturing process. In relation to the educational level, the Lean Six Sigma will be simplified so that the 5th grade educational level person can understand. The deliverable of the methodology section will be to illustrate the appropriate DMAIC tools that will prepare Kishan to producing quality packaging products for sale in the USA.

Data Analysis: In this section, it is clearly demonstrated how the DMAIC tools chosen produce effective communication and efficient processes. Comparison has been done between the current state and future state using data and information gained by working with Kishan. If company does implement a Lean Six Sigma green belt DMAIC phases and tools in their company, they should be able to see visible difference by using a few of the tools and showing how the company's growth, profit, processes and product quality can be improved.

Financial Implications: This is the conclusion section. The Lean Six Sigma program will show the financial projections that affect the company's profit picture. Examples have been given to illustrate how the Kishan will benefit financially.

THESIS STATEMENT

Introducing Lean Six Sigma Green Belt's DMAIC methodology to the small scale Indian packaging industry where there is an 5th to 8th grade education level of manufacturing worker (S. Chaudry, personal communication, June 14,2011). Evidences are provided to support originality of this thesis. Below are four reasons why this research is original.

First of all, based on literature review, packaging companies in India have not implemented Lean Six Sigma. Nor are India packaging companies anywhere close to establishing any continuous improvement methodologies for improving the quality their packaging products. Currently, the method of doing business within India is based on price negotiations of the packaging materials or how low of a price can be negotiated between India manufacturer and India supplier. By implementing Lean Six Sigma, the Indian manufacturer will provide machinery efficiency reasons for buying from its packaging suppliers, as it has been demonstrated in the data analysis section.

Vision of this thesis is based on knowledge of Green Belt and personally witnessed experience, how the India packaging industry can improve to meet the Lean Six Sigma standards established in USA. Based on literature review, Lean Six Sigma has a strong foothold within the USA.

In order to show the Indian country how Lean Six Sigma can become part of its culture, Kishan Plastics-packaging Company, has been selected as a model. All information has been provided by president or owner of the kishan plastics, as he has a desire to do business with the USA companies. Based on this evidence, it is clear that any Indian packaging company that has a business plan to sell products to America needs to implement Lean Six Sigma within its organization.

With this thesis completed, in the future many other Indian packaging industries will implement the Lean Six Sigma. If an Indian Company implements Lean Six Sigma, then the people and processes will be capable of producing quality packaging product for use within the USA. The USA customers can feel secure that the products coming from a foreign nation are produced according to the USA regulations which would enable USA customers to use according to the customer's purpose.

Second, this thesis is original because there is a need in India to improve the quality of packaging processes within India because many of packaging materials are contaminating the area and the animals as my literature review will expose.

Third, the worker's culture in India would benefit from improving the processes as a result of bringing Lean Six Sigma into the India Packaging Industry. Even though Indian packaging companies have machines, most of work in the small scale Packaging Industry (Kishan Plastics) is being done manually. It has been guided to Kishan plastics how to implement Lean Six Sigma into a culture that manufacturers packaging with a heavy concentration on manual labor. The manual labor plays a big part because the equipment in many cases is not state of the art and therefore the quality of the packaging product suffers based on the management's desire to improve conditions for the worker. Kishan's president is dedicated to his workers to make the processes easier for the worker. Therefore, the tools implemented from Lean Six Sigma can improve the worker's job performance.

Fourth, because the educational level of the workers is very low in Indian small scale packaging companies, continuous improvement methods, like Lean Six Sigma, have not been attempted. Appropriate ways to implement six sigma tools based on low educational level of the workers and employees within Kishan has been addressed in this research. This literature review

has revealed that the average education level is between 5th and 8th grade. Therefore, implementing Lean Six Sigma will be a big challenge. The low educational level presents challenges in teaching the president and workers/ employees on how to reduce waste, improve processes and increase profits. Therefore, it has been demonstrated in the methodology section of this thesis how the president can implement Lean Six Sigma by establishing the appropriate communication methodologies for employees and worker who have a lower educational level.

In summary, this research is original because 1) No small packaging companies are using Lean Six Sigma; 2) The quality level is low, currently there is a ban on some packaging materials because they are harming the animals, 3) Producing packaging materials in India is heavy with manual labor, 4) As Educational level is low, communication level should be adjusted between 5th and 8th grade level. Due to these reasons the research is original.

LITERATURE REVIEW

Literature Review shows following area:

1) Six sigma and small scale business
2) Need of Six sigma in Indian packaging industry
3) Education level of Employees (Worker) in Small Scale Industry
4) Top ten Packaging companies in India.

In order to perform the literature review, different sources have been used like: government produced documents, articles from internet, contacted companies for information use company website to find more information. Data and information provided below shows that six sigma DMAIC methodology will be helpful in Indian Packaging industry.

Below is the list of articles collected from internet.

In this literature review part, information has been collected from following articles and sources which will provide information about small scale industries and how Six Sigma can suits to it.

Six Sigma for Small Business

In this article Mohan Mittal has mentioned the characteristics of Six Sigma and also explains some myths about Six Sigma, which can be so crucial for implementing before using Six Sigma tools.

- Six Sigma can work in any size business because the nature of Six Sigma is dependent upon characteristics inherent to any business, not on the size of a business.
- Six Sigma DMAIC (Define, measure, analyze, improve, and control) disciplines work no matter the size of the organization or even the size of the Six Sigma project.

- Small businesses do have constraints that limit their ability to initiate a large scale Six Sigma implementation. However, there are ways to overcome these limitations. Small businesses don't have large reserves of excess cash to earmark for the massive training programs employed by the large corporations in implementing their Six Sigma programs.
- There is a benefit to implementing Six Sigma in a smaller business. Because of the size of a small business, the financial results and cultural transformation that stem from Six Sigma will propagate more quickly through a smaller organization. (Mittal, 2008)
- Focusing the Six Sigma tools at virtually any properly scoped project will drive savings to your bottom line and achieve breakthrough change in your organization.

So this information shows that there is always opportunity for implementing Lean Six Sigma in small scale Indian packaging industry.

Six Sigma Deployment Small Business

In this article Jonathan Rojas mentioned about following areas.

- Six Sigma is designed for all-inclusive deployment across an organization. However, smaller organizations do have constraints that limit their ability to initiate a large scale Six Sigma implementation (Rojas, 2010). If your organization does not have the resources to create an infrastructure for organization-wide Six Sigma deployment then start with a pilot program.
- One of the beauties of Six Sigma is that its central methodology is scalable. Six Sigma emphasizes intensive training and extensive analysis-qualitative characteristics that work regardless of the size of the organization.
- Small and medium-sized organizations may not have the resources of larger companies; however, in most cases, smaller organizations can be more nimble, flexible, and focused

on results. Approaching initial implementation of Six Sigma through a pilot program will yield tangible results without overwhelming your resources from a small "quick-hit" project. These results can then be replicated throughout the organization, in many cases even faster than in a large organization.

- Six Sigma implementation teams can encounter critical resource restrictions, often due to a personnel limitation where people are available for project functions only on a part-time basis. It is essential at project inception that the right people are involved, doing the right things. A small but committed force of the right people with proper training, given the proper authority will go far in getting things started. Good and fluid communication is also critical.

Six Sigma Projects in Small Businesses

Information available on Aveta institute explains in detail that the size of business does not matter when planning to implement Six Sigma. Below are reasons why Six Sigma will not fail in small scale industry.

- There is never any business too small or any process too insignificant to improve upon. While it might seem that you are better off without Six Sigma because it was designed for big companies and larger corporations with bigger problems, you’re very mistaken. In actuality, Six Sigma Projects are very effective for small business. Here’s how.
- A small business needs its customers more than any other type of business. While a company like Motorola might have billions of customers and can afford to lose a few because of an inefficient process, your business that only has a few hundred customers

needs all the support and success that it can get (Aveta Business Institute, January 30, 2011).

- Six Sigma Projects can definitely help to improve the processes within your company and make your success much better than it might have been without it. Don't let yourself be fooled by those who tell you that it's too expensive or that it won't work. You don't have to spend a lot to hire a consulting team to complete these Projects, and you'll definitely see ROI (return on investment) within 4 to 6 months that will amaze you if the projects are completed properly. Alternatively, you can pay to make one of your very own employees or yourself a trained and certified Six Sigma professional, thus always having a valuable 'consultant' on the payroll at all times.
- Choosing a Six Sigma consulting service can prove to be a challenge. However, you simply need to review the credentials of their training and ensure that any person you consider working with has the correct training and credentials that you need. That way, you can guarantee that you're working with a reputable source and making the most of your business improvement budget every single time. As a small business, you have far less room for error, so you will need to pay more attention than anyone else to your quality improvement Projects and selecting the right processes to improve.
- Another reason that small businesses are so adept at utilizing Six Sigma is because their relationships with their customers are much more tight-knit than those companies who have hundreds of thousands of customers to keep tabs on. A small business will value its customers much more because it has fewer of them to rely on for business success. By using quality improvement Projects to reach out to customers and say 'here, let me fix that for you', a small business is proving its worth in the industry that it is in.

- Being the small fish in the big pond always comes with its perks as well as its downfalls. When you are able to take the time to check out all of the different processes that you could improve in your small business and utilize Six Sigma Projects to improve them, you will be setting yourself to a higher standard of customer service and satisfaction that rivals the big companies. Since you are a smaller entity, this dedication to the customers' needs will prove to be much more valuable in the eyes of your customers than it might be for a company that is much larger and has many more customers to appease.

The Small Business Industry Discovers Six Sigma Projects

This article shows how Lean Six Sigma has helped fortune 500 companies and other big companies. Now lots of small scale industry owners are also planning to implement Six Sigma and make as much benefit as possible to their company.

- Many small business owners are discovering the benefits of Six Sigma Projects as they successfully reduce costs and increase profits. Business leaders of all sized companies are learning that this exciting production management doctrine is not just for Fortune 500 companies.
- The principles of this well-known program are being applied across the small business landscape and the success realized is measurable (Aveta Business Institute, May 01, 2011).
- The Six Sigma Methodology has saved one iconic company billions of dollars. Most companies or production managers have been exposed to Six Sigma at some point in their careers. This strategic management program has been highly touted by a wide array of business leaders for many years.

- Small business owners are discovering that they can reduce production costs and increase their profits implementing the same plan large companies have used successfully for years. The opportunity for positive change in small business by using Six Sigma has already been perfected by many major companies.

Six Sigma and Small Business Affecting Your Corporate Culture

Different companies have different work culture. Terminology used in both size of companies are also different. Information provided below will indicate problems occurred to implement Six Sigma in small scale industries and also explain some terminology which can be confusing later on for small industry.

- Those in small business may read the term "corporate culture" and wonder how that term can possibly apply to them. Corporate culture is best defined as the beliefs, expectations, values, behaviors, and ways of operating that characterize the interactions of the people in your business organization.
- Corporate culture is not a term reserved for huge companies, as even the smallest of businesses has its own unique culture. You may not even realize it, but this culture affects every aspect of your business (Aveta Business Institute, December 26, 2010).
- The success of Six Sigma at your small business depends on how prepared the culture of your company is for change. You will need to be willing to look at how things are done at your company. This sounds easy, but it can be a real challenge, especially for those in small business with a personal attachment to the company and product. Every aspect of your company needs to be critically reviewed and you must absolutely be willing to change whatever you need to change in order for your program to flourish.

- The best way to introduce Six Sigma is by emphasizing that no one is doing anything wrong currently. The practices and ways of your operation just sometimes "happen." People approach problems and operations the best way they know how, and sometimes lose sight that there may be a more efficient way of doing the same process that saves time and money.
- Resist the urge to bring in a professional outsider when introducing Six Sigma to your business. The culture will be more likely to resist if someone that doesn't understand your specific business explains it. The success of culture change is dependent on your employees trusting the process and knowing that you, as the small business owner, have made this decision independently as a way of doing better for everyone.
- Considering the culture of the company and how changing these thoughts and ways of operating is necessary for the success of the Six Sigma program is vital.

Importance of Indian Packaging Industry

Picture of economic condition of packaging industry in India has drawn in this research. From information provided below it is clear that packaging industry has great potential to develop in India. Moreover, packaging industry is currently not following Lean Six Sigma DMAIC methodology. Implementing this methodology will increase its production that will increase revenue of a company and later it will increase revenue of the nation. Below is the current state of packaging industry in India. Moreover, as owner of Kishan plastics wants to do some changes in his company to make more profit, so six sigma research in kishan plastics will help company to better as well as to find out what is the difference going on between packaging companies in United states of America and India. Practical knowledge gained in American

companies like: Fisher price and Packaging Corporation of America and All Product Design has played an important role during research.

- The Indian packaging industry itself is growing at 18-20% annually.
- The highly fragmented packaging industry is estimated at Rs 8,000 crore.
- In the next five years, the sector is expected to triple to around $ 60 billion.
- There are about 600-700 packaging machinery manufacturers, 95percent of which are in the small and medium sector located all over India.
- Indian packaging machinery exports are rapidly growing.
- India's packaging industry may achieve an annual turnover as high as US$ 5 billion in the current financial year with a growth rate nearly 25 per cent in significant segments. (India Packaging Show 2011, 2011).
- The Indian packaging industry is expected to grow to Rs 82,500 crore by 2015 from the current Rs 65,000 crore**.**
- "India stands at the 11th position in the world packaging industry, which is $550-billion, and with the rising consumer demand and new technologies, it is expected to grow at 18-20 per cent from the current 15 per cent," said NC Saha, director, Indian Institute of Packaging (IIP) (Samal, 2010).
- Among the total packaging sources, plastic packaging is at 6.8 million tones and growing at 20-25 per cent per annum, whereas paper packaging is 7.6 million tones. "Glass packaging contributes to 4-5 per cent and metal 8 per cent. Forty per cent of the total paper production goes for packaging," Saha added.

- Stating that the packaging industry had become wide, Sanjay Bhatia, IIP chairman, said, "Today, whatever we use needs a packaging. Last year, our GDP growth was 8.5 per cent while the packaging industry grew 15 per cent."
- AVPS Chakravarthy, member of the exhibition committee, said, "With the theme 'Packaging-enhancing the value', the main focus of India pack will be branding not profit, as packaging has become a way of life."
- The four-day exhibition-cum-trade fair by the Indian Institute of Packaging will offer a platform for companies and packaging industries from both domestic and international market to come together. It is expected to see 400 stalls.
- Above data shows how packaging industry is growing in India. Implementing Lean Six Sigma green belt procedure in Indian packaging industry will take this industry at new level.

Education level of Employees (Worker) in Small Scale Industry

Education level of workers plays a crucial role in the success of Six Sigma in small scale industry in India. In United States of America implementing a Six Sigma, education level of employee is not an issue. The educational process in the USA is aided by the American with Disabilities Act. This act regulates that companies implement with reason certain training and work related devises that assist the company and worker in performing the job.

In India, the educational level of the worker is a big issue for a small scale industry. To find out what is the education level of workers in India following sources have been uncovered: Government, Educational Institute, Industrial.

GOVERNMENT

Out of three categories mentioned above data available on government website are more reliable than any other website. Information has been gathered from following two government websites.

1) Labor Bureau Government of India
2) Central Board for workers education

Labor Bureau Government

Information available on this source is as follows:

- The literacy rate for the population of age group 7 years & above is estimated to be 77.7 per cent at the overall level, with 74.6 per cent in rural areas and 86.0 per cent in urban areas (Government of India, October 2010).
- The unemployment rate is estimated at 94 persons out of 1000 persons in the labor force, which implies that 9.4 per cent of the labor force is unemployed at the overall level as per the usual principal status.
- In the rural sector, the unemployment rate is estimated at 101 persons out of 1000 persons in the labor force. Similarly in the urban areas, the unemployment rate is 73 persons out of 1000 persons in the labor force.
- Government is showing data about rural and urban areas but not providing any data about people living in slums. In India 10% of population is living in slums.

So government is not having accurate information. But if government does accurate calculation by considering people living in slums and also on road side then literacy level will be

lower, unemployment rate will be higher then what they are showing on internet to the rest of the world.

- Social security benefits- information available from this sources shows that social security benefits like provident fund, gratuity, health care; maternity benefits, pension, etc are really rare for workers in different sector of industry. According to this source worker getting this benefit is around 10%.

LABOR BUREAU GOVERNMENT OF INDIA

Sector	Not literate			Upto secondary Level			Above secondary level		
	M	F	P	M	F	P	M	F	P
Rural	171	344	254	752	621	689	77	35	57
Urban	92	192	140	709	669	690	199	138	170
Overall	150	303	223	741	634	690	109	63	87

Table 1- Literacy Level

- First of all, It should be clear that secondary level means (6 to10th grade) and higher secondary level (11 and 12 grade).
- Above table contains information on per thousand distribution of male and female population by level of education in urban and rural areas. Per thousand 'Not literate' persons are estimated to be 254 in rural areas, 140 in urban areas and 223 at overall level. In terms of educational attainment, males outnumber females in both categories of 'up to secondary level' and 'above secondary level' in rural as well as in urban areas.

Educational attainments for males up to secondary level have been estimated to be 741 as against 634 females per thousands in this category. Similarly, 109 males are estimated to be educated above secondary level per thousand against 63 per thousand females educated up to this level.

Graph below shows per 1000 distribution of number of persons of age 7 years & above by level of general education for each State/UT surveyed rural +urban area.

Sl. No.	Name of the State/UT	Not literate	Below primary	Primary	Middle	Secondary	Higher secondary	Diploma	Graduate	PG & above	All	Sample persons
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Andhra Pradesh	328	99	99	152	147	73	20	62	20	1000	8362
2	Assam	112	106	215	291	128	88	8	46	6	1000	5177
3	Bihar	267	169	132	174	124	67	8	48	11	1000	16120
4	Chhatisgarh	236	117	199	196	113	84	4	37	15	1000	4942
5	Delhi	141	144	132	203	96	133	3	117	32	1000	3170
6	Goa	56	51	75	153	235	211	32	146	42	1000	1034
7	Gujarat	215	117	167	179	141	80	18	64	20	1000	8055
8	Haryana	176	91	160	189	165	110	24	65	19	1000	8561
9	Himachal Pradesh	139	81	157	185	193	151	17	50	28	1000	3953
10	Jammu & Kashmir	289	60	172	154	158	97	5	44	22	1000	3920
11	Jharkhand	221	109	151	210	142	85	7	70	6	1000	5811
12	Karnataka	252	112	129	168	157	84	41	51	5	1000	11307
13	Kerala	38	91	176	289	165	103	28	82	29	1000	4326
14	Madhya Pradesh	255	143	171	175	94	82	12	52	16	1000	12295
15	Maharashtra	181	63	153	211	187	109	12	61	21	1000	11987
16	Meghalaya	237	180	191	204	105	47	3	30	4	1000	685
17	Orissa	199	121	190	176	163	70	12	59	10	1000	12621
18	Punjab	196	75	144	182	187	120	23	40	33	1000	7279
19	Rajasthan	258	124	177	184	112	63	7	56	19	1000	15062
20	Sikkim	125	107	146	217	182	142	1	71	10	1000	914
21	Tamil Nadu	173	89	169	195	161	96	31	63	23	1000	12672
22	Uttaranchal	155	118	145	208	158	106	10	65	34	1000	5236
23	Uttar Pradesh	260	137	166	183	107	76	5	48	18	1000	35199
24	West Bengal	161	121	228	249	98	62	4	61	16	1000	7064
25	Chandigarh	141	44	144	151	144	106	14	170	87	1000	859
26	Dadra & Nagar Haveli	482	2	60	184	208	45	12	3	5	1000	383
27	Daman & Diu	109	45	177	180	216	183	50	38	1	1000	691
28	Pondicherry	117	56	112	204	183	160	49	87	32	1000	419
	Overall	223	117	163	194	133	83	13	57	17	1000	208104

Table 2- level of general education

It shows that out of 1000 average 22% of the people are illiterate in India in this particular experiment. Around 63% populations have education till Secondary school. Education higher than secondary level is around 15%.

This experiment represents the education condition in entire nation.

- In case of Kishan plastics, most of the workers are from villages around Ahmadabad city where the company (Kishan Plastics) is located. Company has 12 workers but out of 12, 2 workers are illiterate, 10 have secondary school education.
- Most of small scale industries in India are located just outside of city or in some case with in the city. Worker can be from rural area or from urban area or mix of both. It's all depending where the company is located. Most of workers working in these companies migrate from undeveloped state or city of India like Bihar, Uttar Pradesh.

Central Board for Workers Education

This is another website of Indian government. This source shows the annual report which was published for year 2005-2006. There is no information after year 2006. This source is not useful to find any useful data.

EDUCATIONAL INSTITUTE

Educational institute is also helpful to gather useful information about educational level of worker in Indian small scale industry. Below are the four educational resources, which give information about education, training and worker research, related to labor in India:

1) V. V. Giri National labor Institute
2) National Sample Survey Organization
3) Wikipedia on "Literacy in India"
4) Wikipedia on "Education in India"

V. V. Giri National labor Institute

V.V. Giri National Labor Institute is a premier national institution involved with research, training, education, publication and consultancy on labor related issues. The Institute, established in 1974, is an autonomous body of the Ministry of Labor and Employment, Government of India. I look at this web site but did not find any useful information about education level of worker in Indian industry.

National Sample Survey Organization

The National Sample Survey (NSS), initiated in the year 1950, is a nation-wide, large-scale, continuous survey operation conducted in the form of successive rounds. It was established on the basis of a proposal from P.C. Mahalanobis to fill up data gaps for socio-economic planning and policy making through sample surveys. This organization has no information about education level of worker in Indian small scale industry.

Wikipedia on "Literacy in India"

Literacy in India is a key for socio-economic progress, and the Indian literacy rate grew to 74.04% in 2011 from 12% at the end of British rule in 1947. Although this was a greater than six fold improvement, the level is well below the world average literacy rate of 84%, and India currently has the largest illiterate population of any nation on earth. Despite government

programs, India's literacy rate increased only "sluggishly" and a 1990 study estimated that it would take until 2060 for India to achieve universal literacy at then-current rate of progress. The 2011 census, however, indicated a 2001-2011 decadal literacy growth of 9.2%, which is the slower than the growth seen during the previous decade.

About 35% of world's illiterate population is Indian and, based on historic patterns of literacy growth across the world, India may account for a majority of the world's illiterates by 2020.

Wikipedia on "Education in India"

India has made progress in terms of increasing primary education attendance rate and expanding literacy to approximately two thirds of the population.

However, India continues to face stern challenges. Despite growing investment in education, 25% of its population is still illiterate; only 15% of Indian students reach high school, and just 7% graduate. As of 2008, India's post-secondary high schools offer only enough seats for 7% of India's college-age population, 25% of teaching positions nationwide are vacant, and 57% of college professors lack either a master's or PhD degree.

Moreover, due to shortage of resources and lack of political will, this system suffers from massive gaps including high pupil to teacher ratios, shortage of infrastructure and poor levels of teacher training. Education has also been made free for children for 6 to 14 years of age or up to class VIII under the Right of Children to Free and Compulsory Education Act 2009.

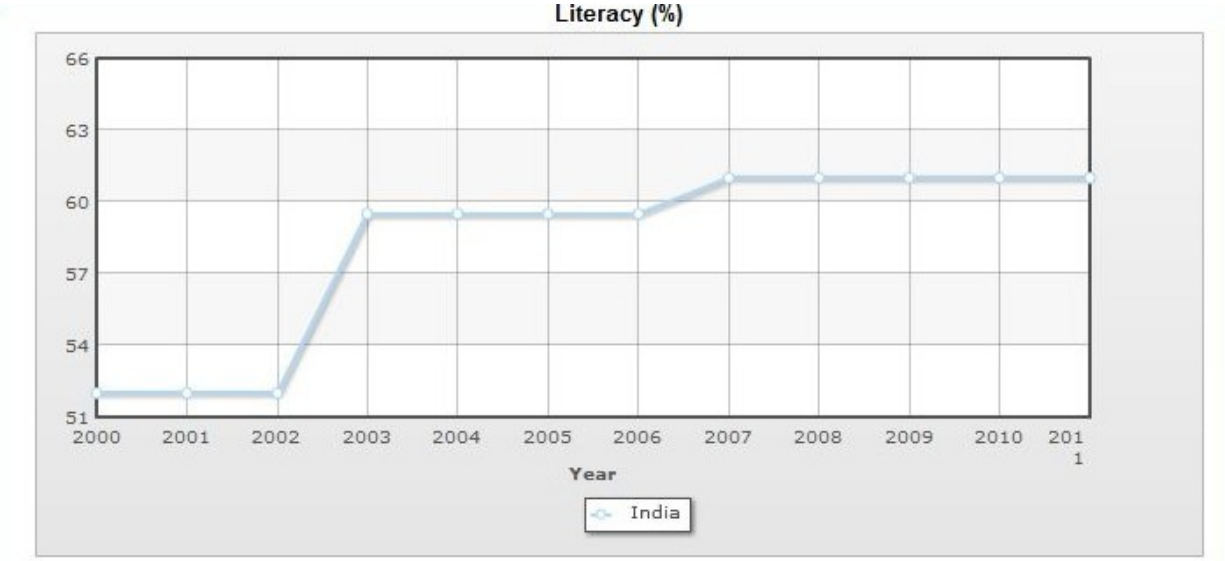
Secondary education covers children 14–18 which covers 88.5 million children according to the Census, 2001. However, enrolment figures show that only 31 million of these children were attending schools in 2001–02, which means that two-third of the population remained out of school.

World Bank statistics found that fewer than 40 percent of adolescents in India attend secondary schools. The Economist reports that half of 10-year-old rural children could not read at a basic level, over 60% were unable to do division, and half dropped out by the age 14.

An optimistic estimate is that only one in five job-seekers in India has ever had any sort of vocational training.(What is vocational training- Vocational education or vocational education and training prepares trainees for jobs that are based on manual or practical activities, traditionally non-academic, and totally related to a specific trade, occupation, or *vocation*.

It is sometimes referred to as *technical education* as the trainee directly develops expertise in a particular group of techniques or technology.)

The graph below shows the literacy pattern in India in last decade.



Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
India	52	52	52	59.5	59.5	59.5	59.5	61	61	61	61	61

Graph 1- Literacy %(Percentage)

The graph above shows that India has done some progress with education level but it's still below the average education level in world which is 84%.

Definition Literacy: This entry includes a *definition* of literacy and Census Bureau percentages for the *total population*, *males*, and *females*. There are no universal definitions and standards of literacy. Unless otherwise specified, all rates are based on the most common definition - the ability to read and write at a specified age. Detailing the standards that individual countries use to assess the ability to read and write is beyond the scope of the *Fact book*. Information on literacy, while not a perfect measure of educational results, is probably the most easily available and valid for international comparisons. Low levels of literacy and education in general, can impede the economic development of a country in the current rapidly changing, technology-driven world.

INDUSTRIAL

In this part of the literature review, Information about education level of worker in their company has been collected from president of Kishan Plastics and Anmol Enterprise. Information collected from these companies represents education level of small scale packaging and textile industry respectively all over India.

- Kishan Plastic is located in Ahmadabad, Gujarat, India. Owner of this company is Satish Chaudry, who has provided all required information. There are 12 workers working in this company and average education level in this company is 8 standard (grade).Some worker has never been to school so can't read or write.
- Anmol Enterprise is located in Surat, Gujarat, India. Owner of this company is Kaushik Patel, who provided all required information. As per information provided by Anmol enterprise, textile industry, having 100 employees; average education level is 5^{th} grade.

This shows that implementing a Lean Six Sigma method in Indian Small Scale industry has to face big problem of lake of education. And this scenario represents the situation of Small scale industry in India

- Moreover, information about top ten packaging companies in India has been provided below.

TOP TEN PACKAGING INDUSTRY IN INDIA

In this part of Literature review status of Lean Six Sigma DMAIC methodology in top ten Indian packaging Industry has been showed. As stated above packaging industry plays vital role in Indian economy, it is important to know their quality control or quality improvement strategies. In this part of literature review, following areas for each company has been discussed.

1) Introduction
2) Current quality improvement plan
3) Implementation of Six Sigma

Below are the top ten packaging industry in India.

Parksons Packaging System

Introduction- Parksons Packaging System is one of the largest producers of high quality folding cartons in India. Moreover, parksons cater to some of the best known brands and leaders in the Food and beverages, pharmaceutical, Electronic, Retail, Apparels and other white good industries.

Current Quality improvement plan- Company has following accreditations: ISO 9001:2000, Pharmaceutical supplier code of conduct and 9001:2000- for pharmaceutical packaging. Moreover, company website says that company has documented quality

policy for continuous improvement and perfection. Furthermore, company has also implemented several productivity improvement plans.

Implementation of Six Sigma- As Company currently has ISO certification and also following other quality improvement tools. Therefore, implementing Six Sigma will be easier in this company.

ITC Limited

Introduction - ITC's Packaging & Printing Business was set up in 1925 as a strategic backward integration for ITC's Cigarettes business. It is today India's most sophisticated packaging house. In 1979, ITC entered the Paperboards business by promoting ITC Bhadrachalam Paperboards Limited, which today has become the market leader in India. ITC's paperboards' technology, productivity, quality and manufacturing processes are comparable to the best in the world.

Current Quality Improvement Plan- Company website does not have any information about quality improvement or quality control plan.

Implementation of Six Sigma - As Company is not following any quality improvement tool it is a challenge to implement Six Sigma in the company.

TATA Tinplate Company of India

Introduction-TCIL is today the largest indigenous producer of tin coated and tin free steel sheets in India, enjoying 35-40% market share and undoubtedly the industry leader for 85 years. The company exports about 20-25% of its production directly to end-users (can-makers) and its products are well accepted in the markets of SE Asia, Middle East and some developed countries in Europe.

Current Quality Improvement Plan- Company is currently using different quality improvement tools like: Value engineering, Quality circles.

Implementation of Six Sigma - Implementing Six Sigma would be easier because the company is currently using tools for better quality.

Hindalco

Introduction-An industry leader in aluminum and copper, Hindalco Industries Limited, the metals flagship company of the Aditya Birla Group is the world's largest aluminum rolling company and one of the biggest producers of primary aluminum in Asia. Its copper smelter is the world's largest custom smelter at a single location.

Current Quality Improvement Plan- Company has following quality tools: ISO 9001:2000, ISO 14001:2004 and OHSAS 18001.

Implementation of Six Sigma – Implementation of Six Sigma is easy as company has experience working on other quality improvement tools.

Moldtek Technologies Limited

Introduction-Packaging Division has world-class facilities in Manufacturing and Printing like Injection Mould machines, In-house Tool Room and Clean Room for Pharmaceutical products. We have three Manufacturing units – two at Hyderabad and one at Daman (India).

Current Quality Improvement Plan-Company is not implementing any quality improvement plan at their locations.

Implementation of Six Sigma- Company will have hard time implementing Lean Six Sigma because it has never implemented any quality improvement plan before.

Gujarat Glass Ltd

Introduction-Gujarat Glass Limited is a leading manufacturer of glass packaging for pharmaceutical and cosmetic products. GGL is the only company in India and one of the few in the world who manufacture and market the entire pharma range of glass bottles and vials (amber and flint, bottles and vials, soda lime and borosilicate).

Current Quality Improvement Plan-Company does not have any information about quality improvement plan.

Implementation of Six Sigma- Implementing of Six Sigma will be a challenge as company is not interested to do any quality improvement program.

Advance Packaging

Introduction-Advance Packaging is a leading manufacturer of packaging machines and packaging equipment believing in giving your products Personality & Protection. Concentration of company's total resources has enabled us to develop an extraordinary understanding of pouch sealing/heat shrinking technology.

Current Quality Improvement Plan-Company does not have any information about quality improvement plan.

Implementation of Six Sigma- Implementing of Six Sigma will be a challenge as company is not interested to do any quality improvement program.

AMAC Plastic Packaging

Introduction-AMAC Plastic Products has been an industry leader in the design and manufacturing of quality plastic boxes.

Current Quality Improvement Plan-Company does not have any information about quality improvement plan.

Implementation of Six Sigma- Implementing of Six Sigma will be a challenge as company is not interested to do any quality improvement program.

E C Packaging Pvt Ltd

Introduction- Company Manufacture & Exports Packaging Machines for Liquid and Dry Products, Machines for Dry Products, Machine for Packing of Mineral Water & Free Flow Liquids, Machine for Packing of Biscuits, Chocolates, Soaps, Ball-Bearings etc, Machine for Packing of Candies of different Length / Width / Height, Machine for packing of Liquids and Powders.

Current Quality Improvement Plan-Company does not have any information about quality improvement plan.

Implementation of Six Sigma- Implementing of Six Sigma will be a challenge as company is not interested to do any quality improvement program.

The Paper Products Limited

Introduction-The Paper Products Limited, India's leading flexible packaging company. PPL is India's leading manufacturer of primary consumer packaging with annual gross sales of about Rs.500 crores, and net capital employed of about Rs.219 crores. PPL is the pioneer and the technology and market leader in Flexible packaging.

Current Quality Improvement Plan-Company does not have any information about quality improvement plan.

Implementation of Six Sigma- Implementing of Six Sigma will be a challenge as company is not interested to do any quality improvement program.

Information provided on all above company website does not even mention about Lean Six Sigma in the company. Moreover, Employees in these companies do not have any information about six sigma. If it is the situation in top 10 companies in India then what can we expect from other packaging companies in India.

Kishan Plastics is also not aware about lean or six sigma. So it is clear that there is no knowledge of DMAIC methodology at all in small scale Indian industry at least. So extra efforts are required to make it work or to just implement it.

INDIAN SIX SIGMA COMPANIES

The India packaging companies can benchmark other India industries where Lean Six Sigma has brought companies success, as briefly explained below. These companies are not packaging companies. Companies listed below represents IT Industry, Hotel Industry etc.

Wipro Technologies

Wipro Technologies is a global services provider delivering technology-driven business solutions that meet the strategic objectives of clients. Wipro has 40+ 'Centers of Excellence' that create solutions around specific needs of industries. Wipro delivers unmatched business value to customers through a combination of process excellence, quality frameworks and service delivery innovation. Wipro is the World's first CMMi Level 5 certified software services company and the first outside USA to receive the IEEE Software Process Award. Wipro is the first Indian company to adopt Six Sigma.

Today, Wipro has one of the most mature Six Sigma programs in the industry ensuring that 91% of the projects are completed on schedule, much above the industry average of 55%. Six Sigma provides the tools for continuous improvement on existing processes thereby helping sustain the SEI-CMM Level 5 and CMMi certifications (Sharma, Pandla, & Gupta, 2008).

Benefits Wipro has achieved following results

- 30-40% lower total cost of ownership
- 20-30% higher productivity
- On-time deliveries (93% projects completed on time)
- Lower field defect rates (67% lower than industry average). The performance enhancement enabled the client to have an improved product with the overriding benefit that the end customer perception of the quality of the client's product is improved.

Sterlite Optical Technologies Ltd

Sterlite Optical Technologies Ltd is an Indian manufacturer of optical fibers, telecommunication cables and power transmission conductors and exports optical fiber to overseas markets in China, Europe and South East Asia. Sterlite's vision is to 'Connect every home on the planet'. Sterlite is also executing multi-million dollar power transmission system projects, pan-India. Sterlite Technologies is today amongst the largest integrated manufacturer of optical fiber and cable manufacturers globally.

With the inherent capabilities in product development, manufacturing efficiencies and technological advancements.

ITC Welcome group Hotels

ITC's hotel division was launched on October 18, 1975, with the opening of its first hotel - Chola Sheraton in Chennai. ITC Hotels, is today one of India's finest hotel chains, with its distinctive logo of hands folded in the traditional Namaste is widely recognized as the ultimate in Indian hospitality. Each of the chain's hotels pays architectural tribute to ancient dynasties, which ruled India from time to time. The design concept and themes of these dynasties play an important part in their respective style and decor. With more and more hotels being added at strategic destinations, the group has joined hands with the Sheraton Corporation to strengthen its international marketing base.

ITC Hotels was perhaps the first hotel chain in the mid 1980s to foresee a boom in business travel and realized distinct needs of the corporate traveler. ITC Hotels has pioneered the concept of **"**Branded Accommodation**"** in the hospitality industry. Branding led to the creation of separate categories of rooms, each with a different service design, aimed at different target segments. The different room categories were branded Executive Club, The Towers and lately, ITC One. The Towers and ITC One introduced the winning concept of a 'hotel within a hotel**'.** The Indian corporate world gave its unqualified approval to this segmentation.

Mumbai's Dabbawals

A dabbawala (Marathi: डबेवाला); also spelled as dabbawalla or dabbawallah; literally meaning "person with a box"), is a person in India, most commonly found in the city of Mumbai, who is employed in a unique service industry whose primary business is collecting the freshly cooked food in lunch boxes from the residences of the office workers (mostly in the suburbs), delivering it to their respective workplaces and returning the empty boxes back to the customer's

residence by using various modes of transport. "Tiffin" is an old-fashioned English word for a light lunch or afternoon snack, and sometimes for the box it is carried in. For this reason, the *dabbawala*s are sometimes called *Tiffin Wallahs*. A collecting dabbawala, usually on bicycle, collects dabbas either from a worker's home or from the dabba makers. The dabbas have some sort of distinguishing mark on them, such as a color or symbol. The dabbawala then takes them to a designated sorting place, where he and other collecting dabbawalas sort (and sometimes bundle) the lunch boxes into groups. The grouped boxes are put in the coaches of trains, with markings to identify the destination of the box (usually there is a designated car for the boxes). The markings include the rail station to unload the boxes and the building address where the box has to be delivered. At each station, boxes are handed over to a local dabbawala, who delivers them. The empty boxes, after lunch, are again collected and sent back to the respective houses (Dabbawala, n.d.).

In 2002, Forbes Magazine found its reliability to be that of a six sigma standard. More than 175,000 or 200,000 lunch boxes get moved every day by an estimated 4,500 to 5,000 dabbawalas, all with an extremely small nominal fee and with utmost punctuality.

According to a recent survey, they make less than one mistake in every 6 million deliveries, despite most of the delivery staff being illiterate.

Information provided below shows that Mumbai’s dabbawalas are having six sigma certification but most of them are illiterate but they are still doing their work without any error. More important thing is that these people are not using any kind of technology, everything is manual. There are more chances to make mistake when work is been done manually. If a group of illiterate and low educated people can make a business according to six sigma standard since last 10 years then why not Kishan Plastics?

SITUATION AT INDIAN INDUSTRIES

Information provided above shows that education level of worker is low in Indian small scale industry. If their education level is low then what is their pay scale, what type of facilities they are getting ect. All these information are provided below by showing the situation of worker in several industrial sectors. Some of the information provided below is hard to believe but it is truth.

In this section, condition of worker in different sector of industries has been mentioned.

Garment Industry

India's garment Industry has been rapidly growing the last few years. Exports have been rising due to an increase of orders from global buyers accompanied by a rise of investments in the Indian garment sector. The growth of the garment sector however, did not go hand in hand with an improvement of working conditions for the garment workers. In contrast, the increase in orders from retailers all over the world led to rising daily production targets for garment workers causing increasing and often unpaid overtime work, verbal abuse and harassment by supervisors.

Tea Industry

Tea workers in India are low-paid, are not treated very well by their employers and lack adequate facilities such as safe drinking water. Poverty and its sisters, starvation and malnutrition appear to be a normal part of life for the tea worker, who typically lives in an agriculturally lush and economically productive region. The issue is serving to draw world attention to the fact that the employees at Nowera are only paid 62.50 rupees a day, which equals $1.35 U.S

Salt Industry

The Salt Cess Act does not provide for the terms or protection or the service conditions of the salt workers. The Saltpan workers suffer enormously from the saline environment in which they live and work in on the coastal strip around the port of Tuticorin on the southeast cost of Tamilnadu. Many of the villages have no fresh water due to salt contamination of the local water table. They get occupational illnesses and disabilities such as sight impairment and blindness caused by the reflected glare of the sun off the salt crystals. They develop skin ulcers which are very painful and do not heal up quickly. They also suffer from stomach problems. Their life expectancy is quite low and infant mortality is high. Their wages are low. The saltpans open for only about eight months of the year. So in the process of making two ends meet the seasonal workers invariably fall into the hands of the local money lenders who generally charge interest at the rate of 10 percent per month. Seasonal workers work during the whole season and perform all kinds of activities on pan. In the beginning of the season the workers get small amount as wages and wages increase as the production of the salt increases with the temperature. The maximum daily wage reaches up to Rs. 55/- at the end of the season.

Status of Ship breaking Workers in India

Workers are mostly illiterate. The workers in this industry have very basic problem of getting safe water and other basic amenities like bathroom, toilet etc. Women workers are more affected by this and they are not provided maternity benefits and other required facilities. All the facilities, be it housing, sanitary, or medical are highly inadequate. The Ship breaking industry presents a dangerous work environment with high risk of injury and accidents with poor equipments and machinery and with inadequate safety devices. There is a low level of education

and training. The safety control measures are absent and there is lack of personal protective equipment (PPE) availability to workers. They live in hutment with weak tin roofing without any ventilation, or toilet facilities, Skin diseases, ringworm, dysentery and anemia are some of the common health problems found among the workers. High incidence of HIV infected cases has also been reported and alcoholism is rampant.

The above situation shows that companies are making lots of money but workers in India are not getting enough to live.

METHODOLOGY

Based on the literature review section, Lean Six Sigma is new to India's packaging industry. In this methodology section, Lean Six Sigma will be introduced to the small scale packaging industry in India. With the help of DMAIC approach Kishan Plastic will be ready to transform their manufacturing process to produce quality packaging products for the USA. Main area of interest of this methodology will be to focus on improving the resin quality. Once Kisan Plastic has better quality resin, they can reduce the machine stoppages.

Following factors are main area of focus.

1. Introduction of Lean Six Sigma.
2. Introduction of the DMAIC Phases.
3. Tools used in each phase of DMAIC methodology.
4. Implementation Strategy for DMAIC methodology in Kishan plastics
   - Define
   - Measure
   - Analysis
   - Improve
   - Control

From literature review it is clear that education level of worker is low in Kishan plastics. So it is really important to understand principals of adult learning process. If a company fails to educate the worker of a company about DMAIC methodology then chances of success of DMAIC methodology is very less. Below are the Principals of Adult learning.

PRINCIPALS OF ADULT LEARNING

Educators must remember that learning occurs within each individual as a continual process throughout life. People learn at different speeds, so it is natural for them to be anxious or nervous when faced with a learning situation. Positive reinforcement by the instructor can enhance learning, as can proper timing of the instruction. Learning results from stimulation of the senses. In some people, one sense is used more than others to learn or recall information. Instructors should present materials that stimulate as many senses as possible in order to increase their chances of teaching success. Moreover, Instructor should pay attention to the education level of workers in the company. For instance, most of the workers in Kishan plastics are having low or moderate education level. So educator has to use a language which is appropriate according to education level of workers.

There are four critical elements of learning that must be addressed to ensure that participants learn. These elements are

1. Motivation
2. Reinforcement
3. Retention
4. Transference

Motivation

If the participant does not recognize the need for the information (or has been offended or intimidated), all of the instructor's effort to assist the participant to learn will be in vain. The instructor must establish rapport with participants and prepare them for learning; this provides motivation. Instructors can motivate students via several means:

- **Set a feeling or tone for the lesson.** Instructors should try to establish a friendly, open atmosphere that shows the participants they will help them learn. Furthermore, instructor should also encourage worker to learn without thinking too much about time limit.
- **Set an appropriate level of concern.** The level of tension must be adjusted to meet the level of importance of the objective. If the material has a high level of importance, a higher level of tension/stress should be established in the class. However, people learn best under low to moderate stress; if the stress is too high, it becomes a barrier to learning. What is worse, in India person who does well get appreciation on the other hand people who does poor get criticized. If an instructor criticize any worker for their poor performance then the worker himself and other worker will not feel comfortable with the instructor. For example, if an instructor is not encouraging worker in Kishan plastics then none of the worker will show interest in learning new things.
- **Set an appropriate level of difficulty.** The degree of difficulty should be set high enough to challenge participants but not so high that they become frustrated by information overload. The instruction should predict and reward participation, culminating in success.

In addition, participants need specific knowledge of their learning results (*feedback)*. Feedback must be specific, not general. Participants must also see a *reward* for learning. The reward does not necessarily have to be monetary; it can be simply a demonstration of benefits to be realized from learning the material. Finally, the participant must be interested in the subject. Interest is directly related to reward. Adults must see the benefit of learning in order to motivate them to learn the subject.

Reinforcement

Reinforcement is a very necessary part of the teaching/learning process; through it, instructors encourage correct modes of behavior and performance.

- Positive reinforcement is normally used by instructors who are teaching participants new skills. As the name implies, positive reinforcement is "good" and reinforces "good" (or positive) behavior.
- Negative reinforcement is the contingent removal of a noxious stimulus that tends to increase the behavior. The contingent presentation of a noxious stimulus that tends to decrease a behavior is called Punishment. Reinforcing a behavior will never lead to extinction of that behavior by definition. Punishment and time out lead to extinction of a particular behavior, but positive or negative reinforcement of that behavior never will.

When the instructors are trying to change behaviors (old practices), they should apply both positive and negative reinforcement.

Reinforcement should be part of the teaching-learning process to ensure correct behavior. Instructors need to use it on a frequent and regular basis early in the process to help the students retain what they have learned. Then, they should use reinforcement only to maintain consistent, positive behavior.

Retention

Students must retain information from classes in order to benefit from the learning. The instructors' jobs are not finished until they have assisted the learner in retaining the information. In order for participants to retain the information taught, they must see a meaning or purpose for that information. They must also understand and be able to interpret and apply the information. This understanding includes their ability to assign the correct degree of importance to the material.

The amount of retention will be directly affected by the degree of original learning. Simply stated, if the participants did not learn the material well initially, they will not retain it well either.

Retention by the participants is directly affected by their amount of practice during the learning. Instructors should emphasize retention and application. After the students demonstrate correct (desired) performance, they should be urged to practice to maintain the desired performance. Distributed practice is similar in effect to intermittent reinforcement.

Transference

Transfer of learning is the result of training -- it is the ability to use the information taught in the course but in a new setting. As with reinforcement, there are two types of transfer: *positive* and *negative*.

- Positive transference, like positive reinforcement, occurs when the participants use the behavior taught in the course.
- Negative transference, again like negative reinforcement, occurs when the participants do not do what they are told not to do. This results in a positive (desired) outcome.

Transference is most likely to occur in the following situations:

- *Association* -- participants can associate the new information with something that they already know.
- *Similarity* -- the information is similar to material that participants already know; that is, it revisits a logical framework or pattern.
- *Degree of original learning* -- participant's degree of original learning was high.
- *Critical attribute element* -- the information learned contains elements that are extremely beneficial (critical) on the job.

Although adult learning is relatively new as field of study, it is just as substantial as traditional education and carries and potential for greater success. Of course, the heightened success requires a greater responsibility on the part of the teacher. Additionally, the learners come to the course with precisely defined expectations. Unfortunately, there are barriers to their learning. The best motivators for adult learners are interest and selfish benefit. If they can be shown that the course benefits them pragmatically, they will perform better, and the benefits will be longer lasting.

Introduction of Lean Six Sigma

Lean Six Sigma has been introduced as a first step to the methodology section. Moreover, some questions should be answered like: What is Lean? What is Six Sigma? What is Lean Six Sigma? This overview information is important because the Kishan's president is unaware of Lean Six Sigma. In order to implement Lean Six Sigma, the president needed to be briefly educated on it.

This continuous improvement methodology should be part of his thought process in conducting business. A brief tutorial on Lean Six Sigma is necessary in order to receive buy–in and support from the management of Kishan.

Second, Both the DMAIC and DMADV phases have been briefly explained. What is the DMAIC? What is the purpose for each phase? What are the tools used in each phase? What are the deliverables for each phase? Main reason for information about DMDAV is to show the differences and similarities between the DMAIC and DMADV.

Third, apply the DMAIC tools to Kishan. In other words, the appropriate six sigma tools should be used for this project and incorporate the data and information that is directly applicable to the Kishan manufacturing operation.

Moreover, this research also shows the Indian packaging industry how to utilize the DMAIC for improving a manufacturing operation. Role of a Green Belt training will be to show the president and his employees how to implement the DMAIC within Kishan and use it as a model for the Indian packaging industry.

What is Lean

Historically lean methods have been used since the beginning of the industrial revolution. Business leaders have been focused on driving performance and response to meet customer expectations while reducing costs. Lean thinking focuses on removing the non-value added (NVA) delay, waste, and rework from your processes. Lean can be used in any industry or business.

Lean methods were quantified and fined tuned during the 1950's and 60's by Toyota, and other forward thinking out of the box companies to the current available Lean methods available to businesses. Lean has been associated with Total Quality Management, re-engineering and Just in Time and other process improvement techniques.

Lean is a continuous improvement methodology that companies apply to ALL aspects of business (NOT just manufacturing and supply chain processes). While it comes from the Toyota Production System, it can be used to streamline and accelerate patient flow in hospitals or transaction processing in computers.

The fundamental objective for Lean and Lean Six Sigma methods in all facets of an organization is the ability to identify waste, reduce it, and aggressively go for the elimination of non-value added activities and improve the internal process so that customer pays for only value added.

Companies working to implement Lean learn to use many different tools to improve processes. Value Stream Mapping is one example that has been provided to Kishan as part of Green Belt effort. It is a visual representation that shows waste like inventory build up and unnecessary waiting times. By just raising the visibility and focusing on an area companies will immediately realize the low hanging and on the ground fruit waiting to be harvested. Lean methods are designed to yield benefits quickly by supporting the company's business objectives and needs while establishing a sustainable process for ongoing improvement.

The following is a list of the seven wastes that are typically found in a company:

1) Over – production: Extra handling, extra space, extra machinery, extra defects, extra people
2) Waiting: Watching the machine run and or waiting for material to arrive
3) Transportation: Double and triple handling, temporary storage, long distance between sites
4) Over – processing: non – value added process, 100% inspection
5) Inventory: Increases costs, damage, out of date material, extra handling, extra space
6) Motion: Walking, locations to far from each
7) Poor Quality: Produced by errors, mistakes, faulty equipment, poor training

Below are the 10 rules of Lean and its relationship to improve Kishan's infrastructure.

1) Eliminate waste	Kishan Plastics can reduce amount of waste and defects in the company. This will help company to lower down the cost of production.

2) Minimize inventory	Lean minimizes inventory. If product is stored in Kishan, it will not generate revenue for the company.
3) Maximize flow	If company is working in smooth flow then money will also flow, which will help company to keep growing.
4) Pull production from customer demand	Small Companies will not produce until the next process really requires it. In the bigger picture, the manufacturers will not produce anything, unless there is a customer demand. The customer demand will pull the products from the manufacturing facility.
5) Meet customer requirements	Lean will also help to meet customer requirements by reducing cost of waste. This will eventually results in cheaper products for customer.
6) Do it right the first time	Small scale industry will learn that doing right thing from beginning will save lot of time during whole production cycle and also reduce waste during production cycle.
7) Empower(workers)	Small company will give more power to their worker to reduce waste, give opinion to make efficient working procedure in

	company.
8)Design for rapid changeover	It also helps company to ready for constant changes. Some company cannot adopt changes easily. Implementing lean will also solve this problem by introducing latest approach constantly.
9)Partner with suppliers	Small companies will contact to suppliers and make sure they are having clear idea about raw material requirement. Different project has different raw material requirement, using same quality of raw material will result in poor quality and customer complains.
10) Create a culture of continuous improvement	Lean also creates an environment in company which encourages innovative ideas. Only innovative ideas can help to progress faster in today's fast growing industries worldwide.

Table 3- 10 Rules of Lean

What is Six sigma

Six Sigma is a business management strategy originally developed by Motorola, USA in 1986. Six Sigma seeks to improve the quality of process outputs by identifying and removing the causes of defects and works to minimize variability in manufacturing and business processes. It uses a set of quality management methods, including statistical methods and creates a special infrastructure of people within the organization ("Black Belts", "Green Belts", etc.) who are experts in the implementation of these methods. Each Six Sigma project carried out within an organization follows a defined sequence of phases called the DMAIC, and has quantified financial targets (cost reduction or profit increase) to reach in the end of the process.

Six Sigma originally associated with manufacturing, specifically terms associated with statistical modeling of manufacturing processes. The maturity of a manufacturing process can be described by a sigma rating indicating its yield, or the percentage of defect-free products it creates. A six sigma process is one in which 99.99966% of the products manufactured are statistically expected to be free of defects or achieving 3.4 defects per million units is the goal. Even though 3.4 defects per million is goal, the real mindset is to strive for perfection.

Below are the 10 rules of Six Sigma for Kishan Plastics:

1) View performance from the position of the customer	Kishan Plastics learns to include the customer's requirements throughout the organization.
2) Understand the process	Kishan understands the entire manufacturing process as efficient as possible.
3) Make decisions based on data and analysis	Kishan learns to make decisions on the data and information generated from using the DMAIC.
4) Focus on the most issues	Kishan learns that most issues can be resolved by

	using DMAIC tools, such as a Fishbone Diagram, where the potential causes to issues are identified.
5) Use statistical models	Kishan learns to use simple statistics to expose and work towards an accurate solution.
6) Pay attention to variation	Kishan quickly learns the reasons for variation when manufacturing packaging products.
7) Use standard methodologies	Kishan learns to control variation by implementing industry quality standards. This will help to produce same quality of product over the period of time.
8) Select projects for financial impact	Kishan learns how to improve financial condition of the company by improving quality of product, increasing customer satisfaction and meeting on time product delivery requirements.
9) Establish project governance structure	Kishan learns that meeting customer requirements governs every project undertaken within the Six Sigma effort.
10) Enlist senior management support	Kishan learns that the owner must be supportive and be directly involved with Six sigma implementation in order for it to succeed within India.

Table 4- 10 Rules of Six Sigma

In summary, Six Sigma focuses upon reducing variation in the process and keeps it within controlled limits. It is a target based approach to reduce defects / variations within a

process. Defects are considered waste. To reduce these defects, six sigma methodologies can be useful. However, Six Sigma can be applied to reduce any kind of defects / achieving any kind of other targets apart from lean wastes.

What is Lean Six Sigma

Very Simply, Lean Six Sigma is a combination of principles / tools / techniques from Lean and Six Sigma. In one sentence, Lean means to reduce the waste in an organization, Six Sigma means to reduce the defects, which is also called waste; and both enable employees to reduce the variation in any process thereby improving the quality products for the customers. Any Indian packaging company desiring to sell products in the USA will benefit from implementing both Lean and Six Sigma or Lean Six Sigma.

Development of this thesis is possible with the help of Kishan Plastics – a small packaging manufacturing company in India. This thesis mainly focuses on showing the president of Kishan how to improve its current manufacturing or production process. It also defines the production process from supplier approval through production and ending at the shipping department within Kishan. It has been further elaborated within the boundaries using a SIPOC map.

DMAIC and DMADV Methodologies

DMAIC and DMADV are two Six Sigma methodologies that eliminate defects from a process or product. It's important to understand DMAIC and DMADV and when it is most appropriate to use each methodology.

Everything in business is a process. Sales people have a list of companies and contacts that they work in a certain fashion to produce a sale, production receives an order and schedules

the manufacturing, the product is built, packaged, shipped and invoiced. If the packing department has a problem with their process then should they fix it with a DMAIC or DMADV (also referred to as DFSS) type project?

DMAIC and DMADV Similarities

Let's first look at the DMAIC and DMADV methodologies and talk about how they're alike. DMAIC and DMADV are both:

- Six Sigma methodologies used to drive defects to less than 3.4 per million opportunities.
- Implemented by Green Belts, Black Belts and Master Black Belts.
- Ways to help meet the business/financial bottom-line numbers.
- Implemented with the support of a champion and process owner.
- Data intensive solution approaches. Intuition has no place in Six Sigma- only cold, hard facts.

DMAIC and DMADV Differences

DMAIC and DMADV sound very similar. The acronyms even share the first three letters. But that's about where the similarities stop.

DMAIC	Define	Define the project goals and customer (internal and external) deliverables
	Measure	Measure the process to determine current performance
	Analyze	Analyze and determine the root cause(s) of the defects
	Improve	Improve the process by eliminating defects
	Control	Control future process performance
DMADV	Define	Define the project goals and customer (internal and external) deliverables
	Measure	Measure and determine customer needs and specifications

	Analyze	Analyze the process options to meet the customer needs
	Design	Design (detailed) the process to meet the customer needs
	Verify	Verify the design performance and ability to meet customer needs

Table 5- DMAIC & DMADV

DMAIC Usage

The DMAIC methodology, instead of the DMADV methodology, should be used when a product or process is in existence at your company but is not meeting customer specification or is not performing adequately.

DMADV Usage

The DMADV methodology, instead of the DMAIC methodology, should be used when: 1) a product or process is not in existence at your company and one needs to be developed. 2) The existing product or process exists and has been optimized (using either DMAIC or not) and still doesn't meet the level of customer specification or six sigma level.

What is DMAIC Methodology?

DMAIC is an acronym for Define Measure Analyze Improve Control. DMAIC is well known term in Lean Six Sigma field. DMAIC represents five sequential phases through which the process under consideration shall pass so that the defects can be removed from process and process can be made stable within control limits. The DMAIC is a systematic and continuous methodology used by company professionals for solving problems, improving the quality of products and reducing the defects or waste within an organization.

Each phase of the DMAIC has questions that need to be answered. By answering the questions, deliverables or outcomes are produced. Each deliverable provides a path for completing the

DMAIC methodology. By completing the DMAIC the team, organization and the president can grasp the process improvement potentials.

DEFINE PHASE

This step identifies the pain area or the process that needs improvement. It also defines the nature of the problem. The objectives for adopting the six sigma improvement process are defined during this step. To improve current process, a team should be form and should be educate about the benefits of adopting the six sigma methodology. It is important that the team that has been formed is motivated and believes in the benefits that will be accrued by completing this project. Next, the team has to identify the customers or the people who would be impacted by this six sigma project. The critical requirements for these customers are also documented.

Phases	Example Questions to be Answered	Potential Answers
Define	1) Who is the customer?	Local dealer who buy plastic bags from Kishan plastics.
	2) What are the customer's critical requirements that need to be researched?	Currently customer does not have any requirement but customer will be happy if they get better product for the same price.
	3) What is the problem specifically?	Specifically problem is Inappropriate quantity of raw material mixture. People usually follow other successful companies rather than doing their own manufacturing procedure.
	4) Who is part of our team?	In this research our team consists of professor Duane Beck, owner of Kishan plastics and I.

	5) What is our plan?	Our plan is to change the traditional manufacturing process in to six sigma process to increase the profit, production and reduce the wastage.
	6) Who is the person we are generating a final report for?	Final report is being generated for owner of Kishan plastics.
	7) What are the team's deliverables?	Increase the production, revenue and decrease the waste.

Table 6- Define Phase

Recommended tools for Define Phase (D phase amongst DMAIC)

1. Project charter
2. SIPOC
3. Brainstorming
4. Current state Analysis
5. Voice of customer
6. Surveys
7. Focus Groups
8. Benchmarking

Following tools are mentioned in detail below:

1) Current State Analysis
2) Project Charter
3) SIPOC

These three tools should be used in sequence. The current state analysis describes the present situation at Kishan. The clear foundation should be set in order to transform Kishan plastics manufacturing process. Secondly, the project charter then lays out a plan to follow. Thirdly, SIPOC gives us an input process output mentality. The president of Kishan Plastics should recognize that the input affects the output, defective input produces defective output or non-defective input produces non-defective output.

Current state Analysis

First, Kishan Plastics was started in year 2008. It is owned by satish chaudry. He started his business to manufacture the plastic bags for Indian market. During, research for his company it has been found that he needs to do make changes in his manufacturing process and need to change his strategy towards his business. Kishan plastics manufacture 120 tons of plastic bags every year with the help of a machine available in the company. Company has only 3 customers who order plastic bags. Most importantly, company neither has any standard manufacturing process nor any safety rules and regulation. The company has been started since 2008 and they have only three consumers who are buying plastic bags.

Second, currently the company has machine which is not as fast as other modern machine available in market now a days.

So implementing machine with more features and more advance technology will also be helpful. Furthermore, using the better quality machine will also help company to get better quality of product. One problem in this scope is the price of modern technology machines. Some time machine manufactured in local market is way cheaper then modern machine.

Third, currently there is no inspection of quality of product produce while manufacturing because they think that they are manufacturing better quality product without any fault. However, the manufacturing process produces defects like: Improper cutting of handle and the waste category is as a result of overheating, improper feeding of raw materials and poor quality of raw material.

It is the poor quality of raw material that becomes the focus within the DMAIC process in this thesis. The poor quality of raw materials negatively affects the machine stoppage and the number of packaging materials produced from Kishan. It is clear from evidence that by

improving the quality of raw material resin input, Kishan will reduce the number of machine stoppages and improve the quality of the final packaging product.

Finally, from information it is clear why the DMAIC methodology will be useful in this application. The tools will reveal current data and production system information in order to provide a foundation to expand the business in right direction with all necessary calculations.

Project charter

A project charter or project definition is a statement of the scope, objectives and participants in a project. It provides a preliminary delineation of roles and responsibilities, outlines the project objectives, identifies the main stakeholders, and defines the authority of the project manager. The project charter is usually a short document that refers to more detailed documents such as a new offering request or a request for proposal. Every time if company starts a new project, a Project Charter template should be completed.

It is used in following circumstances.

- Define the complete scope of the project
- List all of the critical project deliverables
- State the customers and project stakeholders
- List the key roles and their responsibilities
- Create an organizational structure for the project
- Document the overall implementation plan
- List any risks, issues and assumptions

The Project Charter defines the vision and boundaries for the project, as well as the high level roadmap. In addition, the Project Charter also defines the scope of the project, within which the deliverables are produced. With a well defined Project Charter, the Project Manager has a

clear project roadmap for success. Project charters are used in the define stage to document the current (as-is) process. The success of project depends on how accurate the project charter is. The charter outlines the direction and constraints of the project.

The Scope Section of the Charter describes the project objectives and deliverables, customers and their needs and requirements, project stakeholders. The resources section of the charter names the project manager and other key project team members, the deadline, staff effort limit, budget, and other organizational constraints which the project must live within. In order for the team to make the best choices between the three main variables, the resources section describes also project priorities according to the ranks assigned by the sponsor to the scope, schedule, and cost.

PROJECT CHARTER NO.:			
Start Date	May 01, 2011	**Completion Date**	August 2, 2011
Belt Name	Robin P	**Champion**	
Element	**Description**	**Team Charter**	
Objective Statement	What is the objective to be achieved?	By the end of the DMAIC process, Kishan will be able to realize a reduction in the number of machine stoppages by 72.2% by reducing the recycled content in HDPE raw material resin. From 10% down 5 – 7%.	
Project Scope	Which part of the process will be investigated?	This research focus on following area: First of all, new proportion raw material mixing should be implemented. Moreover, Instead of maintaining the machine two times a month (twenty four hours each), it should be changed to four times a month (twelve hours of each).	
Team Members	Who is on the team, internal and external personnel?	Team is consisting of Professor Duane Beck and owner of Kishan plastics and me.	

Project Schedule	What is the projected timeline for each phase of the project?	For each phase of project the time line is not decided as this is research about this company. Most of the time was spent during measure and improve phase.

Project Summary for the Green Belt in MET			
Phases	Demonstrated Skills And Start Date	Deliverable Outcomes	Completion or End Date for Phase
Introduction to the Lean Six Sigma	Convince May 03	Ready to implement DMAIC methodology at Kishan plastics	May 08
Define	Project Charter May 15	Current issues with Kishan plastics manufacturing process	May 21
Measure	Histograms July 1	Measure company's current monthly benefit, manufacturing capacity, amount of wastage.	July 9
Analyze	Fishbone Diagram July 11	Company needs better understanding of manufacturing process.	July 15
Improve	Brainstorming July 16	Company increases its manufacturing capacity and benefit. Company also reduces its wastage.	July 19
Control	Documenting July 21	Documentation of entire process for future references.	July 24
Final Report	Revision	Final report was given to owner of Kishan	July 28

	July 28	plastics to show the difference between two manufacturing process.	

Table 7- Project Charter

SIPOC

SIPOC is the acronym that stands for five elements: Suppliers, Inputs, Process, Outputs, and Customers. A SIPOC diagram is shown here:

Supplier	Input	Process	Output	Customer
Who is the supplier?	What is the type of input?	What activities or functions are used?	What is the type of product or service?	What are the customer's requirements?

Table 8- SIPOC

Supplier – Internal and External providers of the input.

Input – Examples include material, equipment, people, processes, measurements, etc.

Process – A high level activities or functions that transform the inputs into outputs.

Output – The deliverable from the input being transformed by the process.

Customer – The output is produced for Internal and external customers

The purpose of the SIPOC is to show how the five elements consecutively work together to produce the product for the customer. And in reverse order, COPIS shows that the customer's requirements are considered first and these requirements can be given to the supplier. SIPOC begins by identifying the voice of your customer (VOC).

It then gives insight to the inputs (the X variables) of a process that have impact on the critical outputs (the Y variables).The SIPOC is frequently used in the early stages of the DMAIC

process but the information and the thought process that comes from it is used in all phases of the DMAIC. As it helps establish causal relationships between steps. Once complete a SIPOC diagram should be posted so that everyone can refer to it as a high level map of the process. Below is a completed example using a SIPOC for Kishan:

Supplier	Input	Process	Output	Customer
Haldia, Reliance and other local factories	LDPE, HDPE, Reproduced HDPE, Tionpal	Mix the raw material according to the prices and quality requirement by buyers	Plastic bags	Local buyers

Table 9- SIPOC Example

KEY DELIVERABLES

During Define phase key deliverables:

- Current manufacturing issues in company.
- Project out line which will be followed during entire project.
- Probable outcome at the end of the project like- increase production, decrease wastage and reduce machine stoppage time.

MEASURE PHASE

Defining the problem is just the beginning. Next comes the important part of the DMAIC methodology: determining the characteristics that influence the behavior of your process. This is accomplished by making measurements and collecting data from current state of Manufacturing Process in Kishan Plastics Packaging. This step is a little more time-consuming as compared to the Define phase of the six sigma methodology. This phase will clearly shows parameters that will be used to measure performance improvement. This phase define the baseline performance and also the extent to which the process can be improved. The key defects in the process are identified and defined. Once the key measures for improvement are defined, data is collected to analyze the difference between the current performance and the desired performance. Process variations have been established during this phase.

Phases	Example Questions to be Answered	Potential Answers
Measure	1) What is the current measurement?	Currently company is producing approximately 5983398 plastic bags a month and waste bags are approximately 111369.
	2) What are we going to measure?	To Implement Lean Six Sigma DMAIC methodology in Kishan plastics for one month and then compare the result between current and proposed manufacturing process. Comparison between two processes will show the difference in profit and production capacity.
	3) How will we measure it?	With the help of process flow chart, Value Stream Mapping to compare the production rate, profit and wastage.
	4) Where do we find the data or	Owner of Kishan plastics provided all

	numbers?	data of his company.
	5) What industry standard do we use as a benchmark?	To use DMAIC methodology and use packaging companies in USA as a benchmark.
	6) What is the gap between current state and industry standard?	Currently, company does not follow any standards. So there is a big difference between the manufacturing process of industry standard and Kishan plastics likewise: A Kishan plastic does not have any manufacturing procedure to follow. Company may use different process during each cycle. Moreover, company does not have any strategy to develop the business and so on.
	7) What are the team's deliverables?	During this stage team deliverable will be to collect the data of current manufacturing process from owner of Kishan plastics.

Table 10- Measure Phase

Recommended tools for Measure Phase (M phase amongst DMAIC)

1. Value Stream Map
2. Process flow diagram
3. Plant layout
4. Machine Speeds
5. Check sheets
6. Process capability
7. Base line sigma level
8. Waste analysis
9. Graphical analysis

During measure phase following tools are discussed in detail:

- Process Flow chart
- Value Stream Mapping

Process Flow Chart

A process flow chart is a graphical or symbolic representation of a process. Each step in the process is represented by a different symbol and contains a short description of the process step. The flow chart symbols are linked together with arrows showing the process flow direction. It can be applied to illustrate the Global Supply Chain or any part of the chain. It is used for the following reasons:

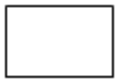
- To develop understanding of how a process is done.
- To study a process for improvement.
- To communicate to others how a process is done.
- When better communication is needed between people involved with the same process.
- To document a process.
- When planning a project.

Flowcharts are used in the measure stage to document the current (as-is) process. It can also be used in the analyze phase, the flowchart will be reviewed to uncover complexities in the form of an excessive number of decision point that may contribute to delays or even defects. It can be easily generated by using simple materials and knowledgeable people of the process. During this process, materials being used: sticky notes or cards, a large piece of flipchart paper or newsprint, marking pens.

Below is the step by step procedure for drawing a process flow chart at Kishan:

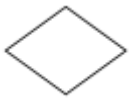
1. Define the process to be diagrammed. Write its title at the top of the work surface.
2. Discuss and decide on the boundaries of your process: Where or when does the process start? Where or when does it end? Discuss and decide on the level of detail to be included in the diagram.
3. Brainstorm the activities that take place. Write each on a card or sticky note. Sequence is not important at this point, although thinking in sequence may help people remember all the steps.
4. Arrange the activities in proper sequence.
5. When all activities are included and everyone agrees that the sequence is correct, draw arrows to show the flow of the process.
6. Review the flowchart with others involved in the process (workers, supervisors, suppliers, customers) to see if they agree that the process is drawn accurately.

Process flowchart consists of symbols



One step in the process; the step is written inside the box. Usually, only one arrow goes out of the box.

Direction of flow from one step or decision to another.



Decision based on a question. The question is written in the diamond. More than one arrow goes out of the diamond, each one showing the direction the process takes for a given answer to the question. (Often the answers are “yes” and “no.”)

Delays or wait (represent non-valued)

Link to another page or another flowchart. The same symbol on the other page indicates that the flow continues there.

Input or output

Document

art and end points

Figure 1-Symbols of Process Flow Chart

Within each symbol, write down what the symbol represents. This could be the start or finish of the process, the action to be taken, or the decision to be made.

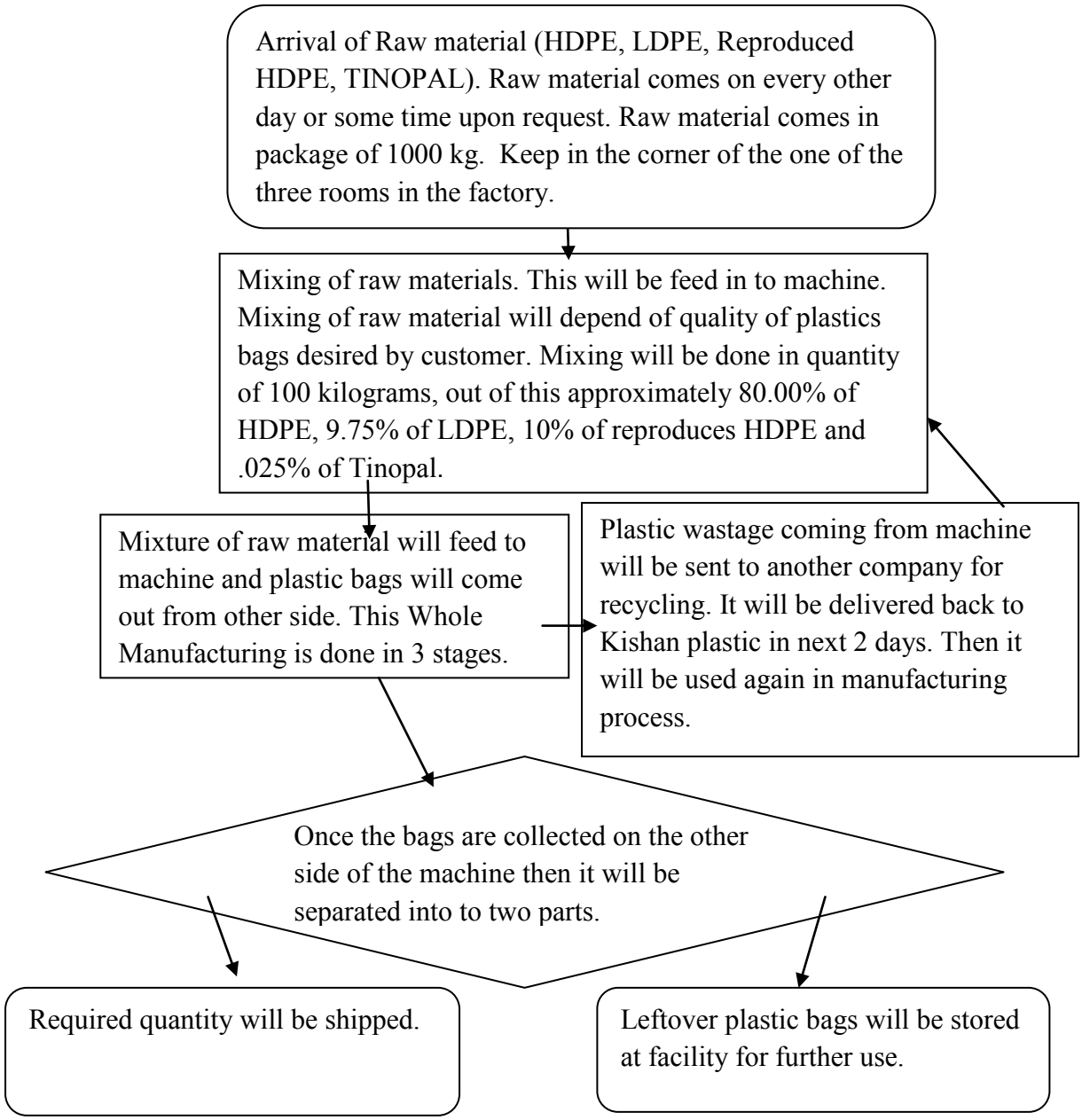
Symbols are connected one to the other by arrows, showing the flow of the process. To draw the flow chart, brainstorm process tasks, and list them in the order they occur. Ask questions such as "What really happens next in the process?" and "Does a decision need to be made before the next step?" or "What approvals are required before moving on to the next task?"

Start the flow chart by drawing the elongated circle shape, and labeling it "Start".

Then move to the first action or question, and draw a rectangle or diamond appropriately. Write the action or question down, and draw an arrow from the start symbol to this shape.

Below is the Process flow chart indicating the complete manufacturing process in Kishan Plastics.

Figure 2- Process Flow Chart



Value Stream Mapping

Value Stream Mapping is a lean manufacturing technique used to analyze and design the flow of materials and information required to bring a product or service to a consumer. At Toyota, where the technique originated, it is known as "material and information flow mapping". It can be applied to nearly any value chain.

It can be applied to nearly any value chain. Value Stream Mapping is most commonly used in organizations which are looking to make improvements in lead times. It is useful to draw a future state value stream map. It is also useful to work toward the future state condition. Moreover, it also assesses the current state value stream in terms of creating flow by eliminating waste.

Although Value Stream Mapping is often associated with manufacturing, it is also used in logistics, supply chain, service related industries, healthcare, software development, and product development.

In Value Stream Mapping the value-added steps are drawn across the centre of the map and the non-value-adding steps are represented in vertical lines at right angles to the value added stream. Thus the activities become easily separated into the value stream which is the focus of one type of attention and the 'waste' steps another type. So consider value stream as a process and the non-value streams as operations.

The thinking here is that the non-value-adding steps are often preparatory or tidying up to the value-adding step and are closely associated with the person or machine/workstation that executes that value-adding step. Therefore, each vertical line is the 'story' of a person or workstation whilst the horizontal line represents the 'story' of the product being created. Value Stream mapping is a recognized method used as part of Six Sigma methodologies.

There are symbols which are important to draw and understand Value Stream Mapping. List of these symbols is provided below.

Symbol use in Value Stream Mapping:

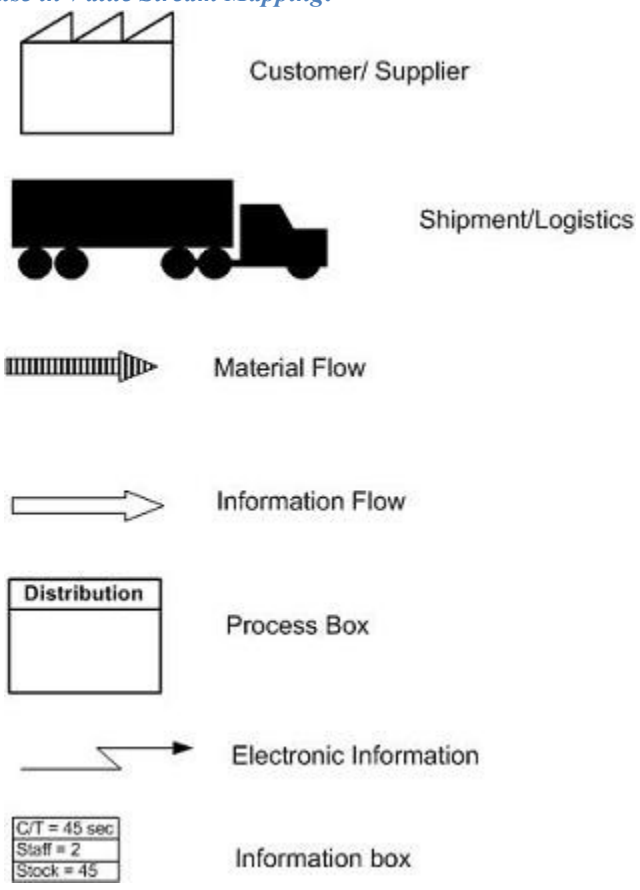


Figure 3- Symbols of Value Stream Mapping

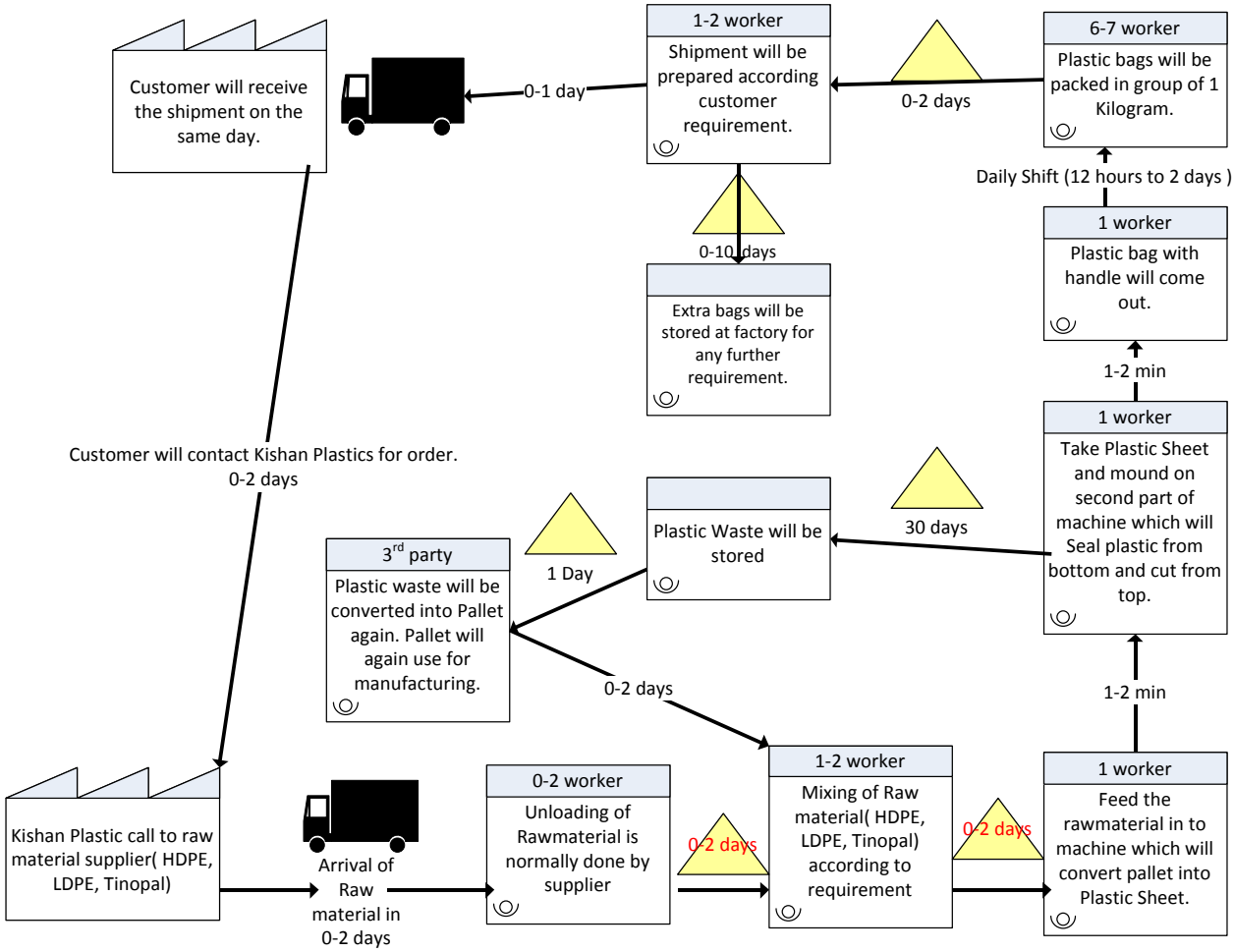


Figure 4-Value Stream Mapping at Kishan Plastics

KEY DELIVERABLES

- Collect data from owner of Kishan plastics about current manufacturing process going on in a company.
- Find out different types of problems in current manufacturing process from the data provided.
- Measure intensity of each problem in the company.

ANALYZE PHASE

In six sigma methodology the third step is Analyze. During this phase, the data collected during the measure phase is used to analyze the gap between the current and desired performance. Moreover, performed a root-cause analysis to define the possible reasons for the performance gap and quantify the main causes for variation. The gap between the current and desired state is also calculated in financial terms.

Phases	Example Questions to be Answered	Potential Answers
Analyze	1) What are the six major causes that can create the problem?	Material, Machinery, people, Environment, Process and measurement.
	2) What are sub causes for each major cause?	Mentioned in fish bone diagram below.
	3) What is a potential root cause within the problem?	Potential root cause within the problem is the improper mixing of raw material being used in manufacturing process.
	4) What was the consensus vote on the root cause?	Not following standard. Just follow procedure without doing any research.
	5) What evidence supports the root cause?	Amount of machine stoppage each month (90) because of poor raw material quality shows the root cause in Kishan plastics.

	6) How does the evidence support the root cause?	Since proportion of raw material in mixture changes the machine stoppage drops down drastically.
	7) What are the team's deliverables?	Change raw material mixture proportion and change machine maintenance timing.

Table 11- Analyze Phase

Recommended tools for Analyze Phase (A phase amongst DMAIC)

1. Brain storming
2. Cause and Effect diagram
3. FMEA
4. Process map
5. Tree diagram
6. Pareto Charts
7. SPC Control Charts
8. Hypothesis testing
9. T Testing

Cause and Effect diagram and Brainstorming are mentioned below.

Cause and Effect Diagram

Ishikawa diagrams (also called fishbone diagrams, or herringbone diagrams, cause and effect diagrams or Ishikawa) are causal diagrams that show the causes of a certain event. Common uses of the Ishikawa diagram are product design and quality defect prevention, to identify potential factors causing an overall effect**.**

It is used for following reasons.

- A Cause-and-Effect Diagram is a tool that is useful for identifying and organizing the known or possible causes of quality, or the lack of it.
- Structure provided by the diagram helps team members think in a very systematic way. Some of the benefits of constructing a Cause-and-Effect Diagram are that it helps determine the root causes of a problem or quality characteristic using a structured approach.
- Encourages group participation and utilizes group knowledge of the process. Uses an orderly, easy-to-read format to diagram cause-and-effect relationships.

Cause and Effect is a popular method of group interaction in all size of business settings. Moreover, Cause and Effect diagram shows potential causes or reasons for possible solutions.

Constructing the Cause and Effect diagrams are tools that are used to organize and graphically display the cause all of the knowledge a group has relating to a particular problem. Specify the effect to be analyzed. The effect can be positive (objectives) or negative (problems). Place it in a box on the right side of the diagram.

Constructing the Cause and Effect diagram is very simple. The steps are:

- Draw a box on the far hand side of a large sheet of paper and draw a horizontal arrow that points to the box. Inside of the box, write the description of the problem a company going to solve.
- Write the name of the categories above and below the horizontal line. Think of these as branches from the main trunk of the tree.
- Draw in the detailed cause data for each category. Think of these as limbs and twigs on the branches.

List the major categories of the factors that influence the effect being studied. The “4 Ms” (methods, manpower, materials, machinery) or the “4 Ps” (policies, procedures, people, plant) are commonly used as a starting point.

Identify factors and sub factors. Use an idea-generating technique to identify the factors and sub factors within each major category. An easy way to begin is to use the major categories as a catalyst. For example, “What raw materials are causing machine stoppage?”

Identify significant factors. Look for factors that appear repeatedly and list them. Also, list those factors that have a significant effect, based on the data available.

Categorize and prioritize your list of causes. Keep in mind that the location of a cause in your diagram is not an indicator of its importance. A sub-factor may be the root cause to all of your problems. You may also decide to collect more data on a factor that had not been previously identified.

Below are the Cause and Effect diagram of Kishan plastics.

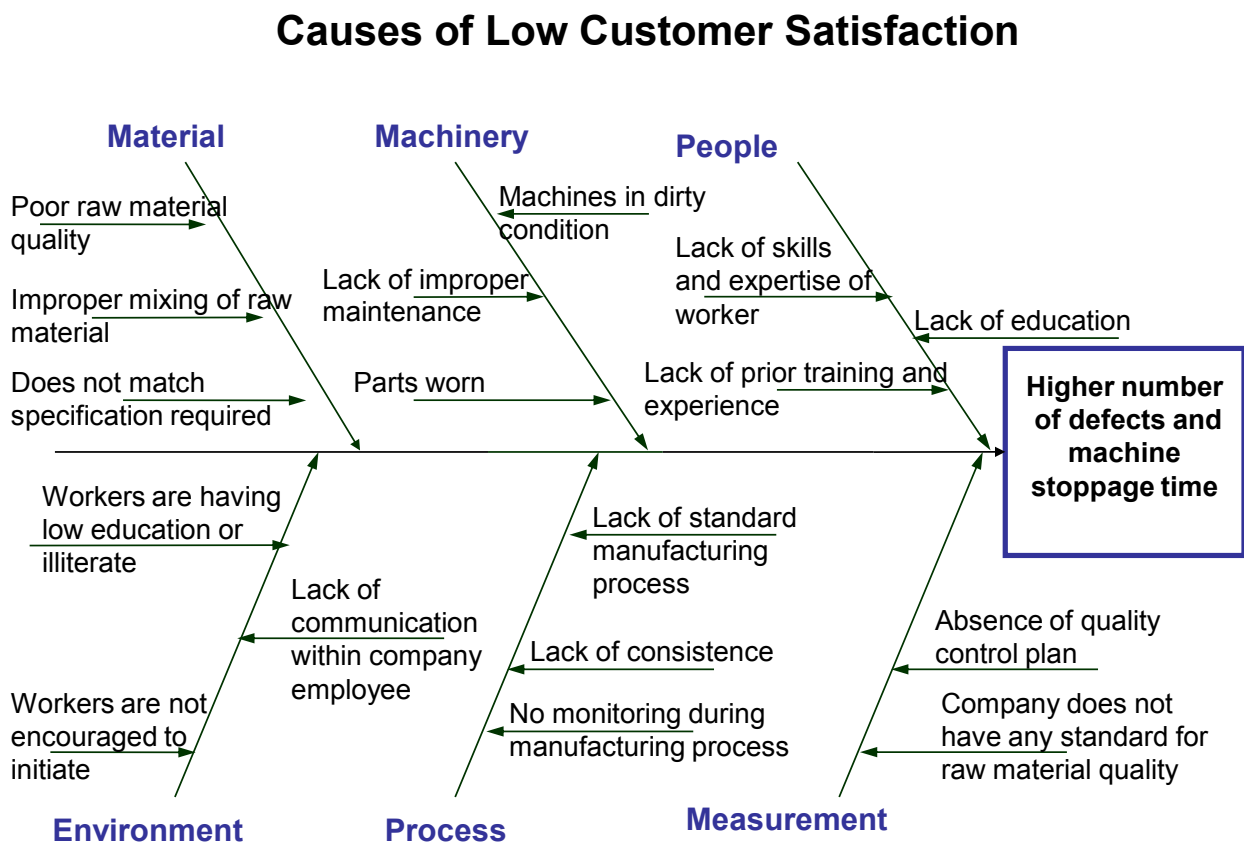


Figure 5- Cause and Effect Diagram

From Cause and Effect diagram it is clear that there are lot of reasons for poor performance in Kishan plastics but main area of focus is raw material quality. Improper mixing of raw material cause inferior quality of plastics bags and frequent machine stoppage. During brainstorming secession, main concentratation are on raw material mixing propertion and raw material quality.

some key words for better understanding are mentioned below.

- NO- represents data collected from number of days.
- Production Date- shows day of the month for perticular results.
- No of Production- Indicates number of plastic bags has been produced approximately.

- Improper cutting of handle- This shows number of plastic bags have improper handle cutting during manufacturing process.

Plastic bags waste- This mentioned the reasons for plastic bags wastage like- overheating of machine, Improper feeding of raw material and poor raw material quality. This category describes the reasons for wastages.

- Overheating- Some time machine setting gets wrong and the temperature of machine become more than required then plastic bags stick to each other during production and results in wastage and rework.
- Improper feeding of raw material- in Kishan plastics worker are instructed to feed quantity of 25 kilogram raw material during each feeding. If a person does not measure the weight properly then he or she might cause problem. Furthermore, if worker feed raw material too fast then also it creates problem.
- Improper raw material mixing- Kishan plastics making plastic bags with mixture of poor raw material to increase the net profit. So improper mixture of raw material results in frequent machine stoppage and thus results in plastic bags waste.
- Total Defects- is a sum of all defects of a particular day.
- Machine stoppage- number of machine stoppage during each day.

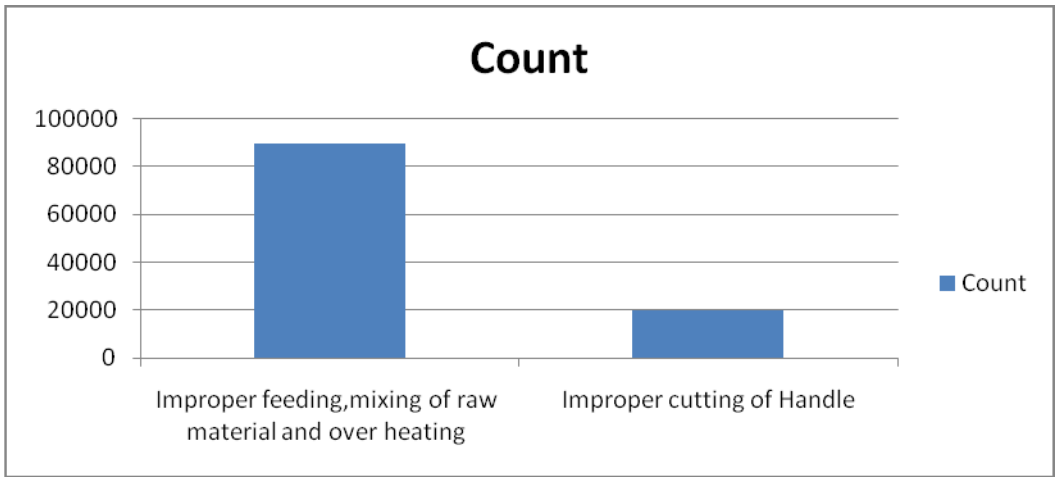
Data provided in below table shows current state of manufacturing process and problems associated in Kishan plastics.

TABLE 1: DEFECT DATA of Plastic Bags of May –2011

No	Production Date	No of Production	Improper cutting of handle	Plastic bags waste due to problems like overheating, Improper feeding of raw material and poor raw material quality	Total Defects	Machine Stoppage
1	1	225000	503	2147	2650	2
2	2	213780	180	1572	1752	3
3	3	205430	423	1820	2243	2
4	4	206544	193	1511	1704	2
5	5	216688	501	2175	2676	2
6	6	204144	817	2265	3082	2
7	7	225216	651	1253	1904	2
8	8	194880	947	1581	2528	4
9	9	185232	826	1958	2784	3
10	10	222496	982	3605	4587	2
11	11	209952	670	3631	4301	3
12	12	219968	495	3016	3511	5
13	13	208944	871	4265	5127	4
14	14	213348	1210	3693	4903	3
15	16	216816	1525	4698	6233	4
16	17	221968	878	1833	2711	3
17	18	201664	926	1494	2420	2

18	19	216696	1120	4138	5258	4
19	20	215968	707	2731	3438	5
20	21	213696	467	3597	4064	4
21	22	221080	512	5328	5840	3
22	23	223584	886	4366	5252	3
23	24	220112	626	5419	6045	5
24	25	203848	514	4104	4618	4
25	26	219488	1465	3652	5117	3
26	27	223088	794	4907	5701	4
27	28	209024	854	5572	6426	3
28	29	224744	1120	3384	4504	4
	TOTAL	5983398	19674	89715	111369	90

Table 12- Defect Data May 2011



Graph 2- Current situation at kishan plastics

Brainstorming

Brainstorming is a group creativity technique by which a group tries to find a solution for a specific problem by gathering a list of ideas spontaneously contributed by its members. It can be applied to nearly any value chain.

Brainstorming process is ongoing process. It is recommended to use brainstorming tool in the beginning of the each project to get as many ideas as possible. But brainstorming is process which will continue till the end of project.

It is used for following reasons.

- Even though there has been an argument about its productivity, brainstorming is still a widely used method for coming up with creative solutions.
- Many solutions to complex problems come from ideas that might seem "crazy" at first, so Brainstorming is intended to encourage fresh thinking and "crazy" ideas.

Brainstorming is a popular method of group interaction in both educational and business settings. In this process a team consisting of owner and employee of Kishan plastics. Before brain storming started, It is necessary to make sure that problem is clearly stated, and everyone understands. In addition, it is also crucial to ask idea of all employees (worker). All workers were given chance to think about better manufacturing process. There was no time limit to think or to make decision. Moreover, no criticism of idea was allowed during brainstorming. All ideas were listed during brain storming.

The Idea which was really nice was decied to take into consideration and put it into action.The main aim of brainstorming was to reduce the waste and machine stopage time.

- First approch is to use 5 to 7% of reproduced HDPE in mixture instead of 10% and to see if he can see any difference in quality of plastic begs or machine stopage time.

- The only reason company is using 10% of reproduced HDPE is to make the bags at cheaper Price. In order to reduce the price of bags company has to deal with inferior quality of HPDE. This research is trying to show that less amount of reproduced HDPE can effect the stopage of machine and quality of bags produced in company.
- Moreover, it is recommended to the owner that the machine needs to have scheduled maintaince once in week at night time rather than stop the machine for 24 hours every 15 days.
- Factory supervisor was not happy with quality of raw material so he wants to buy rawmaterial from different buyer.
- Worker wants to change the machine and get the machine with better features.
- Factory manager thinks that change the staff, which he thinks not doing good in company.
- Lastly, some worker demand increase in salary so that it will encourage worker to work more accurately and efficiently.

Out all changes received from brain stroming to Kishan Plastics, company implemented follwing changes and ignore others.

Below are the chage Kishan plastics has done in the company.

- First, Kishan Plastics tried to use 5% of Reprodused HDPE instead of 10% and get the following result. Owner of Kishan plastics used 5% Reproduced HDPE results was companred with previous.
- Secondly, Kishan plastics also shut down machine on evening of every Monday evening for (9PM to 9 AM) for whole month rather then maintain machine after every 14 days and maintainanace goes for whole day.

Below is the current manufacturing process in Kishan plastics.

KEY DELIBERABLES

- New raw material mixture proportion for Kishan plastics. New raw material mixture(85% HDPE+ 15% LDPE + 5% reproduced HDPE +.25% Tinopal for each 100 kilograms)
- Change the maintenance schedule from once in fifteen days to once in a week for frequent maintenance.

IMPROVE PHASE

The Improve phase is the fourth step of the DMAIC process is the point where the hard work of defining, measuring and analyzing pays off - the point where the ideas for process improvement are formulated and implemented.

This phase of DMAIC mentioned about following results.

- Confirm the key process inputs that affect the process outputs, causing defects.
- Identify the acceptable range of each input so the critical to quality output stays within the specified limits.
- Adjust the process as needed.
- Plan any special measures that are needed for improvements - for example, implementation of a new or modified software system.
- Implement the changes.
- Install and validate a measurement system for the improved process and verify how the new process is working.

Phases	Example Questions to be Answered	Potential Answers
Improve	1) What ideas did we generate for improving the root cause?	With the help of brainstorming we did some changes in current manufacturing process: Change the proportion of raw material mixture down to 5 – 7%.
	2) How did we select the idea or pilot project to move forward on?	Communicate with owner of Kishan plastics and provide lots of choices to choose. Out of all choices, two changes were done for better result in Kishan Plastics.
	3) What does the pilot visually look like? (Using Process Flow Chart)	Process flow chart usually shows the entire manufacturing process from raw material ordering to product

		shipping.
	4) How do the projected results of the pilot compare to the old way?	Comparison between the data from old method versus new method by comparing monthly profit, wastage during manufacturing process, amount of plastics bags produced each month etc.
	5) What can make it fail?	Education level of worker and involvement of owner can fail the project.
	6) How does pilot meet the customer's requirements?	Pilot reduces the waste of plastic bags; improve the quality of plastic bags. This will results in customer satisfaction.
	7) What are the team's deliverables?	Team makes sure that whatever has been chosen must work. So all team members will try making sure that the company achieves whatever they have decided. For example, with change in manufacturing process company must reduce plastic bags wastage, increase production and benefit.

Table 13- Improve Phase

Recommended tools for Improve Phase (I phase amongst DMAIC)

1. Design of experiments
2. Regression analysis
3. Hypothesis testing
4. Control charts
5. Future VSM
6. FMEA
7. 5S
8. TPM
9. Poka yoke

From above mentioned tools ,FEMA tool has been mentioned during Improve phase.

During Brainstorming lot of ideas for improvement has been collected but out of all those Ideas main goal is to concentrate on raw material quality. The reason for concentrating on raw material quality is because of poor raw material, company is producing poor quality of plastic bags and company is facing problems of frequent machine stoppage.

Below is the data shows improvement of Kishan Plastics manufacturing process.

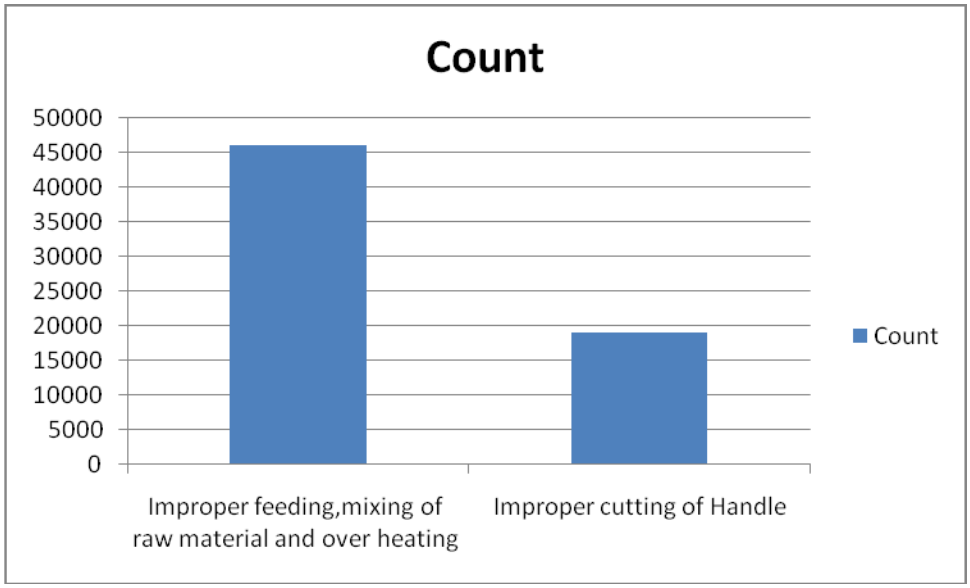
Table 14- Defect Data of June 2011

TABLE 1: DEFECT DATA of Plastic Bags of June –2011

No	Production Date	No of Production	Improper cutting of handle	Plastic bags waste due to problems like overheating, Improper feeding of raw material and poor raw material quality	Total Defects	Machine Stoppage
1	1	331080	518	1126	1644	0
2	2	165021	234	472	706	1
3	3	311350	487	528	1015	1
4	4	296544	613	918	1531	0
5	5	286688	418	1162	1580	1
6	6	304144	528	1068	1596	1
7	7	302216	431	960	1391	2
8	8	295621	347	1072	1419	1
9	9	140854	482	629	1111	1
10	10	284138	742	1745	2487	0
11	11	280552	969	1687	2656	0
12	12	310060	1001	1246	2247	2

13	13	304954	1089	1552	2641	0
14	14	312242	965	1458	2423	1
15	15	303711	851	1886	2731	2
16	16	271668	598	581	1179	1
17	17	301612	926	1108	2034	1
18	18	316696	1120	1991	3111	1
19	19	296186	1197	1842	3089	0
20	20	316386	1168	1750	2918	1
21	21	301028	612	2306	2918	0
22	22	293755	586	2109	2695	1
23	23	140272	228	1242	1470	1
24	24	284858	583	2133	2710	0
25	25	291680	678	2480	3158	0
26	26	283264	651	1996	2647	1
27	27	290721	675	2650	3325	1
28	28	287689	921	2878	3799	1
29	29	294832	641	2345	2986	2
30	30	148752	326	1053	1379	1
	TOTAL	8348574	18986	45973	66602	25

Net Production of bags per month=Total Production- Total wastage=8281972 bags per month



Graph 3-Proposed Situation at Kishan Plastics

From above data is clear that production is increasing of Kishan Plastics. Difference between current and propossed manufacturing process has shown.

FMEA (Failure modes and effects analysis)

A failure modes and effects analysis (FMEA) is a procedure in product development and operations management for analysis of potential failure modes within a system for classification by the severity and likelihood of the failures. A successful FMEA activity helps a team to identify potential failure modes based on past experience with similar products or processes, enabling the team to design those failures out of the system with the minimum of effort and resource expenditure, thereby reducing development time and costs. It is widely used in manufacturing industries in various phases of the product life cycle and is now increasingly finding use in the service industry.

Failure modes are any errors or defects in a process, design, or item, especially those that affect the customer, and can be potential or actual. Effects analysis refers to studying the consequences of those failures.

Failure Modes and Effects Analysis (FMEA) is methodology for analyzing potential reliability problems early in the development cycle where it is easier to take actions to overcome these issues, thereby enhancing reliability through design. FMEA is used to identify potential failure modes, determine their effect on the operation of the product, and identify actions to mitigate the failures. A crucial step is anticipating what might go wrong with a product. While anticipating every failure mode is not possible, the development team should formulate as extensive a list of potential failure modes as possible.

The early and consistent use of FMEAs in the design process allows the engineer to design out failures and produce reliable, safe, and customer pleasing products. FMEAs also capture historical information for use in future product improvement.

FMEA's provide the engineer with a tool that can assist in providing reliable, safe, and customer pleasing products and processes. Since FMEA help the engineer identify potential product or process failures, they can use it to:

- Develop product or process requirements that minimize the likelihood of those failures.
- Evaluate the requirements obtained from the customer or other participants in the design process to ensure that those requirements do not introduce potential failures.
- Identify design characteristics that contribute to failures and design them out of the system or at least minimize the resulting effects.

- Develop methods and procedures to develop and test the product/process to ensure that the failures have been successfully eliminated.
- Track and manage potential risks in the design. Tracking the risks contributes to the development of corporate memory and the success of future products as well.
- Ensure that any failures that could occur will not injure or seriously impact the customer of the product/process.

The process for conducting an FMEA is straightforward. The basic steps are outlined below.

1. Describe the product/process and its function. An understanding of the product or process under consideration is important to have clearly articulated. This understanding simplifies the process of analysis by helping the engineer identify those product/process uses that fall within the intended function and which ones fall outside. It is important to consider both intentional and unintentional uses since product failure often ends in litigation, which can be costly and time consuming.
2. Create a Block Diagram of the product or process. A block diagram of the product/process should be developed. This diagram shows major components or process steps as blocks connected together by lines that indicate how the components or steps are related. The diagram shows the logical relationships of components and establishes a structure around which the FMEA can be developed. Establish a Coding System to identify system elements. The block diagram should always be included with the FMEA form.
3. Complete the header on the FMEA Form worksheet.

AREA	FAILURE MODES	EFFECTS	CAUSES	RECOMMEND -ATIONS
Kishan Plastics manufacturing process	Manufacturing process is outdated and raw material mixture procedure is improper. Maintenance timing is not correct.	1) **Machine stoppages**: • Over feeding of raw material • Improper mixing of raw material 2) **Cost of poor quality** Poor quality results in rework and waste of time. 3) **Less chances to grow business** Since company is using reproduced HDPE to increase profit margin it is really hard to attract the customer with lower quality product.	Results in frequent machine stoppage, poor quality of plastic bags and poor machine condition.	To ensure: 1) Do not follow manufacturing process of other industries. 2) Implement quality control plan 3) Start periodic inspection 4) Machine maintenance should be done according to standard procedure.

		4) Maintenance of Machine Current maintenance timing is not good enough to keep the machine in good condition. **5) Customer satisfaction** The company cannot satisfy customer with poor quality product. **6) Reputability:** As company is not producing good product, company cannot achieve standard to send product to countries like USA, Canada.		5) Implement raw material mixing procedure 6) Make a procedure list to follow for future procedures. 7) Workers should be encouraged to do creative work for company. **For all the above results,** Implementing a standard

				manufacturing process in Kishan plastics is highly important**.**

Table 15- FMEA Worksheet

4. Use the diagram prepared above to begin listing items or functions. If items are components, list them in a logical manner under their subsystem/assembly based on the block diagram which will help to diagnose the problem in Kishan plastics.
5. Identify Failure Modes in Kishan plastics. A failure mode is defined as the manner in which a component, subsystem, system, process, etc. could potentially fail to meet the design intent. Examples of potential failure modes include:
    - Out dated manufacturing process
    - Improper mixing of raw material
    - Machine maintenance
6. A failure mode in one component can serve as the cause of a failure mode in another component. Each failure should be listed in technical terms. Failure modes should be listed for functions of each component or process step. At this point the failure mode should be identified whether or not the failure is likely to occur. Looking at similar products or processes and the failures that have been documented for them is an excellent starting point.
7. Describe the effects of those failure modes. For each failure mode identified the owner of Kishan plastics should determine what the ultimate effect will be. A failure effect is defined as the result of a failure mode on the function of the product/process as perceived by the customer.

President of Kishan Plastics should be described in terms of what the customer might see or experience should the identified failure mode occur. Keep in mind the internal as well as the external customer. Examples of failure effects include:

- Injury to the worker
- Inoperability of the product or process
- Improper appearance of the product or process
- Thickness variation
- Degraded performance of machine
- Too much noise during machine working condition

Establish a numerical ranking for the severity of the effect. A common industry standard scale uses 1 to represent no effect and 10 to indicate very severe with failure affecting system operation and safety without warning. same standard has been established in Kishan Plastics and according to owner of Kishan plastics severity level in his company is 3. The intent of the ranking is to help the analyst determine whether a failure would be a minor nuisance or a catastrophic occurrence to the customer. This enables the owner of Kishan plastics and I to prioritize the failures and address the real big issues first.

8. Identify the causes for each failure mode. A failure cause is defined as a design weakness that may result in a failure. The potential causes for each failure mode should be identified and documented. The causes should be listed in technical terms and not in terms of symptoms. Examples of potential causes include:
    - Improper operating conditions
    - Wrong raw material mixing proportion
    - Improper alignment of machine parts

- Improper maintenance of machine
- Excessive raw material feeding
- Less of awareness towards manufacturing process.

9. Enter the Probability factor. A numerical weight should be assigned to each cause that indicates how likely that cause is (probability of the cause occurring). A common industry standard scale uses 1 to represent not likely and 10 to indicate inevitable. Kishan plastics rank 7 because of higher probability.
10. Identify Current Controls (design or process) in Kishan plastics. Current Controls (design or process) are the mechanisms that prevent the cause of the failure mode from occurring or which detect the failure before it reaches the Customer. The Six Sigma team (Owner of Kishan plastics, I and Professor Duane Beck) should now identify testing, analysis, monitoring, and other techniques that can or have been used on the same or similar products/processes to detect failures. Each of these controls should be assessed to determine how well it is expected to identify or detect failure modes. After a new product or process has been in use previously undetected or unidentified failure modes may appear. The FMEA should then be updated and plans made to address those failures to eliminate them from the product/process.
11. Determine the likelihood of Detection. Detection is an assessment of the likelihood that the Current Controls (design and process) will detect the cause of the Failure Mode or the Failure Mode itself, thus preventing it from reaching the Customer. Based on the Current Controls, consider the likelihood of Detection using the following table for guidance. In this case Kishan plastics ranks detection level is 5.

12. Review Risk Priority Numbers (RPN). The Risk Priority Number is a mathematical product of the numerical Severity, Probability, and Detection ratings:

    RPN = (Severity) x (Probability) x (Detection)

In this case, calculation for RPN for poor raw material quality and its affect on manufacturing process is mentioned below.

RPN= 3 x 7 x 5 =105.

The RPN is used to prioritize items than require additional quality planning or action:

13. Determine Recommended Action(s) to address potential failures that have a high RPN in Kishan plastics. These actions could include specific inspection, raw material quality, mixing of raw material, Maintenance of textile machines, testing or quality procedures; selection of different components or materials; de-rating; limiting environmental stresses or operating range; redesign of the item to avoid the failure mode; monitoring mechanisms; performing preventative maintenance; and inclusion of back-up systems or redundancy.
14. Assign Responsibility and a Target Completion Date for these actions. This makes responsibility clear-cut and facilitates tracking within the Kishan plastics.
15. Indicate Actions Taken. After these actions have been taken, re-assess the severity, probability and detection and review the revised RPN's. Are any further actions required in the company?
16. Update the FMEA as the design or process changes, the assessment changes or new information becomes known.

KEY DELIVERABLES

- Kishan Plastics has new manufacturing process with less machine stoppage. Previously company was having 96 machine stoppages during month. In proposed process it is only 25.
- Company has less manufacturing issues because of change in raw material proportion from 10% of reproduced HDPE to 5% of reproduced HDPE.
- Company has increased its capacity of manufacturing plastic bags and also increases its revenue.

CONTROL PHASE

The main objective of the Control stage is to:

- Statistically validate that the new process or design meets the objective and benefits sought through the project.
- Develop and implement a control plan to institutionalize the new process or design.
- Document lessons learned and project findings.

Phases	Example Questions to be Answered	Potential Answers
Control	1) What are the documented recommendations based on using the DMAIC for making sure the customer's requirements are met?	It is advised that company follow own methodology. Moreover, Company should keep changing their manufacturing process according to customer requirement.
	2) What quality documentation needs to be in place for reproducible results for the pilot project?	Company should make Quality Assurance Plan for same procedure and also include Team recommendations.
	3) What are the documented projected positive and negative cost implications from implementing the pilot?	Positive side is that company is now saving lot more money by higher production and lower machine stoppage. In this case the Kishan plastic does not have any negative impact.
	4) What is our documented evaluation plan for follow up?	During this project standard process for company has been setup.
	5) What documented outside support is needed to sustain the pilot?	Customer feedback is really important which shows that company is manufacturing according to customer requirements.
	6) How does the documented pilot satisfy customer requirements?	The results provided in the project clearly shows that customer requirements have meet like: better plastic bag quality, Quick production.

	7) What is our deliverable? (Final Report)	Kishan Plastics should continue new manufacturing process effectively to achieve higher production rate, lower machine stoppage and fewer plastic bags wastage.

Table 16- Control Phase

Recommended tools for Control Phase (C phase amongst DMAIC)

1. Quality Assurance System
2. Material Specification
3. Receiving and inspecting procedure
4. Standardize processes
5. Certificate of Compliance
6. Supplier Assessment
7. Written procedures
8. SPC Control Plan
9. Plan Do Check Act

Following tools have been explained in detail below. Quality Assurance System, Material Specification, Receiving and inspecting procedure, certificate of compliance.

Quality Assurance system

When the term 'quality system' is used, it means a formal management system you can use to strengthen your organization. It is intended to raise standards of work and to make sure everything is done consistently. A quality system sets out expectations that a quality organization should meet. Typically, these are the stages that organizations implementing a quality system aim to follow:

- Agree on standards. These concern the performance that staff, trustees and users expect from the organization.

- Carry out a self-assessment. This means that you compare how well you are doing against these expectations.
- Draw up an action plan. This will include what needs to be done, who will do it, how it will be done, and when
- Implement. Do the work
- Review. At this stage, you check what changes have been made and whether they have made the difference you were hoping to achieve.

Quality assurance system covers following areas.

- Material Specification
- Certification of compliance
- Written procedure focusing on procedure for receiving and inspection.

Material Specification

It is necessary that Kishan plastics implement material specification chart which describe the required characteristics for raw material. Material specification should cover following characteristics.

- Raw material should be of high quality without mixture of reproduced material.
- Humidity level should be balance.
- Raw material should be of same color. Different shades of raw material should be avoided be inspection.

Certification of compliance

A document certified by a competent authority that the supplied good or service meets the required specifications. Also called conformance, conformity. Certificate of compliance consist of following areas.

Supplier Quality

The Kishan plastics Supplier Quality System ensures the procurement of high-quality materials from approved Suppliers. Suppliers are evaluated, and an approved supplier list is maintained for each raw material. Suppliers are expected to be able to provide materials with zero defects. Accept / reject criteria of 0/1 is used for outgoing sample inspection. In addition, 100% on-time delivery performance (0 days late, 3 days early) is required.

Approval or disapproval

New suppliers of new materials are approved through technical, business, and quality assessments of Kishan plastics. Suppliers of Kishan plastics are disapproved when their material or business is no longer needed at Kishan or when, in the Kishan commodity team's judgment, any of the following are no longer acceptable:

- Supplier Quality and Delivery Performance.
- Material Performance in Kishan’s production process.
- Responsiveness / Ineffectiveness to corrective action requests.
- Customer Service

A disapproved supplier may be considered for re-approval after satisfactorily addressing the actions and requirements on the disapproval communication.

Corrective Actions

A Supplier Corrective Action Request (SCAR) is issued for either quality or delivery discrepancies. A recurring problem is identified through monitoring rejection history and delivery reliability. Metric data is monitored at least quarterly. If four corrective action requests are issued within six months to the same supplier for the same problem, it will be recommended by Procurement to the Commodity Team that the supplier be considered for disqualification. The supplier's implementation of a corrective action is verified by Kishan plastics Procurement.

Continuous Improvement

Using cross-functional teams, Kishan plastics establishes and maintains long-term partnerships with strategic suppliers who share Kishan plastics' commitment to continuous quality improvement and demonstrate an ability to make improvements in their processes, products, and services. Owner of Kishan plastics works directly with the supplier to identify opportunities for improvement in products, processes, and quality systems and to develop strategies to achieve these goals. These partnerships improve material quality and lower cost of ownership.

Kishan plastics recognize suppliers who achieve high quality and delivery levels and attain their targeted performance objectives. Kishan plastics also encourage other suppliers to benchmark companies and investigate improved production methods and quality systems.

Receiving and inspecting procedure

- The Receiving and Inspection Procedures outline steps for receiving and inspecting materials, components, parts, finished goods, etc., and stocking these items or disposing of rejected items.
- The receiving and inspection policy ensures goods and materials will be received in an organized manner and inspected for conformance prior to stocking to provide initial quality control.
- The Receiving and Inspection Procedures apply to the receipt of all inventory items and involves receiving and warehouse personnel, purchasing, accounting, accounts payable and quality control.

Activities Covered in the Receiving and Inspection Procedures

- Receiving Procedures
- Inspection Procedures

Receiving Procedures

1. Locate the PO (purchase order) number in the carrier's shipping documents according to Kishan plastics requirements.
2. Retrieve a copy of the PO. If the PO cannot be located, contact e person who is responsible for purchasing at Kishan plastics to verify that the shipment is intended for the company. If it is, continue the receiving procedure. If you are certain that the shipment is not intended for Kishan plastics, refuse the shipment.
3. If the PO specifies that the shipment should be palletized but is not, contact the vendor and give them the opportunity to palletize it.

4. Compare the items on the PO with the manifest. If the items on the manifest do not match the items on the PO, accept the items that were ordered by Kishan plastic and contact the vendor for instructions for handling the incorrect items. Otherwise, continue the receiving procedure.
5. Compare the number of containers delivered to Kishan plastics to the number on the carrier's manifest. Record any discrepancy on the carrier's shipping documents.
6. Examine the outside of the containers for damage:

   6.1. No Visible Damage if there is no visible damage, proceeds to step 7.

   6.2. Minor Visible Damage Record any damage to the shipping containers on the carrier's shipping document and ensure that it is signed by the delivery person before the shipment is accepted. Recording minor damages to containers provides added documentation in the event that there is concealed damage.

   6.3. Severe visible damage the process for severely damaged containers differs depending on whether the order was shipped locally or from different state.

   6.4 If the shipping containers are damaged enough that it is probable that the contents are also damaged, Kishan representative can perform the following:

   6.4.1. Reject the entire shipment.

   6.4.2. Accept the entire shipment.

   6.4.3. Accept part of the shipment and reject the damaged part of the shipment. 1

   6.4.4 It is strongly recommended that option 2 or 3 to prevent unnecessary delay of required goods. If all or part the shipment is accepted, contact the vendor to obtain replacement instructions for the damaged items.

6.4.5. If the entire shipment is refused, record the reason for refusal on the carrier's shipping documents and notify the vendor that the shipment was refused and needs to be reshipped due to severe damage.

6.4.6. If the shipping containers are damaged enough that it is probable that the contents are also damaged, accept the shipment and then record the damage on the carrier's freight bill.

7. If possible, open the containers and compare their contents with the manifest. If the contents do not match the manifest, contact the vendor to attempt to resolve the discrepancy. If absolutely necessary, refuse the shipment. Otherwise, proceed to step 8
8. Accept the shipment.

Inspection Procedure

1. Inspection Scope: Perform inspections, either programmed or unprogrammed and they fall into one of two categories depending on the scope of the inspection:

1.1. Comprehensive: Perform a substantial complete inspection of the entire shipment. An inspection may be deemed comprehensive even though, as a result of the exercise of professional judgment of owner of Kishan plastics, not all potentially hazardous conditions, operations and practices within those areas are inspected.

1.2. Partial. Perform an inspection whose focus is limited to certain potentially hazardous areas, operations, conditions or practices at the establishment. A partial inspection may be expanded based on information gathered by the worker of Kishan plastic during the inspection process. Consistent with the Kishan plastic worker shall use professional judgment to determine the necessity for expansion of the inspection scope, based on information gathered during records or program review and walk around inspection.

Rejection, Discrepancies and Disposition

Once Kishan plastic finds that the raw material received by supplier does not meet to the requirement, Kishan plastics inform the supplier and tell them to pick up the raw material from Kishan plastics. Moreover, if raw material has a variation then the shipment will be returned. For example, if the raw material color is not confirmed with required color then shipment will be returned.

Stocking and Product Return

Kishan plastics stores product in the separate room of a factory to stock raw material and finished products. Kishan plastic covers raw material to avoid explosion to humidity. Kishan plastic does not accept any return plastic bags from their buyer. During this procedure, Kishan plastic uses following forms at different stage.

Forms Included in the Receiving and Inspection Procedures

- Receiving Log Form
- Receiving and Inspection Report Form
- Inventory Inspection Levels Form

KEY DELIVERABLES

- Documenting the entire project for future use.
- Lesson learned- whatever the six sigma team learned from this particular project.
- Handover the project to the owner of Kishan plastics and sign off the project.
- Set the standard procedure in Kishan plastic for future manufacturing process.

DATA ANALYSIS

Analysis of data is a process of inspecting, cleaning, transforming, and modeling data with the goal of highlighting useful information, suggesting conclusions, and supporting decision making. Data analysis has multiple facets and approaches, encompassing diverse techniques under a variety of names, in different business, science, and social science domains.

Data analysis is a practice in which raw data is ordered and organized so that useful information can be extracted from it. The process of organizing and thinking about data is key to understanding what the data does and does not contain. There are a variety of ways in which people can approach data analysis, and it is notoriously easy to manipulate data during the analysis phase to push certain conclusions or agendas. For this reason, it is important to pay attention when data analysis is presented, and to think critically about the data and the conclusions which were drawn.

Raw data can take a variety of forms, including measurements, survey responses, and observations. In its raw form, this information can be incredibly useful, but also overwhelming. Over the course of the data analysis process, the raw data is ordered in a way which will be useful. For example, survey results may be tallied, so that people can see at a glance how many people answered the survey, and how people responded to specific questions. Data provided below is retrieved from two different manufacturing process used in Kishan plastic for consecutive months May and June of 2011.

Comparision of Data

Category	Current Process at Kishan (May 2011)	Proposed process at Kishan (June 2011)	Difference
No of production Pieces	5983398	8348574	2365176 Increase (28.33%)
Improper Cutting of Bags	19674	18986	668 Decrease (3.5%)
Bags waste	89715	45973	43742 Decrease (48.76%)
Total wastage	111369	66602	44767 Decrease (40.2%)
No of machine stopage	90	25	65 Decrease (72.2%)

Table 17- Data Comparison

Below is the Comparison between cost of manufacturing bags in both manufacturing process.

Cost of 100 kg of rawmaterial used in Current Manufacturing process

- HDPE(80%) + LDPE(9.75%) + Reproduced HDPE(10%) + Tinopal(.25%) = 6400 +780 + 550 + 20= 7750 Rs.

  So the current rawmaterial price for 1 kg of bag is 77.5 Rs.

  5 Rupees cost is added for labour and electricity for each Kilogram of bags.

  So final cost is (77.5+5)=82.5 Rupees

- Seeling prise is 100 rupess.(Selling Price changes 2-5 Rupess up or down. But to make clear claculation we have used 100 as a standerd prise. Usually Selling price of bags decided by committee in Ahmedabad on every Wednesday at 5PM Indian time) so benefit for each kilogram is 100-82.5=17.5 rupess.
- Which produce 5983398 pieces(13296.44 Kilogram) per month.
- Net Production of bags per month=Total Production- Total wastage= 5983398-111369=5872029.
- 5872029/450= 13048.95 Kilogram of bags produced each month
- Net profit for each month=13048.95*17.5=228356 Rupess= $5075

Cost of 100 kg of rawmaterial used in Propossed Manufacturing pprocess

HDPE(85%) + LDPE(9.75%) + Reproduced HDPE(5%) + Tinopal(.25%) = 6800 +780 + 275 + 20= 7875 Rs.

- So the current rawmaterial price for 1 kg of bag is 78.75 Rs.
- 5 Rupees cost is added for labour and electricity for each Kilogram of bags.
- So final cost is (78.75+5)=83.75 Rupees
- Seeling prise is 100 rupess so benefit for each kilogram is 100-83.75=16.25 rupess.
- Company produce 8348574 pieces(18552.39 Kilogram) per month.
- Net Production of bags per month=Total Production-Total wastage=8348574-66602=8281972 bags per month.
- 1 kg contains 450 bags. 8281972 bags equals 18404.38 Kilogram.
- Each Kg of bags can make profit of 100(selling Prise)-83.75(rawmaterial prsie)=16.25
- So overall benefit for Kishan Plastics with proposed process is 16.25 * 18404.38= 299071 Rupess equals to $6646.

Data provided below show manufacturing cost of two current and propossed process.

Catagories	Current Process	Propossed Process
Raw material price for 1 Kg	77.5 Rupess	78.75 Rupess
Labour, electricity and other cost	5 Rupess	5 Rupess
Total cost for 1 Kg	82.5 Rupess	83.75 Rupees
Selling Price of 1 Kg of Plastic bag	100 Rupees	100 Rupees
Profit	17.5 Rupees	16.25
Net Production Per month	13048.95	18404.38
Total Profit in indian rupees	228356 Rupees	299071 Rupees
Total Profit in USD	$5075	$6646

Table 18- Two Manufacturing Process

Difference between two manufacturing process

- Difference is **5,255.95** Kg. So it is a big Difference. Kishan Plastics has approximately manufacture 500 Kilogram of plastic bags each day.So it is clear that propossed manufacture capacity of 30 days is equal to 40 days of current manufacturing process.
- Moreover as machine stopage goes from 90 to 25 which simply means that machine stopage was 3 per day and now is less than 1 a day.
- Benefit Differences is $6646-$5075=$1571. Profit increase by 23.64%.
- Differences is 78.75-77.5 = 1.25 Rs.

- Production in Kishan Plastics increases by 28.33%.
- This is just for rawmatrial. Other expencess like labour cost, electricity cost has not been considered because no changes in those areas. Changing in propotion of rawmaterial so has been discussed in detail.

Above mentioned data shows that with the help of Lean Six Sigma DMAIC methodology if Kishan plastics can increase its prodcutivity, Reduse its waste, Reduse number of machine stopage time then its also can useful for other small scale industries in india who thinks that six sigma is not for small companies.

CONCLUSION

The research conducted in this thesis shows that my work can bring innovation and technology to India. There is also a definite business need for implementing Lean Six Sigma's DMAIC methodology into India, particularly in Indian small scale industry where improvement opportunities in manufacturing are clearly identified. If India companies want to manufacture quality products and services for American consumption, then my original research shows India a beginning place – at Kishan. In this research it is clear that a small company having 12 employees can increase its benefit by 23.64%,machine stopage is reduced by 72.2% and production increased by 28.33%. At Kishan they only have one machine in production line so it was easy to quickly see the production and Lean Six Sigma results. This opportunity at Kishan will be the foundation for what can be achieved at other India companies, who have approximately 50-500 employees or at other companies, who have thousands of workers and employees working together manufacturing and assembling parts.

As DMAIC is successful in American companies, then implementing this methodology in India will also bring many of the same benefits. It is clearly identified that there are cultural challenges. However, it has been clearly shown that there is a need of adult learning strategies for developing the worker in developing countries like India. The opportunity at Kishan has clearly indicated that educational level of the employees should be considered when implementing the DMAIC's tools. Alternative training approaches should be considered in order to sustain this methodology within an organization, like keeping it simple, for transforming new skills into all employees' behaviors.

Working with Kishan's president has also demonstrated that the executive management needs to be involved from the beginning. This experience has showed that an executive needs to take the initiate by learning DMAIC if the entire organization is to learn and implement this process improvement strategies successfully. Furthermore, arranging workshops at regular intervals to educate workers is essential if Lean Six Sigma is to be a new trend in India. (This can be done if company has enough funds to support the workshops.)

With the support of the owner and employees, together they can work on improving the production capacity and quality of its products. But to implement this kind of change, a company has to change the mindsets entire manufacturing team in an environment where owner of small scale industry had to be correct all the time. It may take time to follow this thinking in Indian small scale industry. But we should not forget the famous saying that says "it is better to late than never".

The data that this thesis presented will positively help other proposed manufacturing companies process make other companies in India want to follow Kishan's lead.

It is the vision of our Lean Six Sigma team that other companies in India are going to follow six sigma DMAIC methodology when they see such a big difference in benefits and reduction in machine stoppage time. Moreover, this will also create healthy competition among the companies in India. For example, if a company does something good to increase the production other company will also try to do better by encouraging their workers. What is more, company owners will try to different than what is going in the industries since long time.

From this example, if a person wants to show that if a company which think that they are doing well and does not need any help to do any better and also told that nothing much can be done to make production cheaper and faster. But at the end of this research, company owner was

speechless. This is same case for all other industries in all developing countries. Particularly in India, Lean Six Sigma DMAIC methodology can be implemented in different areas. Companies mentioned in literature review shows that Six Sigma is successfully done in Indian companies but numbers of companies are less. There is one reason for not implementing Lean Six Sigma is misbelieves about Lean Six Sigma that implementing Six Sigma require lot of money required, special procedures to follow, getting expensive equipment and hire somebody with Six Sigma certification in company all the time.

Because of these misbelieves companies hesitate to implement Lean Six Sigma. Kishan Plastics is doing efficient manufacturing since the completion of six sigma project.

REFERENCES

Aveta Business Institute. (2011, January 30).*Six Sigma Projects in Small Businesses*. Retrieved from http://www.sixsigmaonline.org/six-sigma-training-certification-information/articles/six-sigma-projects-in-small-businesses.html

Aveta Business Institute. (2011, May 01). *The Small Business Industry Discovers Six Sigma Projects*. Retrieved from http://www.sixsigmaonline.org/six-sigma-training-certification-information/articles/the-small-business-industry-discovers-six-sigma-projects.html

Aveta Business Institute. (2010, December 26). Six *Sigma and Small Business Affecting Your Corporate Culture.* Retrieved from http://www.sixsigmaonline.org/six-sigma-training-certification-information/articles/six-sigma-and-small-business-affecting-your-corporate-culture.html

BBC News. (2002, May 08). *Planet Earth's new nemesis*? Retrieved from http://news.bbc.co.uk/2/hi/uk_news/1974750.stm

Blue Sky Six Sigma. (2010).*Recommended tools for DMAIC Phases*. Retrieved from http://leansixsigma.co.in/?page_id=102

Blue Sky Six Sigma.(2010). *How to implement six sigma?* Retrieved from http://leansixsigma.co.in/?page_id=106

Blue Sky Six Sigma. (2010).*What is Lean Six Sigma?* Retrieved from http://leansixsigma.co.in/?page_id=106

Compare Infobase (n.d.). *Top 50 Packaging Companies of India*. Retrieved on August 01, 2011 from Best Indian Websites: http://www.bestindiansites.com/top companies/packaging/index50.html

Cristen, A. (2010). *The plastic problem*. Retrieved from http://bagsbegone.com/resources/

Dabbawala. (n.d.).In *Wikipedia, the free encyclopedia*. Retrieved on June 5, 2011 from http://en.wikipedia.org/wiki/Dabbawala

Development Commissioner, Ministry of Micro, Small & Medium Enterprises (n.d.). *Performance*. Retrieved from http://www.dcmsme.gov.in/ssiindia/performance.htm

Digital Journal. (2009, November 14). *Tea workers in India still suffer with low pay & poor condition.* Retrieved from http://digitaljournal.com/article/282149

Dyvadheenam, T. (2006, March). *A Survey on- Status of Ship breaking Workers in India (2004-07)* Retrieved from http://imfmetal.org/files/06042810465779/Shipbreaking_survey.pdf

Education in India. (n.d.).In *Wikipedia, the free encyclopedia*. Retrieved on June 25, 2011 from http://en.wikipedia.org/wiki/Education_in_India

Edwards, R. (2000, October 22). *Plastic bags are choking the life out of India*. Retrieved from http://www.mindfully.org/Plastic/Polyethylene/Bags-Choking-India22oct00.htm

Flowchart. (n.d.). In *Wikipedia, the free encyclopedia*. Retrieved on June 16, 2011 from http://en.wikipedia.org/wiki/Flowchart

Government of India Ministry of Labor & Employment. (2010, October). Report on *Employment & Unemployment Survey (2009-10).* Retrieved from http://labourbureau.nic.in/Final_Report_Emp_Unemp_2009_10_New.pdf

India Packaging Show 2011. (2011). *Packaging: In the route of advanced technology*. Retrieved from http://www.indiapackagingshow.com/industry.htm

Jacowski, T. (2011, September, 13). *How the packaging industry is benefiting from Lean Six Sigma.* Retrieved from http://project-management.bestmanagementarticles.com/a-18811-how-the-packaging-industry-is-benefiting-from-lean-six-sigma.aspx

Kubiak, T.M. & Donald, D.W. (2009). *THE CERTIFIED Six Sigma Black Belt HANDBOOK*. Milwaukee, WI: Quality Press

Literacy in India. (n.d.).In *Wikipedia, the free encyclopedia*. Retrieved on June 25, 2011 from http://en.wikipedia.org/wiki/Literacy_in_India

Mittal, M. (2008, March 24). *Six sigma for small business*. Retrieved from http://mohanmittal.articlesbase.com/business-articles/six-sigma-for-small-business-367588.html

Muchlis, T.I (2004). Research on: *Quality control analysis of packaging process in mineral water industry using six sigma*. Retrieved from https://docs.google.com/a/g.rit.edu/viewer?a=v&q=cache:KLsOFvcWW0oJ:academicpapers.org/ocs2/session/Papers/F3/448-2090-1-DR.doc+PT.+Pusaka+Kali+Agung+Six+sigma+Project&hl=en&gl=ca&pid=bl&srcid=ADGEEShtUZecWN8pWABxh2W-pdmIcglu1ILxu3vwGF3HLHBcRNISy04EXE5yTHqLYEpM6J-lCTTeKmAvkW-VfQBroGVZV8ykG_t6XNAoRQIPu-hioMtB-pqDFkhpceoHuaMJZyPD84ox&sig=AHIEtbQWEBlVYV-fEfoea72DiLoES7BrDw&pli=1

Nnlrj India. (2011, June 16). *People living in Slums*. Retrieved on June 08, 2011 from http://equalityindia.wordpress.com/2011/07/16/people-living-in-slums/

Projects India. (n.d.). *Six Sigma*. Retrieved from http://www.projectsindia.net/pages/541638/sixsigma.htm

Pyzdek, T. & Keller, P. (2010). *The SIX SIGMA HANDBOOK*.

Richards, L. (n.d.). *What are the benefits of Lean Six Ssigma?* Retrieved from http://smallbusiness.chron.com/benefits-lean-six-sigma-2010.html

Rojas, J. *(*2010, March 28*). Six sigma deployment small business.* Retrieved from http://jonathanrojas.articlesbase.com/business-articles/six-sigma-deployment-small-businesses-2059968.html

Samal, I. (2010, July 12). *Packaging industry set to grow 18%.* Retrieved from http://www.business-standard.com/india/storypage.php?autono=401079

Sen, S. (2011, April 16). *Lean Six Sigma Pays Off.* Retrieved from http://www.efytimes.com/e1/fullnews.asp?edid=61557

Sharma, M., Pandla, K & Gupta, P. (2008, May). Case study on: *Six Sigma at Wipro Technologies*: *Thrust on Quality*. *Retrieved from* http://www.google.ca/#sclient=psy&hl=en&source=hp&q=six+sigma+at+wipro+technologies+thrust+on+quality+&pbx=1&oq=six+sigma+at+wipro+technologies+thrust+on+quality+&aq=f&aqi=&aql=1&gs_sm=e&gs_upl=12011723110l7481115l14l0l0l0l0l392l2670l0.9.4.1l14l0&bav=on.2,or.r_gc.r_pw.&fp=848add97f0961db&biw=1366&bih=677

Stellman, J.M. (1998). *Encyclopedia of occupational health and safety,* Retrieved from http://books.google.com/books?id=vW6rXFvm4sQC&printsec=frontcover&source=gbs_atb#v=onepage&q&f=false