DEFECTS ANALYSIS USING CONTROL CHARTS FOR INSTANT FRIED NOODLES.

By

M.H.D. Shailee Kanchana

(00 / AS / 053)

The thesis is submitted in partial fulfillment of the requirement for the degree of

Bachelor of Science

In

Food Science and Technology

Department of Natural Resources,

Faculty of Applied Sciences,

Sabaragamuwa University of Sri Lanka,

Buttala.

March 2004

Declaration

I here declare that the work reported in the project report was exclusively carried out by me, under the supervision of Mr. P. F.S. Pemasiri and Mrs. K.M. Somawathi. Any part of this project report has not been submitted earlier or currently for same or any other degree.

........Kanchana.......

M.H.D.Shailee Kanchana

Date : 30.04.2004

Mr. P.F.S. Pemasiri,
External supervisor,
Quality Assurance/ Research and Development Manager,
Ceylon Agro Industries Limited,
No.346,
Negombo Road,
Seeduwa.

....

Signature.

Date : 30.04.2004

Mrs. K.M.Somawathi,
Lecturer,
Internal supervisor,
Dept. of Natural Resources,
Faculty of Applied Sciences,
Sabaragmuwa University of Sri Lanka.

....

Signature.

Date: 2004.05.11

Prof. M. Rupasinghe,
Dept. Head,
Dept. of Natural Resources,
Faculty of Applied Sciences,
Sabaragmuwa University of Sri Lanka.

M.S. Rupasinghe.......

Signature.

Date: 12.5.2004

AFFECTIONATEY DEDICATED TO MY PARENTS AND TEACHERS

Acknowledgement

First I would like to express my heartfelt thank to my external supervisor, Mr. P.F.S. Pemasiri, Quality Assurance/ Research and Development Manager, Ceylon Agro Industries for his advices, encouragement, and guidance throughout the study and sparing his valuable time in bring this study to a successful completion.

I wish to express my thanks to internal supervisor, Mrs. K.M. Somawathi, Lecturer, Department of Natural Resources, Faculty of Applied Sciences, for her encouragement and guidance throughout this study and for reading the manuscript.

I extended my sincere thanks to Mrs. W.M.D. Priyadharshani, Lecturer, Department of Natural Resources, Faculty of Applied Sciences, for the assistance given me in numerous ways through out this period.

I would like to thank Mr. U.S. Jayarathne, production manager (Noodle Plant), Ceylon Agro Industries Limited, for giving me opportunity to successful completion of the study. Thanks are also extended to the staff of Quality Assurance Department for their support in numerous ways.

Abstract

Control charting is the most advanced tool of Statistical Quality Control (SQC). Control charts can use to identify process variations and what are the causes for it. During the production of instant fried noodles it is difficult to maintain their weight within control limits. This research was carried out to identify the patterns of weight change within control limits and to implement preventive actions for variations for the purpose of defect reduction in instant fried noodles.

Initially, final packing place was used to check the process capability and the X bar / R charts were prepared for that place. X bar / R charts obtained from final packing place indicated great variation within control limits. Therefore secondly, X bar / R charts were prepared at the place where noodles strands cut into desired size and shape. Again process capability was checked at this place and control charts were constructed. Then preventive measures were implemented to reduce the variation within control limits.

The control chart help to identify the weight changes took place and the cause for it. Problem associated with machinery and involvement of inexperienced operators were the major causes for weight changes of finish products. Some of the implemented preventive actions were able to reduce variation in the weight of the instant fried noodles and hence reduce the defect in finished product.

CONTENT

Page no

Abstract i

Acknowledgement.. .ii

Abbreviations iii

List of Figures vi

List of Tables v

Content...vi

CHAPTER 01

1 .1 Introduction.. 1

1.2Objectives..1

CHAPTER 02

Literature Review 2

2.1. Noodles 2

2.1.1. What is it?..2

2.1.2. Origin...2

2.1.3. Instant noodles...2

2.1.4. Instant fried noodles..2

2.1.5. Characteristics of instant fried noodles......................3

2.1.6. Composition...3

2.1.7. Flour for noodles..3

2.1.8. Defects in noodles... 4

2.2. Control charts...5

2.2.1. History..5

2.2.2. Benefits...5

2.2.3 Types of charts...6

2.2.4. Uses of control charts..6

2.2.5. Graphical representation...7

2.2.6. Sub group..7

2.2.7. Variation..8

2.2.7.1. Factors for variation...8

2.2.7.1.1. Operators(Workers)..9

2.2.7.1.2. Machines..9
2.2.7.1.3. Method..9
2.2.7.1.4. Material..9
2.2.7.2. Causes for variation..10
2.2.7.2.1. Random causes/Common causes.......10
2.2.7.2.2. Assignable causes............................10
2.2.8 Interpretation of control charts..10
2.2.9 Analysis of patterns on control charts........................ .11
2.2.10 X bar and R chart.. 12
2.2.11 Steps to start a control charts.. 13
2.2.12 Process capability.. 14
2.2.12.1 Process capability index (C_p)...... 15
2.2.12.2 Process performance index (C_{pk})... 15
2.2.12.3.Relative process capability.......................... 15
2.2.12.3.1 High relative capability........................ 15
2.2.12.3.2 Medium relative capability.................. 16
2.2.12.3.3 Low relative capability..................... 16

CHAPTER 03

Materials and Methodology.. 17
3.1 Location.. .17
3.2 Materials.. 17
3.3 Equipments.. 17
3.4 Methodology.. . 17
3.4.1 Identification of the defects which affect the whole production 17
3.4.2 Determination of process capability at Place 1........... 18
3.4.3 Constructing control charts at Place 1...................... 18
3.4.4 Determination of process capability at Place 2.... 19
3.4.5 Constructing control charts at Place 2..................... 19
3.4.6 Identification of causes for variation........................ .19
3.5 Calculations.. 20

CHAPTER 04

Results and Discussion 22
4.1. Defect analysis using pareto chart 22
4.2. Determination of process capability at Place 1 24
4.3. Constructing control charts at Place 1 25
4.4. Determination of process capability at Place 2 31
4.5. Constructing control charts at Place 2 32

CHAPTER 05

Conclusion and Recommendation 44
5.1. Conclusion 44
5.2. Recommendations 44

REFERENCES 45

APPENDIX

Appendix I 47
Appendix ii 48
Appendix iii 48
Appendix iv 49
Appendix v 49
Appendix v i 50
Appendix v ii 50
Appendix viii 51
Appendix ix 51
Appendix x 52
Appendix x i 53
Appendix x ii 53
Appendix xiii 53
Appendix xiv 54
Appendix xv 54
Appendix xvi 54
Appendix xvii 54
Appendix xviii 55
Appendix x ix 55
Appendix xx 55

Abbreviations

$\overline{\overline{X}}$	Grand average
LCL	Lower control limit
LSL	Lower specification limit
LCL_R	Lower control limit of the range chart
X bar	Mean
R bar	Mean range
C_p	Process capability index
C_{pk}	Process performance index
R	Range
SPC	Statistical process control
σ	Sigma
UCL	Upper control limit
USL	Upper specification limit
UCL_R	Upper control limit of the range chart
A_2	Value obtained from a table
D_4	Value obtained from a table

List of Figures

Page No

Figure 2.1 Statistical Process Control.......... 6
Figure 2.2 Flow chart for control chart interpretation.......... 11
Figure 2.3 High relative capability.......... 15
Figure 2.4 Medium relative capability.......... 16
Figure 2.5 Low relative capability.......... 16
Figure 3.1 Process flow chart for instant fried noodles production.......... 21
Figure 4. 1 Pareto chart for defect identification.......... 23
Figure 4.2 Process capability analysis at Place 1.......... 24
Figure 4.3 X bar / R chart 01.......... 25
Figure 4.4 X bar / R chart 02.......... 25
Figure 4.5 X bar / R chart 03.......... 26
Figure 4.6 X bar / R chart 04.......... 27
Figure 4.7 X bar / R chart 05.......... 27
Figure 4.8 X bar / R chart 06.......... 28
Figure 4.9 X bar / R chart 07.......... 28
Figure 4.10 X bar / R chart 08.......... 29
Figure 4.11 Rearrangement of noodle pieces.......... 30
Figure 4.12 Conveyer belts.......... 30
Figure 4.13 Process capability at place 2.......... 32
Figure 4.14 Dough sheet divide in to five sections.......... 33
Figure 4.15 X bar / R chart for Line 1-(Before).......... 33
Figure 4.16 X bar / R chart for Line 1-(After).......... 34
Figure 4.17 X bar / R chart for Line 2-(Before).......... 35
Figure 4.18 X bar / R chart for Line 2-(After).......... 35
Figure 4.19 X bar / R chart for Line 3-(Before).......... 36
Figure 4.20 X bar / R chart for Line 3-(After).......... 37
Figure 4.21 X bar / R chart for Line 4-(Before).......... 38
Figure 4.22 X bar / R chart for Line 4-(After).......... 38
Figure 4.23 X bar / R chart for Line 5-(Before).......... 39
Figure 4.24 X bar / R chart for Line5-(After).......... 40
Figure 4.25 Reduction rollers.......... 40
Figure 4.26 Conveyor belt A and B.......... 43

List of Tables

Page no

Table 2.1 Composition of instant noodles.. 3

Table 2.2 Differences in sample selection methods..................................7

Table 4.1 The extent of defects in the processing line.................................22

Table 4.2 Summary of grand average and range of Line 1..........................34

Table 4.3 Summary of grand average and range of Line 2........................ 36

Table 4.4 Summary of grand average and range of Line 3..........................37

Table 4.5 Summary of grand average and range of Line 4......................... 39

Table 4.6 Summary of grand average and range of Line 5..........................41

Table 4.7 Weight changes from line 01 to 05...................................... 41

CHAPTER 01

1.1 Introduction

According to krishnamoorthi 1989, all processing plants has troubles those are associated with the manufacturing process. In the noodles manufacturing plant itself contain problems those are associated with quality of the product. In the manufacturing of instant fried noodles, variation of weight causes fro poor quality because underweight products are not desirable in consumer point of view as well as over weight products are not desirable in the consumer point of view. When consider about Prima instant fried noodles its weight is 85g. But due to some reasons weight changes take place and cause to generation of defects in finish product.

With the development of process control, Statistical Process Control (SPC) provides better opportunities for quality control and quality improvement (Krishnamoorthi, 1989). One of the statistical process control methods, control charts can used to identify the variation within control limits and what are the causes for the variations. Maintaining control chart will provide answer to reduce defects, which occur during noodle manufacturing process (Blanton and Juran, 2000).

To identify the variation during instant fried noodles manufacturing process variable control charts are essential. Among variable control charts X bar / R charts are suitable because the chart for averages is used to control the mean or central tendency of the process, whereas the chart for ranges is used to control the variability. Unnatural pattern such as sudden shifts in level, bunching or clustering determine the causes for variation (Sedrick et al., 1996). And then can implement the preventive actions to reduce the defects.

1.2 Objectives

1). Identification of weight changes in instant noodles within upper control limit and lower control limit.
2). Determination of causes for variation in instant fried noodles.
3). Implementation of preventive actions for causes.

CHAPTER 02

Literature Review

2.1 Noodles

2.1.1 What is it?

Noodle is a one type of pasta product. The word instant is the term used in conjunction with the name of a food to indicate that it would be reconstituted rapidly, since it has been cooked (SLS 420 :1989).

2.1. 2 Origin

Noodles are thought to have originated in China and are still a popular food throughout Asia. During the 1970's a product was launched named instant noodle snacks coming directly from the instant ramen a product which appeared in Japan during the 1950's (Hoseney, 1998).

2.1.3 Instant noodles

A product made from a dough prepared from wheat flour and water, with or without other optional ingredients, kneaded, extruded, through an extrusion press filled with a die of the desired size, precooked in boiling edible oil, cooled and packed (SLS 420 :1989).

2.1.4 Instant fried noodles

Instant fried noodles are cut, waved, precooked with steam, formed in to individual servings, and dried by deep fat frying to 5-8% moisture. They are called ramen or ramyoen and are usually packed with seasoning (Hoseney, 1998). Instant noodles have become one part of the most important types of the noodles in Southeast Asia and have become a popular convenience food on global level They are either steamed and dried or steamed and fried before packaging. The instant fried noodles have a taste distinctive from that of the other noodles, probably because they pick up about 20% fat during drying (Mercier and Cantarelli, 1996).

2.1.5 Characteristics of instant fried noodles

The noodles should have a uniform shape and cleanly cut out sides. Frying of steamed noodles remove excess water and form a porous structure. In the presence of porous structure that rehydrates quickly when boiled water is added. When this noodles are cooked by consumer in boiling water, no fat should separate in the cooking water. After cooking with water should have a relatively strong bite and a firm, non sticky surface. Dull gray or brown color noodles are considered inferior. Because of the importance of color, highly purified colors are generally used (Hoseney, 1998).

2.1.6 Composition

Instant noodles are flavored with seasonings. Institute of Australia showed that instant fried noodles have on following percentages;

Table 2.1 Composition of instant noodles

Composition	Percentage
Moisture	6.6%
Protein	9.5%
Fat	21.1%
Ash	1.7%

Source; Catharina Y.W. et al., (1999), Asian Food Science and Technology

2.1.7 Flour for noodles

Protein quality and quantity are important in noodle making. High amounts (10%-14%)of strong protein produce noodles with a chewy, elastic texture. Flour with low a protein content gives noodles with poor cooking tolerance (Hoseney, 1998).Wheat flour milled from soft wheat with moderate to low protein content is desirable because it facilitates rapid cooking upon addition of water (Catharina et al .,1999).

2.1.8 Defects in noodles

The word defect can be define as the nonfulfilment of intended usage requirement. The definition covered the departure or absence of one or more quality characteristic from intended usage requirement (SLS 825:1988).

There are three major problems identified in instant noodle production.

- Defects in weight

  This defect occurs due to under weight or over weight product. Because these products are not confirmed the specification.

- Defects due to damages.

  This kind of defected product are removed from each production line before packing. This damage occur due to under frying or over frying, oil retention, etc.,.

- Defects occur during sealing.

  This take place due to incorrect wrapping machine adjustments, problems in machine (machine deterioration.) and personal carelessness.

In the presence of these defects, the manufactures faces some drawbacks such as reduce the production, reduce consumer satisfaction and it is also economic losses. To control this problem effectively, statistical process control application is a must. Process Control is a vital element of virtually every industrial enterprise. Since profitability, productivity and product quality depend very fundamentally on effective total control of the process producing a product. The most intense application are found in the process industries such as chemicals, drugs, food.....etc (John et al., 1997). Process control can be achieved by Statistical Quality Control (SQC). Under SQC there seven tools namely,

1. Cause and effect diagram
2. Stratification analysis
3. Check sheet
4. Histogram
5. Scatter analysis
6. Pareto analysis
7. Control charts

2.2 Control charts

Control charting is the most technically sophisticated tool of SQC. Dr. Shewhart in 1924, developed the control charts as an statistical approach to the study of manufacturing process variation for the purpose of improving the economic effectiveness of the process. These methods are based on continuous monitoring of process variation (Sedrik et al ,1996).

2.2.1. History

With the invention of quality control charts by Shewhart Laboratories of United States, in 1924, the way was opened for the development of many methods for the application of statistical test for the evaluation of product quality variation (Gupta, 1998). An unpublished memorandum by Shewhart ,1924 contain the first known control chart and later the concept was developed more completely. The first application of the control chart in 1931 were on fuses, heat controls and station apparatus of an electric company. Control charts are now widely used in every industry as principle tools of Statistical Process Control (SPC). The control chart is the most important tool available to study this variation and it's reduction in order to quality improvement of a manufactured good (Blanton and Juran , 2000). Objectives of the control charting;

1) Control chart can be use as a source of information to help decide whether an item should be realized to the customer or some alternative disposition made.
2) It provides information for current decisions in regard to the production process.
3) To provide information for decisions in regard to product specification.
4) Construct a control chart for maintains control in the future.
5) Control chart could be used to check whether process is in a state of control.

2.2.2 Benefits

Trouble is a common state of affairs in manufacturing. Whenever the trouble consists of difficulty in meeting quality specifications they are expressed in terms of variables, the Shewhart control charts for X-bar and R dispesable tools in the hands of the trouble shooter. They provide information on three matters all of which need to be known as a basis for action. These are;

1) Basic variability of quality characteristic.
2) Consistency of performance.
3) Average level of quality characteristic (Gupta, 1989).

2.2.3 Types of charts

For statistical process Control (SPC) there are two types of control charts use. A control chart based on the observations can be effective for statistical process control (George, 2002).

SPC

Variables qualitative data	Attributes qualitative data.
X bar and R chart	P chart
R charts	c chart
X charts	U chart
Sigma charts	np chart

Figure 2.1 Statistical Process Control

2.2.4 Uses of control charts

1) It is a proven technique for improving quality.
When product quality is good, there is no longer a need to push out low-grade goods to meet delivery. Customers have more confidence in the quality product.

2) It is effective in defect prevention.
Because defective products use more material, machine time, and man power. When these resources are used in making good products there is less waste and therefore, more to sell.

3) It prevents unnecessary process adjustments.
Control chart will tell us when a process must be adjusted and when it must be left alone.

4) It provides diagnostic information.
The control charts give timely signals when the process behaves abnormally so that the process can be corrected before it produces large quantities of defective product.
5) It provides information about process capability.
It is very beneficial to know which process is capable and what is not. This helps to improve process capability to meet a give specification (Krishnamoorthi, 1989).

2.2.5 Graphical representation

A typical control chart is a graphical display of a quality characteristic that has been measured or computed from a sample versus the sample number or time. The chart contains a center line that represent the average value of the quality characteristic corresponding to the control state. Two other horizontal lines, called the upper control limit (UCL) and the lower control limit (LCL) are also drawn. Most of the time control limits are calculated on the basis of average ± 3 sigma (X-double bar ± 3sigma). The use of ±3 sigma limits means that if only random causes alone are percent 99.75% of the charted values will fall within control limits.

2.2.6 Subgroup

A set of units or quantity of material obtained by sub dividing a larger groups of units or quantity of materials (Anon, 1996). Subgroup size can be define as the number of observations in one subgroup.
Principles of sub group selection;
There are two schemes for selecting the sub group sample.

1) Instant time method

In this method select the sub group samples are selected from product produced at one instant of time or as close to that instant as possible.

Table 2.2 Differences in sample selection methods

Instant Time Method	Period of Time Method
1. Minimum variation within a sub group. 2. Maximum variation among subgroups	1. Maximum variation within a subgroup 2. Minimum variation among subgroups.

Source; Juran and Frank, (1988), Juran's Quality Control Handbook

2) Period of time method

This method is to selection of produced product is done over a period of time so that it is a representative of all the product.

The instant time method is the one most commonly used since it provides a particular time reference for determining assignable causes. It also provides a more sensitive measure of changes in the process average. For industrial purposes, 5 seems to be the most common sample size because the essential idea in a way that gives minimum opportunity for variation within the subgroup. It is desirable that subgroup as small as possible the distribution of X bar is nearly normal for sub groups of four or more even though the samples are taken from a abnormal universe (Gupta, 1998).

2.2.7 Variation.

2.2.7.1 Factors affecting for variation

The production process unable to produce all items of product exactly alike. Variation is inevitable. The amount of this variation on a production process depend on various quality characteristics such as the operators, method, materials and machines are used.

2.2.7.1.1 Operators (Workers)

People are the greatest underutilized resources in food industry. Every worker in food plant should be given a thorough education about for accepted product quality and they should be shown how to seek ways to constantly improve existing products. The action of operators in trying to correct a process may actually be an assignable cause of quality variation (Gupta, 1998). All plant employees must first understand that quality is conformance to requirements (Wilbour and Roland, 1993).

2.2.7.1.2 Machines

All machines in a food plant are designed to perform given functions or unit operations. These functions or unit operations vary widely with the type of food being processed and of course, the size of the operation.

2.2.7.1.3 Method

The method used in manufacture are designed to perform given functions to the food. All the methods are unique and have a definite purpose. From quality control stand point, the operator must learn all he or she can about the method, in order to better control the unit operation. The operators are responsible for managing the unit operation within given tolerances to meet the required specifications.

Food industry is the most complicated one even though the operator may understand his unit operation and how to make measurement, raw materials and method (Wilbour and Roland, 1993).

2.2.7.1.4 Materials

Raw materials are the life blood of the food industry. Research is greatly needed to improve the quality of the raw material so that high quality finished product can be produced. All materials coming in to food plant must be accepted only on the basis of achieving the given specification, that is; acceptable quality level.

2.2.7.2 Causes for variation

2.2.7.2.1 Random causes/ Common causes

These are events that cause relatively minor fluctuations in the data. Each may be small that its occurrence is not important or may be form a pattern. Shewhart concluded from the central limit theorem and form empherical observations that they often form approximately a normal distribution (Blanton and Juran, 2000).

2.2.7.2.2 Assignable causes

That is a cause which can be assigned for the fluctuations observed. These are sources of variation that cause a significant departure of the data from the pattern formed by the chance causes. Any observation falling out side these limits indicate the presence of an assignable cause. These causes tend to cause not normal frequency distribution (Blanton and Juran, 2000).

2.2.8 Interpretation of control charts

Control chart interpretation is the process analyzing to understand the performance of the system being studied. Chart interpretation is a matter of asking key questions and recognizing patterns(Anon, 1996).

The purpose of all control charts is to help people who are managing systems to make the right decisions about how to control or run them. There are two types of mistakes ;

Mistakes of under control

Mistakes of over control

System improvement will not come magically by making a control chart. System improvement comes only from planed change of the right kind.

After plotting control charts can see there are different kinds of patterns due to assignable causes can be seen. Following information give what are the patterns that can be observed and what are the causes for them.

2.2.9 Analysis of patterns on control charts

A control chart may indicate an out of control condition either when one or more points fall beyond the control limits, or when the plotted points exhibits some non random pattern of behavior.

The process is out of control if any one or more of the following criteria is met.

1. One or more points outside of the control limits. This pattern may indicate :

   A special cause of variance from a material, equipment, method or measurement system change.

   Mismeasurement of a part or parts. Miscalculated or misplotted data points.

   Miscalculated or misplotted control limits.

2. A run of eight points on one side of the center line. This pattern indicates a shift in the process output from changes in the equipments, methods or materials or shift in the measurement system .
3. Two of three consecutive points out side the 2-sigma warning limits but still inside the control limit. This may be the result of large shift in the equipment, methods, materials or operator or a shift in the measurement system.
4. Four of consecutive limits beyond the 1-sigma limits.

5. An unusual or nonrandom pattern in the data.
   a) A trend of seven points in a raw upward or downward. This may show
      i) Gradual deterioration or wear in equipment.
      ii) Improvement of deterioration in techniques.
   b) Cycling of data can indicate
      i) Temperature and recurring changes in the environment.
      ii) Differences between operators or operator techniques
      iii) Regular rotation of machines.
      iv) Difference in measuring or testing devices that are being used in order
6. Seven points near the warning or control limits (Sedrick et al., 1996).

The flow chart shows that control chart interpretation is a series of questions leading to a decision about the stability of the system.

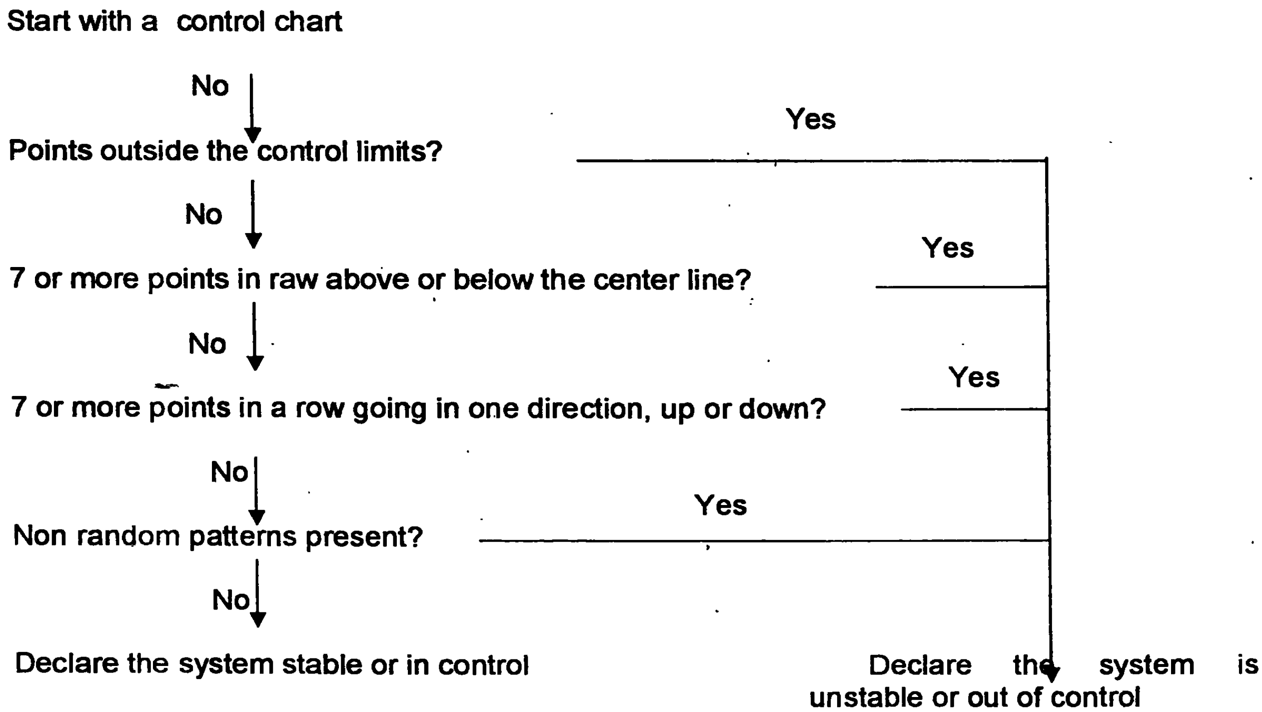


Figure 2.2 Flow chart for control chart interpretation.

2.2.10 X bar and R chart

X-bar and R chart is the most sensitive control chart for tracing and identifying causes. This is used for variable data which can be measured. The R pattern is read first, from this it is possible to identify many causes directly. The X bar patterns read in the light of the R chart, and this makes it possible to identify other causes. Finally the X-bar pattern and R pattern are read jointly, which gives still further information. Mean and range which measures the accuracy and the precision. Control charts for variables should be established to achieve a particular purpose and their use should be discontinued when the purpose or objective has been achieved. When variable chosen for an X-bar and R chart must be a quality characteristic that is measurable and can be expressed in numbers (Mortimore and Wallace,1998).

Average chart

1 Sudden changes in average

If the change is sudden, then the cause must also be sudden. Reasons;

a) The machine jammed up, so altering its setting.
b) The process suddenly picked up an impurity.
c) There was an unauthorized alteration of switches, taps, valves, etc., on the control equipment
d) There were sudden changes in the setting of a temperature controller.
e) The start of a new batch of new material of quality different from usual.
f) The start of a different operator, inspector, /especially if inexperienced.
g) Changes made by an engineer or supervisor for some other reasons which he did not think would upset the process.

2) Drifts of the average.

This indicates progressive change in the setting. Many processes always drift a little ;

As tool wears

As chemical solutions become spent.

2.2.11 Steps to start a control chart.

1) Choose the quality characteristic to be charted. In making this choice, there are several things to consider:

    a. Choose a characteristic that is currently experiencing a high number of nonconformities or items that do not confirm.

    b. Identify the process variables contributing to the end product characteristic to identify potential charting possibilities.

    c. Choose a characteristic that will provide appropriate data to identify and diagnose problems.

    d. Determine a convenient point in the production process to locate the chart.

2) Choose the type of control chart
    a. the first decision is whether to use a variables chart or an attribute chart. A variable chart is used to control individual measurable characteristic ;whereas an attribute chart may be used with no go–go type of inspection.
    b. Choose a specific type of chart to be used.
3) Choose the center line of the chart and the basis for calculating the control limits.
4) Choose a rational subgroup or sample. Samples of more than one are desirable for control charts if feasible. For variable charts, samples of size 4 or 5 are usually used, whereas for attributes charts, samples of 50 to 100 are often used. In addition to the size of sample, the samples should be selected in such a way that the chance of a shift in the process is minimized during the taking of the sample (thus a small sample should be used) whereas the chance of a shift, if it is going to occur, is at a maximum between samples. Thus it is better to take small samples periodically than to take single large sample.
5) Provide a system for collecting the data. Measurement must be made simple and relatively free of error. Measuring instrument must give quick and reliable readings.
6) Calculate the control limits and provide adequate instruction to all concerned on the meaning and interpretation of results (Kolarik, 1995).

2.2.12 Process capability

Process capability is a critical performance measure which address process results with respect to product specification. A processing method that includes man, machine, material and method is studied to determine total variability. Process may be made capable by frequent machine adjustments, tool changes, or redressing a wheel. If this must be done so often it interferes with the production standard, the process can not be considered truly capable. Two process capability measures or indices are widely used.

C_p index - An inherent or potential measure of capability.

C_{pk} index - A realized or actual measured capability (Kolarik, 1995).

Capability analysis is based on the idea that reducing the variation around the target value.

2.2.12.1 Process capability index,(C_p)

This index used to summarize a system's ability to meet two sided specification limit (upper specification limit and lower specification limit)(Anon, 1996) It really evaluates only the process spread and ignores the process average. If the system is not centered at the middle of the specification, the C_p index may be misleading.

2.2.12.2 Process performance index.(C_{pk})

This value tells how well a system can meet specification limits while accounting for the location of the average. C_{pk} modifies the C_p index to account for the location of the average or center (Anon, 1996). If C_{pk} =1 it declares that the process is a marginally capable .If C_{pk}<1, it declares that the process is incapable and if C_{pk}>1 it declares that the process is capable.

Capability indices help to change the focus of improvement. The focus of improvement has traditionally been to reduce the proportion of product or service not meeting the specification, using measures such as percent rework (Anon, 1996). The idea of these values are to shrink the variation around the target value.

2.2.12.3 Relative process capability

It is useful to have a simple capability index to show how capable or otherwise a process is with respect to its specification limits. There are three types of capabilities.

2.2.12.3.1 High relative capability

If (USL–LSL) exceeds 8 standard deviations, the process is said to have a high relative capability, and corresponds to a C_p value greater than 1.33. For satisfactory production quality a C_p of 1.33 or more is desirable, and the larger it is the better.

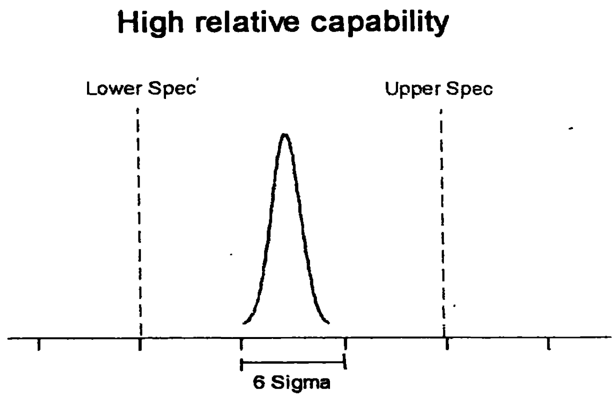


Figure 2.3 High relative capability

2.2.12.3.2 Medium relatively capability

If (USL–LSL) is between 6 sigma and 8 sigma, corresponding to a C_p of 1.00 to 1.33, then the process is said to be of medium relative capability. Production quality will only be satisfactory if the mean can be held constant and central throughout the production run.

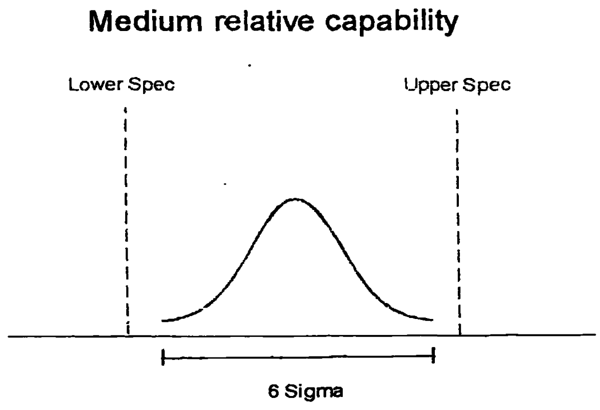


Figure 2.4 Medium relative capability

2.2.12.3.3 Low relative capability

The term low relative capability is used for the completely. unsatisfactory situation where (USL – LSL) is less than 6 sigma, giving a C_p of less than 1.0 (Caplen , 1988) .

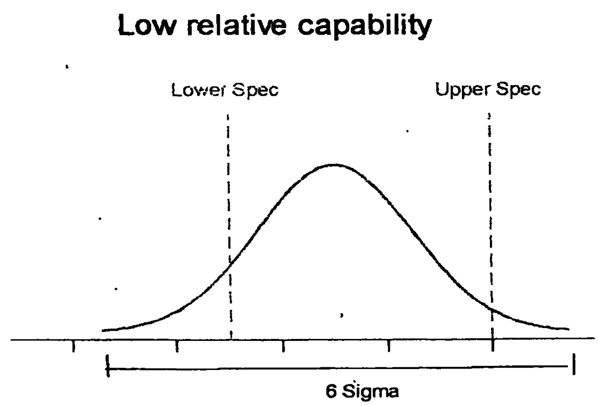


Figure 2.4 Low relative capability

CHAPTER 03

Materials and Methodology

3.1 Location

This project was done at noodles manufacturing plant. For this purpose two places were used.

Place 1 – Final Packaging place

Place 2 – Place at which noodles pieces cut into desired size and shape.

(Figure 3.1)

3.2 Materials -

Noodles pieces

Graph papers

3.3 Equipments

Check weigher

3.4 Methodology

Defects analysis during noodles production.

To identify the priority of the problems pareto chart was used. According to some industrial problems there is a assumption that many problems arise due to few reasons.

Many problems ⟶ Few reasons

3.4.1 Identification of the defects, which affect the whole production.

Major concerning problems that affect to the production of instant fried noodles were identified qualitatively.

To identify the share occupied by each component, following information was gathered.

Average amount of defects due to damages occurred when 300 product produced.

Average amount of defects occurred in weight when 300 products produced.

Average amount of defects occur during sealing when 300 products produced.

Then the above three values were entered into Minitab worksheet and then graph was obtained (Figure4.1).

3.4.2 Determination of process capability at Place 1

As considered earlier before starting the Statistical Process Control using control charts need to check whether the process is capable or incapable.

Eighty five samples (noodle samples) were selected randomly from the final packaging place (Place 1) and weight was recoded.
Then these observations were arranged into 5 separate columns (see Appendix i). Then these observation were entered in to the Minitab worksheet and graph was obtained (Figure 4.2).
For this step Upper specification limit was 91 and Lower specification limit was 80.
Then the C_p value was obtained form that graph for the interpretation of results.

3.4.3 Constructing control charts at Place 1

At very first time 5 consecutive noodles samples were selected randomly and then it was weighted. (subgroup number 1).
Fifteen minutes later another 5 consecutive samples were taken and was recorded the weight. (subgroup number 2).
Furthermore this step was followed until the subgroup number was 10 – 15 depending on the time allocated for the processing.
After that recorded data was entered into Minitab worksheet (Appendix ii to ix) and plotted the X bar/ R charts were plotted.

1). Using above steps can construct a control chart for one day.

2). All above steps (see 3.4.3) were followed to prepare 8 control charts.

3). Before use the Minitab statistical package following values were calculated using equations.

After plotting all above charts patterns on the control chart was identified and they were interpreted.

3.4.4 Determination of process capability at Place 2

Eighty-five samples (noodle pieces) were selected randomly and weight was recorded (Figure 3.1).

Then these observations were arranged into 5 separate columns (Appendix x).

Then these observations were entered into Minitab worksheet and graph (Figure 4.13) was obtained.

- For this graph upper specification limit was 95 and lower specification limit was 85.

Then the C_p value and C_{pk} value were obtained from that graph for the interpretation of results.

3.4.5 Constructing control charts at Place 2

- In this place (Place 2) there are five different noodle lines move parallel to each other.

At initial stage 5 samples were selected randomly from 5 lines. (Subgroup number 1).

After 15 minutes later another 5 samples selected and the weight was recorded.

Above steps were followed until the subgruoup number was 10 -15.

After that recoded data were entered into Minitab worksheet and obtained the X bar / R chart was plotted.

Then another 5 separate graphs (Figure 4.15, Figure 4.17, Figure 4.19, Figure 4.21) were obtained from each line.

Same procedure was followed for sample selection and the graphs were plotted.

Then variations in the pattern were identified.

Above five graphs were obtained within one day. After identification of the causes for variation, preventive measures were applied.

After implementing preventive measures for variation 5 separate charts obtained again within one day (Figure 4.16, Figure 4.18, Figure 4.20, Figure4.22).

3.4.6 Identification of causes for variation

Four noodle pieces were selected randomly from Line 1 and weight as recorded.

Then number of strands per piece was calculated for each sample.

After that 4 separate strands were selected from one piece and weight was recorded.

Then the average weight was calculated.

Above 3.4.6 was applied for all 5 Lines (Table 4.2).

3.5 Calculations

a). Control limits

The limits are calculated from laws of probability is such a way that highly improbable variations are presumed to be due to assignable causes and not due to chance causes.

For most control charts the control limits are calculated on the basis of average ± 3 times standard deviation of statistic used.

Average chart

Average of the subgroup	=X bar
Grand average	=ΣX bar ÷ # of subgroup
Upper control chart (UCL)	=Grand average. + 3σ
Lower control chart (LCL)	=Grand average. – 3σ

But 3σ $= A_2 \times$ R bar

Therefore

Upper control limit (UCL)	=Grand average. + A_2R bar
Lower control limit (LCL)	=Grand average. – A_2R bar

Range chart

Central line	=ΣR ÷ # of subgroup
	=R bar
UCL_R	$= D_4 \times$ R bar
LCL_R	=0

b). Process capability

Process capability index (C_p) $= \frac{USL-LSL}{6\sigma}$

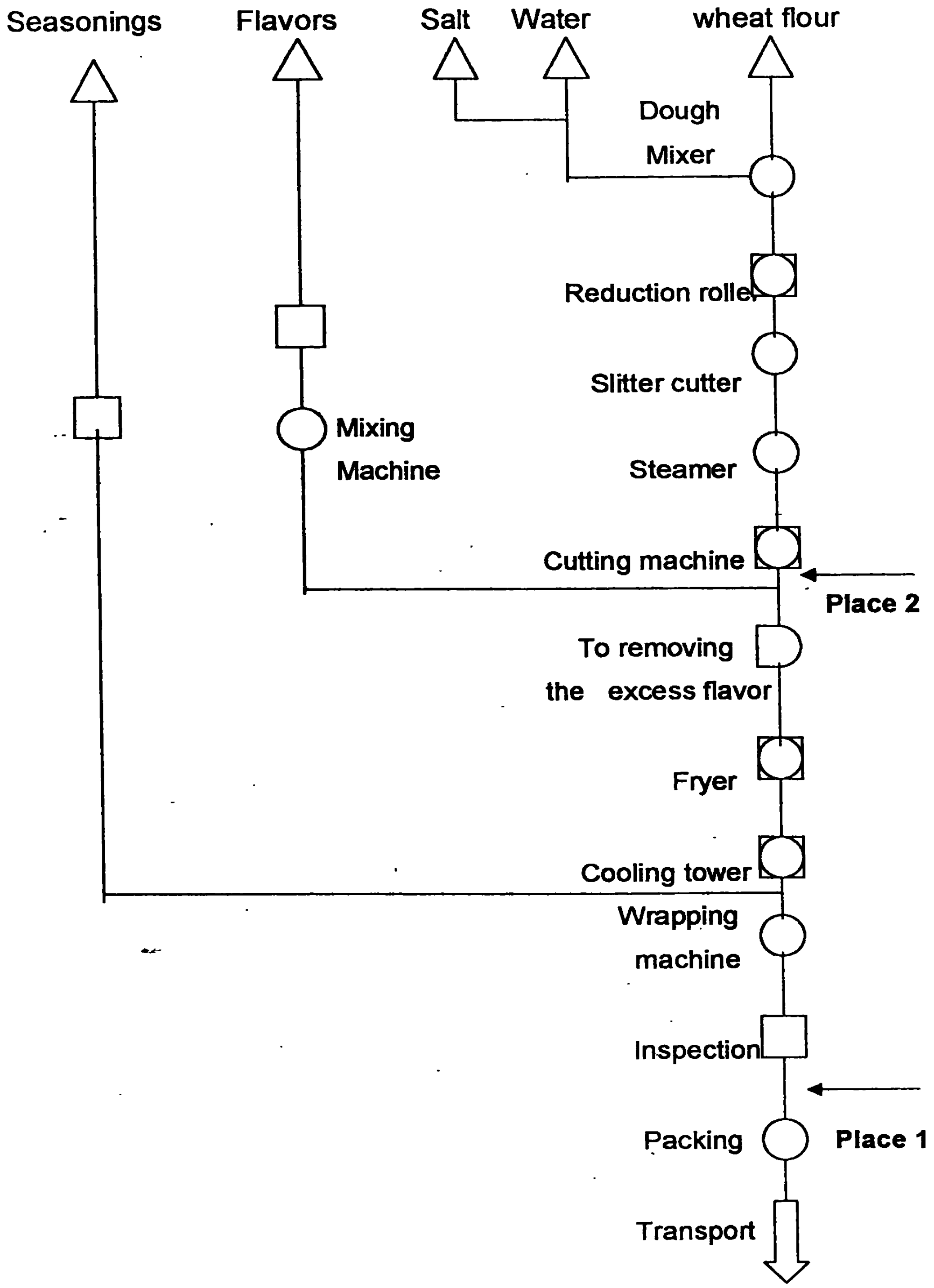


Figure 3.1 Process flow chart for instant fried noodles production.

CHAPTER 04

Results and Discussion

4.1 Defects analysis using pareto chart

It is necessary to identify what are the major concerning problems in noodles from initial dough mixing to final packaging. According to the economic point of view there were three major problems identified in noodles plant.

a) Defects due to damages

b) Defects in weight

c) Defects during the sealing.

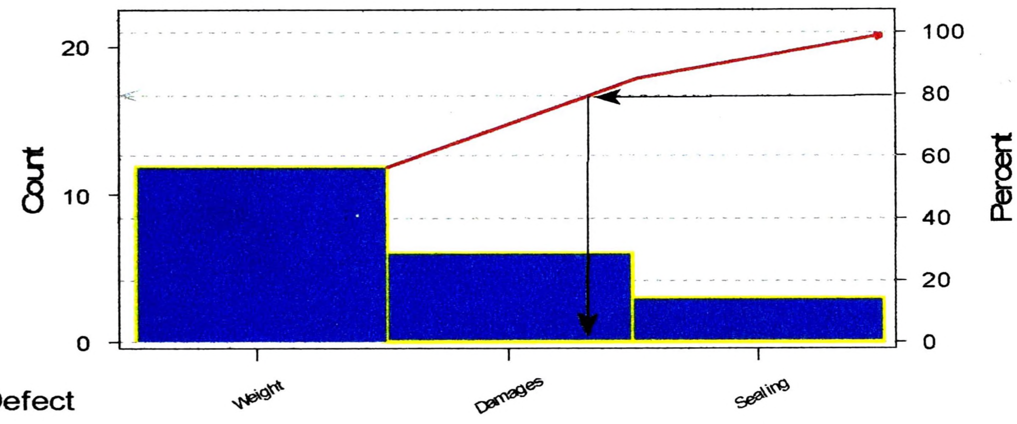
The pareto chart graphically represents (Figure4.1) the share occupied by each and every problem mentioned above.

Table4.1 The extent of defects in the processing line

Types of defect	Frequency
a) Defects due to damages	06
b) Defects in weight	12
c) Defects during the sealing	03

The Table 4.1 represent the number of items defected when 300 packets were prepared. Following pareto chart was obtained using above table.

The pareto chart principle, which can be applied to quality, suggest that the majority of the quality losses are maldistributed in such away that a 'vital few' quality defects or problems always contribute to a higher percentage of the overall quality losses. Figure 4.1 show that 80 precentage problems were due to weight changes and defects due to damages. Out of these two, higher percentage was observed due to weight changes.



Defect	Weight	Damages	Sealing
Count	12	6	3
Percent	57.1	28.6	14.3
Cum %	57.1	85.7	100.0

Figure 4.1 Pareto chart that use to identify defects

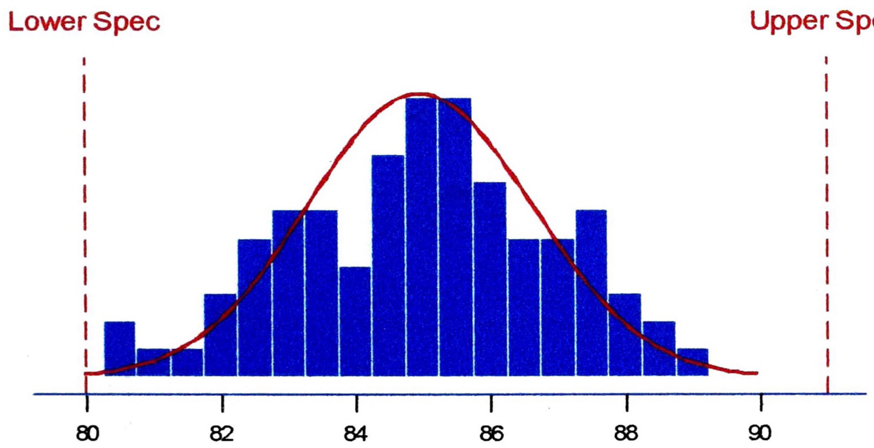
If there is any possibility to minimize the weight changes during instant noodles production the target production can be increased. Hence the product weight should be maintained within specification limits (80-91) and improve the production process.

Defects occur due to weight changes can easily reduce than other two defects reduction. Because sealing defect occur due to lack of proper machine maintenance and at the time of packing material change. Product rejection due to damage may occur due to few reasons such as oil retention inside the fried noodles, under frying and over frying condition and fragments breaking when moving through machines and conveyer belts.

To reduce the weight changes (under and over weight) it is essential to apply some statistical process control methods. For that control chart was used as a quality tool. Using this control limits and variations that normally take place in the production process were identified. These limits and variations vary depending on man, material, method and machine. According to the noodles production steps wheat flour and other ingredients incorporate with different mechanical actions and finally produce instant fried noodles. From initial stage to final stage noodle piece passes through various kind of machines and due to this reason final significant amount of defects were observed in final product. If the variation around grand average is high (that means standard deviation is high) need to take preventive action to reduce and eliminate the causes. After reduction of this causes (assignable causes) again the control charts are constructed and check whether there is an improvement or not.

4.2 Determination of process capability at Place 1

Prior to do control chart need to determine whether the process is capable or not.
Figure 4.2 show the pattern of normal distribution of observation. According to the noodle production specification limits 91 was the upper specification and 80 was the lower specification limit. Specifications are not the same as control limits. Specifications are set by the customer, engineering or management and control limits are based on the data collected to make a control chart(Appendix i).



Cp	1.10	Targ	*	Mean	84.9679	%>USL Exp	0.01	PPM>USL Exp	146
CPU	1.21	USL	91.0000	Mean+3s	89.9627	Obs	0.00	Obs	0
CPL	0.99	LSL	80.0000	Mean-3s	79.9731	%<LSL Exp	0.14	PPM<LSL Exp	1423
Cpk	0.99	k	0.0967	s	1.6649	Obs	0.00	Obs	0
Cpm	*	n	85.0000						

Figure 4.2. Process capability analysis at place 1

According to above Figure 4.2 C_p was1.10. If C_p=1 declare that the process is potentially capable (in a marginal sense). C_p is used to summarize a system's ability to meet two sided specification limits. It really evaluates only process spread and ignores the process average. If the system is not centered at the middle of the specifications the C_p index may be misleading. Since the C_{pk} is developed relative to the process location parameter (the mean) it provides a realized measure of actual production. C_{pk} tells how well a system can meet specification limits and it modifies C_p index accounting for the location of the average (or center). As C_p was closer to 1 the production process was capable at Place1. After checking the process capability readings for control charts were taken from the final packaging place. After that control charts were prepared using the data.

4.3 Constructing control charts at Place 1

In Figure 4.3,

Point 1 is out of lower control limit and point 4 is out of upper control limit in the X bar chart. From point 6 to 10 there is upward trend (Appendix ii).

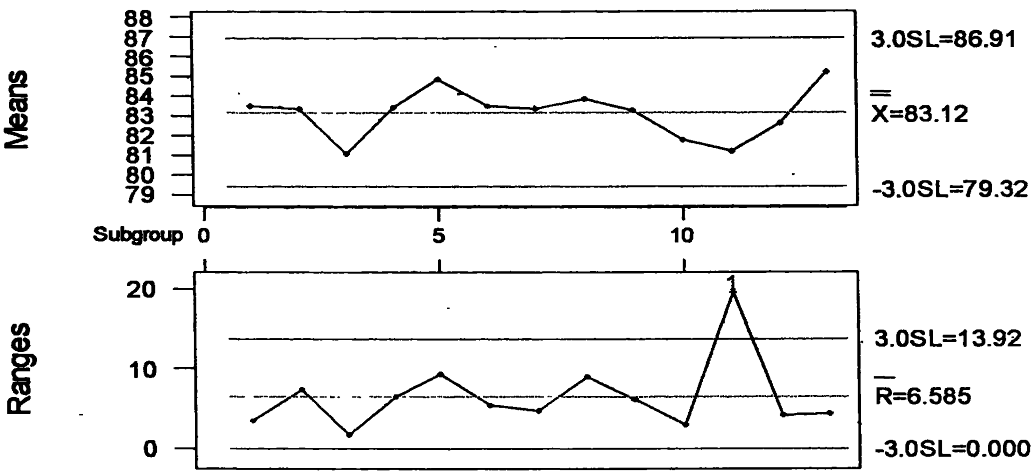


Figure 4.3 X bar / R chart 1

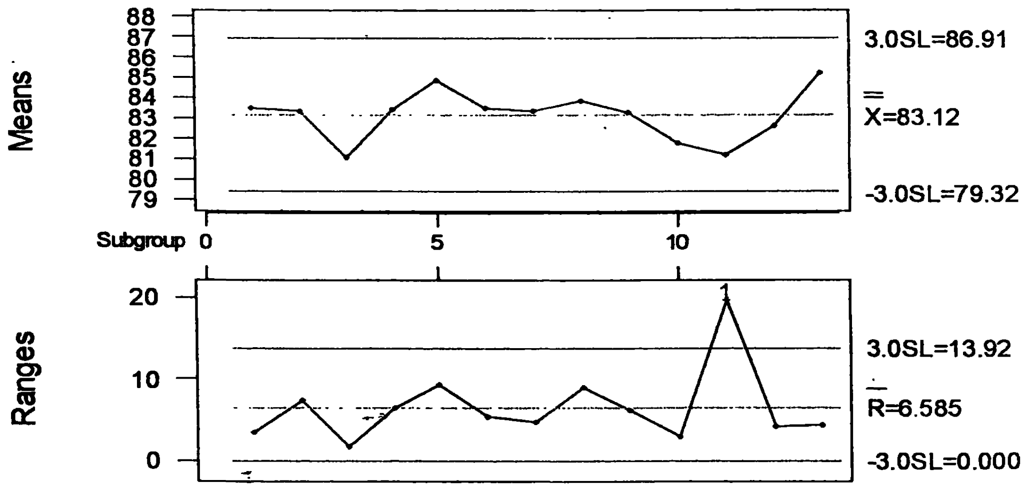


Figure 4.4 X bar / R chart 2

In Figure 4.4 chart

At the subgroup number 11 (range chart) has high range in range chart.

A cyclic pattern and recurring pattern were observed in mean chart and range chart respectively (Appendix iii).

In Figure 4.5 ,

Range chart show saw tooth pattern and from point 7 to point 11 all the points were in one side in the mean chart (Appendix iv).

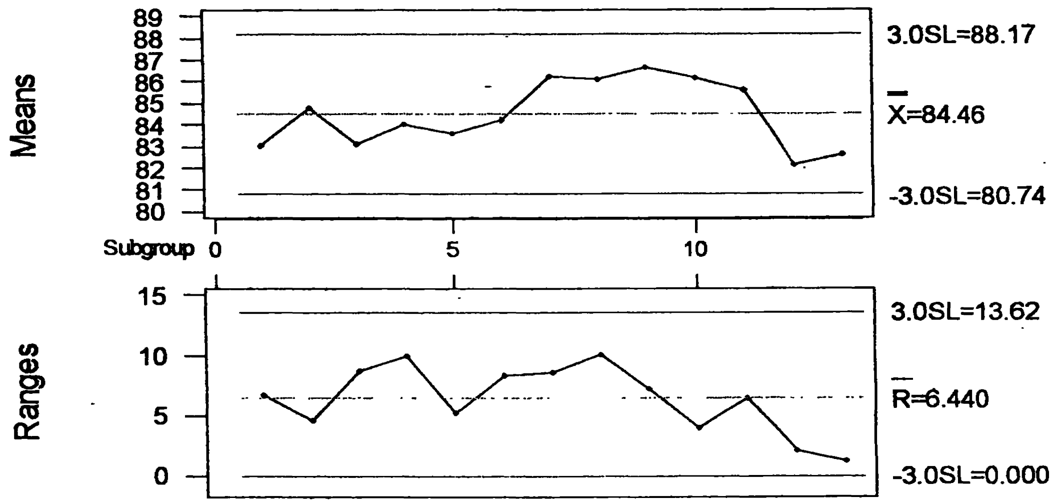


Figure 4.5 X bar / R chart 3

In Figure 4.6

Point 11 at average chart was lower than lower control limit and range also high at this point (Appendix v).

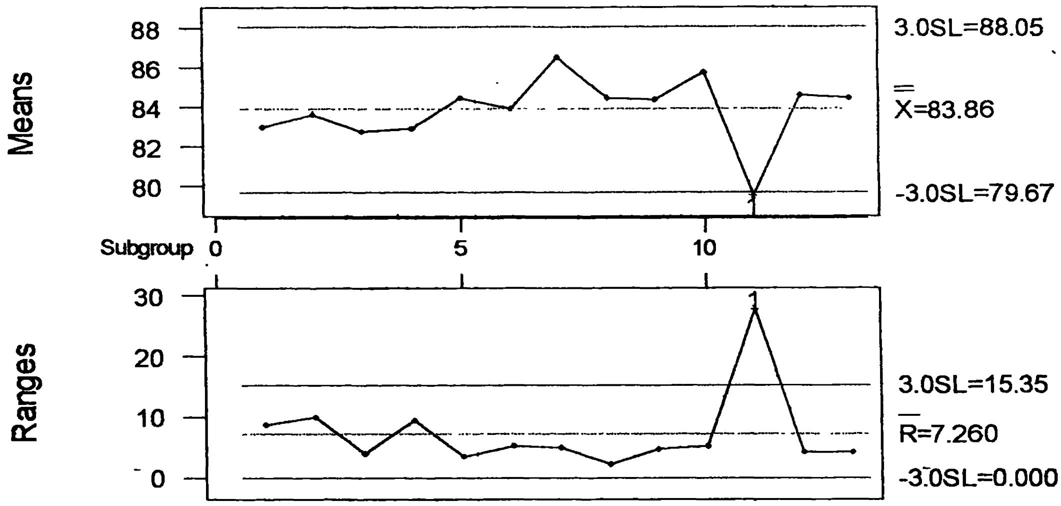


Figure 4. 6 X bar / R chart 4

In Figure 4.7

Downward trend from point 2 to point 7 was observed (Appendix vi).

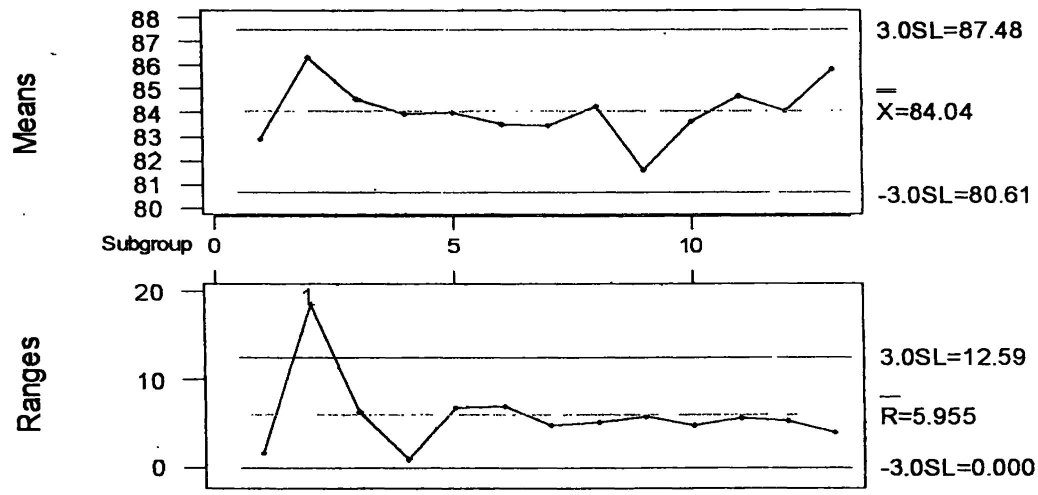


Figure 4. 7 X bar / R chart 5

Figure 4.8 show downward trend from point 2 to point 7 in X bar chart (Appendix vii).

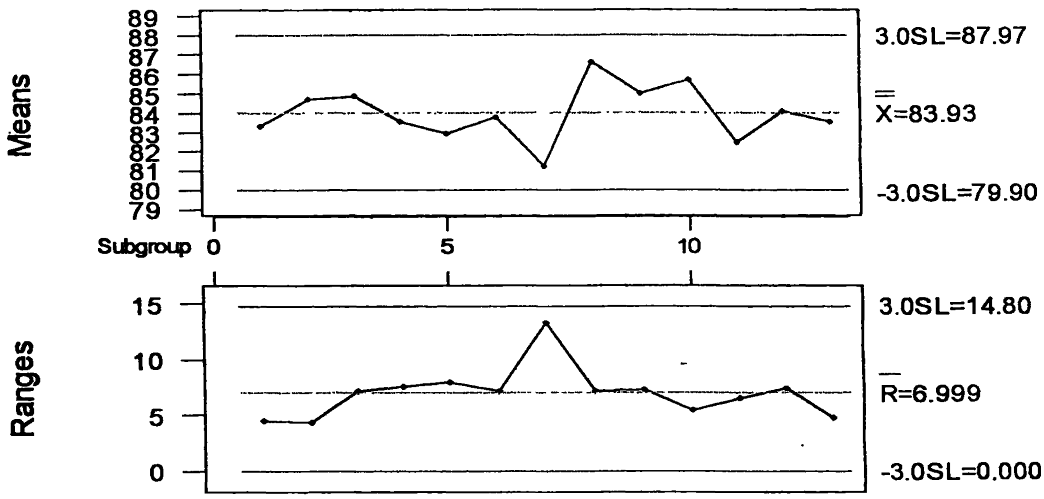


Figure 4.8 X bar / R chart 6

Figure 4.9 average chart show reoccurring cycles (Appendix viii).

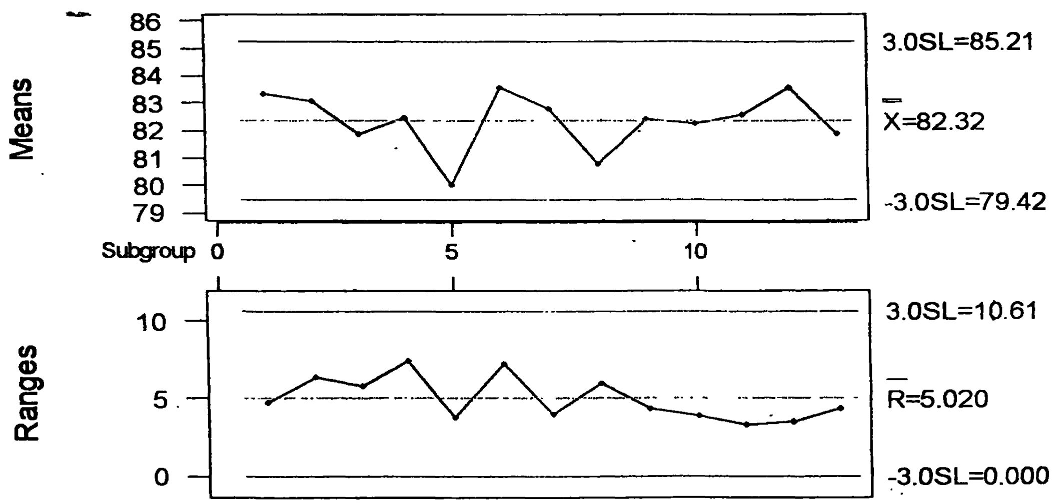


Figure 4.9 X bar / R chart 7

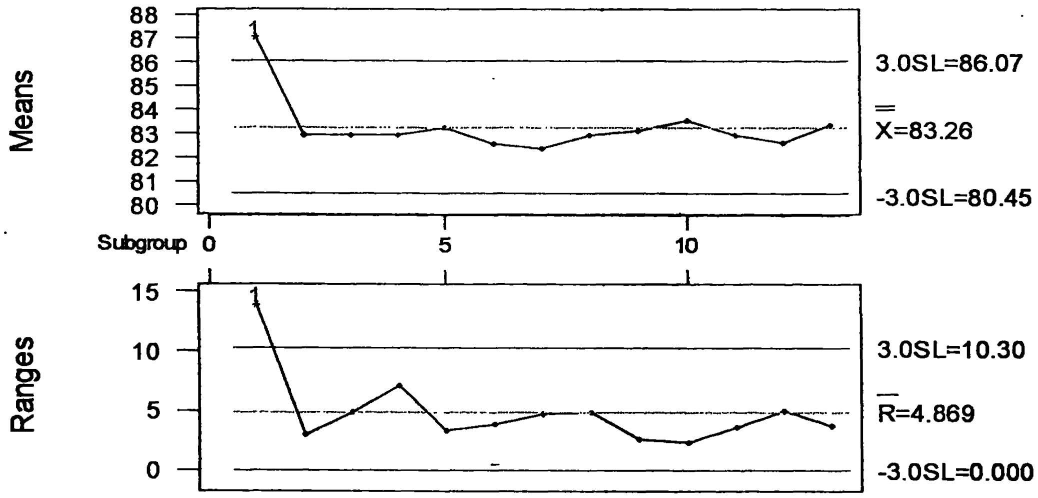


Figure 4.10 X bar / R chart 8

Figure 4.10 show average values do not exhibit large deviation from the grand average (Appendix ix).

All the above characteristics considered about the charts were variations in the process. The variation identified in the process line were mainly external variations. They were machinery problems, equipment breakdown and problems associated with operators such as carelessness, inexperience and poor attitudes. Frying in an oil bath where temperature maintained at 155°c is essential in instant noodle production. In the present production process the temperature was maintained manually by operators. This lead over frying and under frying of the product.

The fried noodles pieces were arranged in to another direction by operators after cooling (Figure 4.11). At this time significant amount of noodles fragments was broken and it lead to the weight loss.

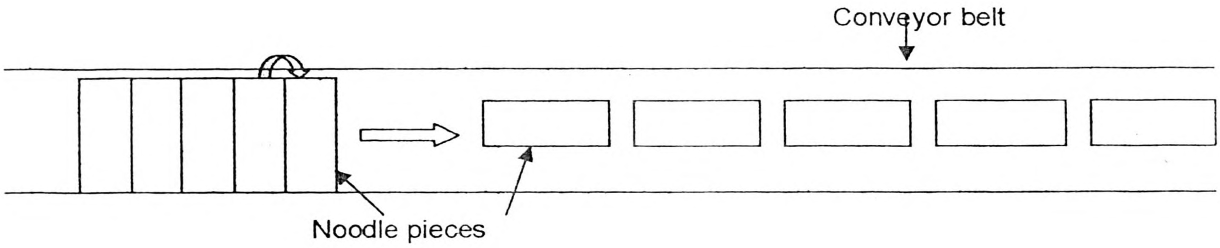


Figure 4.11 Rearrangement of noodle pieces.

When consider about the row materials wheat flour is the major ingredient of noodles. For the production of noodles hard wheat flour with high gluten content is suitable. Because the amount of gluten is responsible for the dough properties. Dough stretchability and sheeting ability without breakage is very essential in this production. But due to some reasons such as variety, seasonal variations and chemical composition of the wheat flour gluten content may change.

This may lead to break down of noodles pieces during processing. This inherent causes may also lead to weight changes which was not identified in the present study.

When consider about machines, the conveyer belts were not adjusted to same levels as shown in the Figure 4.12. Hence sometimes small pieces of noodles were broken and removed form the piece.

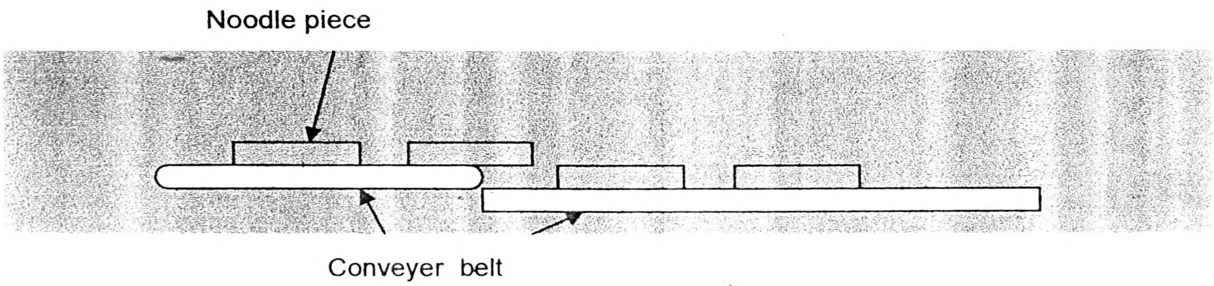


Figure 4.12 Conveyer belts

Before pack the noodles pieces, seasoning packets were inserted into it. The weights of these seasoning packets were not uniform and it was one of the causes for weight changes. The variations of a production process may occur due to either inherent (natural) variations or external (Unnatural) variations. External variations occur due to assignable cause such as causes systematically entering the process, causes suddenly entering the process and changes in environment. The four factors responsible for causing these variations are man, machine, method and material. When consider about all the above factors final product weight can not maintain within upper and lower control limit. This condition can see in the above charts.

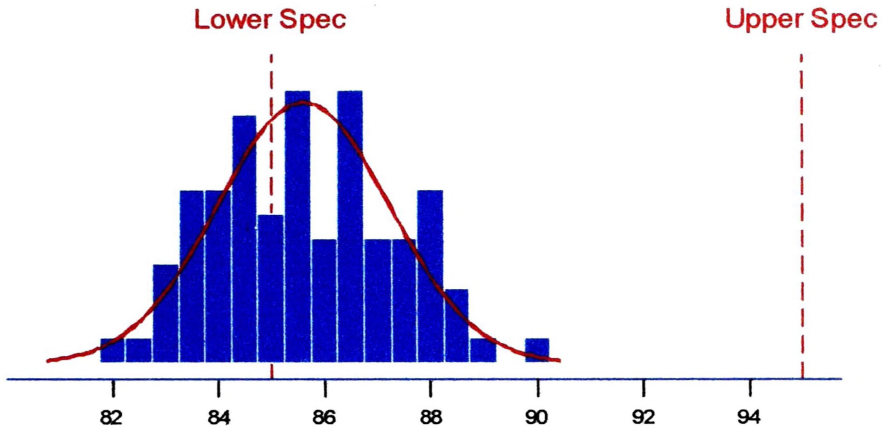
4.4 Determination of process capability at Place 2

Capability Index (C_p) = (USL-LSL) / 6σ

For a capable process C_p value must be greater than 1.33. According to the Figure 4.2 the C_p value was 1.10 and process is just capable. As a result of this process variation can be taken place.

Considering the entire above reasons final packaging place has significant amount of assignable causes and random causes. To maintain and improve the product quality it must be maintained at initial stage. Therefore the readings (weight) were taken from Place 1 where noodles strands cut in to desired size.

At this place upper and lower specification limits were 85-95 respectively. According to Figure 4.13 process capability analysis can see C_p value as 1.03 and standard deviation is 1.61. Under this circumstance control charts can obtain from this place. Because of why this place (Place 2) is medium capable and the standard deviation somewhat lower than previous place process capability analysis (Appendix x).



Cp	1.03	Targ	*	Mean	85.6124	%>USL Exp	0.00	PPM>USL Exp	0
CPU	1.94	USL	95.0000	Mean+3s	90.4605	Obs	0.00	Obs	0
CPL	0.13	LSL	85.0000	Mean-3s	80.7642	%<LSL Exp	35.24	PPM<LSL Exp	352374
Cpk	0.13	k	0.8775	s	1.6161	Obs	41.18	Obs	411765
Cpm	*	n	85.0000						

Figure 4.13 Process capability analysis at Place 2

After cutting weight at Place 2 should be 90g or more to achieve final weight of 85g (packet weight). Frying in oil medium was the cause to remove considerable amount of water and furthermore when noodles pass through machines it was observed that the fragments were broken. As a result weight loss occur.

In above charts (Figure 4.3 to Figure 4.10) there was a big variation from the grand average. In range charts range was very much higher and it's average also higher than other values. To achieve quality control this kind of variations must be eliminated from the production line.

4.5 Constructing control charts at Place 2

In noodles processing one dough sheet was divided into 5 sections as shown in Figure 4.14. To identify the variations within the five lines control charts were plotted separately for each line.

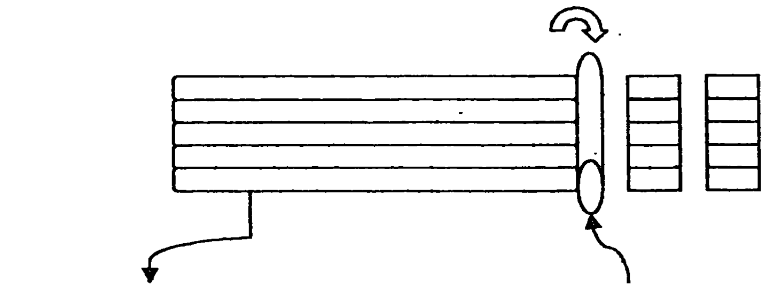


Figure 4.14 Dough sheet, which divide into 5 sections

Line 1

In Figure 4.15 all the points occur within the control limits. There was a recurring cycle at range chart. At subgroup number five range was near to the grand average. Then 15 min later range reached to one and within another 15 min range was very high. That means the standard deviation was high. Average of the point 7 reached to the upper control limit. It was an abnormal condition and process was not functioned properly.

For this there may be some reasons;

Due to changes in dough sheet thickness weight one strand may increase resulting increase weight of whole noodle piece.

The periodic rotation of operators or machines.

Frequent adjustments in settings.

X bar and R chart 1.1

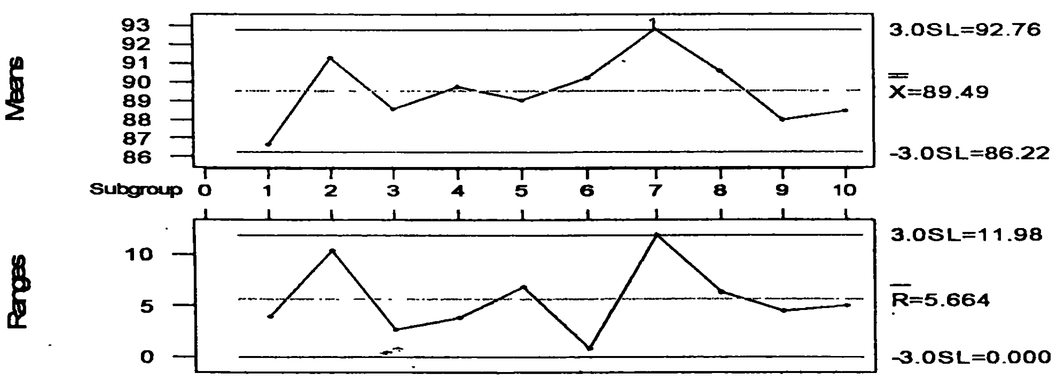


Figure 4.15 X bar / R chart for Line I (Before)

After applying some preventive measures to reduce above abnormal conditions Figure 4.16 shows a considerable reduction in the variation. It's grand average was somewhat higher than the previous day grand average (Appendix xi).

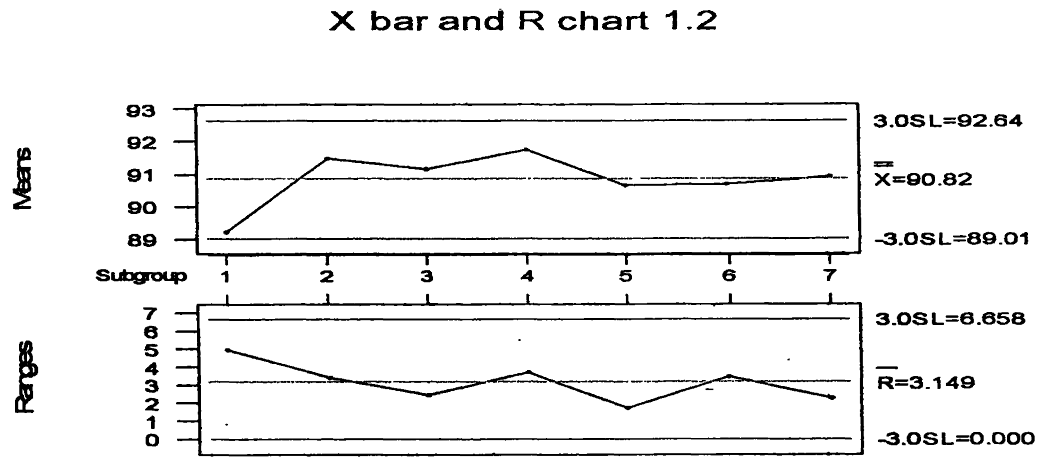


Figure 4.16 X bar / R chart for Line I (After)

In Figure 4.16 mean range was smaller than Figure 4.15 (Appendix xii). As a result of this standard deviation was reduced and controlled the Line 1 to some extent (Table 4.2).

Table 4.2 Summary of grand average and range of the line 1

	Figure 4.15	Figure 4.16
Grand Average	89.49	90.82
Range	5.664	3.149

Line 2

According to Figure 4.17 all the points placed within the lower and upper control limits. But the grand average is below than 90g. The expected weight of 90g or more can be achieved by increasing the number of strands in Line 2 or increasing the weight per strand (Appendix xiii).

X bar and R chart 2.1

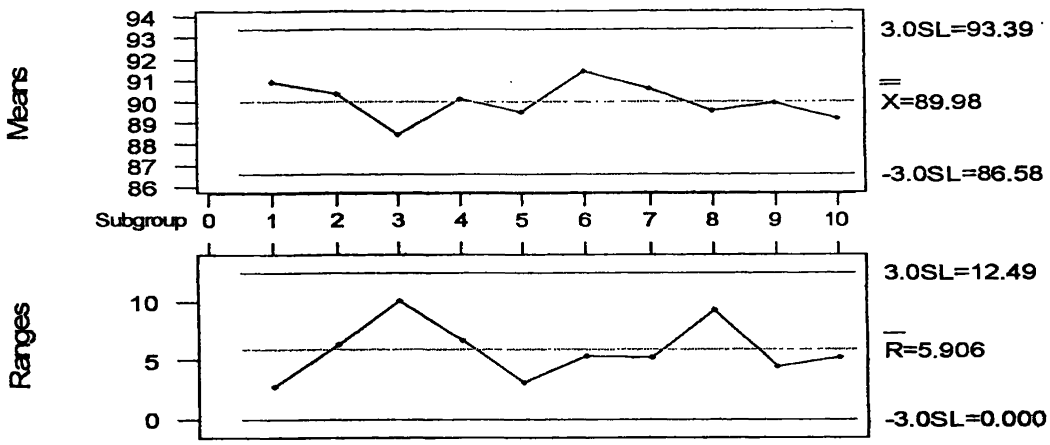


Figure 4.17 X bar / R chart for Line 2 (Before)

According to the Figure 4.18 there was a big variation and downward trend in range chart. This was due to reduction in the amount of strands in one piece or weight per strand in noodle pieces (Appendix xiv).

X bar and R chart 2.2

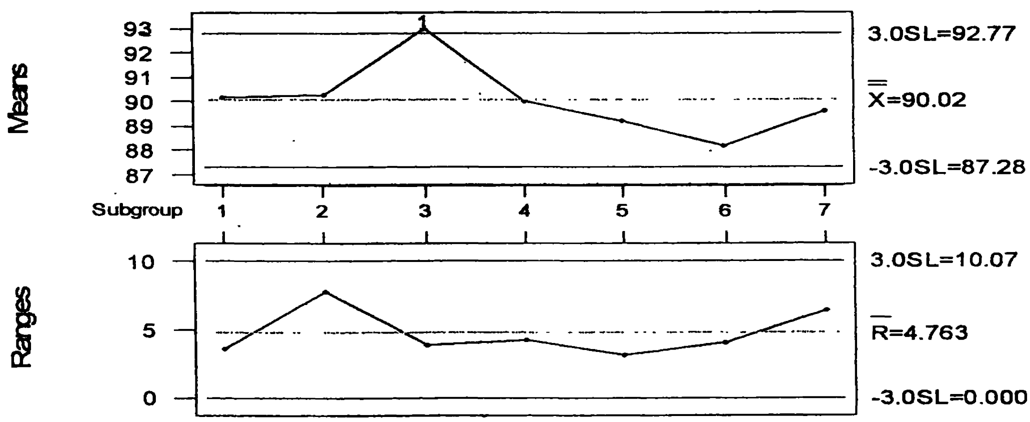


Figure 4.18 X bar / R chart for Line 2 (After)

But in Figure 4.18 average range was 4.763 and in the previous day (Figure 4.17) this value was 5.906. This caused reduction in standard deviation. To prevent this kind of downward trend roller system need to be properly maintained and the dough sheet thickness should be maintained.

Table 4.3 Summary of grand average and range of Line 2

	Figure 4.17	Figure 4.18
Grand Average	89.98	90.02
Range	5.906	4.763

Line 03

In Figure 4.19 there was a upward trend and downward trend. This may be due to changes in the raw material (wheat flour) and the periodic rotation of operators (Appendix xv).

To prevent this it is necessary to take wheat flour which is suitable for noodles production. It is necessary to check the composition of the wheat flour because dough properties affect the weight and if gluten content changes it also change the weight of the dough. If material composition changes process is unable to produce desired product even if other factors (operators and machines) are capable to perform their duty.

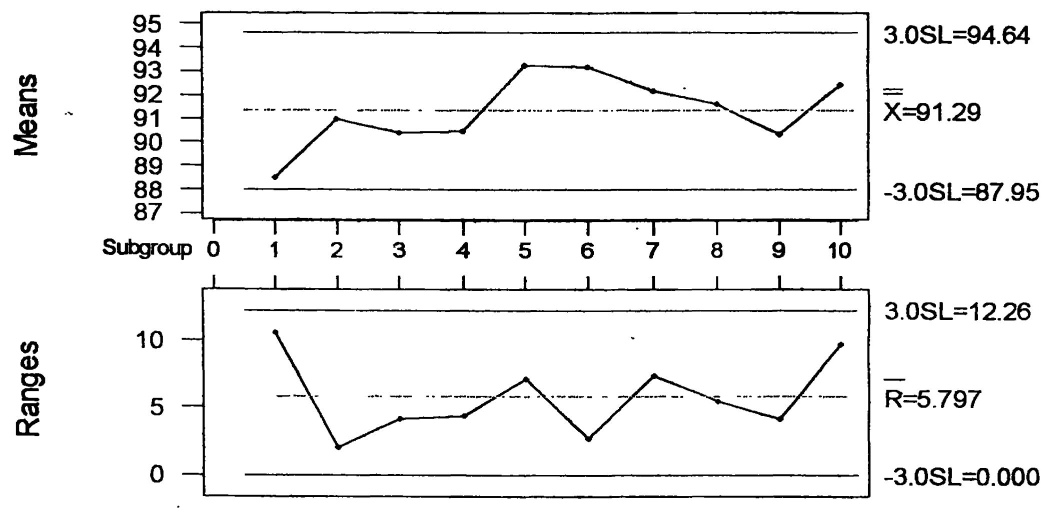


Figure 4.19 X bar / R chart for Line 3 (Before)

According to the Figure 4.20 it's grand average was lower than previous day readings (Appendix xvi). This was due to slitter cutter adjustments, because this line had the lowest amount of noodle strands. To prevent this amount of noodle strands per piece must be increased.

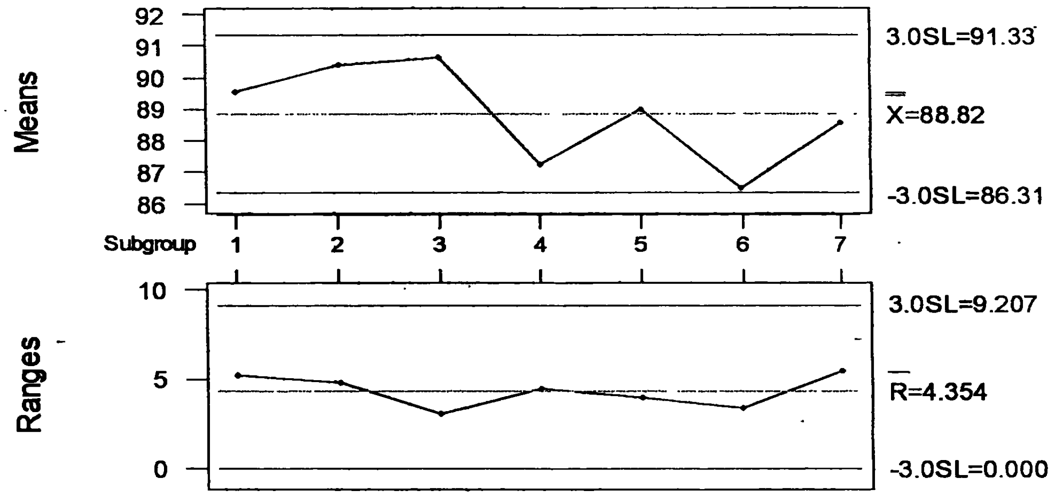


Figure 4.20 X bar / R chart for Line 3 (After)

Table 4.4 Summary of grand average and range of the Line 3

	Figure 4.19	Figure 4.20
Grand Average	91.29	88.82
Range	5.797	4.354

Line 04

According to the Figure 4.21 from sub group number 5-10 there was reoccurring cycles in mean chart. It's grand average was 90.25 and the average range was 4.850. At the point 8 in range chart range was lower than R bar. But the average (X bar) of this subgroup was small. After 15 min this value was increased more than 91 and range was also increased(Appendix xvii).

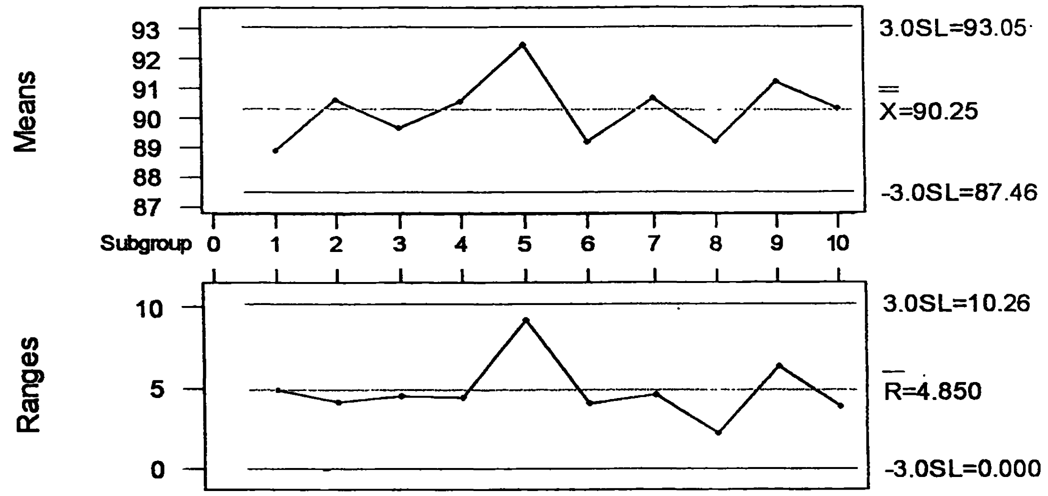


Figure 4.21 X bar / R chart for line 4 (Before)

This was due to gradual incensement of dough thickness in one side of the dough sheet and maintaining the thickness for in next 15 min.

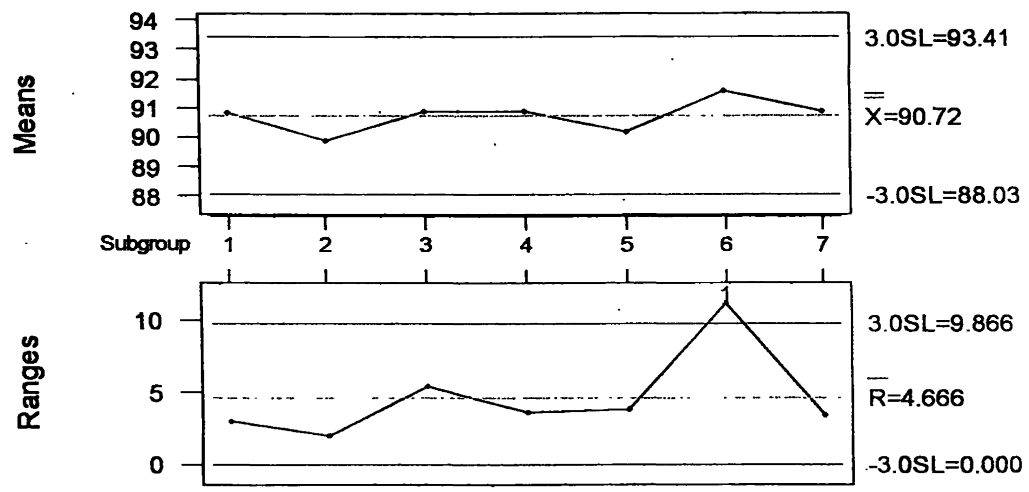


Figure 4.22 X bar / R chart for Line 4 (After)

In Figure 4.22 grand average was 90.72 and range was 4.67. But the variation was less. This was duet to quality improvement after applying some preventive measures (Appendix xviii).

Table 4.5 Summary of grand average and range of the Line 4

	Figure 4.21	Figure 4.22
Grand Average	90.25	90.72
Range	4.850	4.67

Line 05

According to the Figure 4.23 there was a upward trend. In range chart range was somewhat higher at subgroup number 2. After that range was gradually reduced closer near to the central line Range values were maintained within the control limits. But in X bar chart there was upward trend(Appendix xix). This was due to changes in the noodles during steaming and gradual incensement in dough thickness. That means changes took place in roller settings.

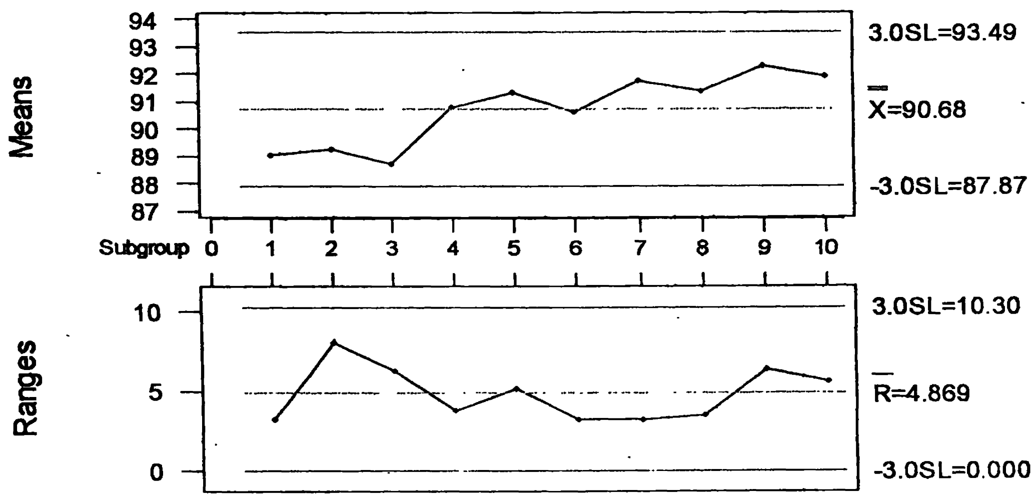


Figure 4.23 X bar / R chart for Line 5 (Before)

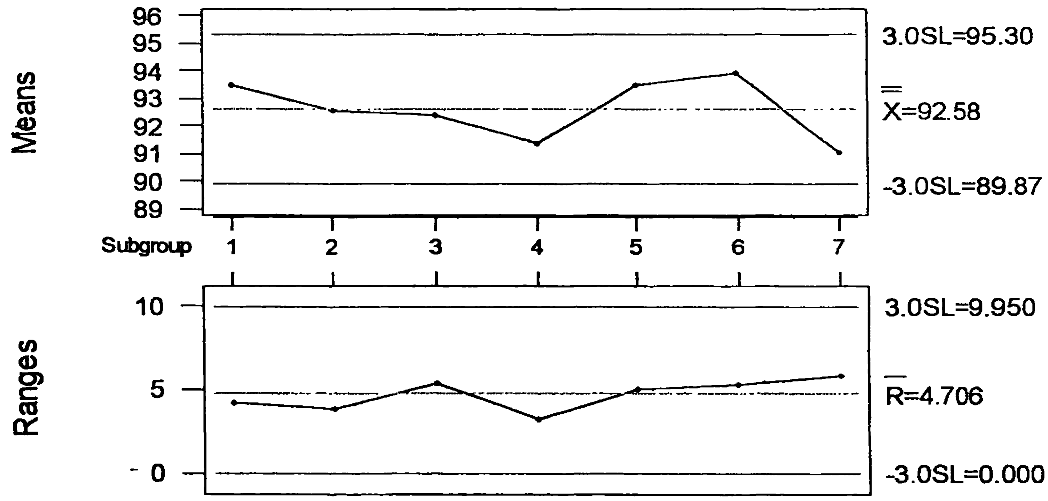


Figure 4.24 X bar / R chart for Line 5 (After)

To prevent this kind of changes it was suggested to maintain the roller system in a correct way.

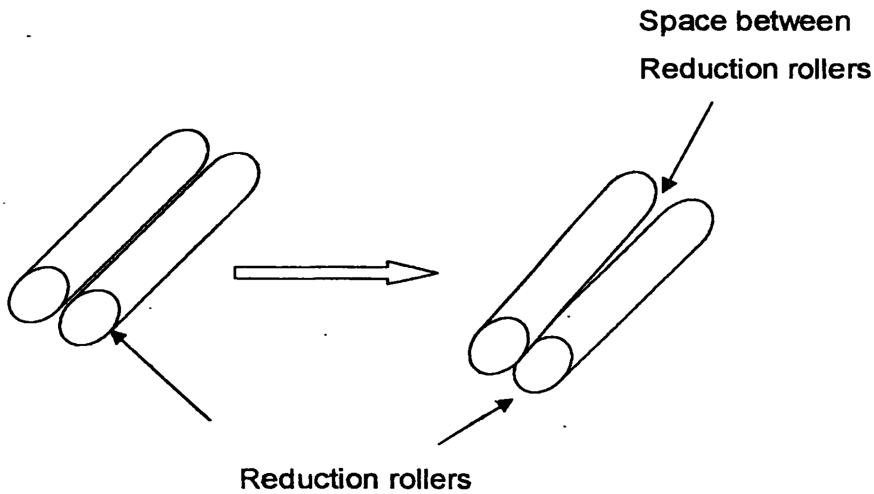


Figure 4.25 Reduction rollers

According to the Figure 4.24 in average chart grand average was better than previous day value. But the average range was not changed. According to X bar chart there were variations in subgroup number 4, 6 and 7. When consider about grand average it was 92.58 (Appendix xx). This was a better condition and indicated that the quality level improvement.

Table 4.6 Summary of grand average and range of the Line 5

	Figure 4.23	Figure 4.24
Grand Average	90.68	92.58
Range	4.869	4.706

According to the instant noodles processing line slitter cutter is the responsible part for cutting the dough in to strands and after that it divides into 5 sections (Lines). The amount of strands per line can be changed adjusting the position of dividers. If one line changes other Line also changed according to that.

When consider about above reasons need to identify the amount of strands in one noodle piece and the weight of randomly selected noodles strands. Table 4.7 shows how the weight changes of piece, number of strands,-weight per strand and average weight of a strand for all 5 Lines.

Table 4.7 Weight changes from Line 1 to Line 5

Line number	Weight (g) of a piece	Number of strand	Weight per strand	Ave weight of strand
1	90.36	72	1.06, 1.20, 1.22, 1.20	1.17
1	93.68	72	1.16, 1.24, 1.22, 1.20	1.20
1	89.42	73	1.18, 1.12, 1.10, 1.16	1.14
1	90.82	72	1.22, 1.22, 1.14,1.10	1.17
2	84.94	68	1.1, 1.10, 1.12, 1.08	1.10
2	87.66	69	1.02, 1.18, 1.24, 1.22	1.16
2	91.52	69	1.34, 1.30, 1.34, 1.32	1.32
2	92.18	69	1.34, 1.34, 1.36, 1.36	1.35
3	83.24	67	1.16, 1.20, 1.22, 1.20	1.14
3	86.80	67	1.30, 1.36, 1.26, 1.22	1.29
3	88.10	67	1.30, 1.28, 1.24, 1.36	1.29
3	86.28	67	1.36, 1.26, 1.26, 1.36	1.31
4	86.92	67	1.24, 1.12, 1.16, 1.20	1.18
4	88.2	66	1.16, 1.14, 1.12, 1.10	1.13
4	92.68	71	1.30, 1.26, 1.30, 1.28	1.28
4	88.18	71	1.16, 1.14, 1.16, 1.18	1.16
5	88.16	71	1.18, 1.18, 1.16, 1.12	1.16
5	85.68	68	1.22, 1.10, 1 18,1.16	1.16

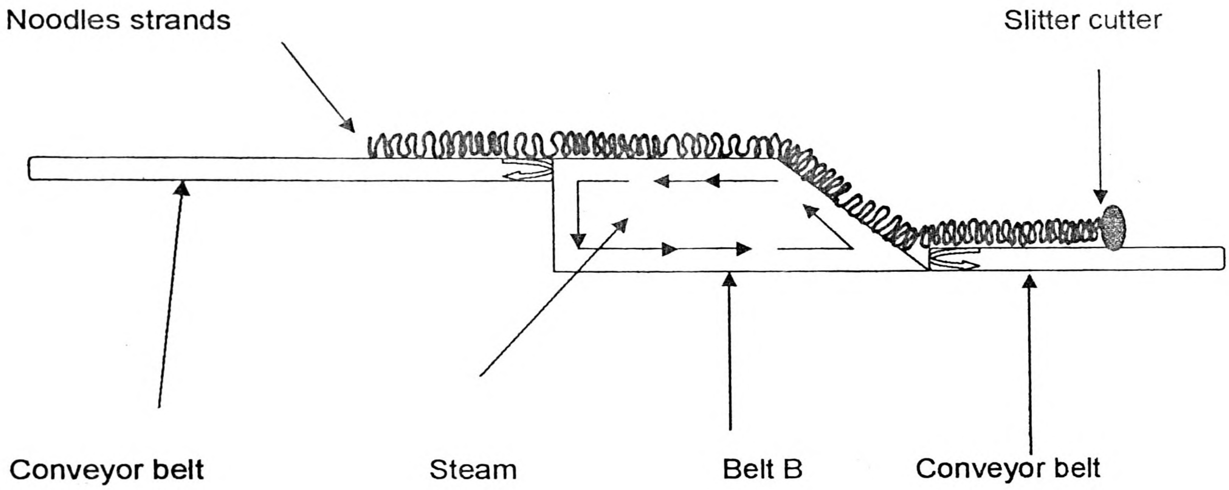


Figure 4.26 Conveyor belt A and B

As shown Figure 4.26 the noodles strands coming along the conveyor belt after separating in to five Lines pass into the another conveyer belt B which goes through steam. When noodles strands were dropped in to this belt B some strands were too closer to each other and some were not. Due to this there was no even distribution of strands in noodles pieces. The reason for this was the differences in the speed of two conveyor belts (A and B). If these conveyor belt move at same speed this kind of changes does not occur.

CHAPTER 05

Conclusion

5.1 Conclusion

Both random and assignable causes affect to the production process. Problem associated with machine and involvement of inexperienced operators were the governing factors for the weight changes in finished product.

Application of preventive action at initial stage of processing line was effective in minimizing defects.

5.2 Recommendation

Machines (Fryer and Reduction rollers) involve in the instant noodles manufacturing process need to maintain by skilled persons as well as need to determine machine capability during predetermine time intervals.

Need to identify the weight changes take place when noodle pieces pass through oil bath (fryer). Further studies should be carried out to find oil absorbance by noodle pieces. Then need to check relationship between oil absorbance and weight of the noodle piece.

REFERENCES

Anon, (1996) Capability analysis: Total quality tools, (1st edn.), PQ systems Inc., pp 58-101.

Arnold, L.K. and Holler (1998) Quality assurance for food industry, (2nd edn.), CTI publishers Co,...Inc., pp. 546-548.

Blanton, A.O., and Juran, J.M.,(2000) Statistical Process Control: Juran's Quality Handbook, (5th Ed.), Mcgrow-hill international edition, pp.568-628.

Caplen,R.H., (1988) Statistical Process Control: A Practical Approach to Quality Control, (5th edn.), Random century New Zealand limited, pp.141-201.

Catharina, Y.W., Keshun, L. and Huwang, Y.W.,(copyright 1999) Wheat Products: Asian Food Science and Technology,(1999), Technomic publishing Co,...Inc., pp. 48-66.

George, C.R. (2002) Assignable Causes and Autocorrelation: Control Carts for Observation or Residuals.J.Quality Technology,v.34,pp.1268-1269.

Gupta,R.C., (1996) Statistical Quality Control,(4th edn.),Khanna publishers,pp. 1-1413.

Hoseney,R.C., (1998) Pasta and Noodle Snacks: Principles of Cereal Science and Technology,(2nd edn.),American association of cereal scince chemist.Inc.,pp. 285-290.

Juran, J.M. and Frank, M.G.(1988) Jurans Quality Control Handbook,(4th edn.), Donnelly and sons, chapter. 24.12-24.36.

Kolarik, W.J., (1995) Creating Quality Concepts, Systems, Strategies and Tools, Mcgrow- hill International edition, pp.389-402.

Krishnamoorthi, K.S. (1989) Quality Control for Operators and Foremen, ASQ quality Press, pp.17-20.

Maynard, H.B. (1971) Process Chart Procedures: Industrial Engineering Handbook, (3rd edn.),The maple press company, pp.13-92.

Mercier, C. and Cantarelli, C. (1986) Instant Noodle Snacks: Pasta and Extrusion Cooked Foods, Elsevier applied science publishers, pp.98-105.

Mortimore, S. and Wallace, C. (1998) How to do a HACCP study: HACCP a Practical Approach, (2nd edn.), Aspen publishers,pp.191-192

Sedrick, S.,Teraria, K.,Troha, K. and kiby, W. (1996) www.continous quality improvement .Hanford.com.

Wilbour, A.G. and Roland, W.G. (1993) Total Quality Assurance for Food Industry, (2nd ed.),CTI publishers,pp.25-90.

Anonymous, 1988.ISO guide 2, general terms and their definitions concerning standardization and certification. Sri Lanka Standard Institution.

Anonymous,1989.specification for pasta products. Sri Lanka Standard Institution.

APPENDIX

Appendix i

Process capability at Place 1

Sub group number	Observations (Weight g)				
	1	2	3	4	5
1	85.36	84.88	82.10	82.74	83.20
2	86.28	88.26	86.52	87.78	87.28
3	86.58	84.26	84.72	86.98	85.86
4	87.76	89.92.	87.14	82.96	83.66
5	86.52	84.82	84.44	84.78	86.04
6	82.94	84.92	82.28	85.36	84.06
7	85.82	83.74	82.30	81.98	83.76
8	84.16	86.32	83.74	83.96	83.56
9	83.30	87.70	86.98	86.82	87.06
10	85.18	80.42	83.98	80.76	85.46
11	83.68	86.46	86.54	83.22	83.50
12	87.92	85.76	85.46	84.74	87.74
13	87.90	85.60	83.08	84.54	83.16
14	83.08	86.58	86.74	88.22	87.14
15	85.26	82.94	83.66	87.68	82.86
16	85.48	87.68	84.50	83.48	83.32
17	86.28	88.76	82.30	88.82	

Appendix ii

Sub group Number	Observations (Weight g)				
	1	2	3	4	5
1	81.10	79.98	79.52	82.91	79.78
2	83.38	80.82	81.94	82.28	88.62
3	84.52	86.12	83.96	83.92	84.58
4	89.12	87.16	86.48	87.60	89.14
5	84.12	80.55	84.76	79.38	83.94
6	84.78	8.2.84	79.66	79.84	83.64
7	81.84	84.62	84.16	85.22	84.18
8	83.96	85.68	83.04	85.02	82.92
9	85.32	82.34	86.40	84.76	83.78
10	85.82	89.26	85.46	84.66	86.42
11	85.06	84.30	84.02	87.26	8.92
12	90.06	86.16	85.02	82.54	84.04
13	85.06	84.36	82.90	87.86	82.72

Appendix iii

Sub group Number	Observations (Weight g)				
	1	2	3	4	5
1	84.80	82.40	84.36	81.20	84.66
2	86.22	84.01	84.58	83.22	78.96
3	80.78	82.10	80.42	81.32	80.41
4	84.64	84.22	78.42	84.96	84.85
5	88.68	85.98	85.32	79.21	84.88
6	82.24	81.64	87.08	82.38	84.04
7	81.65	81.36	86.02	83.78	83.84
8	82.32	85.58	88.78	82.46	79.80
9	86.28	84.06	80.00	82.28	83.48
10	80.82	83.42	81.88	82.05	80.34
11	88.28	86.58	83.33	83.28	82.28
12	83.84	83.70	82.38	83.65	79.68
13	83.98	86.61	83.56	87.86	83.44

Appendix iv

Sub group Number	Observations (Weight g)				
	1	2	3	4	5
1	82.84	80.65	85.58	79.58	86.38
2	82.02	85.24	86.66	83.28	86.52
3	82.46	81.66	81.04	89.56	80.80
4	78.92	84.82	88.92	82.38	8490
5	85.06	86.82	81.52	82.16	82.14
6	80.56	88.96	83.20	80.54	87.84
7	83.62	83.62	85.68	90.82	82.20
8	88.28	82.16	82.24	83.86	83.78
9	90.66	86.66	86.18	86.36	85.76
10	84.86	85.16	85.52	88.86	88.60
11	87.48	82.10	84.56	85.25	82.34
12	83.16	81.96	82.00	81.10	82.11
13	82.52	83.24	81.98	83.09	82.08

Appendix v

Sub group Number	Observations (Weight g)				
	1	2	3	4	5
1	84.02	78.04	83.26	86.84	82.68
2	85.18	83.56	84.54	87.42	77.34
3	81.74	85.26	83.16	81.36	82.32
4	87.52	83.84	78.04	82.06	83.00
5	83.54	85.58	85.12	85.62	82.14
6	86.90	83.90	83.40	85.96	81.66
7	84.36	89.34	85.34	85.16	86.12
8	84.56	83.36	85.52	82.78	84.78
9	85.08	84.12	85.96	86.64	85.32
10	89.22	85.38	85.61	86.48	84.00
11	85.18	85.90	82.78	78.04	86.80
12	84.40	82.38	86.64	85.12	84.44
13	83.62	84.64	86.48	83.40	82.42

Appendix vi

Sub group Number	Observations (Weight g)				
	1	2	3	4	5
1	82.02	82.62	83.10	83.64	83.12
2	85.28	87.58	79.46	87.82	78.84
3	84.56	83.84	85.46	83.84	81.18
4	83.22	85.80	84.26	84.42	84.28
5	81.92	84.64	79.29	79.92	86.72
6	80.72	86.16	87.82	87.82	82.46
7	81.56	83.98	81.28	81.28	83.90
8	83.32	82.58	86.58	86.58	81.34
9	83.76	84.24	81.98	81.98	81.40
10	84.02	87.68	85.02	85.02	84.48
11	84.87	87.12	83.16	83.16	82.04
12	86.96	80.72	82.56	82.56	84.14
13	86.12	79.16	87.48	87.48	83.46

Appendix vii

Sub group Number	Observations (Weight g)				
	1	2	3	4	5
1	83.36	82.26	81.16	83.76	85.94
2	80.24	83.72	80.94	83.86	86.16
3	81.62	80.90	82.18	79.38	85.18
4	82.02	79.54	86.98	80.62	83.12
5	78.10	80.82	81.94	80.72	78.30
6	84.46	86.62	79.31	86.62	80.60
7	82.32	83.38	84.26	80.26	83.06
8	82.68	84.36	76.232	78.34	79.90
9	80.88	85.28	81.74	81.16	82.90
10	80.84	81.54	84.78	81.16	82.72
11	82.68	81.18	82.94	81.32	84.52
12	84.04	84.68	84.42	83.48	81.10
13	83.54	79.12	79.80	83.45	83.26

Appendix viii

Sub group Number	Observations (Weight g)				
	1	2	3	4	5
1	84.08	84.98	80.14	84.54	82.32
2	86.82	82.24	85.50	85.30	83.48
3	79.88	87.12	85.88	85.35	85.68
4	78.88	86.04	86.46	82.46	83.16
5	78.46	82.06	86.40	82.42	85.08
6	81.46	81.84	83.74	82.80	88.72
7	78.06	86.94	83.78	83.44	73.06
8	90.16	89.20	87.20	82.64	83.86
9	82.64	89.34	82.06	84.84	85.88
10	83.16	85.28	88.60	85.96	84.92
11	81.16	77.98	84.56	84.24	83.90
12	82.34	85.92	79.86	85.20	87.10
13	86.68	82.96	81.90	82.80	83.24

Appendix ix

Sub group Number	Observations (Weight g)				
	1	2	3	4	5
1	84.86	83.84	79.78	84.36	84.36
2	81.82	83.24	81.48	84.24	84.24
3	84.19	80.48	85.38	81.88	81.88
4	82.86	82.16	83.04	79.74	86.88
5	81.38	83.76	83.32	82.99	84.76
6	80.48	82.48	81.88	84.38	83.48
7	84.24	79.54	83.38	83.22	81.34
8	81.00	84.24	84.12	85.02	80.16
9	84.58	82.22	8232	82.86	83.28
10	84.16	84.56	83.38	82.94	82.16
11	82.70	85.20	83.18	81.34	82.41
12	79.84	84.25	83.64	83.00	82.34
13	83.36	84.60	81.62	80.88	83.28

Appendix x
Process capability at place 2

Sub group number	Observations (Weight g)				
	1	2	3	4	5
1	85.36	84.88	87.10	84.47	85.32
2	86.28	88.26	86.52	87.78	87.28
3	86.58	84.26	84.72	86.98	85.86
4	87.76	89.9	87.14	84.69	85.66
5	86.52	84.82	84.44	84.78	86.04
6	83.94	84.92	86.28	85.36	84.06
7	85.82	83.74	84.30	81.98	83.76
8	84.16	86.32	83.74	83.96	83.56
9	83.30	87.70	86.98	87.96	87.06
10	85.18	83.42	83.98	85.76	85.46
11	84.68	86.46	86.54	83.22	85.50
12	87.92	85.76	85.46	84.74	87.74
13	87.90	85.60	83.08	84.54	88.16
14	83.08	86.58	86.74	88.22	87.14
15	85.26	83.94.	83.66	87.68	84.86
16	85.48	88.68	84.50	83.48	85.32
17	86.28	88.76	82.30	88.82	83.12

Appendix xi

Sub group number	Observation (Weight g)				
	1	2	3	4	5
1	84.92	88.72	84.76	87.46	87.27
2	87.78	91.04	98.18	87.74	91.48
3	87.30	89.44	89.90	87.22	88.62
4	90.50	91.84	90.26	87.96	87.98
5	88.06	87.88	93.64	88.54	86.78
6	89.96	90.64	89.76	90.40	90.10
7	87.06	95.06	90.38	92.38	99.02
8	88.32	92.30	90.34	87.70	94.04
9	86.64	86.18	86.22	89.68	90.72
10	88.98	88.10	85.54	90.64	88.84

Appendix xii

Sub group number	Observation (Weight g)				
	1	2	3	4	5
1	89.02	86.52	91.52	89.26	89.66
2	93.40	92.02	90.01	91.82	90.20
3	92.48	91.34	90.20	90.03	91.46
4	93.94	90.62	92.66	90.22	91.26
5	91.54	89.80	90.54	90.44	90.44
6	89.84	89.52	93.00	89.84	91.20
7	92.10	91.10	89.58	90.45	91.06

Appendix xiii

Sub group number	Observation (Weight g)				
	1	2	3	4	5
1	89.92	91.56	92.76	90.00	90.34
2	87.06	93.46	90.56	90.02	90.62
3	91.02	87.14	88.48	82.52	92.68
4	86.40	89.44	89.46	93.18	91.84
5	89.52	90.32	88.58	87.94	91.10
6	93.64	93.58	93.04	88.52	88.28
7	91.22	90.86	87.82	90.08	93.21
8	86.48	87.32	90.62	95.78	87.38
9	89.78	88.70	87.42	91.90	89.52
10	92.32	87.40	89.52	87.04	91.84

Appendix xiv

Sub group number	Observation (Weight g)				
	1	2	3	4	5
1	89.10	92.42	89.32	90.98	88.82
2	90.32	85.82	88.26	92.70	93.66
3	94.20	90.58	91.08	94.48	94.48
4	88.28	91.40	87.44	89.06	92.20
5	89.52	90.46	89.60	89.00	87.32
6	88.70	85.44	89.65	88.28	88.62
7	88.26	88.20	87.12	93.60	90.64

Appendix xv

Sub group number	Observation (Weight g)				
	1	2	3	4	5
1	90.72	80.72	91.30	90.20	89.50
2	92.07	90.04	90.76	89.98	91.48
3	88.40	91.86	90.20	92.18	89.60
4	89.23	90.52	88.28	91.34	92.74
5	95.52	88.64	91.70	95.78	94.62
6	93.20	94.62	91.88	92.50	93.56
7	93.18	93.08	88.16	95.60	90.66
8	90.54	94.00	91.22	88.50	93.48
9	91.80	87.72	91.86	90.36	89.78
10	90.38	91.98	89.78	91.72	89.02

Appendix xvi

Sub group number	Observation (Weight g)				
	1	2	3	4	5
1	90.28	86.77	91.48	90.64	89.04
2	89.04	92.06	91.41	92.26	87.54
3	90.60	90.88	89.90	92.44	89.40
4	86.10	84.42	88.36	89.38	87.32
5	90.78	90.00	86.86	88.76	88.28
6	88.12	88.28	85.48	85.64	84.88
7	85.74	88.78	91.24	89.16	87.74

Appendix xvii

Sub group number	Observation (Weight g)				
	1	2	3	4	5
1	86.00	89.00	89.44	90.88	89.06
2	92.64	88.48	90.92	92.42	89.18
3	91.08	87.32	91.00	87.12	91.68
4	89.72	90.52	88.28	91.34	92.74
5	89.54	91.20	89.82	89.58	93.08
6	88.44	88.42	87.98	88.90	9202
7	89.64	92.46	89.22	93.22	88.62
8	90.30	88.08	90.00	88.78	88.70
9	91.58	88.20	94.58	91.04	90.30
10	91.54	87.62	91.34	90.36	90.32

Appendix xviii

Sub group number	Observation (Weight g)				
	1	2	3	4	5
1	91.70	91.30	91.28	91.20	88.64
2	90.56	88.68	90.08	89.92	90.09
3	93.62	91.70	92.64	88.64	88.41
4	89.50	91.88	92.56	88.92	91.44
5	88.92	92.58	89.18	88.78	91.42
6	90.40	87.28	89.50	89.54	92.50
7	90.78	89.68	90.50	93.12	90.36

Appendix xix

Sub group number	Observation (Weight g)				
	1	2	3	4	5
1	90.70	89.72	89.58	87.62	87.42
2	89.12	90.40	84.66	89.30	92.76
3	90.68	84.48	89.62	90.32	87.78
4	92.16	91.60	90.32	91.34	88.40
5	90.00	93.06	91.60	88.44	92.46
6	91.30	92.50	89.28	90.36	89.36
7	90.12	91.34	91.32	92.42	93.40
8	90.08	89.80	90.84	93.38	91.90
9	93.00	91.90	92.18	95.34	88.96
10	93.14	89.38	93.38	94.38	88.69

Appendix xx

Sub group number	Observation (Weight g)				
	1	2	3	4	5
1	91.28	95.52	93.02	92.26	95.30
2	92.84	93.66	93.16	92.82	89.78
3	92.94	91.06	93.80	95.20	89.60
4	90.88	92.18	89.34	91.74	92.60
5	93.58	95.06	90.54	92.52	95.06
6	90.86	93.76	95.76	96.14	93.00
7	90.38	91.28	94.22	90.78	88.42