Moisture Content Control During Cattle Feed Production -An Spc Based Approach

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Abstract: **Excess moisture content in cattle feed adversely affects its storability, microbiological stability, nutritional value etc. Since moisture content directly affects nutrient concentration and money value per ton, a producer must contain the moisture in order to properly compare the feeds when buying and selling. One of the best technical tools for improving product and service quality is Statistical Process Control. The present study uses control charts to check whether the process is in control or not. A Cause and effect diagram is used to identify the root causes of the problem. The present study proposes solution techniques to eliminate the identified root causes.**

Keywords: **Control chart, Pareto diagram, Cause and effect diagram, Statistical Process control**

I. INTRODUCTION

The manufacturing industries have gone through significant changes in the last decade. New firms in markets have increased the competition dramatically. Most of them focus on product quality, production time and cost of the product. Because of these, a company should introduce a quality system to improve and increase both quality and productivity continuously. One of the best technical tools for improving product and service quality is Statistical Process Control (SPC).

SPC tools are used most frequently because they identify quality problems during the production process. One reason offered to explain the prominence of SPC is the positive impact that the deployment of SPC has on quality and costs. Once effectively deployed, SPC would induce operational and financial benefits. It helps to identify a change or variation in some quality characteristic of the product or process. Variation in the production process leads to quality defects and lack of product consistency. Chance causes of variation are based on random causes that cannot be identified. These types of variation are unavoidable and are due to slight differences in processing. Assignable causes of variations involve variations where the causes can be precisely identified and eliminated. If the problem is allowed to persist, it will continue to create a problem in the quality of the product.

SPC constitutes a set of statistical and cognitive problem solving techniques whose effective applications to manufacturing processes effect improvements in quality. Ever since W.E. Deming reintroduced SPC to corporate America in the 1980s (Walton, 1986), SPC has been implemented in diverse industries, not only in the US but also by companies around the world. For example, documented evidence of the deployment of SPC has been reported in such manufacturing industries as automotive (Dale and Shaw, 1989), automotive suppliers (Lascelles and Dale, 1988), chain saw (Chen, 1991), chemical (Chaudhry and Higbie, 1989), consumer electronics (Kumar and Gupta, 1993), etc. SPC has even been embraced by service industries, including healthcare (Welsh, 1997), transportation (Benneyan and Chute, 1993), and fast food chains like Kentucky Fried Chicken (Apte and Reynolds, 1995).

For the production of cattle feed a wide range of raw materials are used which is supplied from various parts of the country. The raw materials are divided into main and micro materials according to its quantity used in the production. The main raw materials are de-oiled rice bran, rose bran, jersey, calcite, rice polish, soya husk, coconut cake, coffee husk, rape seed, maize and cotton seed. The micro raw materials are Sodium Bicarbonate, Bentonite, vitamins and trace mineral concentrate. The raw materials are mixed homogenously according to the proportion. To manufacture cattle feed in pellet form, steam at desired temperature from the boiler is mixed with the raw material mixture. The wet mixture is fed to the pellet-mills where the rotors compress the mixture and drive it to a die which is having holes of the diameter of the desired pellet. Blades are employed to cut the pallets at desired length. These pallets are at a high temperature and need to be cooled which is done with the help of a blower. The temperature is reduced to the desired level.

II. PROBLEM DEFINITION

The objective of the study is to control the moisture content in the cattle feed within the predefined limits. As per regulations of livestock feed, moisture content should not be more than 11.5%. Excess moisture content in cattle feed results in serious quality problems. It adversely affects storability, microbiological stability, nutritional value etc. Improperly implemented dairy cattle nutrition programs affect milk production, health and reproductive performance of dairy cows. Because moisture content directly affects nutrient concentration and money value per ton, a producer must correct for moisture in order to properly compare feeds when buying and selling.

III. METHODOLOGY

Moisture content of the product is tested using near infra-red technology in every shift of production. 25 samples are collected and 3 sets of reading are noted from each sample. A Statistical Process Control study is conducted using the collected data. For the SPC study, control chart for variables is selected and the aim is to check whether the process is in control or not. R Chart is used to monitor process variation when the variable of interest is a quantitative measure and $\overline{X}$ chart is used to monitor the mean of a process. These two charts are used to check whether the process is controllable or not. R chart is drawn first, which is followed by $\overline{X}$ chart.

A. Data Collection

25 samples are collected and 3 sets of reading are noted from each sample. The data is tabulated in table 1. As per regulations of livestock feed, moisture content should not be more than 11.5%.

TABLE I
SAMPLE READINGS OF MOISTURE CONTENT IN CATTLE-FEED

Day	Percentage of moisture		
	Shift A	Shift B	Shift C
Day 1	10.62	10.82	11.18
Day 2	10.86	10.88	11.42
Day 3	10.64	10.84	10.98
Day 4	10.9	10.68	10.6
Day 5	10.96	11.44	10.98
Day 6	10.96	10.86	11.45
Day 7	10.72	10.82	10.52
Day 8	10.4	10.78	10.96
Day 9	10.88	10.4	10.84
Day 10	10.52	10.46	10.76
Day 11	10.62	10.48	11.08
Day 12	10.32	10.66	10.82
Day 13	10.86	11.2	10.96
Day 14	11.42	11.24	11.32
Day 15	11.26	11.46	11.36
Day 16	10.94	11.44	11.08
Day 17	10.96	11.25	11.08
Day 18	10.84	10.96	10.9
Day 19	10.88	11.42	10.92
Day 20	10.42	10.58	10.82
Day 21	10.46	10.8	10.38
Day 22	10.84	11.16	11.48
Day 23	10.88	11.24	10.7
Day 24	10.78	11.46	10.92
Day 25	10.88	10.8	10.6

With the data collected, the control charts are drawn for the statistical process control study and they are given in figure 1 and 2. R chart shows any deviations from desired limits within the quality process and, in effect allow the firm to make necessary adjustments to improve the quality. $\overline{X}$ chart is used to monitor the average value, or mean of a process over time. The upper and lower control limits define the range of inherent variation in the subgroup means, when the process is in control.

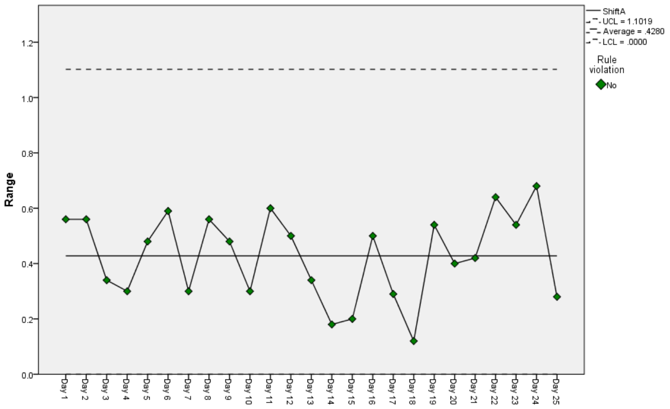

Fig.1 R Chart

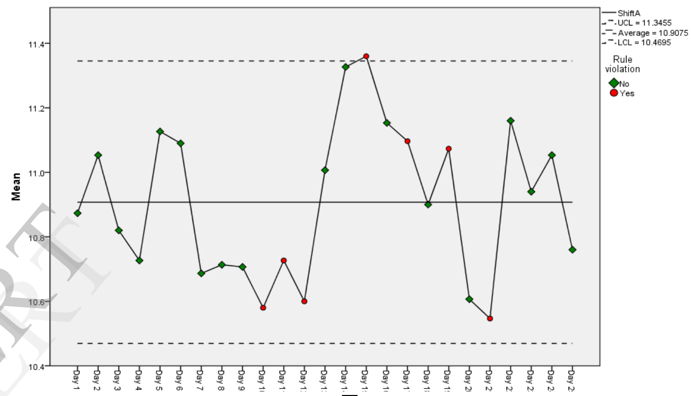

Fig.2 $\overline{X}$Chart

In the $\overline{X}$ chart it is observed that 9 points violate the rules, including a point which is outside the control limits. The explanations of rule violations are given in table 2.

TABLE 2:
VIOLATION OF RULES IN THE $\overline{X}$ CHART

Date	Violations of rules
Day 12	4 points out of the last 5 below -1 sigma
Day 13	4 points out of the last 5 below -1 sigma
Day 14	2 points out of the last 3 below -2 sigma
Day 14	4 points out of the last 5 below -1 sigma
Day 17	Greater than +3 sigma
Day 18	2 points out of the last 3 above +2 sigma
Day 20	4 points out of the last 5 above +1 sigma
Day 23	4 points out of the last 5 above +1 sigma
Day 25	2 points out of the last 3 below -2 sigma

By examining the control charts it can be concluded that the process is not under control. Assignable causes of variation are present. To make further studies, complaints occurred in plant during the period of examination is collected from the log book and is given in table 3.

During the process of palletisation, steam at desired temperature from the boiler is mixed with the raw material mixture. The steam thus injected may have water contents. Pallets are at a high temperature and need to be cooled. It is done with the help of a blower. Due to the failure of blower, the products may carry excess moisture. Even though raw materials are checked for moisture content, these quality checks are sometimes compromised due to unavailability of the materials. Due to prolonged storage, raw materials absorb moisture from the atmosphere. Improper settings of steam release valve and molasses mixing also causes excess moisture content in the cattle feed produced.

TABLE 3:
COMPLAINTS OCCURRED IN THE PLANT
DURING THE PERIOD OF EXAMINATION

Complaints from the log book	No. of occurrences
Presence of water in steam injected	152
Poor exposure to blower	55
High moisture content in raw materials	24
Raw material storage period more than 4 months	17
Steam release valve settings	13
Molasses mixing	8

B. Data Analysis

Pareto chart is constructed by segmenting the range of the data into groups. The left-side vertical axis of the Pareto chart is labelled with frequency, the right-side vertical axis of the Pareto chart is the cumulative percentage. The horizontal axis of the Pareto chart is labelled with the group names of response variables. This bar chart is used to separate the 'vital few' from the 'trivial many'. These charts are based on the Pareto principle which states that 80% of the problems come from 20% of the causes. From the Pareto diagram in fig.3, it can be seen that 77% of the complaints are occurring due to the presence of water in steam injected and poor exposure of raw-materials to blower. These are to be eliminated to improve the process and to eliminate the assignable causes.

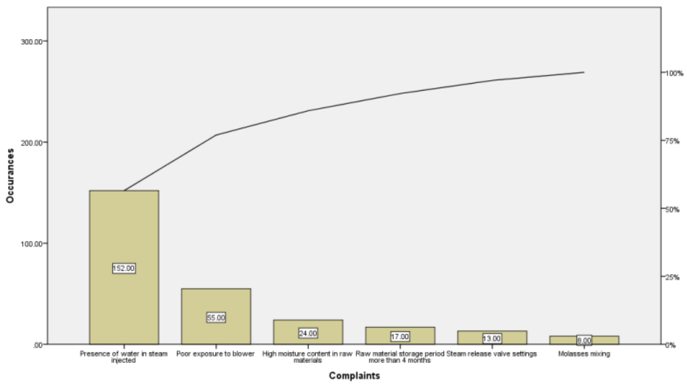

Fig 3: Pareto Chart

C. Identifying the root causes

Root Cause Analysis (RCA) is a method that is used to address a problem or non-conformance, in order to get to the 'root cause' of the problem. It is used so we can correct or eliminate the cause, and prevent the problem from recurring. There are many analytical methods and tools available for determining root causes. A Cause & effect diagram is such a tool that helps identify, sort and display possible causes of a specific problem or quality characteristic. It graphically illustrates the relationship between a given outcome and all the factors that influence the outcome. Constructing a Cause & effect diagram help to identify the possible root causes, the basic reasons for a specific problem and to sort out and relate some of the interactions among the factors affecting a particular process. It helps to analyse existing problems so that corrective action can be taken.

The diagram is constructed by brainstorming technique. Brainstorming is a group or individual creativity technique by which efforts are made to find a conclusion for a specific problem by gathering a list of ideas spontaneously contributed by its members. The brainstorming session involves works manager, three shift engineers and four senior boiler operators of the plant. The causes for the presence of moisture in steam supplied to the raw materials are classified as mechanical, chemical, design parameters, load characteristics and operating conditions.

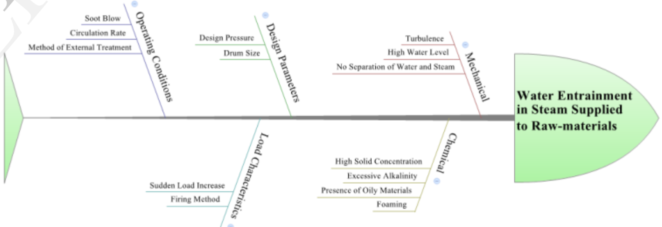

Fig 4: Cause & Effect Diagram

The root causes from the diagrams are found out by voting procedure of the persons who involved in this brainstorming. Each person can vote to one or more cause and the maximum percentage of vote is taken as the root causes. The sub causes which have maximum votes are taken as the root causes. The 'vital few' causes of the problem were found to be turbulence and absence of a system to separate water and steam. If we were able to solve these problems, there will be a significant increase in the quality.

IV. RESULTS AND DISCUSSIONS

The steam produced in a boiler designed to generate saturated steam is inherently wet. A separator in the steam line will remove moisture droplets entrained in the steam flow, and also any condensate that has gravitated to the bottom of the pipe. Although there are a number of different designs of separator, they all attempt to remove the moisture that remains suspended in the steam flow. There are three types of separator in common use in steam systems and they are baffle or vane type separator, cyclonic or centrifugal type separator and coalescence type separator.

One of the main differences in performance between the baffle type and the cyclonic and coalescence types of separators is that the baffle type is capable of maintaining a high level of efficiency over a wider pipeline velocity range. Separator efficiency is a measure of the weight of the water separated out in proportion to the total weight of the water carried in by the steam. Cyclone and coalescence type separators typically exhibit efficiencies of 98% at velocities of up to 13 m/s, but this falls off sharply, and at 25 m/s, the efficiency is typically around 50%. For a baffle type separator, the efficiency remains close to 100% over a range of 10 m/s to 30 m/s. The conclusion is that, the baffle type separator is more suited to steam applications, where there is usually some degree of velocity fluctuation.

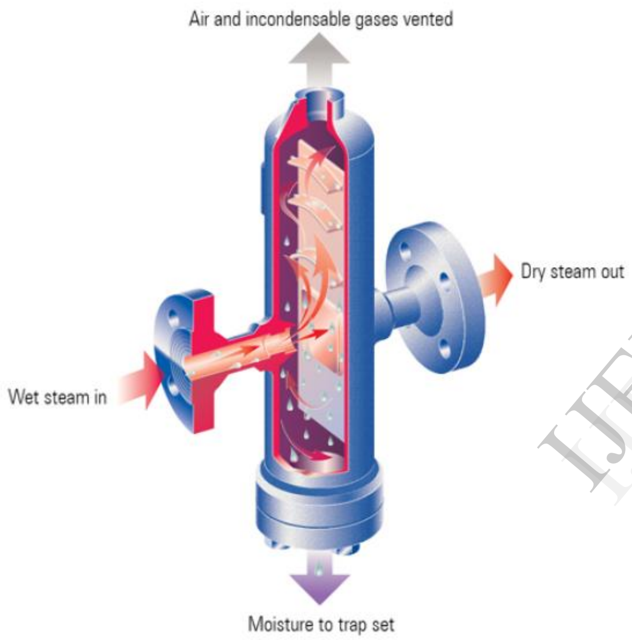

Fig 5: Baffle Or Vane Type Separator

A baffle or vane type separator consists of a number of baffle plates, which cause the flow to change direction a number of times as it pass through the separator body. The suspended water droplets have a greater mass and a greater inertia than the steam; thus, when there is a change in flow direction, the dry steam flows around the baffles and the water droplets collect on the baffles. Furthermore, as the separator has a large cross-sectional area, there is a resulting reduction in the speed of the fluid. This reduces the kinetic energy of the water droplets, and most of them will fall out of suspension. Thus the baffles create an obstacle for the heavier water droplets, while the lighter dry steam is allowed to flow freely through the separator. The moisture droplets run down the baffles and drain through the bottom connection of the separator to a steam trap. The condensate collects in the bottom of the separator, where it is drained away through a steam trap.

V. CONCLUSION

Moisture content directly affects nutrient concentration and money value per ton. So the producer must correct for moisture in order to properly compare feeds when buying and selling. The present study aims to control moisture content in cattle feed production. Statistical Process Control study shows that the process is not in control, and the production process needs an improvement. From the Pareto analysis, it is seen that the major problem for the presence of water content in cattle feed is the entrainment of water in steam injected to the raw material mixture. Cause and effect diagram is plotted by conducting brainstorming. The root cause of the problem is identified as the lack of separation of steam and water in the steam line. A separator in the steam line will remove moisture droplets entrained in the steam flow. Properties of different type of separators are compared and a baffle type separator is found to be most appropriate for this purpose

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