Various possibilities of improving feed production efficiency in a feed milling plant

M Kanagaraj
Catalyst Techvisors Pvt Ltd.

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Overview

- Factors influencing feed milling efficiency
- Process Control
- Critical steps in feed mill operation & SPC
- Preventive Maintenance Program
- Latest trends in Feed mill operation
Production Efficiency

- “Optimum combination of inputs to produce maximum output with minimum cost”

- More for less.
Feed Manufacturing Process

Feed Milling Process

Man
- Skilled & Unskilled

Materials
- Grains, By products etc.

Machines
- Hammer mill, Mixer & Pellet press etc.

Methods
- Formula, SOPs

Mother Nature
- Temperature & Humidity

Nutritional & Physical Specification

Finished Feed
Feed Milling Efficiency

• Productivity
  – TPH
  – Cost per Ton

• Feed Quality
  – PDI
  – Nutritional values
  – Mould and toxin levels
PROCESS EFFICIENCY
Process Control

• Controlling a Process means “controlling its variations”

• CTP – Critical To Process

• CTQ – Critical To Quality

• Control Plan is a dynamic document describing the systems for controlling process.
Control Plan

Control Plan for Feed Mill

- **Document No**: CPN-006
- **Process Name**: Pelleting
- **Machine Name**: Pellet Press
- **Revision status**: 00

**Input**: Conditioned (cooked) mash feed

**Pelleting process**

**Output**: Hot pellet feed

<table>
<thead>
<tr>
<th>CTQ/CTQ</th>
<th>Specification Limit</th>
<th>Gauge</th>
<th>Responsibility</th>
<th>Frequency</th>
<th>Document Number</th>
<th>SPC Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pellet feed moisture</td>
<td>15±0.5%</td>
<td>Oven method</td>
<td>QA</td>
<td>Each shift</td>
<td>CPD-004-01</td>
<td>Histogram</td>
</tr>
<tr>
<td>Pellet feed temperature</td>
<td>80-85°C</td>
<td>Temperature gauge</td>
<td>Production</td>
<td>1 hour</td>
<td>CPD-005-01</td>
<td>Control chart</td>
</tr>
<tr>
<td>Throughput (TPH)</td>
<td>Calculate as per design</td>
<td>Counting</td>
<td>Production</td>
<td>1 hour</td>
<td>CPD-005-01</td>
<td>Control chart</td>
</tr>
<tr>
<td>Specific energy (kW/T)</td>
<td>Calculate as per design</td>
<td>Energy meter</td>
<td>Production</td>
<td>1 hour</td>
<td>CPD-005-01</td>
<td>Control chart</td>
</tr>
</tbody>
</table>
Receiving

CTP

Temperature

CTQ

Moisture content

Protein content

Bulk density
Batching

CTP: Batches per hour

CTQ: Target weight versus actual weight
Grinding

CTP
- Grinding rate – Tons/Hr
- Electrical usage per Ton – kWh/Ton

CTQ
- Particle size
Grinding

Particle Size Distribution

- < 0.25 MM: 1.4% Actual, 20.0% Standard
- 0.25 - 0.5 MM: 25.2% Actual, 24.0% Standard
- 0.5 - 1.0 MM: 44.2% Actual, 30.0% Standard
- 1.0 - 2.0 MM: 28.4% Actual, 20.0% Standard
- 2.0 - 3.0 MM: 0.5% Actual, 5.0% Standard
- > 3.0 MM: 0.3% Actual, 1.0% Standard

Catalyst
Connecting Dots, Creating Communities
Energy Conservation

Plant 1 - Mash section Energy Conservation

Month | TPH | Specific Energy
-----|-----|------------------
Apr/16 | 10.1 | 8.4
May/16 | 10.4 | 9.0
Jun/16 | 10.1 | 8.5
Jul/16 | 10.9 | 8.8
Aug/16 | 11.2 | 8.8
Sep/16 | 10.6 | 9.9
Oct/16 |  |  
Nov/16 |  |  
Dec/16 |  |  

TPH | kW/Ton
Mixing & Molasses Mixing

CTP
CV

CTQ
Mash moisture
Conditioning

**CTP**

- Steam pressure at conditioner

**CTQ**

- Mash moisture content after conditioning
- Feed temperature after conditioning
• Finished feed moisture is 10.4%
Pelleting

CTP
TPH – Tons Per Hour
kWh – Kilowatt hour per ton

CTQ
Pellet temperature post die
Cooling

CTP
- Air velocity - CFM

CTQ
- Pellet temperature post cooler
  - Pellet moisture post cooler
Moisture Management

Moisture addition through steam is 2.1% and 2.4% in Plant 1 and Plant 2 respectively. Moisture loss is 0.8%

Provision should be made to take feed sample from molasses mixer.
Bagging & Finished Feed

CTP
- Bag weight
- Bags per hour

CTQ
- PDI
- Moisture content
- Protein content
Pellet Durability Index

PDI is defined as the percentage of pellets in the finished pellet feed

Feed = Pellet + Fines

\[
PDI = \frac{\text{Pellet} \times 100}{\text{Feed}}
\]
Pellet Quality

- Pellet Durability Index (PDI) is an indicator

- PDI tester
  - KSU Tumbling
  - Holmen Tester
  - Khal Tester
PDI Tester

Khal Tester

Holmen Tester
Factors Influencing PDI

FACTORS INFLUENCING PELLET QUALITY. DR. KEITH C. BEHNKE Professor Department of Grain Science and Industry Kansas State University Manhattan, Kansas, USA 66506-2201

- 60% of pellet quality is decided before the mash enters the conditioner
- Pellet quality further increases to 80% after conditioning
- It means before mash has even entered the pellet die the pellet quality is decided

Formulation 40%
Cooling 5%
Pellet die 15%
Conditioning 20%
Particle size 20%
CTXs

- CTP – Critical To Process
- CTQ – Critical To Quality
- CTC – Critical To Cost
- CTD – Critical To Delivery
- CTS – Critical To Safety
Trends in Process Control

• **Statistical Process Control (SPC)**

• Benefits of SPC
  – Increased product uniformity
  – Less rework and material waste
  – Increased production efficiency
  – Increased customer satisfaction
  – Less money invested in finished product inspection
SPC Tools

Frequency Histogram

Control Charts

Pareto Chart

Cause & Effect Diagram
Frequency Histogram
Bag Weight: X - Chart

![Chart showing bag weight values and control limits (UCL, X, LCL)]
Bag Weight R - Chart

UCLR
Pareto Chart - Example

- Fines: 10 occurrences, 42% cumulative
- Foreign Material: 8 occurrences, 75% cumulative
- Low Fat: 4 occurrences, 92% cumulative
- Mouldy Feed: 1 occurrence, 96% cumulative
- Colour: 1 occurrence, 100% cumulative

Number of Occurrence:
- 10
- 8
- 4
- 1
- 1

Cumulative %:
- 42%
- 75%
- 92%
- 96%
- 100%

Catalyst - Connecting Dots, Creating Communities
Cause & Effect Diagram (or) Fishbone Diagram

- Man
- Machines
- Materials
- Method
- Environment
- Process deviation
• Minimize process variation $\rightarrow$ delivers Controlled process $\rightarrow$ leads to better Process efficiency
MACHINE EFFICIENCY
Machine Efficiency Indicators

• Down Time
• Cost of maintenance
• Life of machines
• Structured Maintenance Program helps in
  – predict “next potential machine failure”
  – achieve “Zero Breakdown”

• Maintenance Program should have goals and objectives
Goals and objectives:

- It can be based
  A. Productivity
  B. Expenses
  C. Safety
A. Productivity based goal

- Limiting plant downtime to increase productivity
- Ex: Zero downtime
B. Expenses based goal

- Expense guideline should be developed
- Total Rs. spent for maintenance or cost of maintenance per Ton (Calculate per hr cost)
- Can be broken down *individual cost center* or combined basis (Storage, batching, pelleting etc.)
C. Safety based goal

- Ensure feed plant machine and facility are in compliance with Company and Government safety standards
- Ex: Zero accident
Preventive Maintenance

1. Qualified Personal
2. Machine Data & History Record
3. Maintenance Schedules
4. Spare Parts & Ordering of Spare Parts
5. Documentation & Management
1. Qualified Personal

- Should posses knowledge and experience
- Technical knowledge in
  - Mechanical
  - Electrical
  - Electronics/ Instrumentation
2. Machine Data Sheet

The data sheet should have the following details

- Motor
- Gear box
- Drive belt
- Bearing
- Mechanical
- Electrical
- Hydraulic
- Pneumatics items
3. Maintenance Schedule

- Weekly, monthly & quarterly
- What to check during inspection?
- Type and quantity of lubricant required
- Duplication of equipment
4. Spare Parts

- How large an inventory of parts should be in stock?
- How often should spare parts be recorded?
- Who is responsible for parts inventory?
- Critical machines for manufacturing
4. Spare Parts

• Can the plant afford to inventory parts?
• Are necessary parts readily available from local suppliers?
• Are the parts specially ordered?
4. Spare Parts Assessment

- By assessing cost of parts against cost of downtime, decision can be made.
- Machine Information Sheet & Machine History Record can be a source.
- “Standardization of machines” helps reducing parts inventory.
5. Documentation

- Master List of Machines
- Machine Information Sheet
- Machine History Record
- Maintenance Schedule
- Spare Parts Inventory
- Equipment Manual
- Purchase Records
Downtime Analysis

LINE 1 - DOWN TIME IN HOUR

- Machine down time: 50%
- Process down time: 44%
- Maize not available: 6%

Line 1 - Down Time Analysis

- Down Time in hours
- Occurance

- Product Change: 5
- Shifter Sieve Damaged: 1
- Hammer Mill Problem: 1
- Cooler Bed Motor Problem: 1
- Intake Elevator Jam: 2
- Maize Nil: 2
- Hammers Change: 1

Down Time in hour: 0.0, 4.0, 8.0, 12.0, 16.0, 20.0
Occurance: 0, 1, 2, 2, 4, 6
## Trouble Shooting

<table>
<thead>
<tr>
<th>Breakdown Detail</th>
<th>Root Cause</th>
<th>Corrective Action</th>
<th>Preventive Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sifter sieve damage</td>
<td>Sieve life is exhausted and not replaced</td>
<td>Sieve replaced</td>
<td>Predict the life of sieve and change it before damage</td>
</tr>
</tbody>
</table>
Trends in Maintenance Program

• Predictive Maintenance

• Condition Monitoring Maintenance
  – Vibration analysis
  – Thermal analysis
  – Oil analysis
MOTHER NATURE’S ROLL ON FEED MILLING
Mother Nature

- India is classified as **Humid sub tropical** climatic country
- Three climate zones of India are
  - Hot and Humid
  - Hot and Extreme dry
  - Cold and dry
The raw materials are **hygroscopic** in nature.

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Effect</th>
<th>Challenges</th>
<th>Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot and Dry</td>
<td>Raw material tend to loose moisture</td>
<td>Shrinkage</td>
<td>Financial loss</td>
</tr>
<tr>
<td>Hot and Humid</td>
<td>Raw material tend to absorb moisture from atmosphere</td>
<td>More availability of free water</td>
<td>Mould problem – Quality issue – Feed palatability problems</td>
</tr>
</tbody>
</table>
Effect of Weather on Material

Molasses Application

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Density at 20°C (kg/l)</td>
<td>1.4-1.44</td>
</tr>
<tr>
<td>Viscosity (cps) at 20°C</td>
<td>About 5000-20000</td>
</tr>
<tr>
<td>Solubility in water (% weight)</td>
<td>Forms infinite aqueous solution</td>
</tr>
<tr>
<td>Vapour pressure (hPa)</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Thermol decomposition (°C)</td>
<td>Begins about 60</td>
</tr>
</tbody>
</table>

- Variation in molasses dosing
- Periodic calibration of Molasses dosing system
- Temperature of mash after steam addition
Conditioning

- Conditioning process significantly influences
  1. Feed quality
  2. Pellet Durability (PDI)
  3. Power requirement of pellet mill
Conditioning

- Quality of Steam Conditioning depends on
  - Particle size of mix
  - Steam Quality
  - **Initial moisture content of mash feed**
  - **Initial temperature of mash feed**
  - Residence time of Conditioner
Key Factors of Conditioning

• Residence Time
• Degree of fill
• Steam quality
  – Dryness of steam describes steam quality
  – 80% dryness faction is accepted in feed milling
5 Categories of Feed

- **High Fibre Dairy**
  - Mash Temp: 60°C
  - Moisture: 2% only absorbs
  - Thick pellet die

- **High Urea or Molasses**
  - Mash Temp: < 60°C
  - Moisture: 2% only absorbs

- **High Starch Feed**
  - Mash Temp: 80 – 85°C
  - Moisture: 6%

- **Heat Sensitive High Starch**
  - Mash Temp: < 45°C
  - Thinner die

- **High Protein**
  - Mash Temp: 75°C
  - Moisture: 3% point addition
Effect of Weather on Conditioning

Variation in mash moisture and ambient temperature at input affects Conditioning quality

- **Mash Feed with moisture and temperature**
- **Good Quality Steam (80% dryness fraction)**
- **Conditioning Process**
- **Hot Conditioned mash at 15-16% moisture**
Effect of Weather on Pelleting

- Varied frictional force at pellet die
- Variation in PDI – too hard or soft pellets
- Use different L/d ratio pellet die
Pellet Die on Pellet Quality
Effect of Weather on Cooling

- Directly influenced by climate condition

Temperature: 60 to 75°C
Moisture: 15% ±1%

Temperature: Ambient
Moisture: Same as mash
Effect of Weather on Cooling

- Hot and humid conditions
  - capacity of air to absorb feed moisture is reduced
  - coolers will remove less moisture than standard level

- Hot and extreme dry conditions
  - the ambient air removes excess moisture than the standard level
  - significant financial loss
Efficiency Status

• Operation Performance
  – Design point Vs Operation performance
  – Operation Performance Analysis
Operational Performance

Design Point vs Operation Performance

Design Point

- TPH: 20
- kWh/Ton: 25

Operation Performance

- TPH: 18
- kWh/Ton: 30
Operational Performance Analysis

• There are KPIs (Key Performance Indicators) for a feed mill
• These parameters are to be analysed periodically
• Monthly, quarterly performance are to be compared with previous period
KEY PERFORMANCE INDICATORS
KPI Tree

KPIs

- Manufacturing Cost
- Labour Productivity
- Manufacturing Productivity
- Delivery Productivity
- Quality
- Safety
KPIs

**Manufacturing Cost**
- Personal costs
- Property costs
- Operating Costs
- Shrink/Gain costs

**Labour Productivity**
- Man hours per ton
- Overtime hours

**Manufacturing Productivity**
- Tons per run & Pellet mill changeovers
- Bagged tons per day
- Actual vs scheduled time
- Downtime hours

**Delivery Productivity**
- Tons delivered per load
- Load-out waiting time
- Tons delivered or miles driven per driver
KPI - Manufacturing Cost

Personnel costs:
- Salaries (Feed mill employees, management & staff)
- Hourly wages
- Benefits (tax, insurance, retirement plan)
- Uniforms
- Employees PPE
- Employee appreciation program
KPI - Manufacturing Cost

Property costs:
- Depreciation
- Property tax and insurance
- Equipment repair & Preventive maintenance
- Die & roll cost
- Equipment leases
- Vehicle leases
KPI - Manufacturing Cost

Operating costs:
• Utilities
  – Electricity
  – Water
  – Boiler fuel
  – Sewer
  – Garbage
• Feed mill consumables
  – Boiler chemicals
  – Greases
  – Oils
• Office supplies
• Communication
KPI - Manufacturing Cost

Shrink/Gain costs:

• Calculate the shrink and gain of raw material and feed separately

• (Beginning inventory + receipts) - (Ending inventory + shipments) = Shrink (Gain)

• Shrink (Gain) by weight X Monetary Value/Weight Unit = Monetary Value of Shrink (Gain)
KPI - Manufacturing Productivity

• Tons per run – batching/ pelleting

• Pellet mill changeover
  – Number of changeovers each day
  – Average time required to stop & start production
  – Opportunity tons – potential loss in capacity

• Bagged tons per day
KPI - Manufacturing Productivity

- Actual vs scheduled time
  - Scheduled time = Number of shifts per week X hours per shift

- Reasons for more than the scheduled time
  - Difficult to pellet due to formulation
  - Machine breakdown
  - Additional feed demand
  - Lack of ingredients (raw materials)
  - Problems associated with feed delivery
  - Low employee productivity
**KPI - Manufacturing Productivity**

- **Downtime hours**
  - the time each week feed mill is not manufactured feed

- It may be due to
  1. Planned shutdown for preventive maintenance
  2. Unscheduled downtime
    - Lack of ingredients
    - Breakdown of machines
    - Finished feed bins are full
KPI- Labour Productivity

• Tons per man hour – Integrated feed mill
  – How many tons can be produced per man hour
(OR)
• Man hours per ton – Commercial feed mill
  – More labours are required for manufacturing
• Overtime hours
KPI – Delivery Productivity

• Tons delivered per load
  – Net tons delivered on each delivery

• Load-out waiting time
  – How long each driver spent waiting to get the truck loaded

• Tons delivered or miles driven per driver
  – Number of miles driven and tons delivered per driver (OR)
  – Tons delivered each week per driver (short distances)
Feed Milling Challenges

- Raw material moisture
- Molasses addition
- Steam addition
- Cooler operation
Production Efficiency Index

1. Increase TPD
2. Decrease Down Time
3. Reduction of Spares cost
4. Better Energy Conservation

- Capacity utilization
- Process Down Time
- Machine Down Time
- Power
- Boiler Fuel
- Pellet dies & rolls
- Other spares
Feed Milling Efficiency

Productivity

Feed Quality

Animal Performance
Thank You