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

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Overview

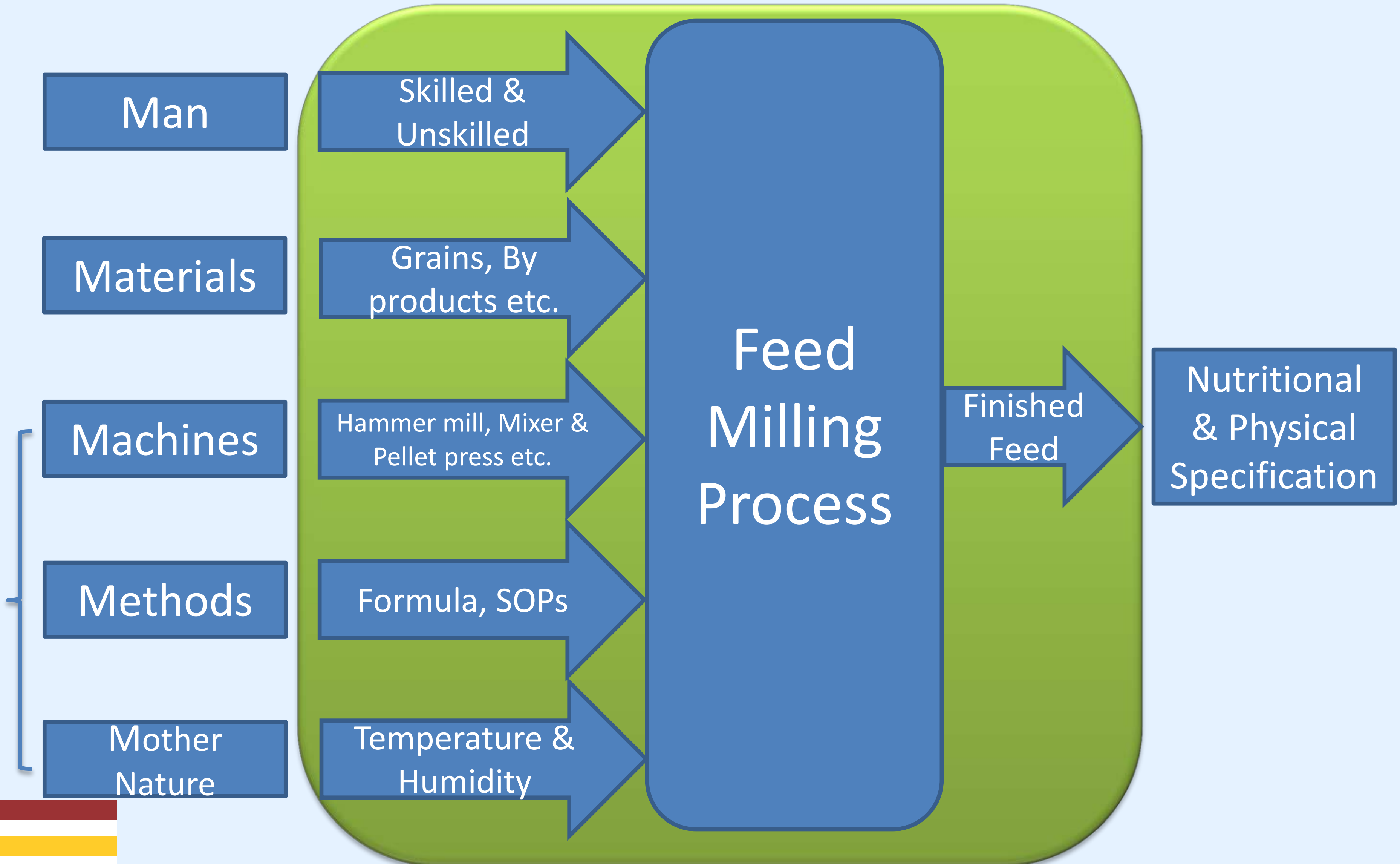
- Factors influencing feed milling efficiency
- Process Control
- Critical steps in feed mill operation & SPC
- Preventive Maintenance Program
- Latest trends in Feed mill operation

Production Efficiency

- *"Optimum combination of inputs to produce maximum output with minimum cost"*

- More for less.

Feed Manufacturing Process



Feed Milling Efficiency

- Productivity
  - TPH
  - Cost per Ton

- Feed Quality
  - PDI
  - Nutritional values
  - Mould and toxin levels

Process Flow

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

Catalyst
Connecting Dots, Creating Communities

Control Plan for Feed Mill

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

Input: Conditioned (cooked) mash feed → Pelleting process → Output: Hot pellet feed

CTP/ CTQ	Specification Limit	Gauge	Responsibility	Frequency	Document Number	SPC Tool
Pellet feed moisture	15±0.5%	Oven method	QA	Each shift	CPD-004-01	Histogram
Pellet feed temperature	80-85° C	Temperature gauge	Production	1 hour	CPD-006-01	Control chart
Throughput (TPH)	Calculate as per design	Counting	Production	1 hour	CPD-006-01	Control chart
Specific energy (KWT)	Calculate as per design	Energy meter	Production	1 hour	CPD-006-01	Control chart

Receiving

CTP

Temperature

CTQ

Moisture content

Protein content

Bulk density

Batching

CTP

Batches per hour

CTQ

Target weight versus actual weight

Grinding

CTP

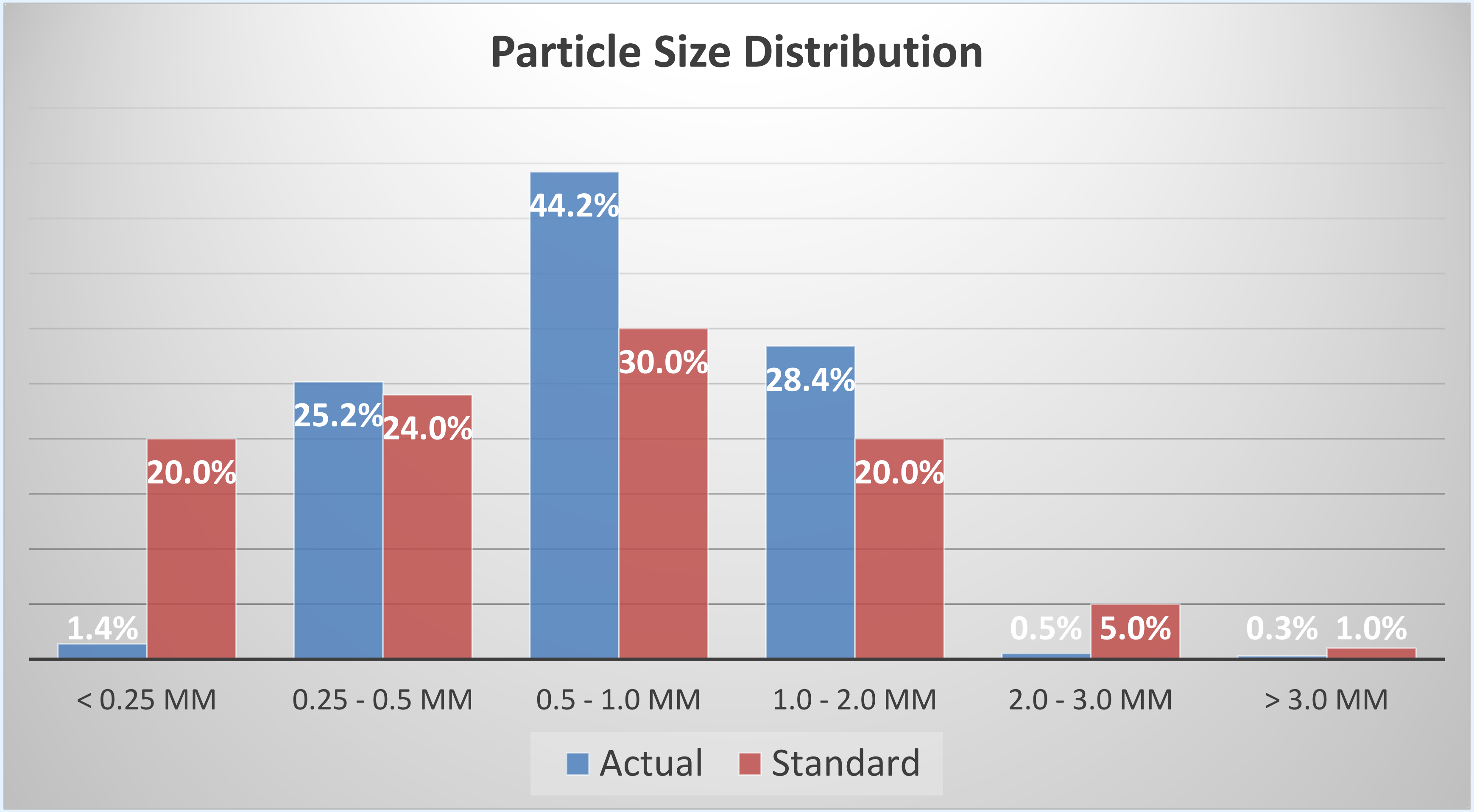
Grinding rate – Tons/Hr

Electrical usage per Ton – kWh/Ton

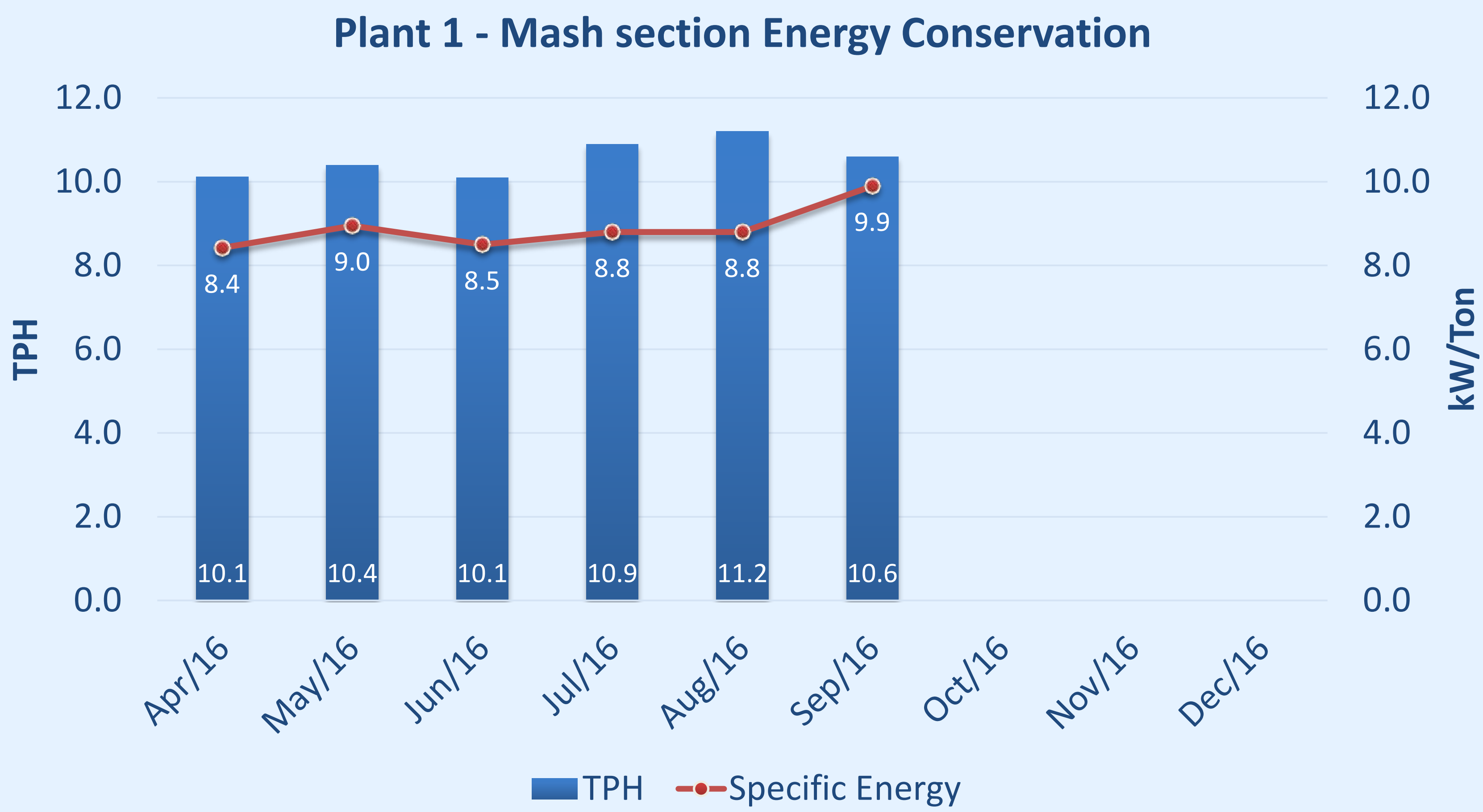
CTQ

Particle size

Grinding


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

Energy Conservation



Mixing & Molasses Mixing

CTP

CV

CTQ

Mash moisture

Conditioning

CTP

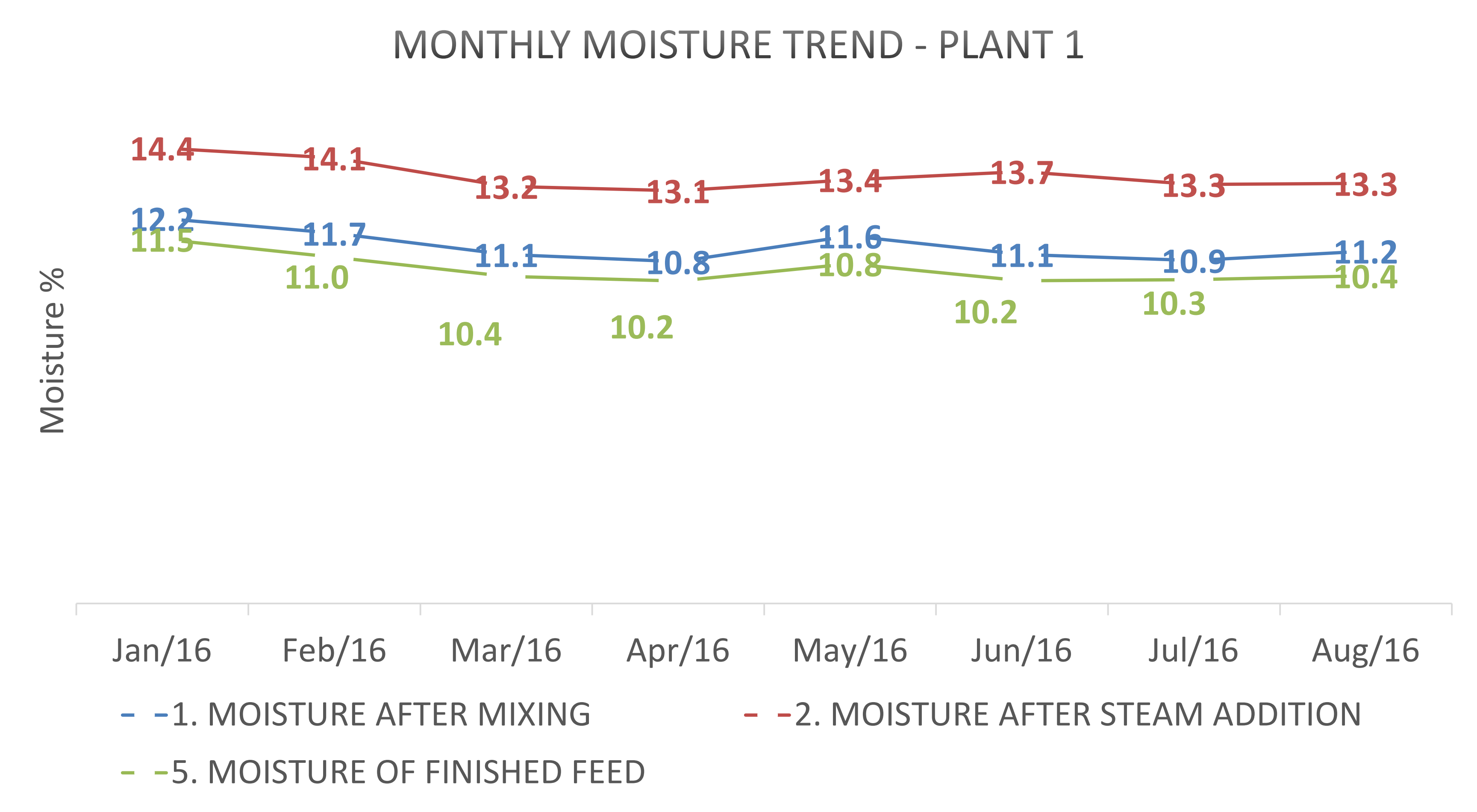
Steam pressure at conditioner

CTQ

Mash moisture content after conditioning

Feed temperature after conditioning

Moisture Management



- Finished feed moisture is 10.4%

Pelleting

CTP

TPH – Tons Per Hour

kWh – Kilowatt hour per ton

CTQ

Pellet temperature post die

Cooling

CTP

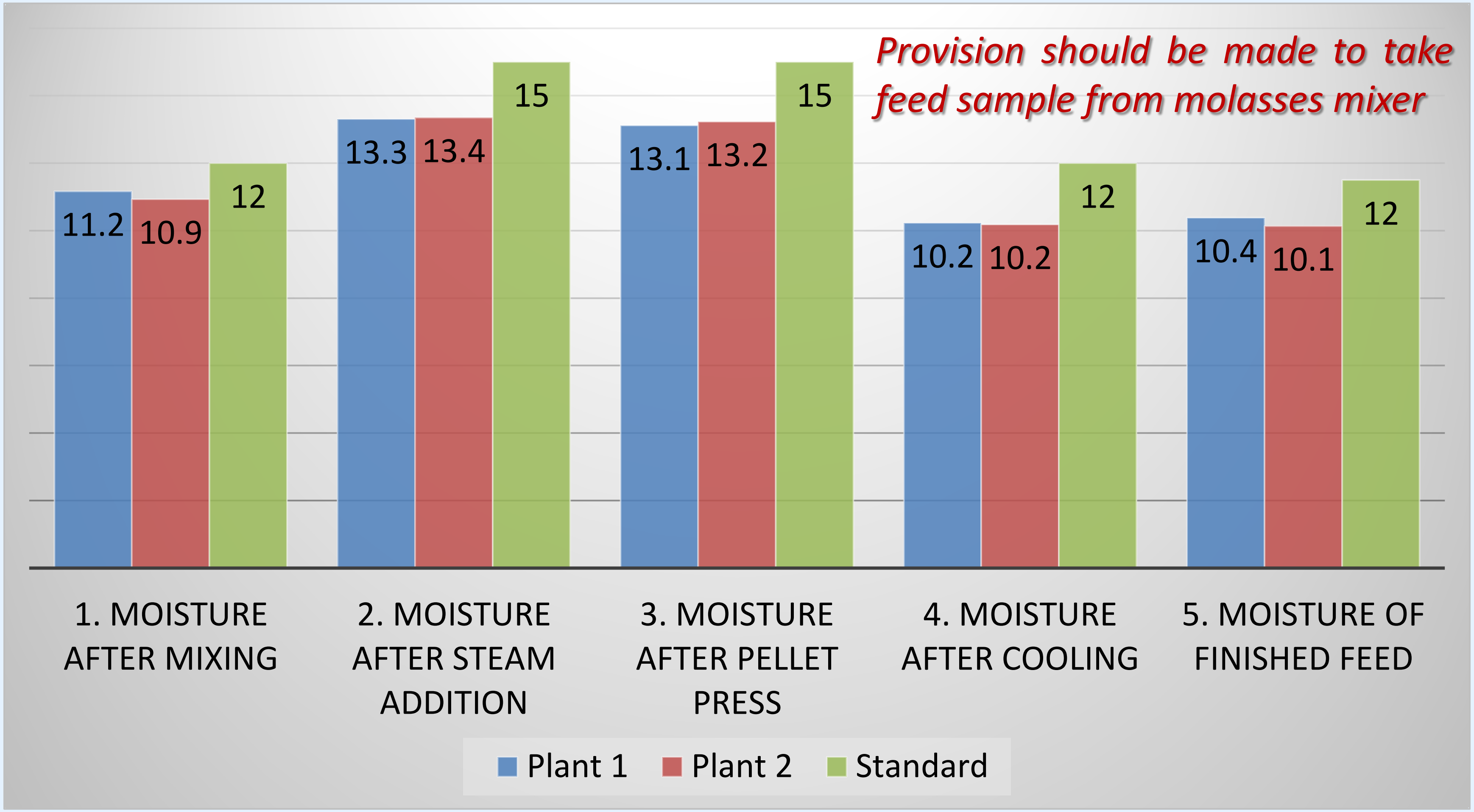
Air velocity - CFM

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%

Bagging & Finished Feed

CTP

- Bag weight
- Bags per hour

CTQ

- PDI
- Moisture content
- Protein content

Pellet Durability Index

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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

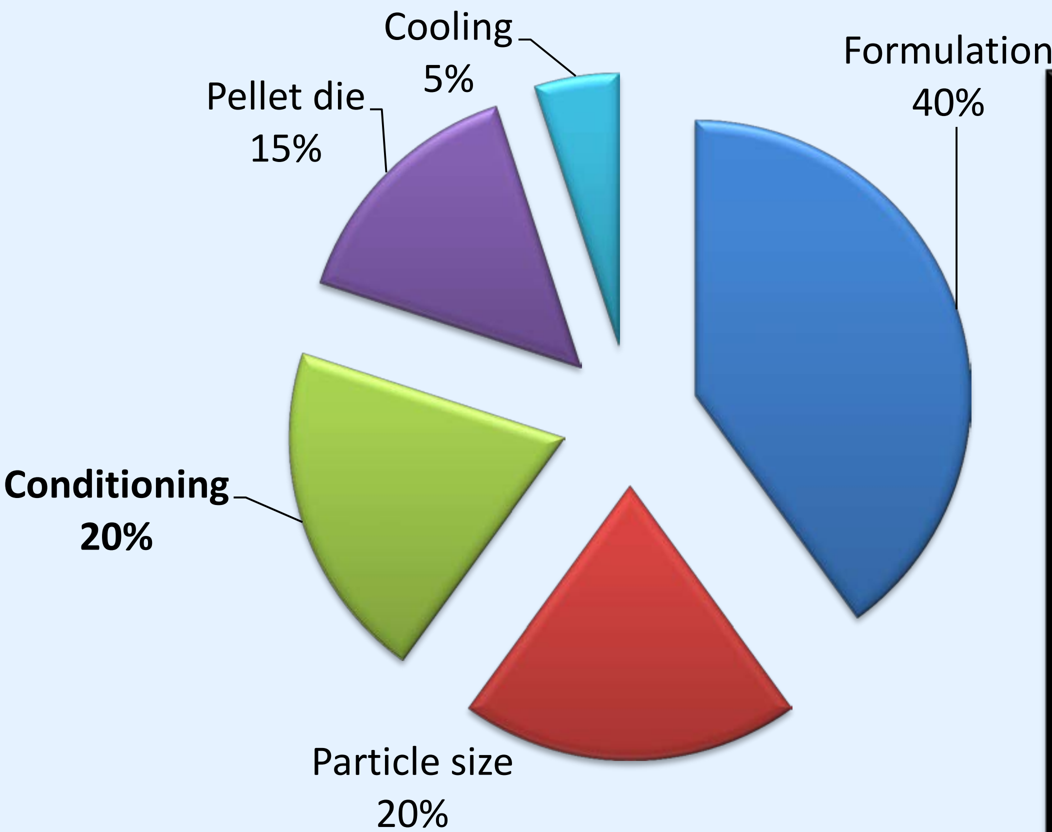
PDI Tester

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

CTXs

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

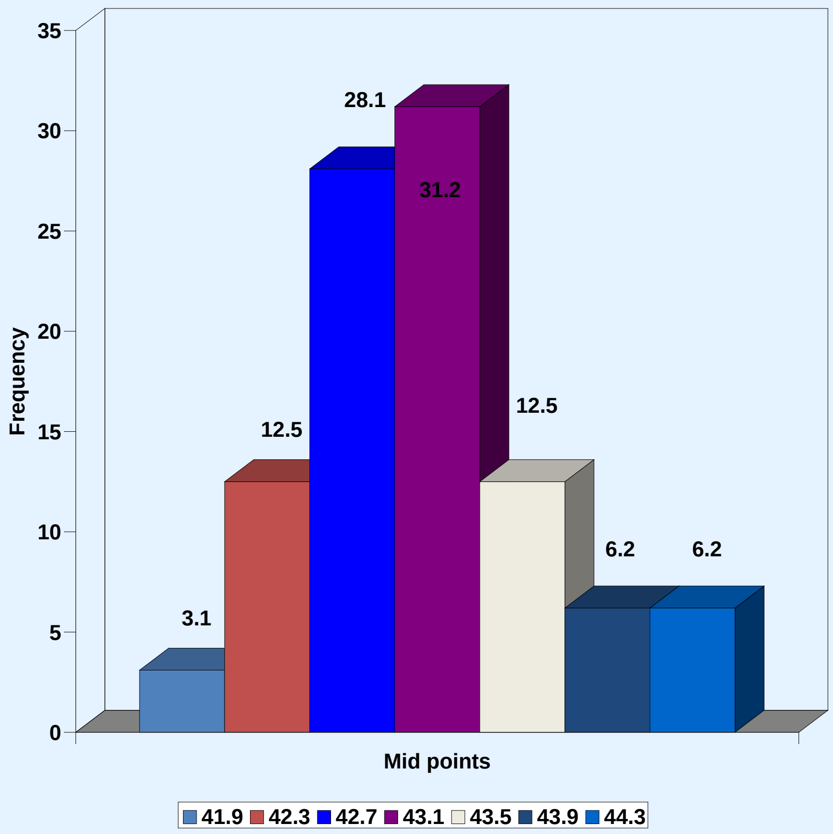
Trends in Process Control

- **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

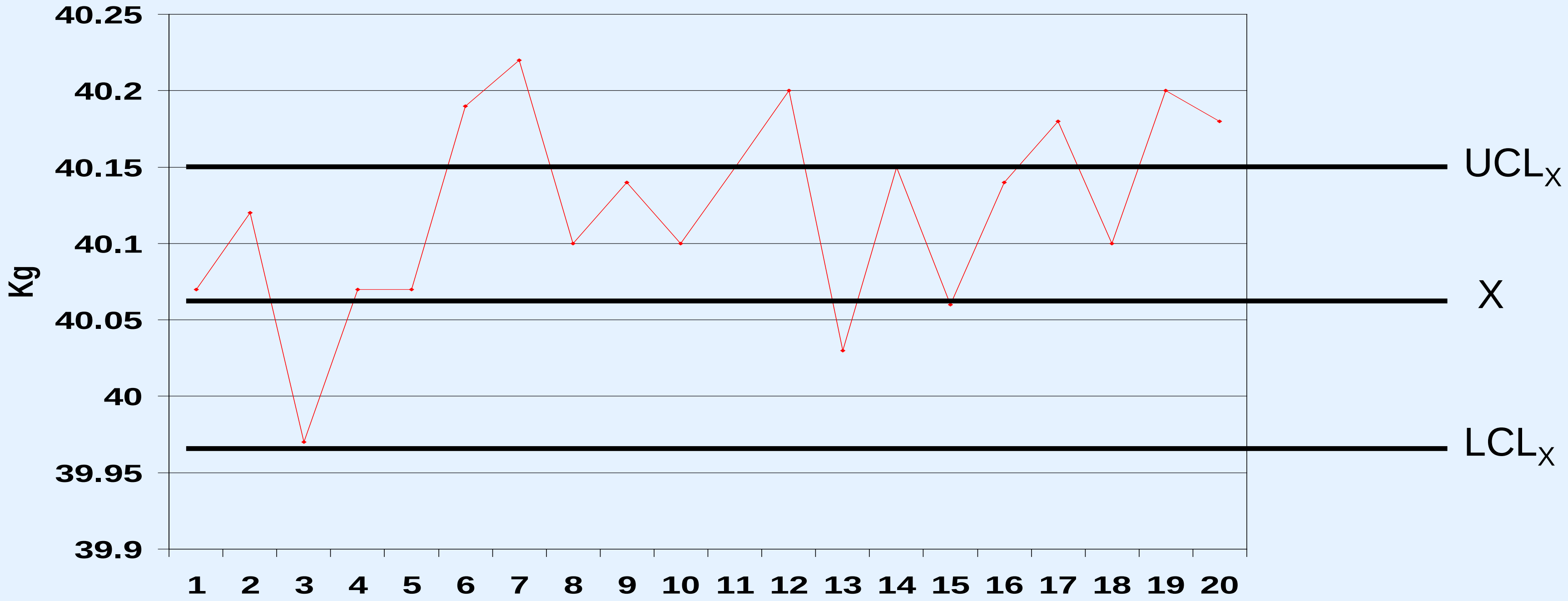
SPC Tools

- Frequency Histogram
- Control Charts
- SPC
- Pareto Chart
- Cause & Effect Diagram

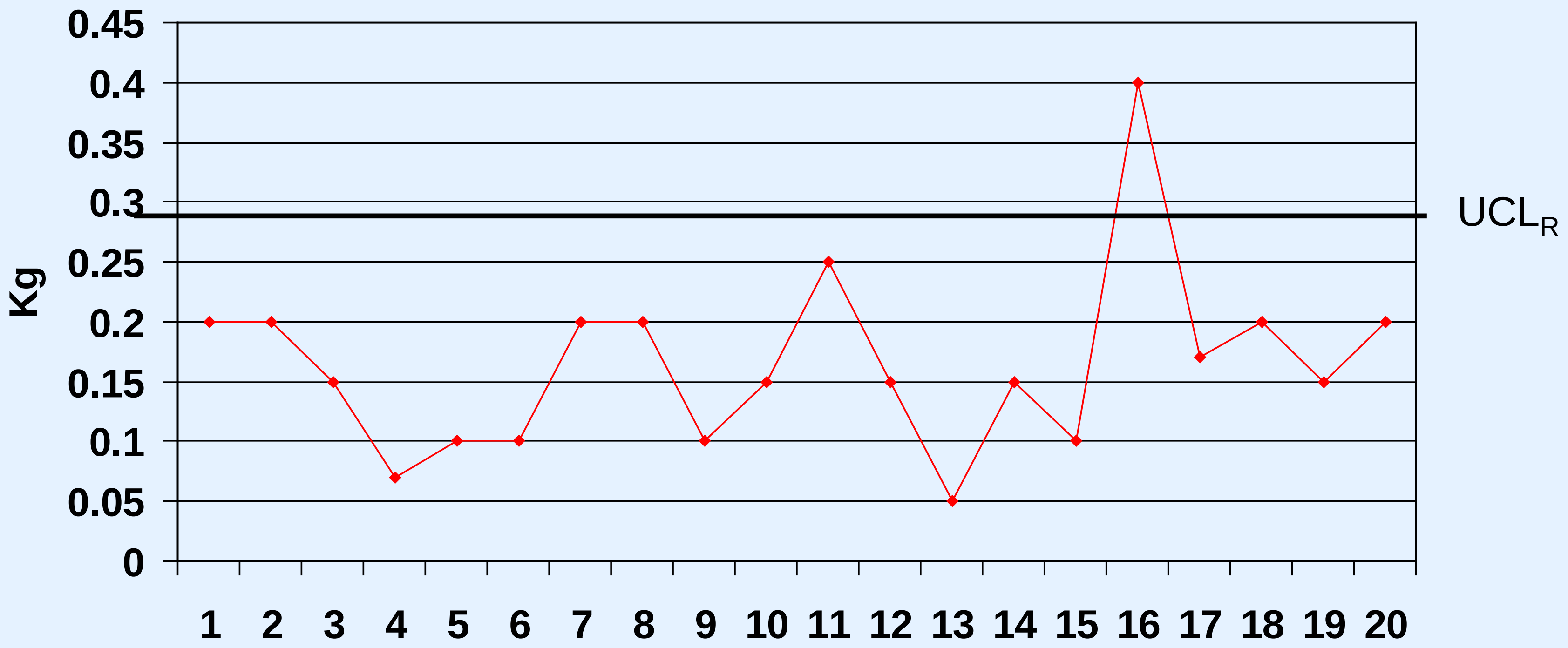
Frequency Histogram



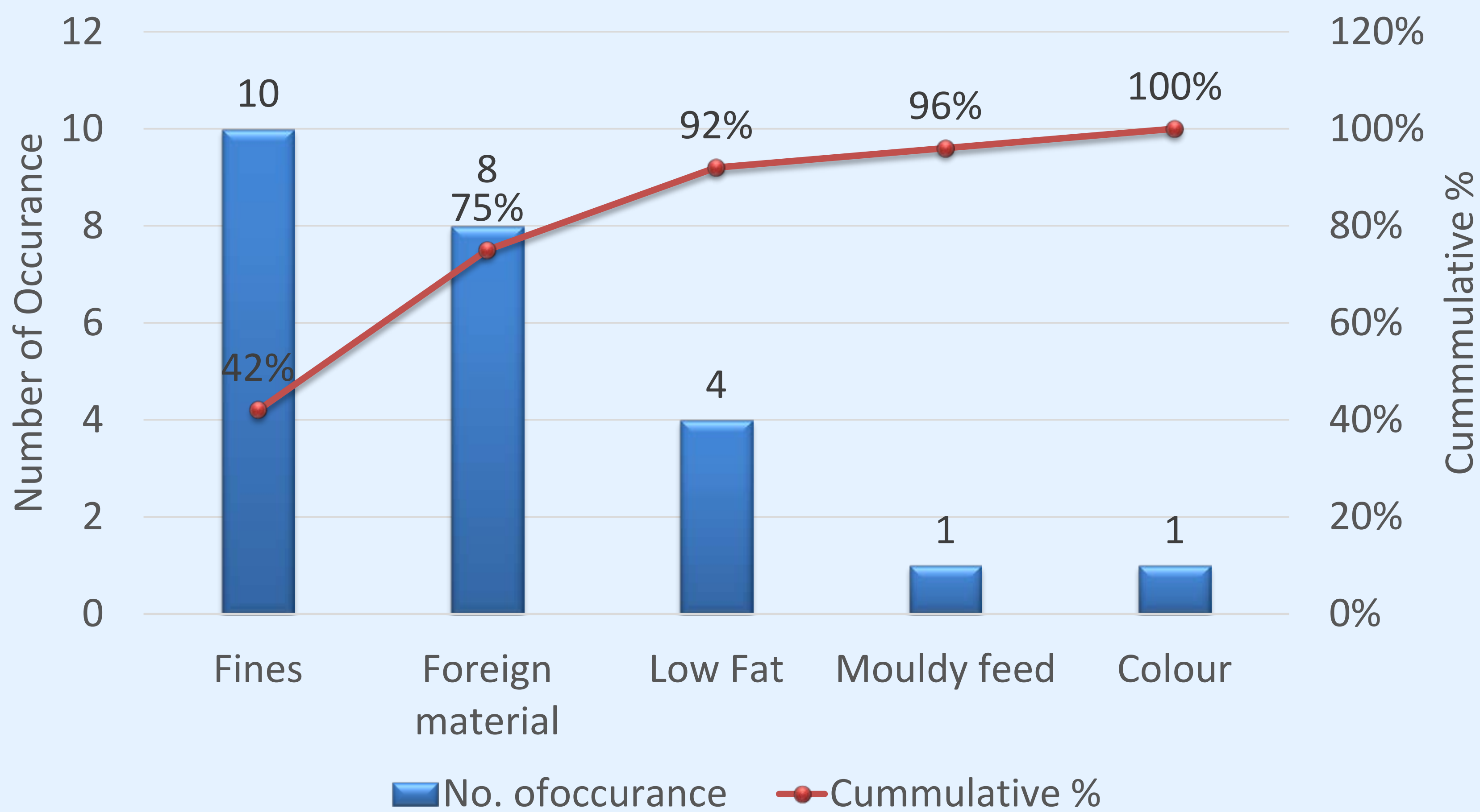
Bag Weight: $\bar{X}$ - Chart



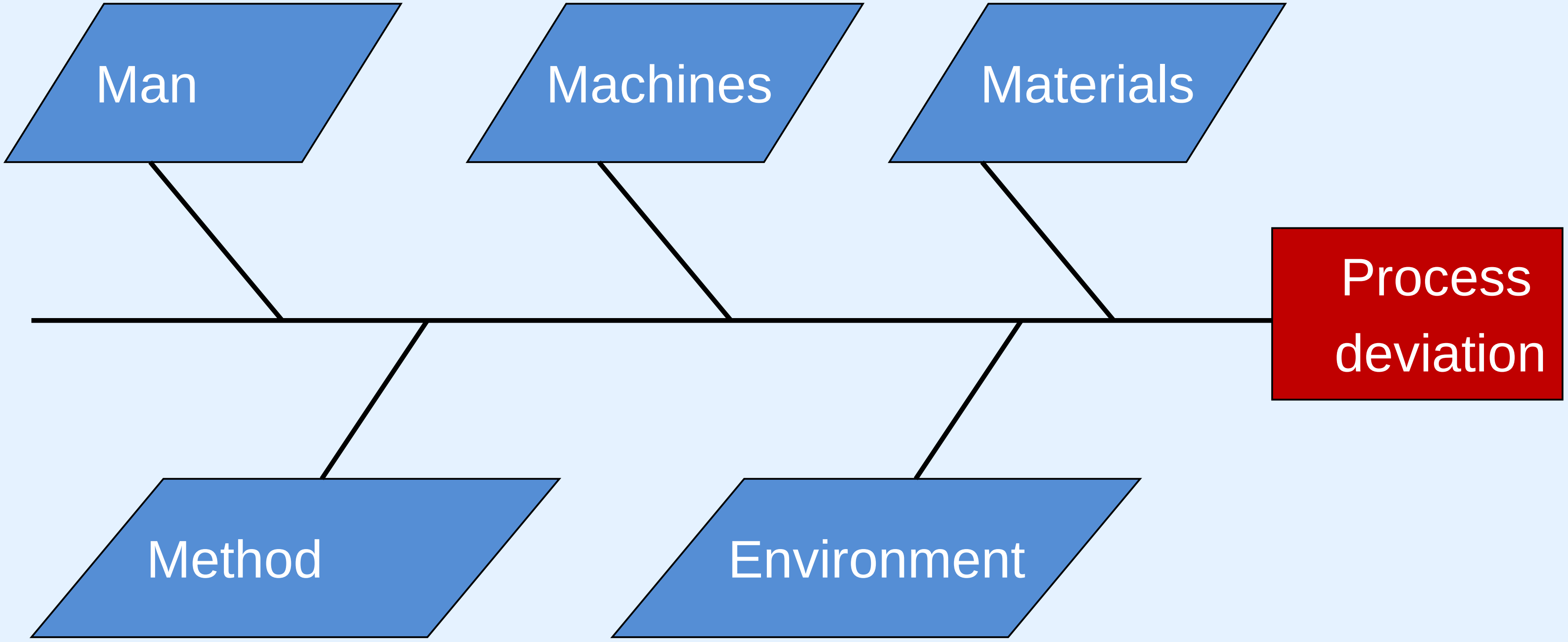
Bag Weight R - Chart



Pareto Chart - Example



Cause & Effect Diagram (or) Fishbone Diagram



- Minimize process variation → delivers Controlled process → leads to better Process efficiency

Machine Efficiency

Machine Efficiency Indicators

- Down Time
- Cost of maintenance
- Life of machines

Maintenance Program

- 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

PREVENTIVE MAINTENANCE PROGRAM

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 to 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?

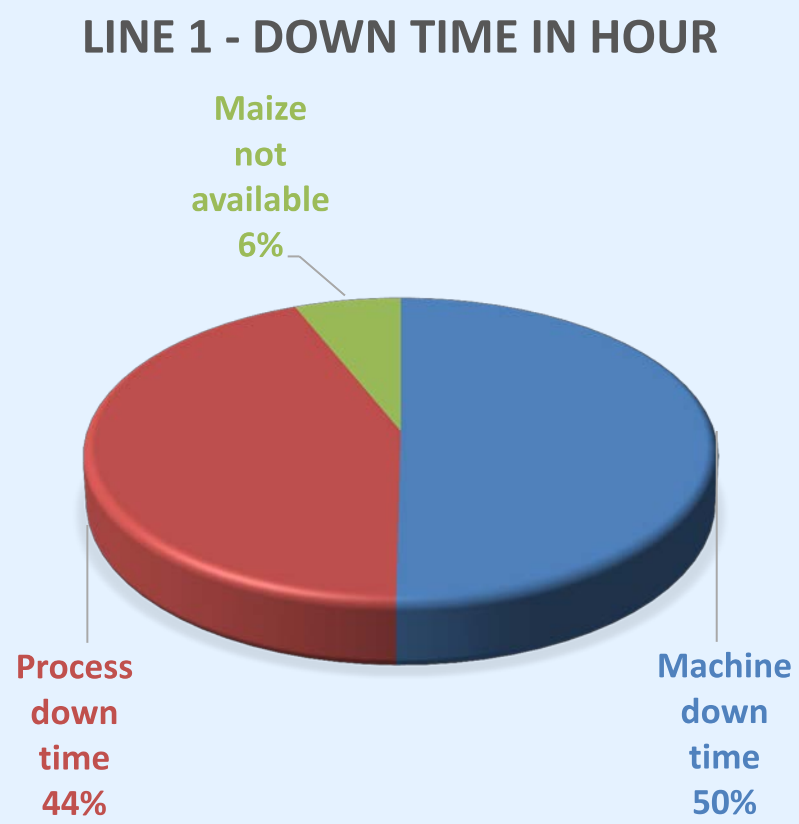
4. Spare Parts Assessment

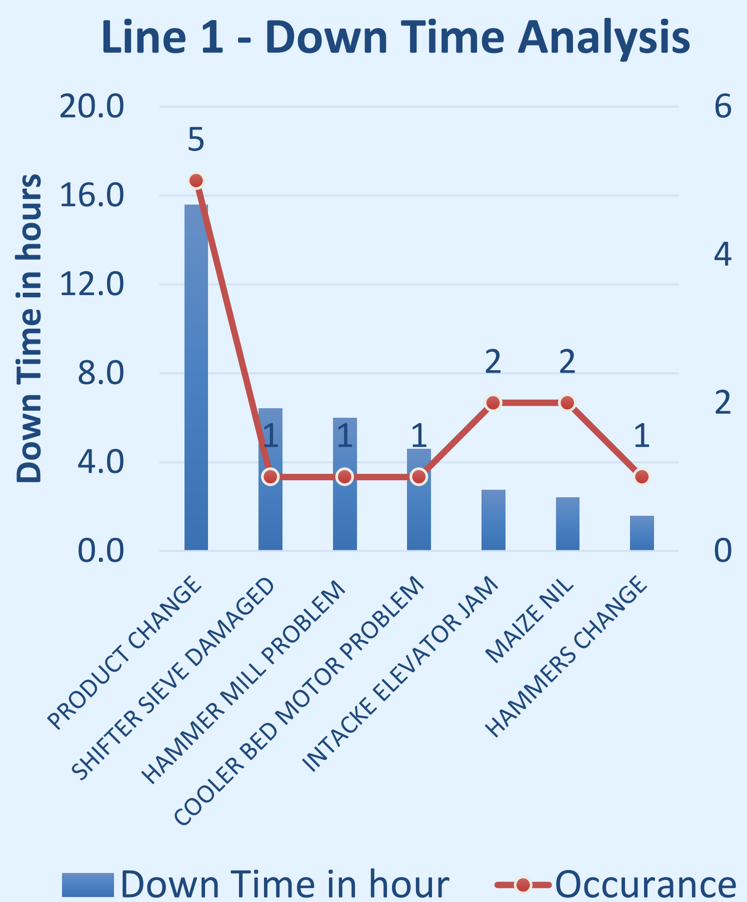
- By assessing cost of parts against cost of down time, decision can be made
- Machine Information Sheet & Machine History Record can be a source
- “Standardization of machines” helps reducing parts inventory

5. Documentation

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

Downtime Analysis





Trouble Shooting

Breakdown Detail	Root Cause	Corrective Action	Preventive Action
Sifter sieve damage	Sieve life is exhausted and not replaced	Sieve replaced	Predict the life of sieve and change it before damage

Trends in Maintenance Program

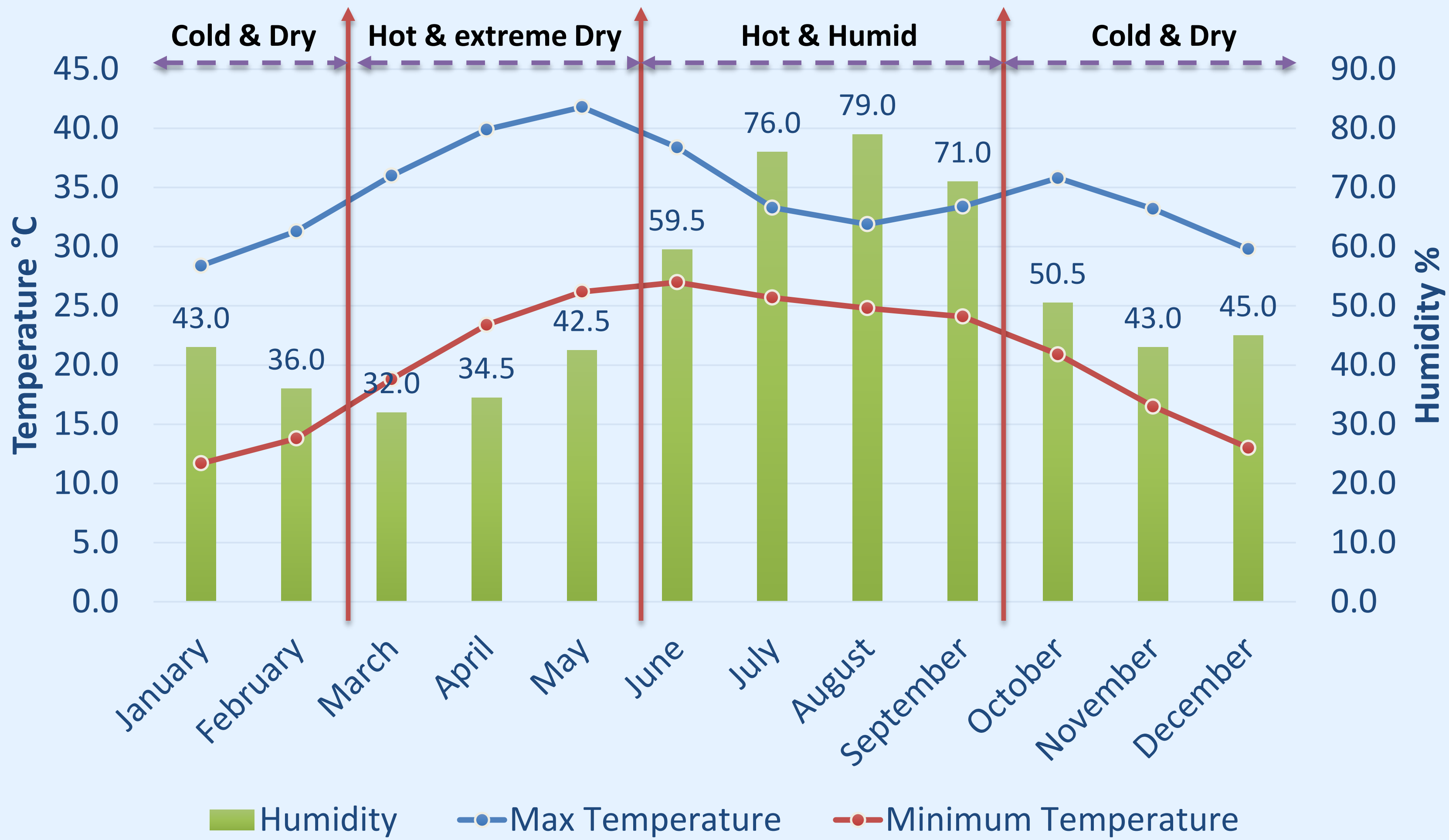
- Predictive Maintenance
- Condition Monitoring Maintenance
  - Vibration analysis
  - Thermal analysis
  - Oil analysis

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

Temperature-Humidity of Ahmedabad



Effect of Weather on Material

- The raw materials are hygroscopic in nature

Climate Zone	Effect	Challenges	Consequences
Hot and Dry	Raw material tend to loose moisture	Shrinkage	Financial loss
Hot and Humid	Raw material tend to absorb moisture from atmosphere	More availability of free water	Mould problem – Quality issue – Feed palatability problems

Effect of Weather on Material

Molasses Application

Relative Density at 20 °C (kg/l)	:	1.4-1.44
Viscosity (cps) at 20°C	:	About 5000-20000
Solubility in water (% weight)	:	Forms infinite aqueous solution
Vapour pressure (hPa)	:	Not applicable
Thermol decomposition (°C)	:	Begins about 60

- 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%

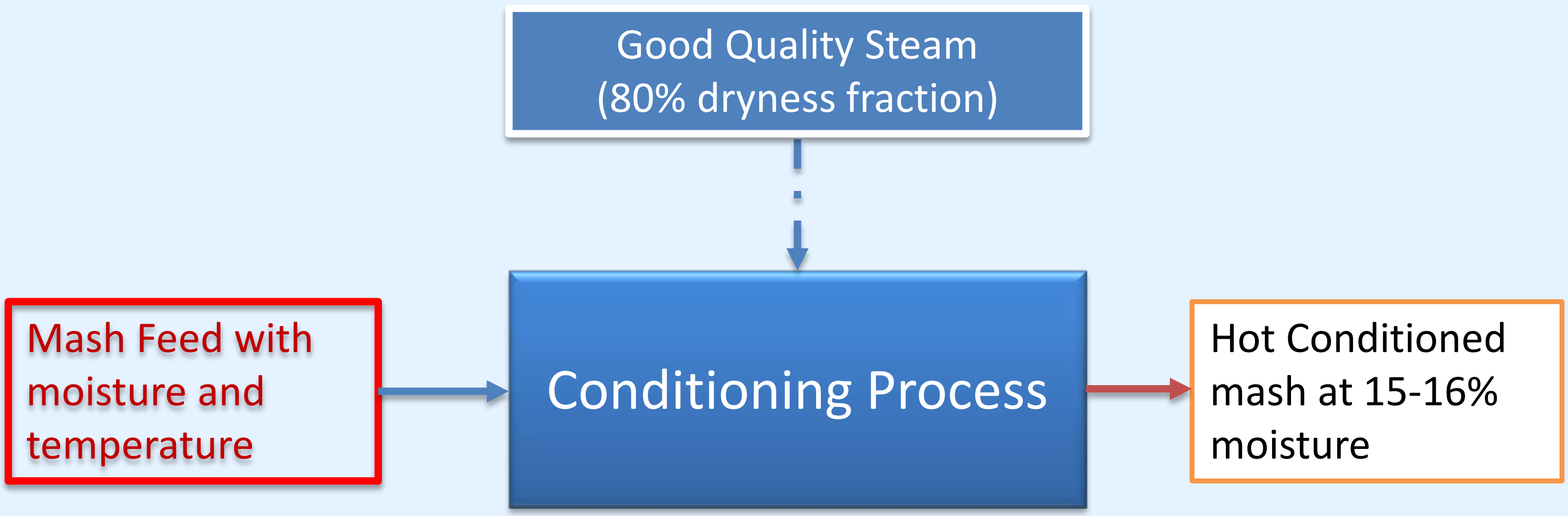
Heat Sensitive High Starch

- Mash Temp: < 45°C
- Thinner die

High Protein

- Mash Temp: 75°C
- Moisture: 3% point addition

Effect of Weather on Conditioning

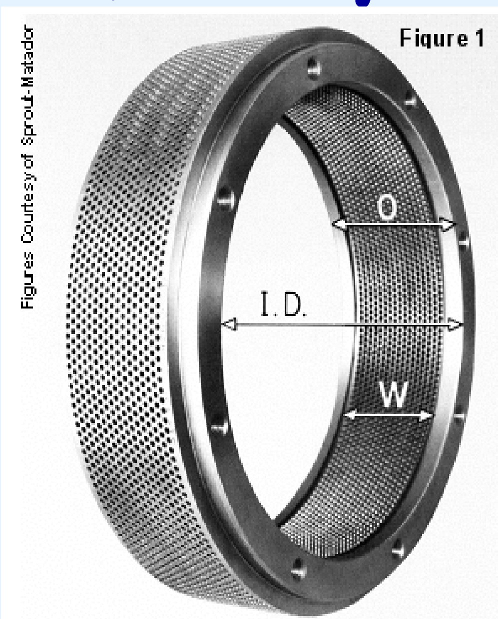


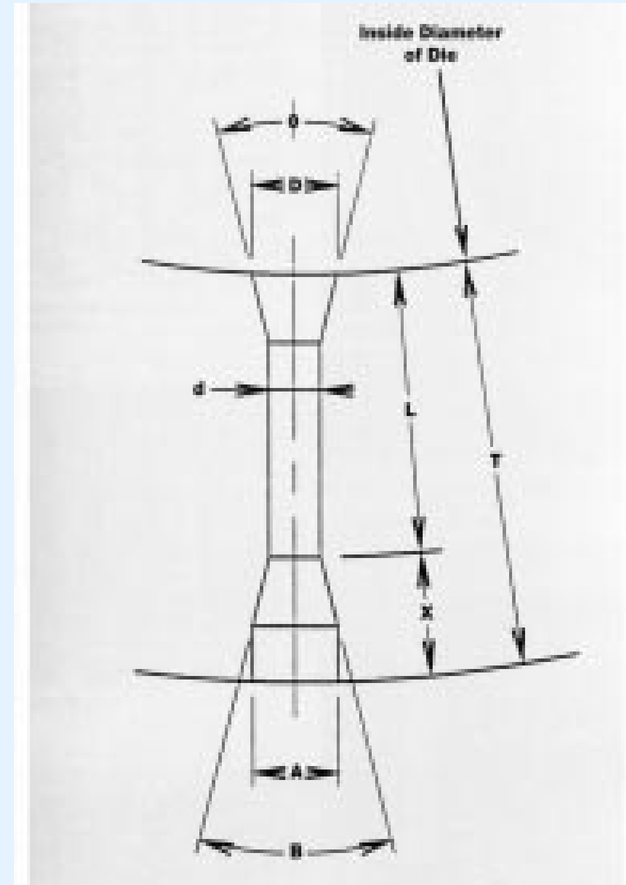
- Variation in mash moisture and ambient temperature at input affects Conditioning quality

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

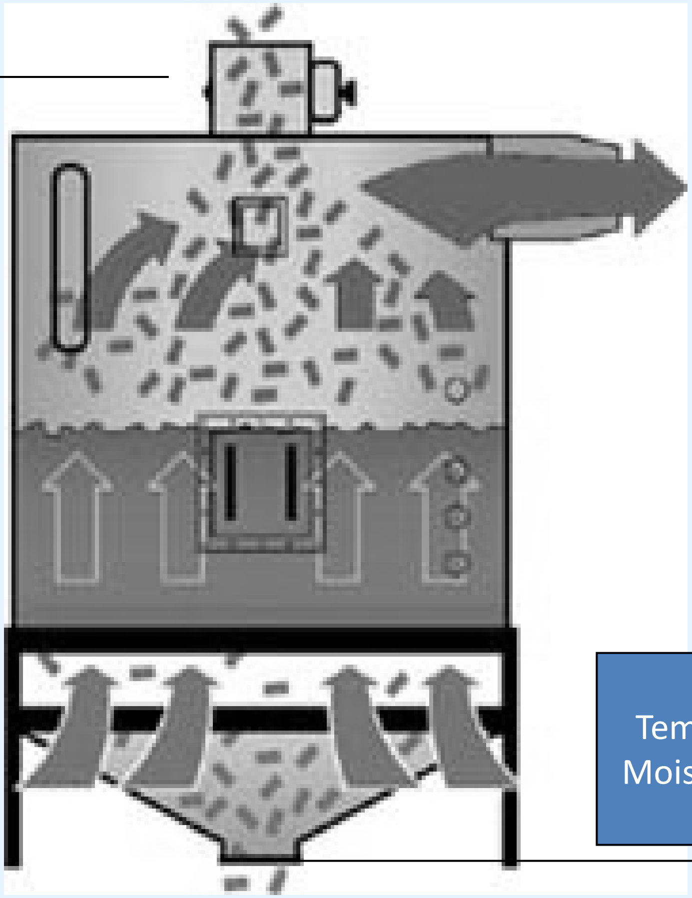




Effect of Weather on Cooling

- Directly influenced by climate condition

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



Hot air

Temperature: Ambient
Moisture: Same as mash

Environmental air

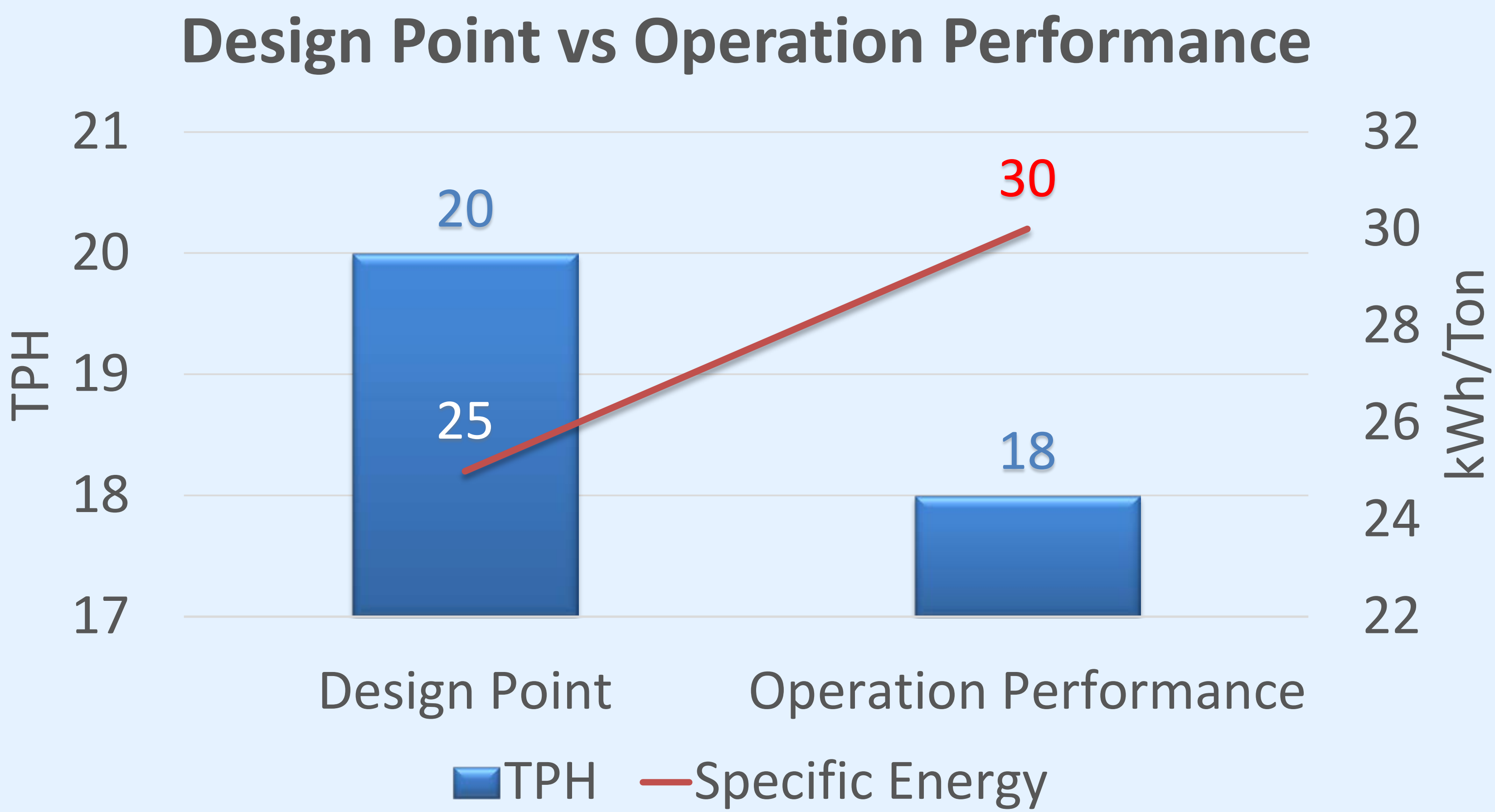
Effect of Weather on Cooling

- 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

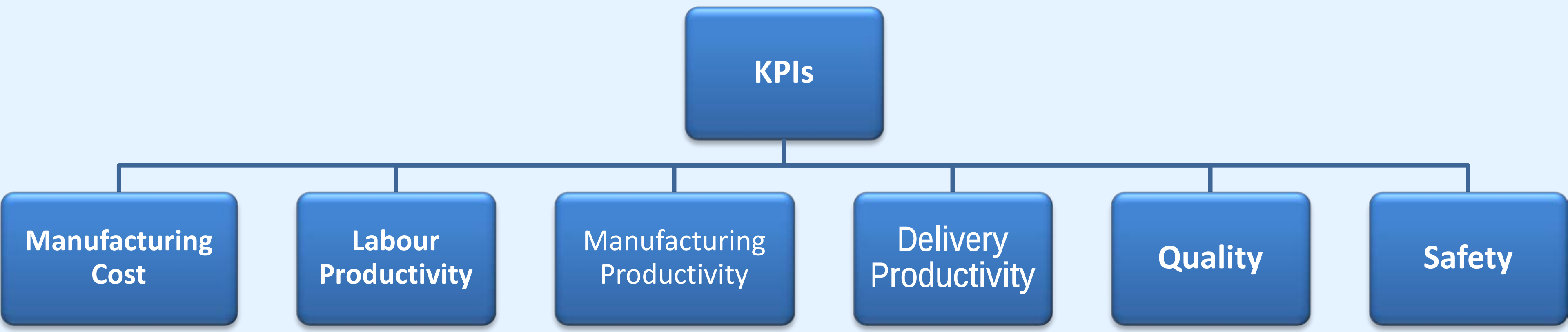


Operational Performance Analysis

- 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
     i. Lack of ingredients
     ii. Breakdown of machines
     iii. 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

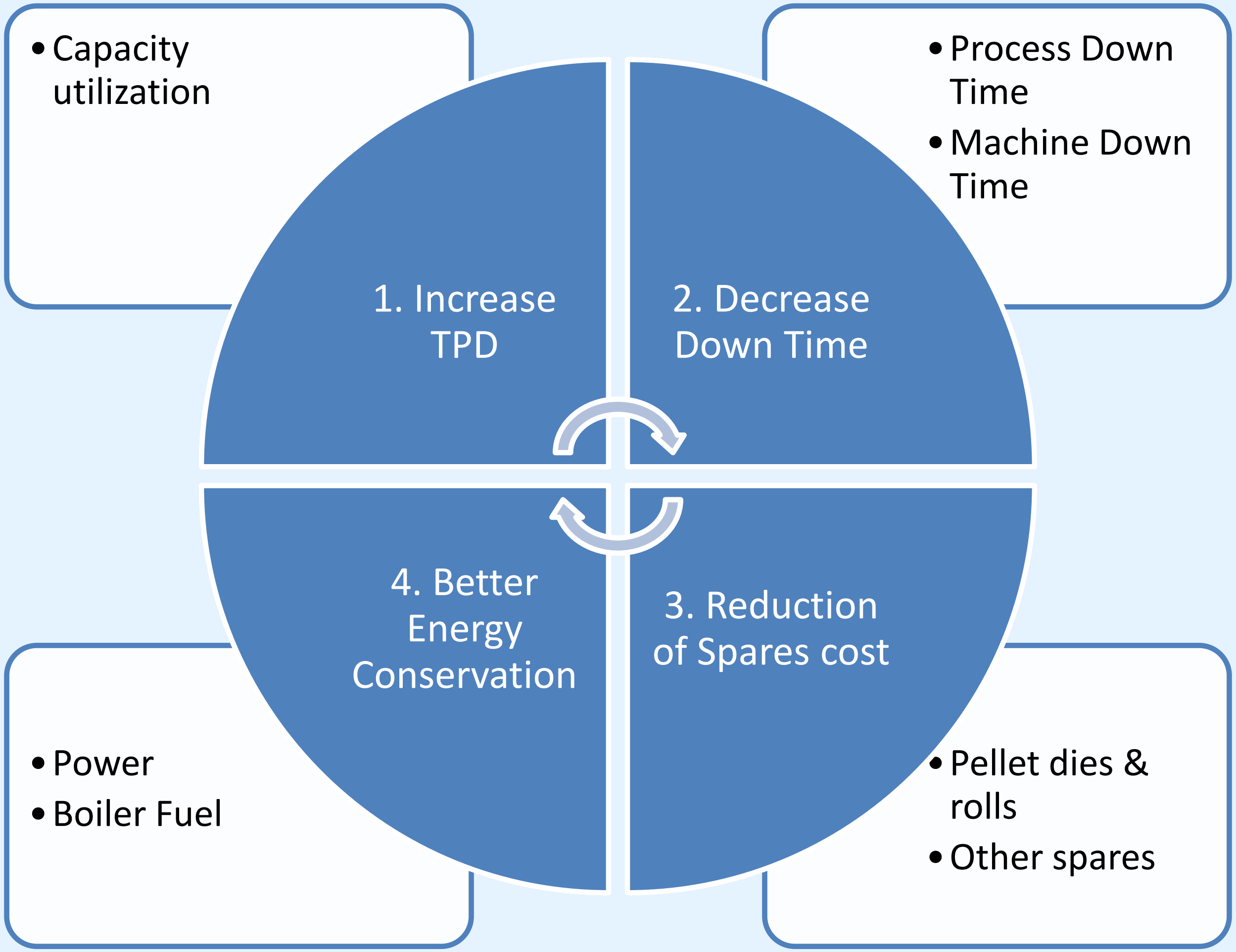
KPI – Delivery Productivity

- 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




Feed Milling
Efficiency
Productivity
Feed Quality
Animal Performance

Thank You