IOWA STATE UNIVERSITY

Feed Technology Program

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ADVANCES IN FEED TECHNOLOGY – Artificial Intelligence, Measurement Technology and Operational Efficiency

15 TUYEM International Feed Congress and Exhibition

Antalya, Turkey April 18-21, 2024

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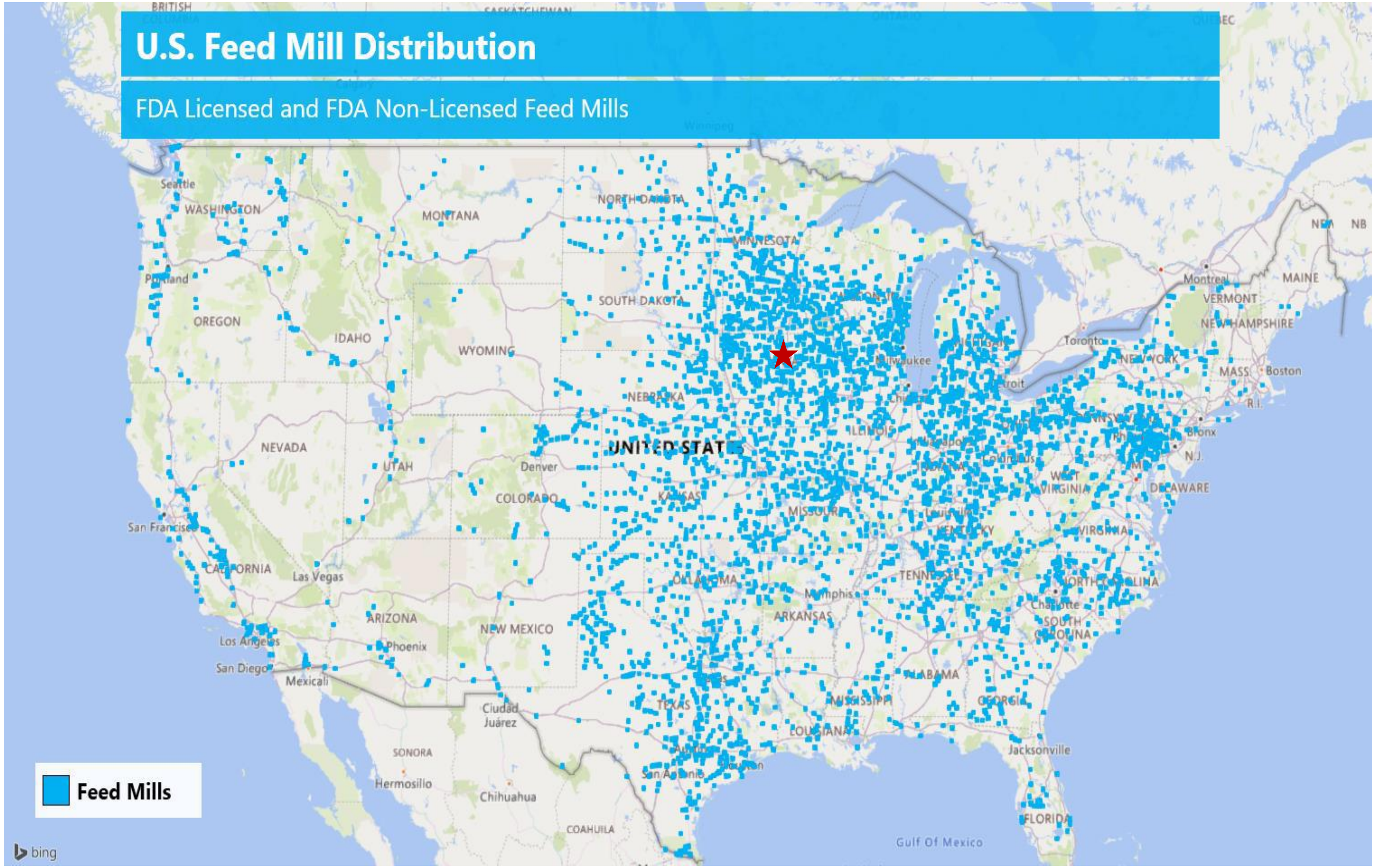
U.S. GRAINS

COUNCIL



About 738 mills have FDA medicated feed license

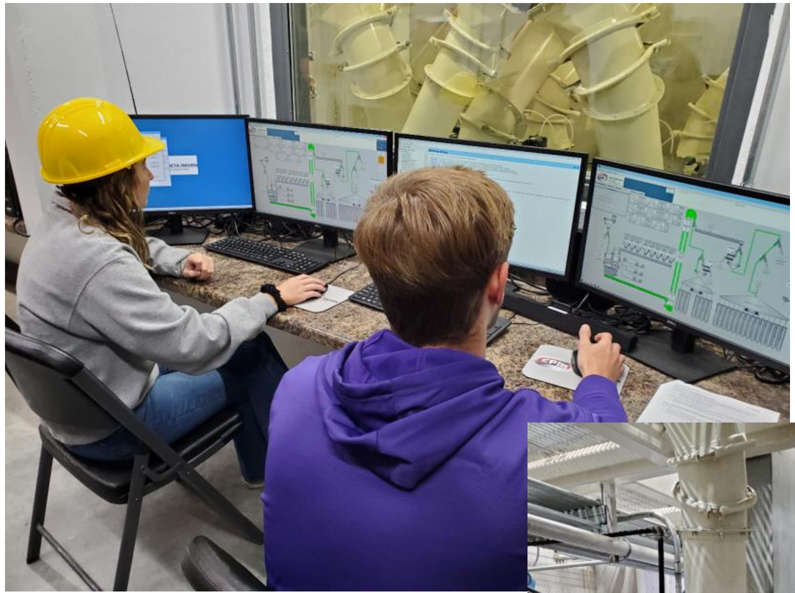
Source: 2020 U.S. Animal Food Consumption Report

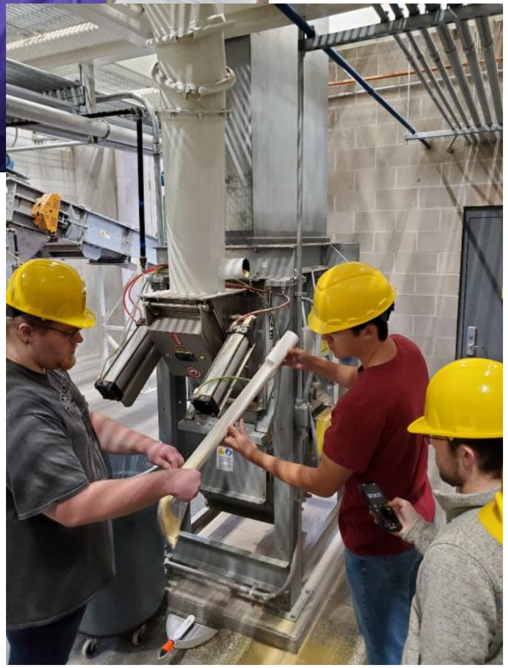
ISU Kent Feed Mill & Grain Science Complex

Looking to the Northwest

TSM 455 Feed Processing & Technology

F23 class – 1st to utilize commissioned FMGSC





Feed Technology & Mill Management Traineeship Program – Purpose

To raise awareness, recruit and prepare qualified students for careers in the feed (and allied) industry and to match them with companies sponsoring the ***ISU Feed Technology & Mill Management Traineeship Program***.

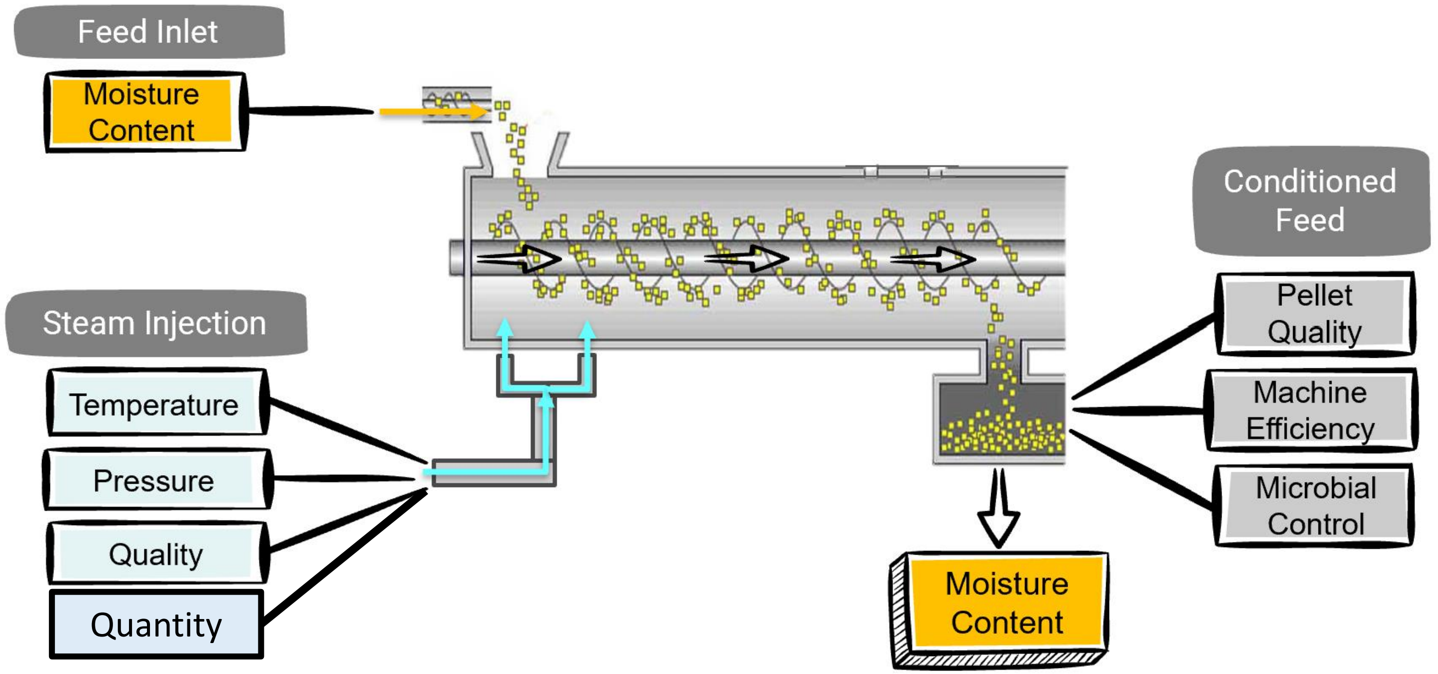
2023 USGC Team from Nigeria, Senegal and Kenya

ADVANCES IN FEED TECHNOLOGY – Artificial Intelligence, Measurement Technology and Operational Efficiency

- Predictive modeling
- Inventory management optimization
- Real-time management decision making
- Cloud-based collaboration platforms

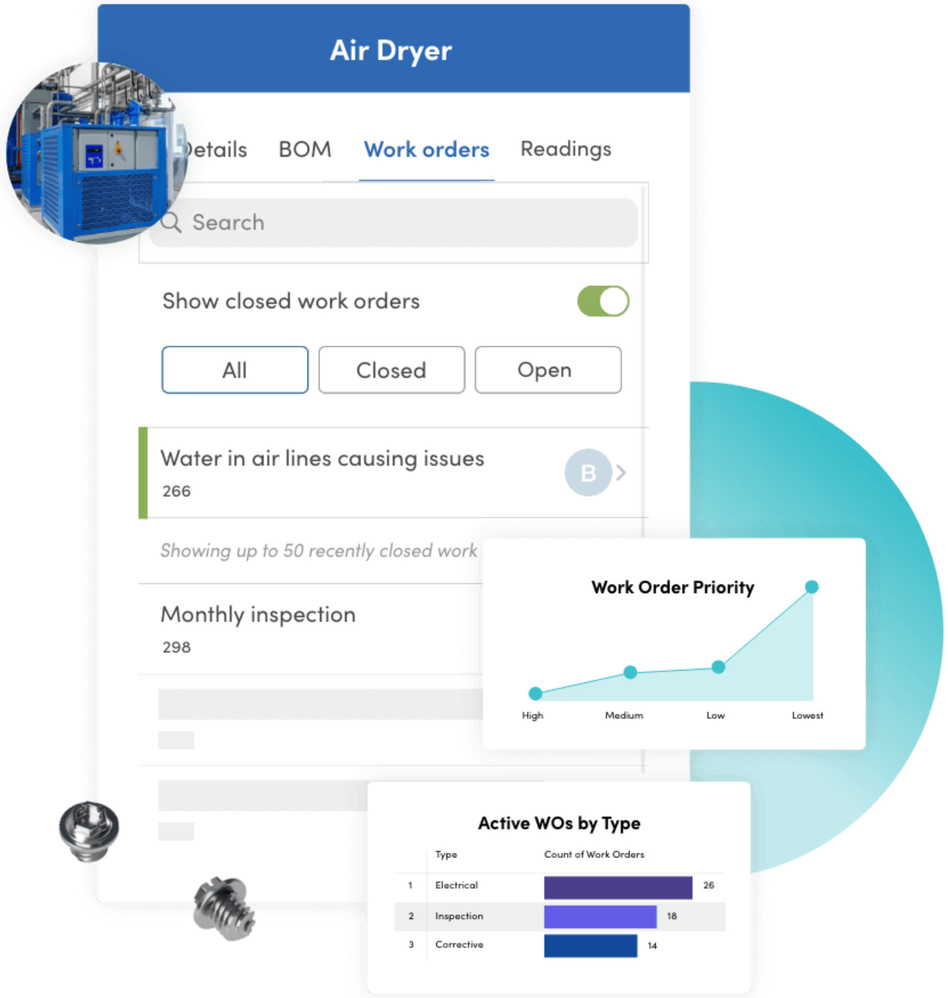
Predictive Modeling of Hydrothermal Processing

- Model development to *__predict__* feed mash moisture content *__after__* hydrothermal processing
  - conditioning feed mash ahead of a hygienizer/retentioner or a pellet mill
- Continuous data collection during hydrothermal processing
- AI integration improves predictive modeling for steam, energy, and moisture optimization



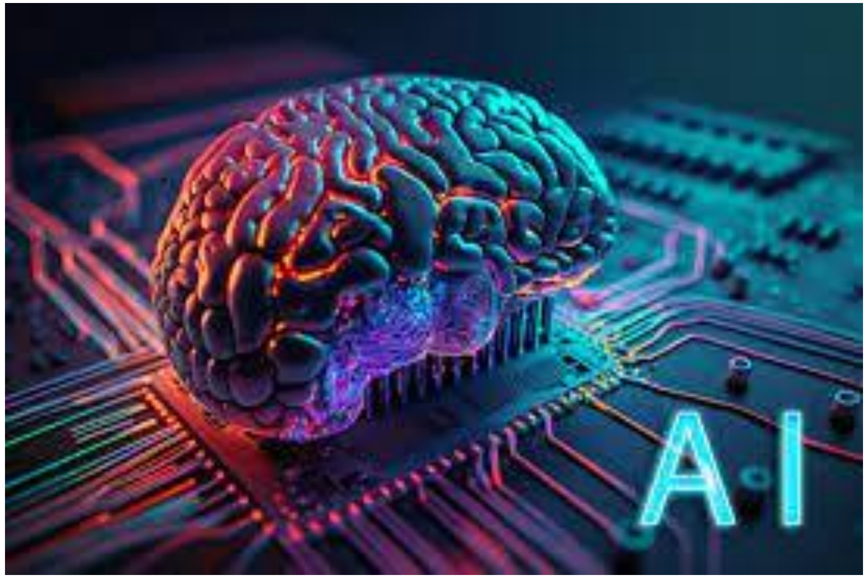
Predictive Modeling of Equipment Maintenance

- Computerized maintenance management system to schedule maintenance and improve operational efficiency predictively
- Hazard monitoring sensors measure continuously and detect & predict onset of equipment component degradation
- Predictive maintenance with Fiix Asset Predictor (from Rockwell Automation)
  - tracking of hazard monitoring sensor data
  - tied-in with plant automation system
  - predictive modeling of degradation



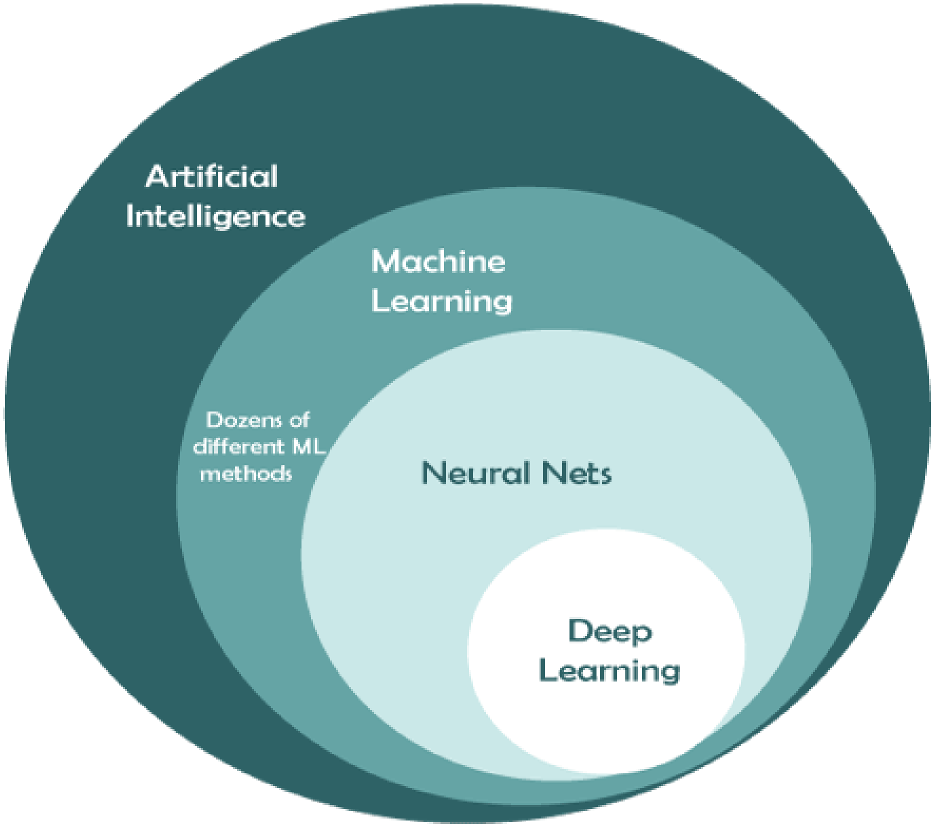
Artificial Intelligence – What is it?

- Technology that enables computers and machines to _simulate_ human intelligence and problem-solving capabilities
- Goal: Software that can *reason an input* and *explain an output* without human interference
  - *a tool to assist humans not to replace humans*



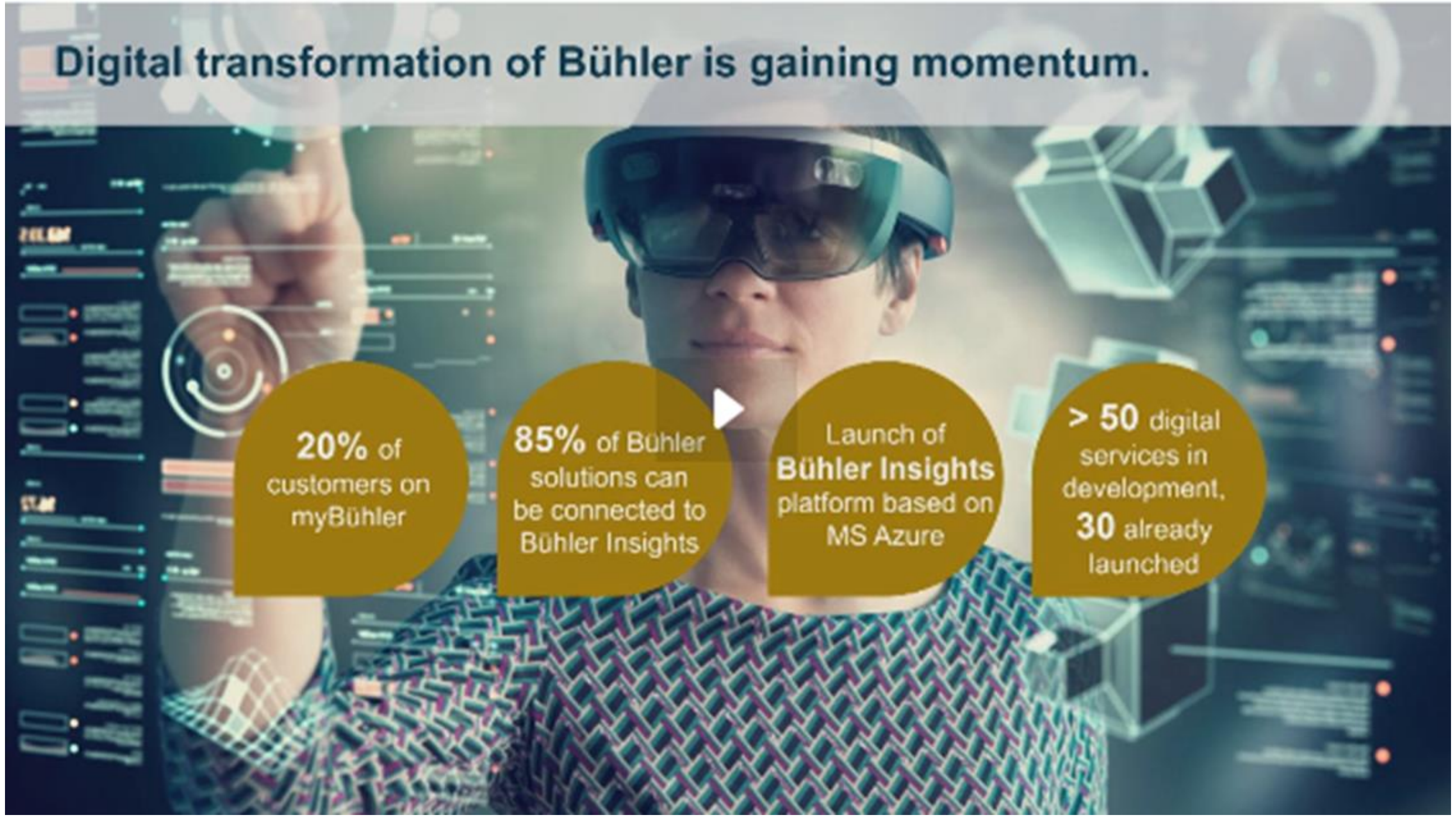
Artificial Intelligence – How does it work?

- **Machine learning:** Process that focuses on using data and algorithms to imitate the way humans learn
  - gradually improves accuracy
- **Neural networks:** Machine learning program that makes decisions similar to the human brain
  - uses processes that mimic biological neurons to identify phenomena, weigh options, and draw conclusions
- **Deep Learning:** Multi-layered networks to simulate complex decision-making
  - What-if scenarios



Artificial Intelligence Capabilities

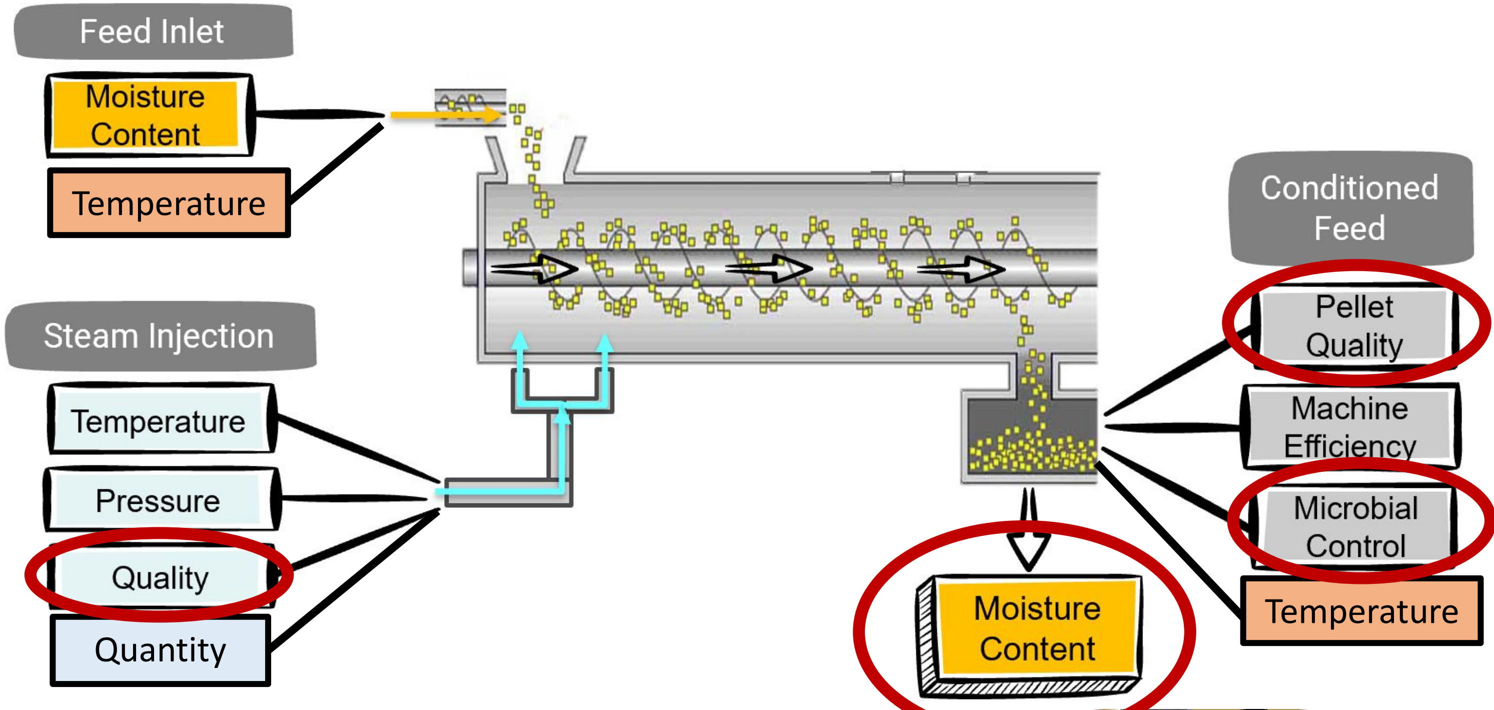
- Computer Vision
- Natural Language Processing (NLP)
- Graphical Processing
- Internet of Things (IoT)
- Advanced Algorithms
- Application Programming Interfaces (API)



Backbone of Artificial Intelligence: Data

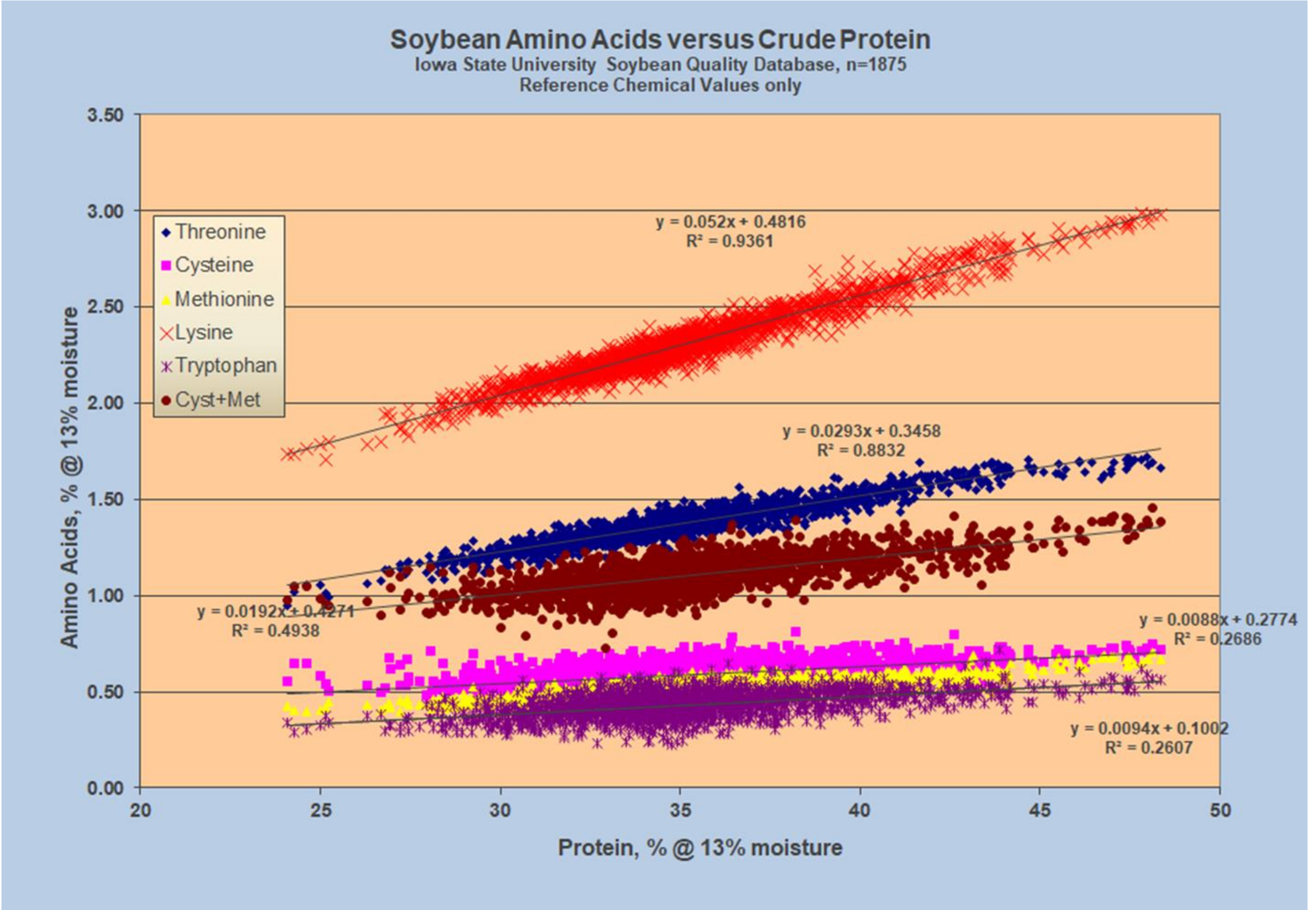
- **Artificial Intelligence is dependent on *GOOD* data**
- Most important factors of *good data* are:
  - Quantity
  - Quality

➔ Garbage in, garbage out!



Data Quantity

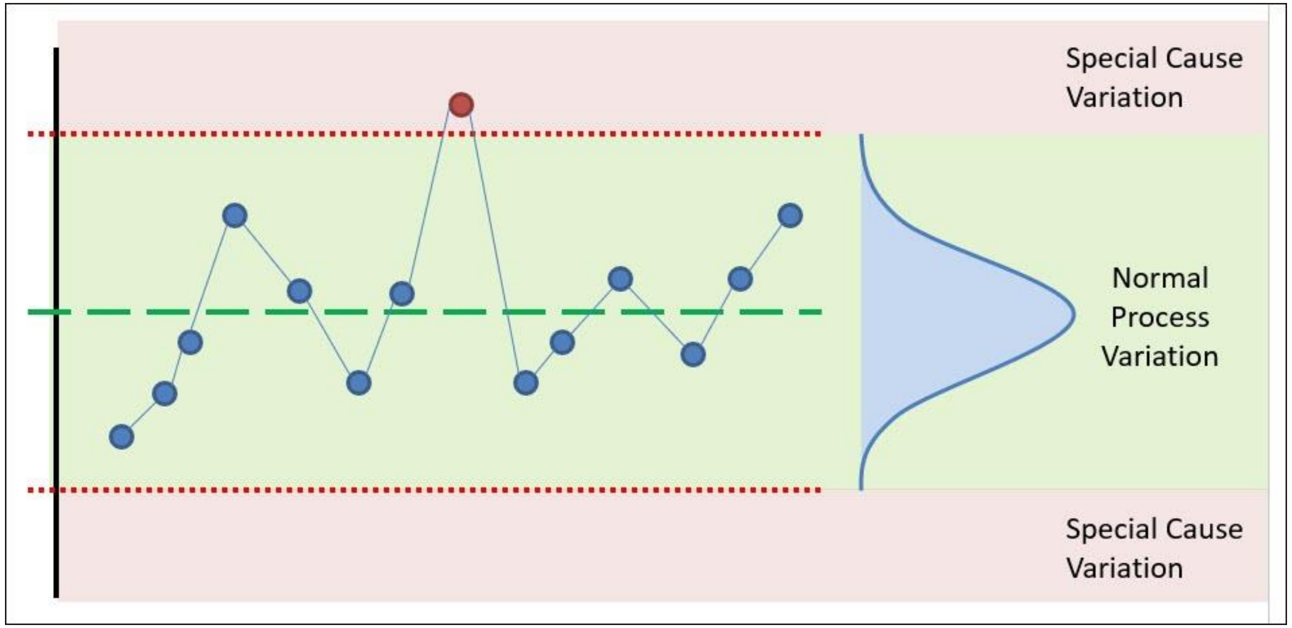
- Amount of data depends on:
  - Type of problem
  - Predictive model complexity
  - Accuracy of data
  - Availability of labeled data



- Statistical methods to estimate sample size should be utilized for large datasets

Statistical Process Control

- Existing technology of constant data collection over time
- Statistical process control helps determine if process variation is consistent or unpredictable
- Monitoring process behavior can find issues in internal systems and find solutions for production issues



Data C

- Sensors are used to collect data and transmit data through physical wires or wireless (IoT)
- Hard-wired physical sensors that measure changes in the environment (e.g., temperature, humidity, vibration, voltage, amperage, frequency, scale weights) are still most commonly used in the feed industry
- *Data is useless if it contains erro from sensors that are inaccurate unreliable, non-functioning*

Predictive Modeling of Hydrothermal Processing

- Model development to ***predict*** feed mash moisture content ***after*** hydrothermal processing
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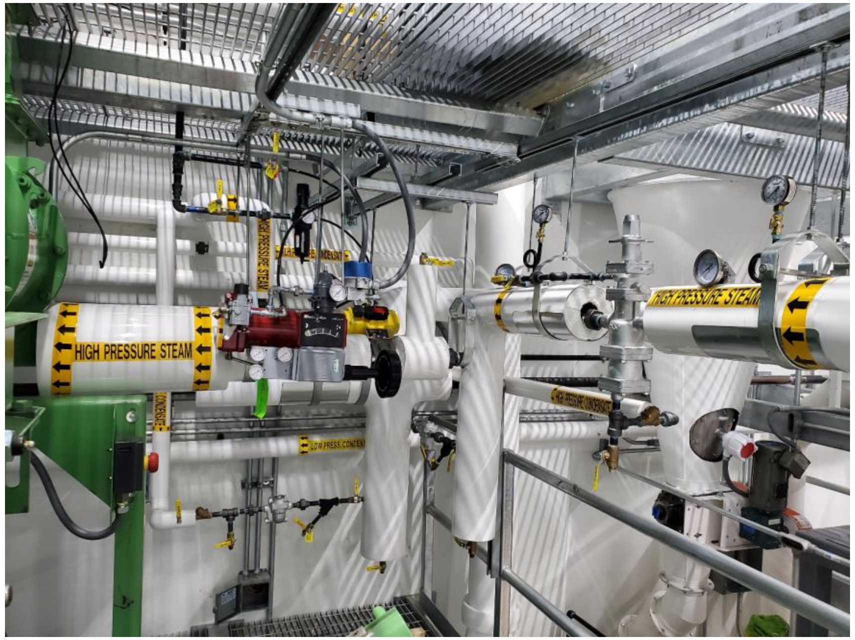
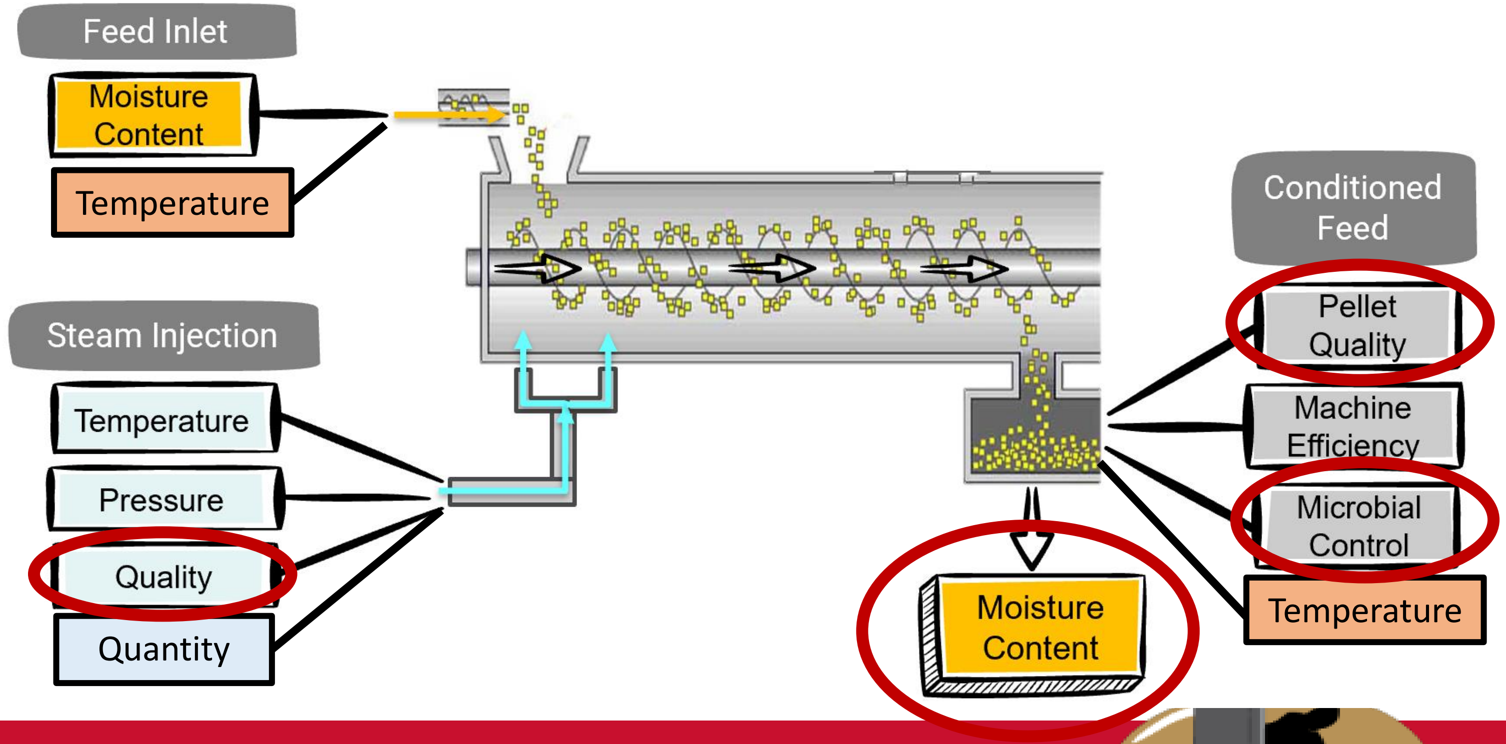
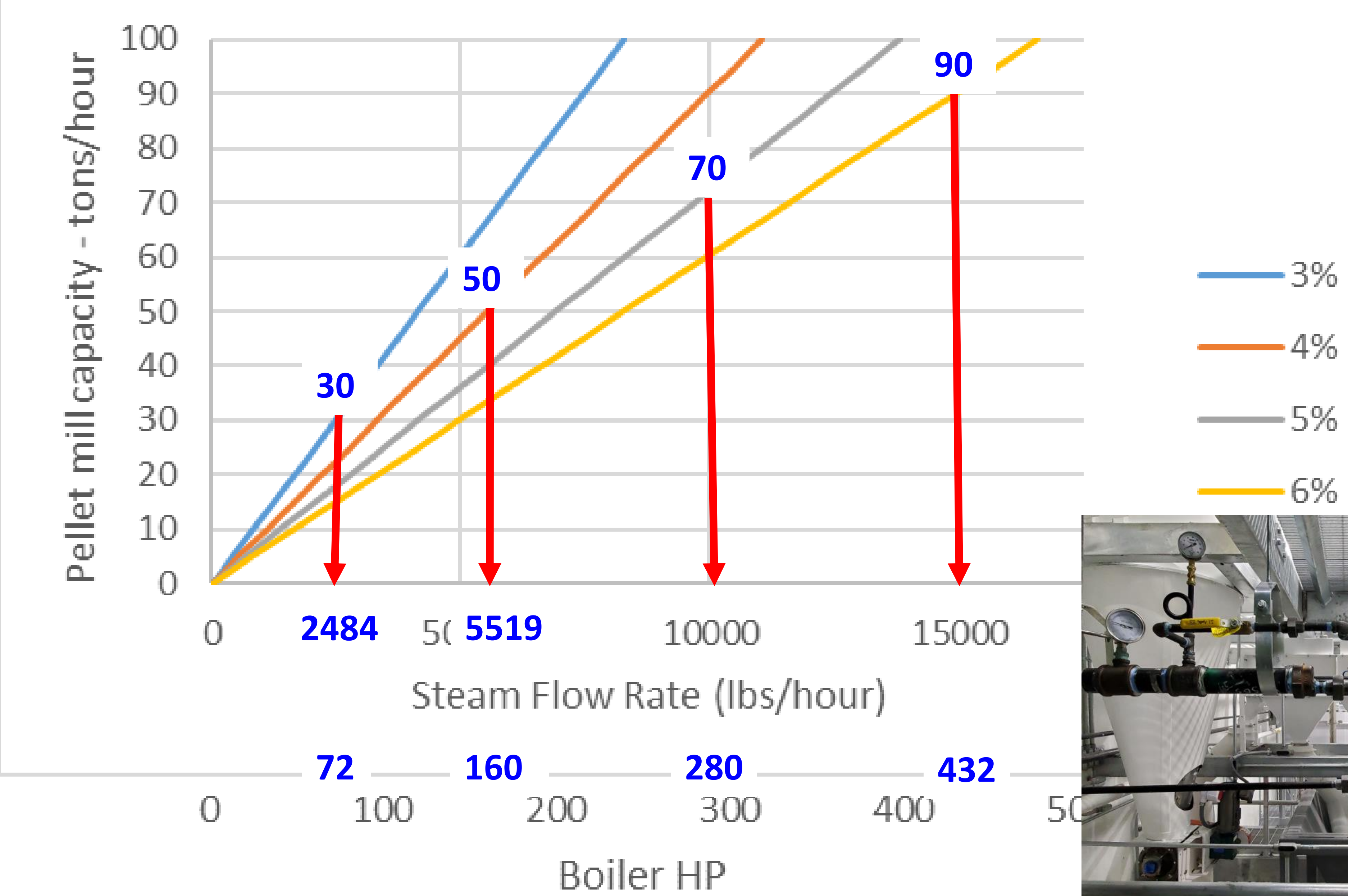
- Continuous data collection during hydrothermal processing

➔ *AI integration will improve predictive modeling for steam, energy, and moisture optimization*





@ 70% Steam Utilization Efficiency
and Ideal Conditioner Energy Balance



Liquid Addition at the Mixer

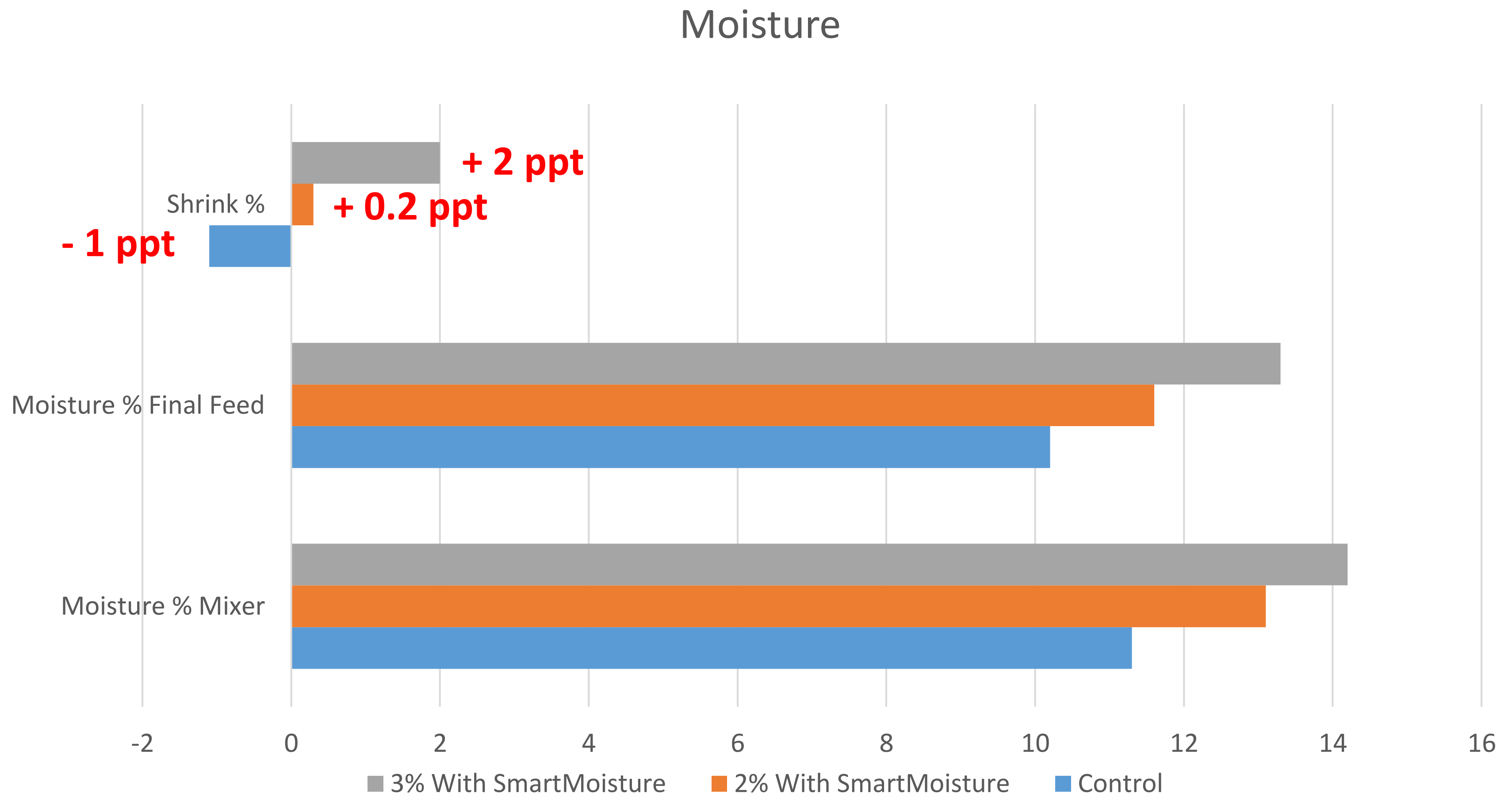
	Control	Added Moisture	
	Moisture	Moisture	
Mixer	11.86	12.80	+0.94 ppts
Conditioner	14.10	15.10	+1.00 ppts
Final Product	11.30	12.50	+1.20 ppts

➔ Note importance of water addition when main ingredients such as corn are too dry!!!

Impact of Moisture Addition – Feed Mill Trial in Egypt

	Control	Added Moisture	Change
Throughput (ton feed/hour)	14.7	15.1	+2.72%
Amps	362	298	-17.7%
Power consumption/hour	12.95	10.37	-19.9%
Temperature	75.8	82.0	+8.18%
Pellet Hardness	6.14	5.85	-4.72%
Pellet Durability index	70%	80%	+14.3%

Impact of Moisture Addition on Inventory Management



Why Moisture Management!?

Why?

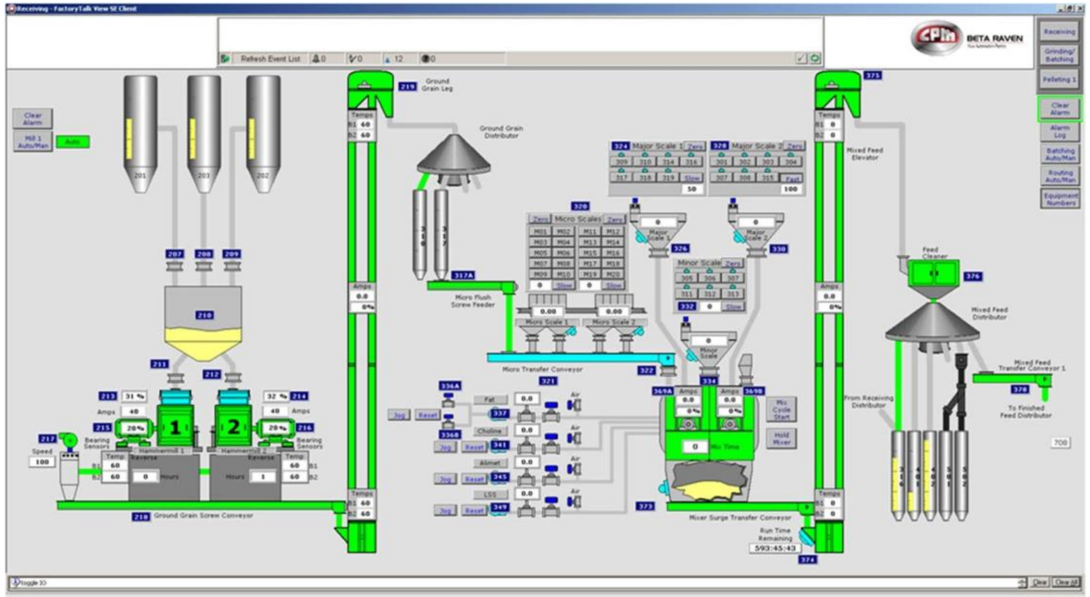
- Increase Production
- Control Shrink
- Lower energy usage
- Increase PDI
- Decrease die wear
- Lower operating costs

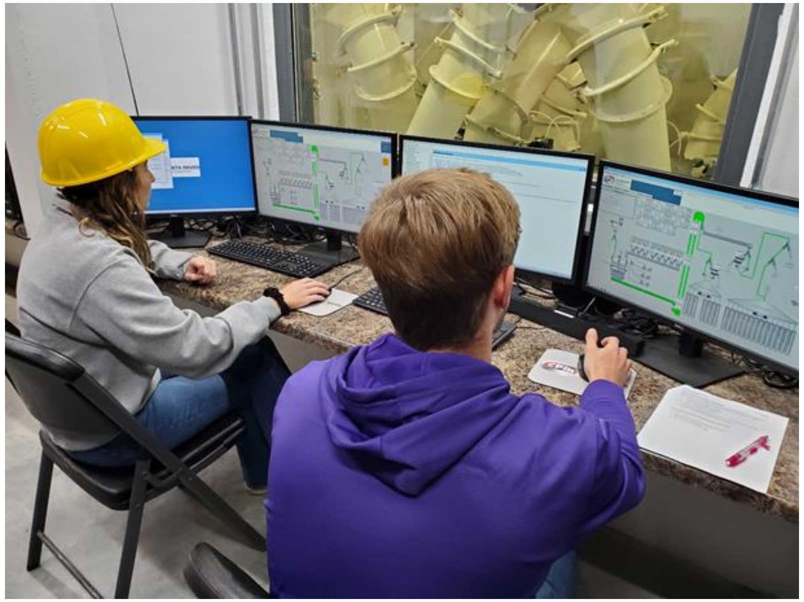
➔ AI + Measurement Technology will allow operators to manage moisture predictively

Plant Automation Systems – CPM BetaRaven

- Process automation software for ingredient scaling system and process controls
- Used for ingredient handling, grinding, batching, mixing, thermal processing, and pelleting operations

➔ *Will include Artificial Intelligence capabilities in the near future…*





Inventory Management – Operational Efficiency

What is Shrink?

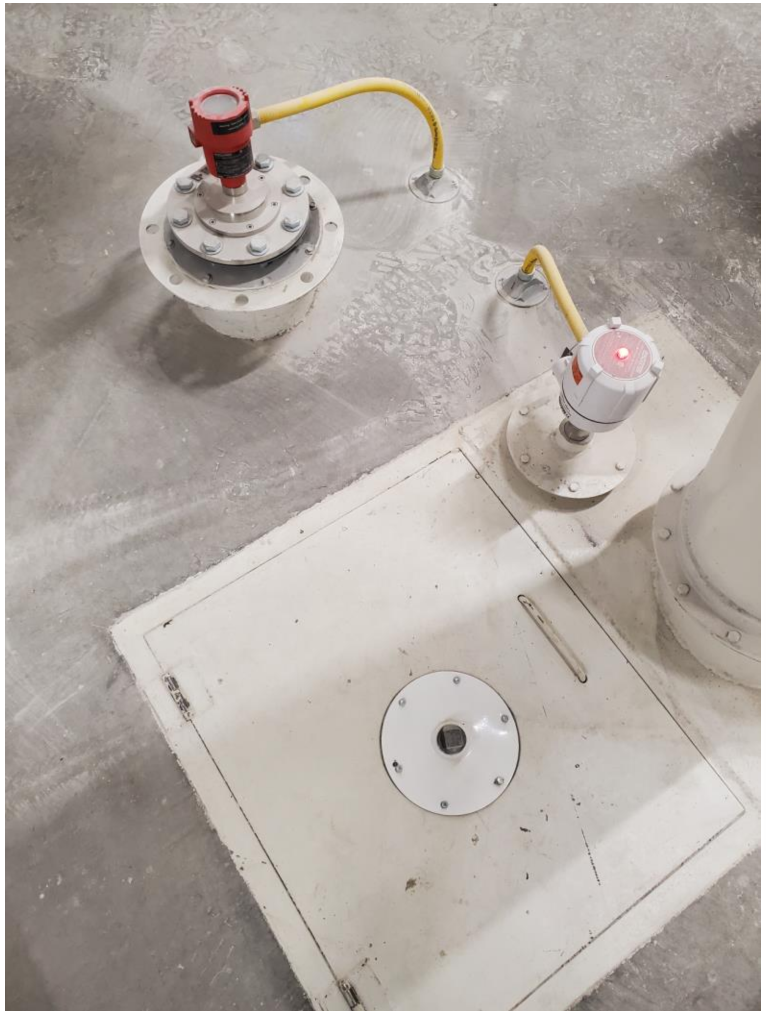
Expressed by weight: (Beginning Inventory + Receipts) - (Ending Inventory + Usage) = Shrink (Gain)

Expressed by percentage: Shrink (Gain) by weight / Shipments by Weight x 100 = % Shrink (Gain)

Principle causes of Shrink:

- Moisture loss
- Dust Control
- Scale Calibrations
- Packaging
- Warehousing
- Plant Security
- Pest Control
- Reporting and inventory practices

Inventory Management with BinView by BinMaster



Inventory Management – Operational Efficiency

Major Scale

Minor Scale

Micro Scale

Liquids

Scale Accuracy!?

Ingredient	Beginning Inventory	Received	Production Usage	Theoretical Ending Inventory	Physical Inventory	Shrink (Gain)	%
Corn	250000	100000	155000	195000	187000	8000	5.2%
Soy	123000	50000	72000	101000	96876	4124	5.7%
DDGS	95000		24000	71000	69876	1124	4.7%
Total	*468000*	*150000*	*251000*	*367000*	*353752*	*13248*	*5.3%*
Limestone	45000		2000	43000	42987	13	0.7%
Phosphate	15000	8000	900	22100	22200	-100	-11.1%
Salt	15000		500	14500	14490	10	2.0%
Total	*75000*	*8000*	*3400*	*79600*	*79677*	*-77*	*-2.3%*
Mineral Premix	1500		95	1405	1404	1	1.1%
Broiler Vitamin	900		27	873	872	1	3.7%
Lysine	200	200	38	362	363	-1	-2.6%
Methionine	320		26	294	295	-1	-3.8%
Copper Sulfate	500		10	490	490	0	0.0%
Total	*3420*	*200*	*196*	*3424*	*3424*	*0*	*0.0%*
Fat	24000		2000	22000	21998	2	0.1%
Choline	10000		500	9500	9501	-1	-0.2%
Total	*34000*	*0*	*2500*	*31500*	*31499*	*1*	*0.0%*
Total	**580420**	**158200**	**257096**	**481524**	**468352**	**13172**	**5.1%**

Finished Feeds

Total Shrink (Gain)

Shrink Target!?

Feed	Beginning Inventory	Produced	Shipped	Theoretical Ending Inventory	Physical Inventory	Shrink (Gain)	%
Broiler Starter	48700	24237	16987	55950	57654	-1704	-10.0%
Broiler Grower	32100	125367	110567	46900	51564	-4664	-4.2%
Broiler Finisher	52001	107492	123987	35506	40523	-5017	-4.0%
Total	**132801**	**257096**	**251541**	**138356**	**149741**	**-11385**	**-4.5%**
Net Total	**713221**	**415296**	**508637**	**619880**	**618093**	**1787**	**0.71%**

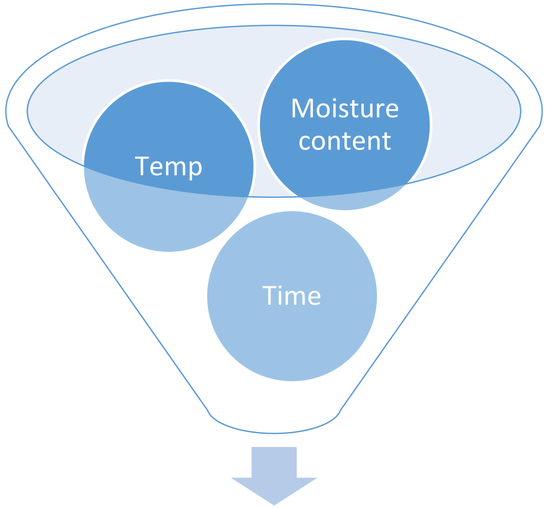
Operational Efficiency – Where to Start?

Begin with the end in mind → a clear set of operating requirements

- Particle size requirements
- Mixer CV%
- Pellet durability index (PDI)
- Pellet hardness
- Crumble size and quality
- Microbial load (Feed Safety)

→ *AI + Measurement Technology will allow operators to gain operational efficiency by optimizing among multiple variables*

Biosecurity and Feed Safety – Salmonella Inactivation



Pathogen Destruction

Process of Ongoing Improvement

What should we do to improve operational efficiency?

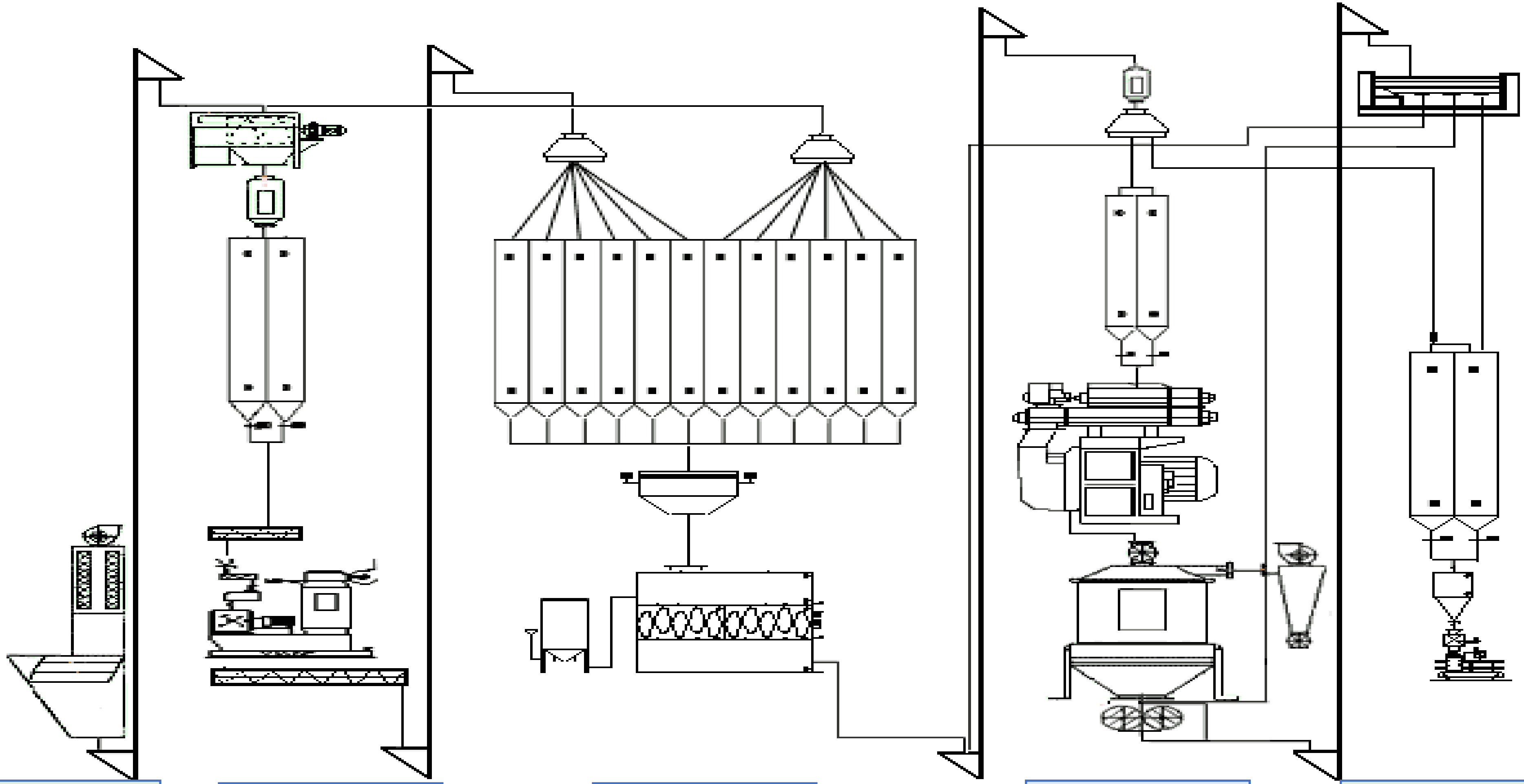
- Increase the plant **Throughput** without increasing or only marginally increasing Operational Expense or Inventory
  - *Increase design utilization from 69.6% to 81%*
- Decrease the plant **Operational Expense** without decreasing Throughput
  - *Decrease shrink from 0.93% to below 0.75%*
- Decrease **Inventory** without decreasing Throughput
  - *Decrease inventory turn-over from every 2 weeks to every week*

Process	Intake	Grinding	Batching	Pelleting	Bagging
Capacity	100 TPH	60 TPH	40 TPH	40 TPH	60 TPH

Plant Capacity

40 TPH

Equipment vs Throughput Capacity



Calculating Overall Equipment Effectiveness (OEE) for Availability, Performance, Quality

- Availability = Run Time / Planned Production Time
- Performance = Actual Production / Rated Capacity
- Quality = Conforming Product / Total Production

A X P X Q = OEE

A		P		Q		OEE
108HR / 120HR		32TPH / 40TPH		3820T / 3840T		
90%	X	80%	X	99%	=	72%

Summary – Artificial Intelligence, Measurement Technology, Operational Efficiency

- *<u>Artificial Intelligence</u>* is technology that enables computers and machines to simulate human intelligence and problem-solving capabilities
    - predictive modeling; statistical process control
- *<u>Measurement Technology</u>* requires reliable sensors that collect lots of good data that can be analyzed, displayed and utilized across collaborative cloud platforms
- *<u>Operational Efficiency</u>* is gained by understanding, defining and utilizing Process Improvement model approach and determining Overall Equipment Effectiveness (OEE)
    - 25-55 needs improvement; 55-70 typical
    - 70-85 high performance; 85-100 world class

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Questions?

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