Final Year Design Project Showcase
Batch-2022
Year 2026

	Department: Food Engineering **Programme:** BE
1	**Project Title** AI-Assisted Energy Optimization and Fault Prediction in Spray Drying of Dairy Products
2	**Project Idea** The process of spray drying is the common industrial process for converting liquid dairies (fresh buffalo milk) into stable milk powder, but is one of the most energy consuming step of food manufacturing and there doesn't exist a cheap real-time fault detection system. The project concept was to integrate the energy optimization model with a sensor system based on the Arduino low cost microcontroller, and develop a controlled laboratory experiment to simultaneously optimize energy use and detect equipment faults in real-time.
3	**Process** A controlled lab experiments were carried out on the lab scale spray dryer using fresh buffalo milk, systematically varying the atomization pressure (0.5–2.0 bar), air temperature (100–140°C) and feed flowrate (35-40%). Empirical polynomial regression equations were developed from this experimental data for powder yield and intermediate product formation and an AI model using random forest was trained to classify faults, predict yield and energy. The temperature data captured by the thermocouple was displayed in real time by the MAX6675 module and Arduino Uno and then fed into a Python GUI where the dryer was classified into 7 categories (Normal, Heater Failure, Milk Flow Failure, Fan Failure, Nozzle Clogging, Incomplete Drying, Pressure Anomaly) every second.
4	**Outcome** The optimal operating condition was determined as 130°C exhaust temperature, 1.5 bar atomization pressure and 40% feed flowrate, which resulted in 35.7 g of powder per liter of feed together with 44 mL of intermediate (waste) formation, a 78% reduction when compared to the worst condition. The Specific Energy Consumption at this condition was 2419-2506 kJ/kg of water evaporated, which is the lowest for all conditions tested. The fault detection system was able to detect fault in 10-45 seconds with a low cost setup of hardware using thermocouples and Arduino (total cost of the setup is under Rs 2000).
5	**Evidence (Theoretical Basis)** The project is based on the thermodynamics and mass and energy balance of spray drying processes, and on the use of empirical polynomial regression models to describe the relationships between process parameters (temperature, pressure, flowrate) and powder yield and intermediate formation. Uses Random Forest machine learning (ensemble learning theory) to perform multi-output regression and fault classification, with Leave-One-Out Cross-Validation (LOO-CV) and 80/20 holdout testing validation. The real-time hardware layer adopts the theory of thermocouple sensing and embedded systems (K-type

	thermocouple + MAX6675 cold-junction compensation) and Arduino Uno programming skills.	
6	**Competitive Advantage or Unique Selling Proposition**	
a	**Attainment of any SDG** Implements directly SDG 2 (Zero Hunger — reduces milk loss during post production), SDG 7 (Affordable & Clean Energy — lowers Specific Energy Consumption by optimizing operating parameters), SDG 9 (Industry, Innovation & Infrastructure — low cost AI + sensor based smart monitoring) and SDG 12 (Responsible Consumption & Production — reduces raw material waste).	
b	**Any Environmental Aspect** Lowers the carbon footprint of one of dairy processing's most energy intensive steps by reducing energy use per kg of water evaporated (2419-2506 kJ/kg at optimum vs. higher values at unoptimized settings).	
c	**Cost Reduction of Existing Product** The formation of the intermediate products (waste) is reduced from 200 to 44 mL per 1 L batch (78% reduction), directly reducing the raw material loss and material cost per 1 L batch of milk powder produced.	
d	**Process Improvement which Leads to Superior Product or Cost Reduction, Efficiency Improvement of the Whole Process** Switches from slow and error-prone manual, experience based operator monitoring to an automated AI system, which predicts optimal operating settings and identifies 6 types of fault (heater failure, milk flow failure, fan failure, nozzle clogging, incomplete drying, pressure anomaly) in 10-45 seconds, resulting in improved consistency, yield and product quality.	
7	**Target Market** Small and medium sized dairy processing units, in Pakistan and other South Asian economies which do not have automated process control and manual monitoring by the operator. Applicable to academic or research laboratories conducting spray drying experiments and require inexpensive, integrated monitoring and predictive tools as opposed to expensive industrial systems.	
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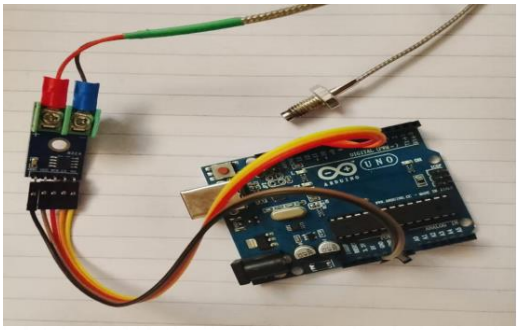
10	**Supervisor Name**	Supervisor: Mr. Muhammad Hassam Siddiqui, Assistant Professor (hassamsiddiqui@cloud.neduet.edu.pk) Co-Supervisor: Dr. Aisha Jilani, Assistant Professor (aishajilani@neduet.edu.pk)
11	**Video (If any)**	FYP

Pictures (to be pasted below)



LIVE SPRAY DRYING AI MONITORING SYSTEM
Automatic Excel File Monitoring | Real-time Predictions | Auto-Training Mode
Live Prediction
Energy Balance
Monitoring Log
Training Data
Process Visualization
LIVE PREDICTION RESULT
Time: 2026-05-20 19:22:20
INPUT PARAMETERS
Temperature: 45.0°C
Pressure: 1.5 bar
Flow Rate: 40.0%
Feed Volume: 2000.0 ml
PREDICTED OUTPUTS
Powder Yield: 115.9 g (57.9 g/kg feed)
Intermediate Loss: 277.1 ml (138.6 ml/kg feed)
PROCESS EFFICIENCY
Powder Recovery: 29.5% (POOR)
FAULT DETECTION
CRITICAL: Temperature too low (45.0°C) - Risk of incomplete drying
CRITICAL: High intermediate loss (277.1ml) - Check nozzle
CRITICAL: heater off - on heating element