Where There's A Prill, There's A Way

Autonomous Extruder-Spheronizer

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Background

The Lawrence Livermore National Laboratory uses extrusion-spheronization to convert slurry-like energetic material into pellets for capsule storage by pressing the material into strands and rounding it with a rotating friction plate. Currently, operators must manually transfer material between extrusion, spheronization, and collection processes, increasing exposure to hazardous energetics. This conflicts with the explosives manufacturing safety principle of the "3 M's": minimum people, minimum time, and minimum exposure. At Sphero-Ex, we aim to produce a system that assures energetic material manufacturing is safer and continuous by fully automating the process.

Design Specifications

Objective: Develop a fully autonomous extruder-spheronizer that integrates extrusion, gravity-fed spheronization, cam-actuated discharge, and compressed-air pellet collection to produce high-quality throughput. The spheres produced by our system exceed the quality of those produced by the manual equipment currently used at LLNL.

Need	Engineering Characteristic	Specification
Consistency	Diameter	1-1.3mm
Production	Cycle Quantity	1g/min
Uniformity	Aspect Ratio	>0.7
Roundness	Circularity	>0.7

System Diagrams

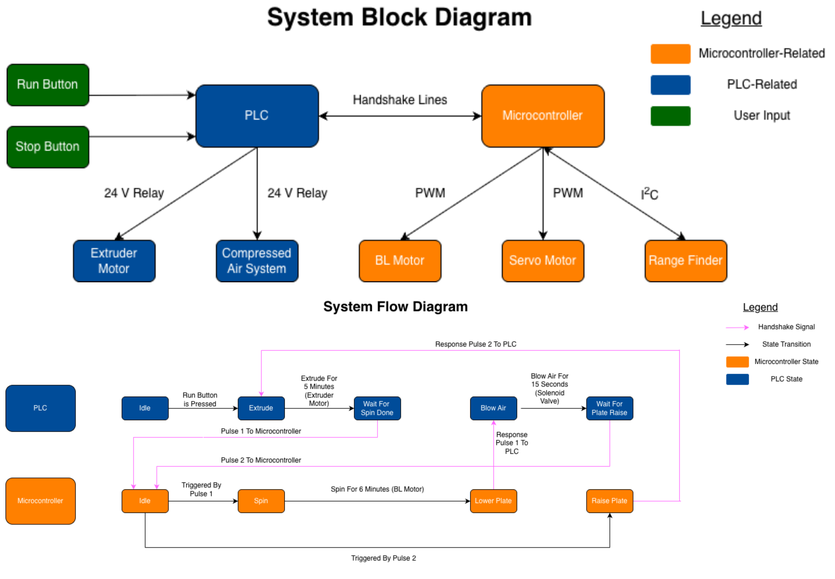
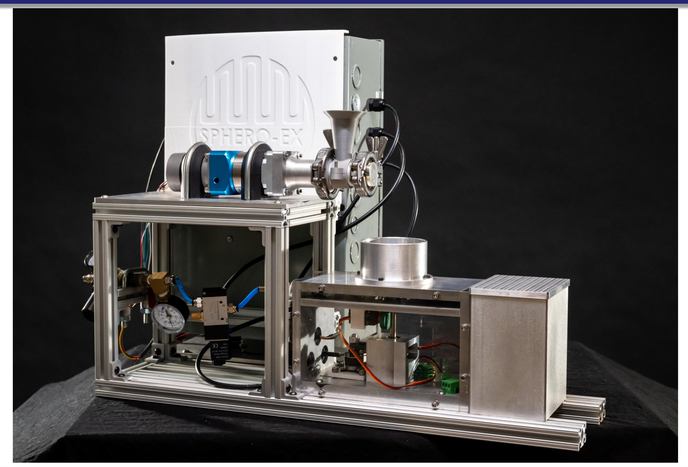
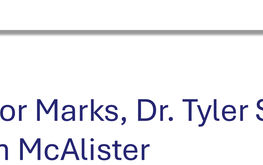


Figure 1: System Block Diagram and System Flow Diagram

Final Product

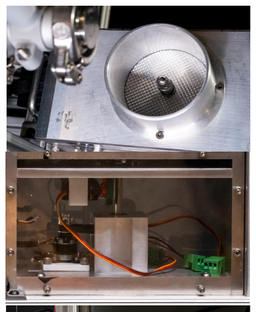


Key Components



Extruder

Converts slurry into noodles for spheronization
Operates at 75 RPM (adjustable rate)
50:1 Reduction gearbox for torque production

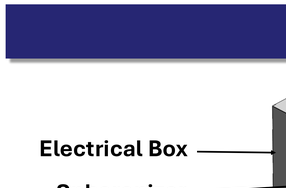


Spheronizer Chamber

Friction plate with 70° grooves 3 mm apart
Operates at 1300 RPM (adjustable rate)
Spring-washer clutch system to transmit power

Drop-Down Actuation System

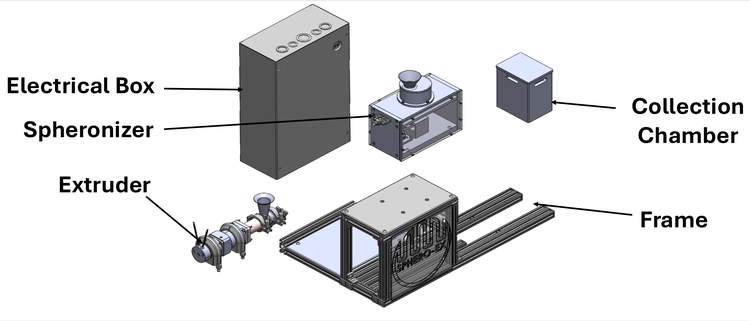
Servo motor actuates cam system
Cam vertically shifts plate with precision
Anti-binding sleeve ensures smooth plate travel



Compressed Air Transfer

Air blows across dropped plate to direct spheres to collection chamber
Solenoid valve opens and closes airway

Exploded View



Quality Comparison

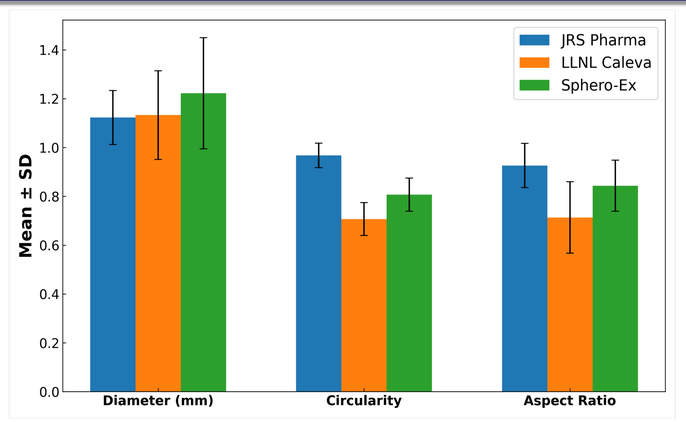


Figure 2: Mean and Standard Deviation vs. Quality Characteristic Comparison

The particle comparison evaluates Sphero-Ex spheres against LLNL-produced spheres and commercial JRS Pharma standards. Particle diameter, circularity, and aspect ratio were measured using image-based particle analysis to assess spherical quality and consistency. The results show that Sphero-Ex produced spheres that are competitively within the target size range with characteristics comparable to benchmark materials.

Particle Size Comparison

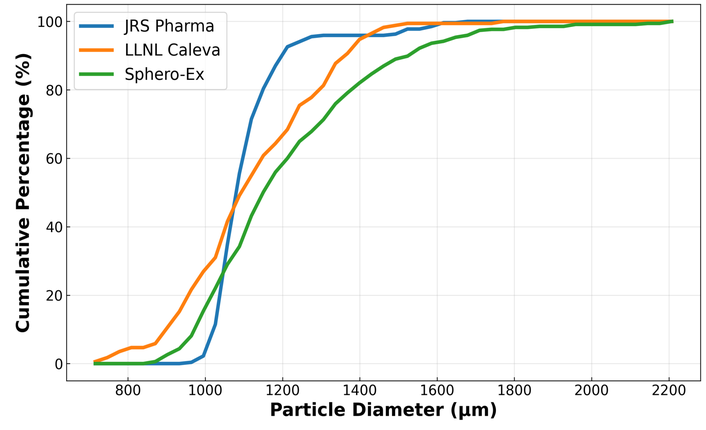


Figure 3: Cumulative Percentage vs. Particle Diameter Comparison

The particle size comparison evaluates the percentage of throughput below a given diameter for each sample. Steeper curves indicate greater particle size consistency, while broader curves suggest increased variability across the sample. Approximately 60% of Sphero-Ex produced spheres were within the target size range and demonstrated a distribution comparable to LLNL-produced spheres. This indicates that Sphero-Ex sufficiently produced spheres sufficiently to satisfy the consistency requirement.

Lawrence Livermore National Laboratory

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