

PELLETIZING SYSTEMS

Numerical Insights into Design and Performance of Centrifugal Dryers

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Motivation and Objectives

Centrifugal dryers are commonly used in polymer pelletizing to remove residual moisture, ensuring pellet quality, stable downstream processing, and energy efficiency. Rotor design, particularly flight angle, spacing, and speed, significantly affects pellet transport, residence time, and drying performance. Understanding rotor geometry and operating conditions is key to improving efficiency. Advanced simulations, such as coupled DEM–MPS, enable a detailed study of particle–fluid interactions that are difficult to capture experimentally.

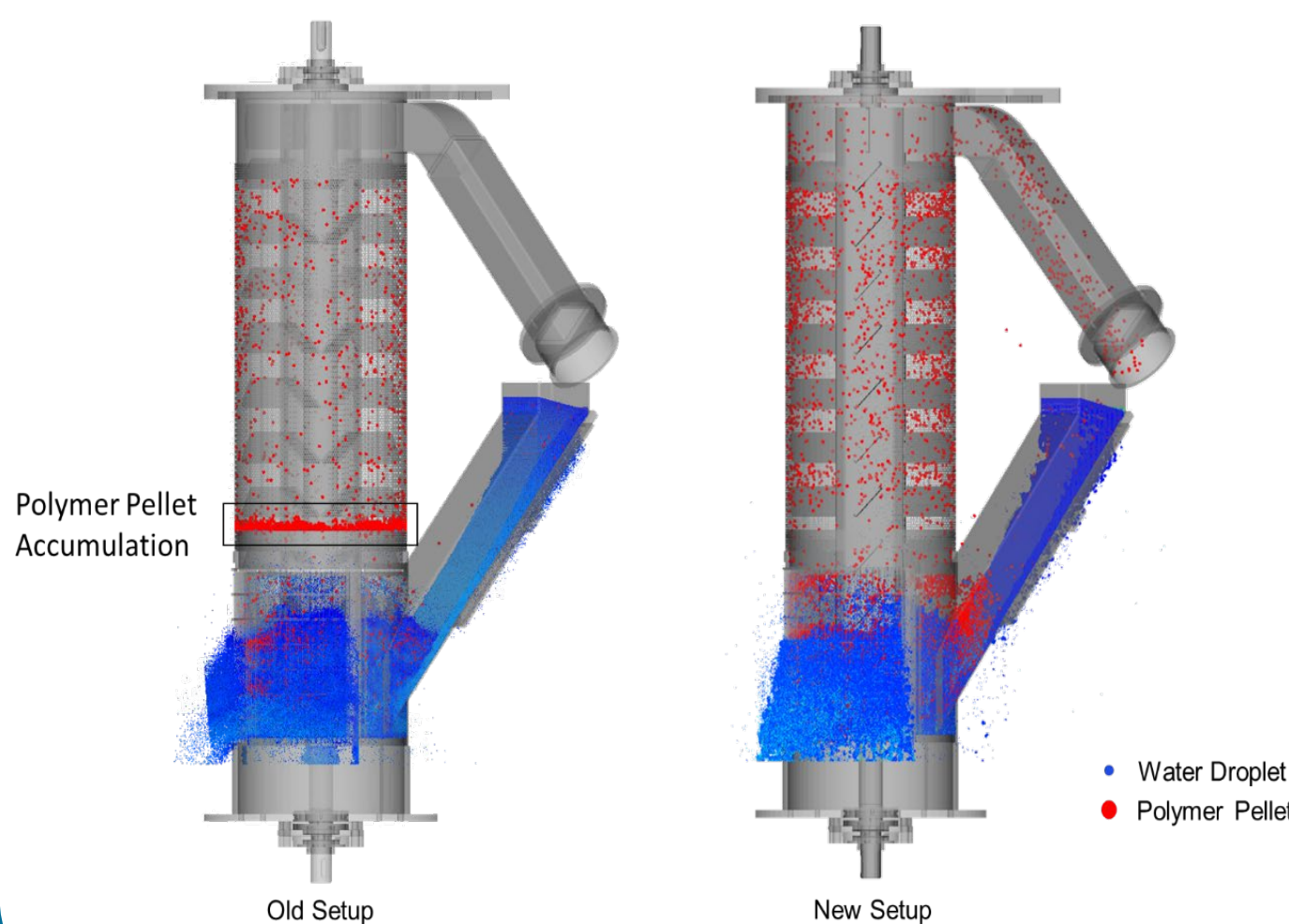
Motivation: Drying performance strongly depends on rotor geometry and operating conditions, creating a need for energy-efficient solutions that ensure stable pellet discharge and uniform residence times.

Objectives: This study aims to assess the effect of rotor flight angle (10°, 45°, 70°) on pellet transport and discharge, analyze how flight count (10–25) influences particle confinement and residence time, and investigate the impact of rotor speed (920–1600 rpm) on throughput and process stability. Key performance metrics, including pellet discharge rate, residence time, discharge time, and energy consumption, will be measured to identify an optimal rotor configuration for efficient, stable, and energy-effective drying.

Results and Discussions

Quasi-Steady-State Behavior

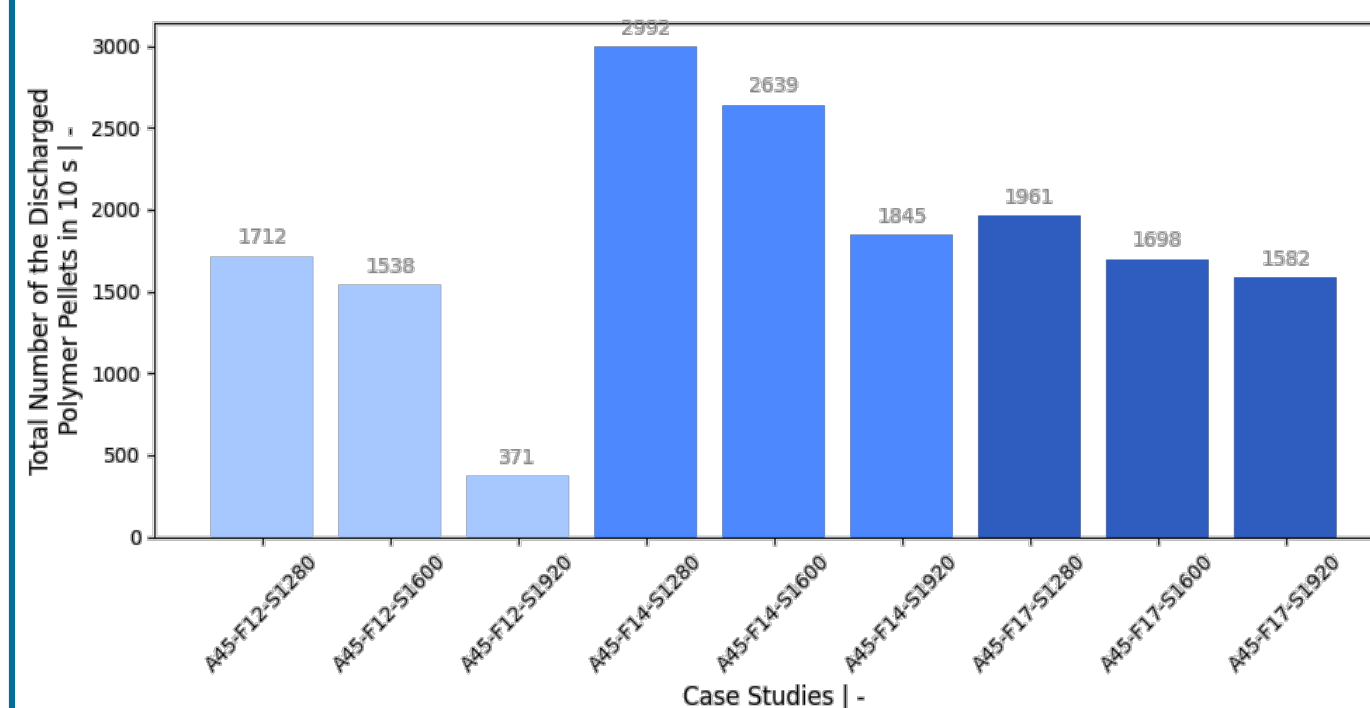
The system reaches a quasi-steady-state after ~8 s, characterized by temporally stable mass flow and uniform pellet discharge. The elimination of pellet stagnation beneath the screens indicates improved flow continuity and reduced dead zones.



Pellet Discharge Performance

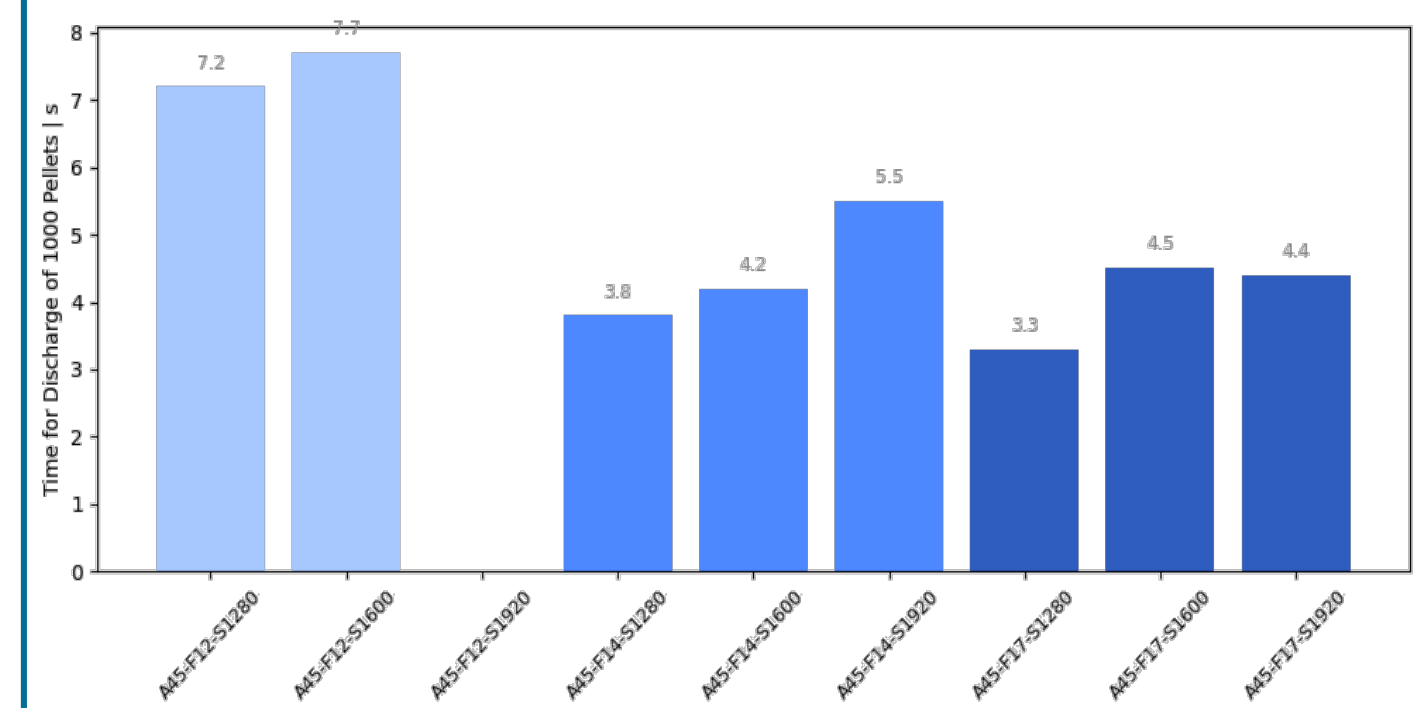
A rotor angle of 45° yields optimal discharge efficiency, whereas 10° results in insufficient particle lift and 70° promotes recirculation. An intermediate number of flights maximizes throughput, whereas excessive flights induce particle congestion.

Example: 1,280 rpm: F12 → 1,712 pellets; F14 → 2,962 pellets; F17 → 1,961 pellets.



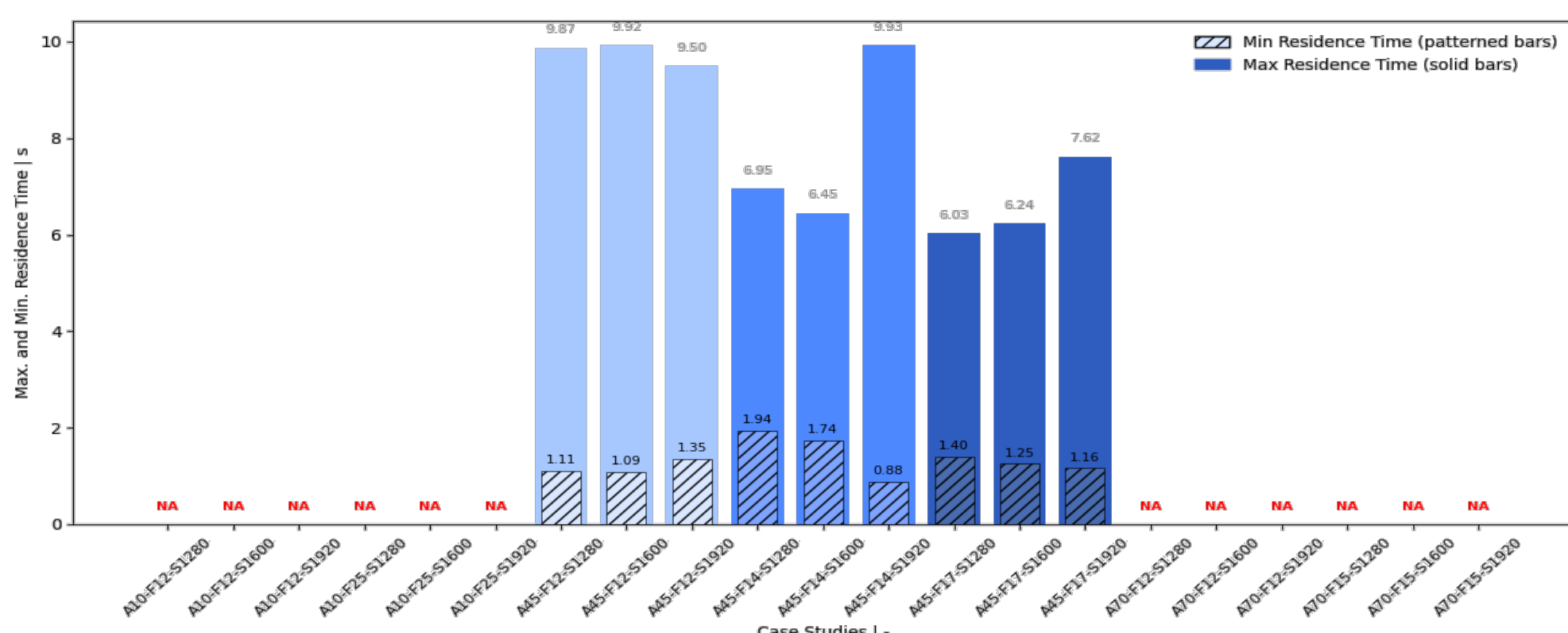
Discharge Kinetics

Only 45° configurations achieve 1,000 discharged pellets within 10 s, indicating superior transport kinetics. An increasing number of flights enhances the discharge rate. However, high rotational speed combined with low flight count leads to flow instability.



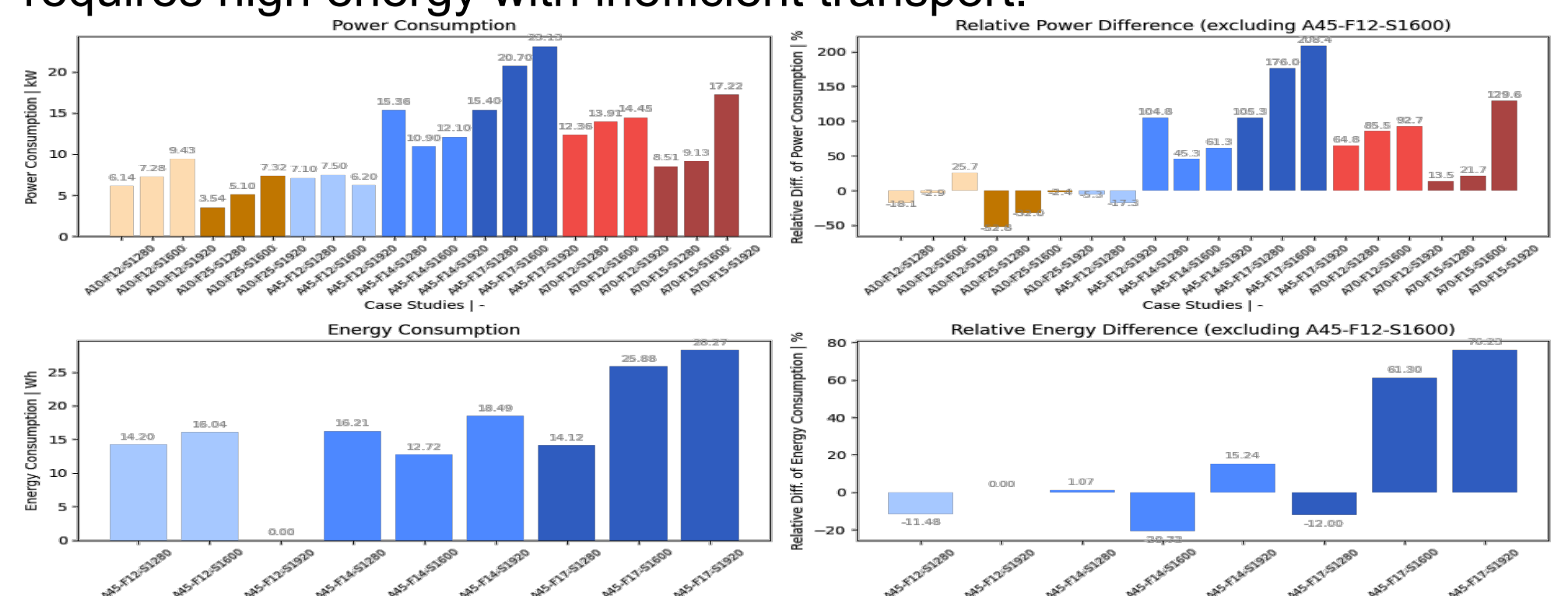
Residence Time Distribution

Narrow residence time distributions indicate more homogeneous flow. The optimal case (F17-S1280) shows a range of 1.4–6.03 s. Configurations at 10° and 70° show no measurable residence time due to the absence of discharge.



Power and Energy Consumption

Power demand rises with flight number and rotor speed, peaking at F17-S1920 (23.1 kW, 28.3 Wh). The most energy-efficient case is F14-S1280 (16.2Wh), balancing power and discharge. The 10° angle consumes low energy but performs poorly, while the 70° angle requires high energy with inefficient transport.



Conclusion

The study demonstrates that rotor geometry and speed strongly influence centrifugal pellet dryer performance. A 45° rotor angle, 14 flights, and 1280 rpm provided the best balance of high discharge, stable particle flow, narrow residence times, and moderate energy use. Rotor flight count improves flow uniformity but excessive counts or high speeds can reduce efficiency. These findings identify an optimal configuration for industrial applications and highlight the potential for future work incorporating thermal and airflow effects.

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