TECHNICAL CASE STUDY & PRODUCT EVALUATION

AL Series Rotary Lobe Pump

Ampco Pumps GmbH
A Member of the KRONES Group

Category: Optimizing Shear-Sensitive Transfer and CIP Reliability in Commercial Bakery Processing

Executive Summary

In industrial commercial baking operations, maintaining product integrity while ensuring robust Clean-in-Place (CIP) performance represents a critical engineering challenge. This technical case study evaluates the deployment of the Ampco AL Series Rotary Lobe Pump within a high-throughput bakery processing environment. The system was tasked with transferring shear-sensitive liquid egg blends and dense cake batters containing delicate suspended solids.

By leveraging the precision-engineered clearances and bi-wing lobe geometry of the AL Series, the facility mitigated product degradation issues caused by traditional pump designs, while simultaneously eliminating mechanical seal failures through the integration of an innovative front-loading seal configuration.

1.The Challenge: Product Shear & CIP Demands

A Tier-1 commercial baking facility faced severe processing constraints using legacy positive displacement pumps in their primary liquid egg and batter preparation lines. The application presented two compounding engineering difficulties:

- **Shear Sensitivity:** Liquid egg whites and structured batters are highly sensitive to mechanical shear stresses. Excessive shear forces degrade proteins, leading to premature aeration or loss of emulsification properties. This directly impacted the finished product's crumb structure, density, and volume.
- **Sanitary Maintenance Downtime:** Daily sanitization protocols required comprehensive CIP processes. The legacy pumps suffered from internal "dead zones" where heavy starches and sugars became baked onto surfaces, resulting in extended manual strip-down cleanings (COP) and frequent premature mechanical seal failures due to abrasive particle crystallization.

Process Parameters & Operating Criteria:

- **Fluid Viscosity:** 2,500 cP to 8,000 cP depending on temperature and formulation
- **Operating Temperature:** 4°C (39°F) for raw egg storage to 22°C (72°F) during batter blending
- **Discharge Pressure:** 6.2 bar (90 psi) nominal
- **Required Flow Rate:** 95 GPM (21.5 m^3/hr)

2. Technical Evaluation & Solution Design

Ampco Pumps engineers recommended the implementation of the AL Series (Model AL51) Rotary Lobe Pump, configured with standard bi-wing rotors and a front-loading mechanical seal layout. The technical selection was justified by several core design characteristics unique to the AL line.

A. Optimized Fluid Internal Dynamics

Unlike standard positive displacement gear or progressive cavity options, the AL Series features large fluid cavities between the lobes. This ensures that a large volumetric displacement is achieved at a lower rotational velocity (N ≤ 240 ext{ RPM}). By minimizing the rotor tip speed, fluid shear rate (y) is kept well within the laminar regime, preserving the structural proteins of the liquid egg matrix.

B. Front-Loading Seal Ergonomics

The AL Series is engineered with mechanical seals located directly behind the front rotor case cover. This eliminates the traditional design flaw where seals are buried deep within a rear stuffing box. During CIP cycles, the sanitizing solution directly impinges upon the seal faces, ensuring a complete 100% sweep of fluid areas and eliminating product stagnation points.

3. Performance & Operational Metrics

Following an initial 90-day baseline testing period, operational performance data was collected to contrast the AL Series against the previous process baselines.

Performance Metric	Legacy Equipment Baseline	Ampco AL51 Implementation	Net Process Improvement
Product Degradation Rate (%)	4.2% (Emulsion breakdown)	< 0.1% (Maintained integrity)	97.6% Reduction in waste
CIP Cycle Efficiency	Failed automated validation; required manual COP	Passed 100% automated microbiological swab validation	Eliminated 2.5 hours daily manual labor
Seal MTBF (Mean Time Between Failures)	45 Days (Average)	> 320 Days (Ongoing)	711% Improvement in uptime
Volumetric Efficiency (n_v)	78% at 6.2 bar	91% at 6.2 bar	16.6% Increase in pump efficiency

Mathematical Formulation of Mechanical Shear Reduction

The reduction in product shear damage can be quantified using the Newtonian shear stress relation relative to internal pump clearances:

$$au = \mu \cdot \left(ac{v}{h} ight)$$

Where **au** is the fluid shear stress, \mu is the dynamic viscosity, **v** is the rotor tip velocity, and **h** is the radial clearance between the rotor tip and the pump casing. The AL Series maximizes **h** through tight manufacturing tolerances and material consistency while minimizing **v** due to its high displacement per revolution, yielding a substantial reduction in total processing stress (**au**).

4. Conclusion

The deployment of the Ampco AL Series Rotary Lobe Pump successfully resolved the dual constraints of product shear degradation and CIP maintenance efficiency at the commercial baking facility. The combination of low-shear bi-wing rotor geometry, robust stainless steel construction, and easily serviceable front-loading mechanical seals provided a highly reliable, sanitary solution that directly enhanced product yield and operational profitability.

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