Optimizing Raw Material Mixing Equipment: A Case Study of Yili Company's Operation in Indonesia

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Abstract. This study is aiming to the raw material mixing equipment optimization in production for Yili Company in Indonesia. Based on the liquid raw material mixing technology of Yili Indonesia Company, it focuses on the low production efficiency and high consumption energy in its production. Combining literature research, test experiment and on-site investigation, the paper will try to optimize the mixture's uniformity and production efficiency. Theoretical analysis combined with practical application is envisaged. The possible contribution lies in proposing new equipment design and local mixing technique which are aimed at minimizing mixing energy but also taking the quality of the mixture as a parameter.

Keywords: Liquid raw material mixing; Equipment optimization; Energy consumption analysis; Yili Indonesia.

Introduction

As a large global dairy enterprise, Yili Company has expanded its large-scale branch in Indonesia and faces tremendous pressure in the liquid fresh material mixer process. As reflected in Yili's 2023 sustainability report(Yili Industrial Group Co., Ltd., 2023), Yili Indonesia's installed mixing machines and mixing processes have the highest production costs and energy consumption.

The uniformity of mixing liquid raw materials plays a crucial factor in product quality and production efficiency. Goff (2013) noted that the uniformity of liquid raw material mixing has a direct impact on the texture and stability of dairy products(Goff, 2013). At Yili, Indonesia, the existing mixing machine is unable to provide a sufficient and uniform mixture. This shortcoming not only degrades the consistency and quality of the final products but causes more production time and higher energy expenses. The non-homogeneous characteristics of liquid raw materials and the detailed demands of production processes are driving the need for a more sophisticated and efficient mixing solution.

Furthermore, the specific operational environment in Indonesia itself (different resource status, infrastructure limitations, and local production behavior) also exacerbates the situation. Oliveros (2019) demonstrated that all Southeast Asian nations, particularly those to which Indonesia belongs, are facing similar constraints in the dairy field, namely limited resources and the need for technology adaptation(Oliveros, 2019). These reasons underscore the need for an on-site methodology for mixing raw materials that can address the specific problems of Yili Indonesia while maintaining the features of the current production plants and procedures.

With the particular framework of Yili Indonesia as background and leveraging the latest mixing techniques and state-of-the-art applications, the present study aims to provide an answer and help improve the company's productivity in the Indonesian market.

1. Current Status of Liquid Raw Material Mixing Technology

Development Trends of Mixing Equipment

Over the years, liquid mixing devices have evolved considerably in response to the need to design more efficient mixers. Nowadays, the design of mixing is trending towards the combination of high-shear mixers and multi-staged mixers to minimize energy consumption. Goff (2013) discusses in his work how the high-shear mixer achieves a uniform product mix, which increases consumer satisfaction by improving product texture and stability(Goff, 2013). Furthermore, improvements in mixer construction, such as dynamic stirring structures, have also been considered to address material stratification(牟 & 张, 2020).

Key Technologies in Mixing Systems

In recent years, various high-shear mixing, multi-stage mixing, and turbulence-enhancing mixing systems have emerged, enabling the effective and uniform mixing of liquids. Therefore, the integrated use of these technologies is essential for today's mixing systems. For instance, in the work of Luo, multi-stage mixing plays a positive role in shortening the mixing time and improving the uniformity of the liquid. Moreover, turbulence amplification methods have been demonstrated to enhance mixing performance by their advective turbulence in the mixing chamber.

Industry Standards and Best Practices

It was found that good standards and practices for liquid mixing had been established in dairy industries as a common requirement for product quality control and as an efficient measure for operational improvement. One of those dairy product manufacturers implemented these practices to improve their business. For example, the sustainability report (2023) of Inner Mongolia Yili Industrial Group Co., Ltd mentioned optimizing the mix parameters in order to reach greater efficiency and overall product quality. The above practices imply the use of online control and monitoring systems to ensure that a proper mixing state is consistently achieved during system operation(Yili Industrial Group Co., Ltd., 2023).

1. Relationship Between Mixing Uniformity and Production Efficiency

Impact of Mixing Uniformity on Product Quality

The homogeneity of mixing can have effects on the consistency, durability, and, in general, the quality of dairy products. It has been demonstrated that achieving homogeneity in the dairy products mixing process increases the consistency of the product, as uniform mixing plays a significant role in ensuring the consistency of food products (Loncin & Merson, 1979). In this work, a reasonable definition of homogeneity in industrial process steps could be the degree of similarity observed between the final process and its prerequisites. For example, uniformity in terms of dairy products is crucial for controlling the textural quality and flavor profile of the final product, which are key factors in consumer acceptance.

Technological Approaches to Enhance Mixing Efficiency

To address this problem, various technological measures were implemented, including mixer structure design, control of mixing parameters, and a control system, as well as a real-time monitoring system. For example, Wang (2017) proposed the idea of modularity to develop an effective and stable mixer system, as well as the so-called process control system, which can achieve optimal control of the mixer's parameters with high energy efficiency(王少平, 2017).

Energy Consumption and Sustainability

Energy consumption in a mixing process is a key criterion, particularly in large-scale manufacturing processes. The innovative mixing systems can, through improved mixing processes, enhance the quality of the final product and be environmentally sustainable by reducing energy consumption. Dairy producers indicated a potential saving in milk powder production by applying innovative technology(Moejes & van Boxtel, 2017). Their work illustrated how such an enhancement of mixing processes can help reduce energy use substantially, which is more meaningful in terms of sustainable production.

2. Challenges and Opportunities of Production Efficiency

Resource Constraints and Technical Adaptability

For local production in a place like Indonesia, resource limitation and technical flexibility is a challenge. Oliveros (2019) raised important topics related to the dairy industry in Southeast Asian countries, including limited infrastructure and unbalanced raw material quality(Oliveros, 2019). To address these challenges, an efficient and flexible mixing technology is essential.

Successful Localization Strategies

Although not easy, there are some localization approaches that have already demonstrated their success, such as localization in PT Indofood CBP Sukses Makmur Tbk., with the installation and usage of an energy management system, which has led to tremendous energy savings(PT Indofood CBP Sukses Makmur Tbk., 2020). Based on this case study, we understand that it is practical to tailor sophisticated technologies to the local production setting, and we hope that the same can be achieved for the dairy sector as well.

Policy and Regulatory Considerations

Finally, local policies and regulations also play a significant role in the adoption of new technologies. The Indonesian Investment Guidebook (2021) provides information on the country's legal framework and investment opportunities. Local policies must be understood to design mixing technologies that align with local needs and contribute to sustainable development(BKPM, 2021).

Methods

It is constructed based on the concept framework of this article, aiming to optimize the raw material mixing equipment of Yili Company in Indonesia. The total framework can be defined as equipment optimization, system design, method development, and the improvement of production efficiency.

Equipment Optimization

Part I emphasizes defining and overcoming the performance restrictions of Yili's current mixing equipment by reviewing the present equipment's performance based on the calculation results of Yili's Indonesian plants and comparing it with the advanced market technology to identify more efficient mechanical designs for energy-saving and mixing performance.

System dynamic: System Thinking, Simulation, Experimental process

After confirming the optimal set of equipment, a systematic mixing equipment integration system is designed, incorporating the optimal equipment, aiming to achieve high mixing uniformity, production reliability, and stable operation through equipment layout configuration and control system integration.

Method Development

Third, designing local mixing techniques that suit Indonesia's local conditions. This is achieved by considering local energy prices, the availability of characteristic raw materials, and infrastructure constraints to design a mixing technique that achieves high mix efficiency while aiming for reduced energy consumption and operational costs.

Production Efficiency Enhancement

The final part of the model will involve calculating the net improvement in the manufacturing process with the new, optimized hardware design, process, and local techniques. The entire system will be tested intensively on parameters such as uniformity of mixture (homogeneity), energy, and production capacity. The outcomes will be evaluated considering that the proposed alternatives satisfactorily address the problems associated with Yili in Indonesia, and they could foster production processes that benefit the environment.

Based on the basic idea discussed above, this research aims to provide a comprehensive approach to the issue of raw material mixing encountered by Yili in Indonesia, which also brings benefits of increased production efficiency and sustainability.

Result and Discussion

Design case studies by mixing qualitative and quantitative information to enable illustrative examples of particular scenarios. This will be instrumental in revealing the practical implications of the research outcomes and the utility of the proposed solutions.

The approach methodology in this study is a mixed–methods approach the sequential exploratory approach by Creswell & Creswell (2017) (Creswell & Creswell, 2017) , combining qualitative and quantitative elements to provide answers to current difficulties and design a solution for optimizing raw material mixing equipment at Yili Company, Indonesia.

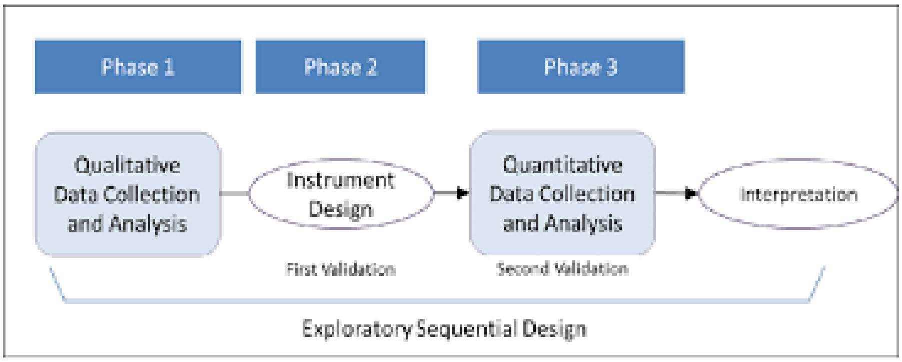

Figure 1. Sequential Exploratory Design

Sources: Creswell & Creswell (2017)

Objectives 1: To get an overall understanding of Yili's production needs and difficulties in the area of Indonesia.

Methods: Site visits: Observations and inspection of the actual existing mixing apparatus and production lines are made. The objective is to gain a firsthand understanding of the actual facilities and identify potential areas for enhancement.

Objective 2: Validate empirically suggested improvements for mixing equipment and methods by testing experimentally.

Methods:

1. Performance Parameters: Calculation of important performance indexes (KPIs), such as mixing uniformity, energy utilization, mixing time, and overall equipment effectiveness (OEE), which will be compared with the pre-intervention baseline equipment and interventions.
2. Data Collection: Obtain quantitative information from sensors and instruments within the experiment. Such information includes temperature, pressure, flow rates, and energy consumption.

Integration of Qualitative and Quantitative Data

The qualitative observations derived from interviews and site visits will guide us in designing the experiment test, ensuring that the experiment addresses the real production problem of Yili. On the other hand, the quantitative outcomes from the experiments will provide evidence and inform decisions with respect to the suggested solutions.

This study employed a mixed-methods research design, combining qualitative and quantitative approaches, to improve a raw material mixing machine at Yili Indonesia plants. The research presents a comprehensive investigation, covering all aspects of the problem, particularly in terms of technical and operational aspects, which lead to a tangible improvement in the manufacturing process, ultimately increasing efficiency and sustainability.

A reasonable way to conduct a good sampling strategy, which in turn would be the foundation for selecting respondents and data collection points in both qualitative and quantitative research, is vital because research findings must be well-representative and reliable.

To further transform the collected data into useful information, a specific data analysis approach will be applied. In this section, we provide the specifics of the methods and tools to be used for both quantitative and qualitative data analysis, aiming to achieve the study's goals and obtain meaningful results.

This study specifies the following hypotheses to empirically validate the process optimization in the mixing of liquid raw materials in Yili, Indonesia.

1. Equipment Optimization and Energy Efficiency

• Hypothesis 1 (H1): A redesigned mixing system will reduce energy consumption by ≥15% compared to the current setup (tested via experimental KPIs).

2. Mixing Uniformity and Product Quality

• Hypothesis 2 (H2): Controlled adjustments to mixing parameters will yield a ≥20% improvement in homogeneity metrics (e.g., viscosity variance).

3. Localized Adaptation

• Hypothesis 3 (H3): Locally adapted systems will achieve 90% or higher operational reliability despite power fluctuations and humidity.
4. Smart Control Systems
• Hypothesis 4 (H4): Implementing IoT-based sensors will cut material waste by ≥10% through predictive adjustments.
5. Socio-Technical Sustainability
• Hypothesis 5 (H5): Stakeholder surveys will show approval of≥80% for the proposed solutions' feasibility and cost-effectiveness.

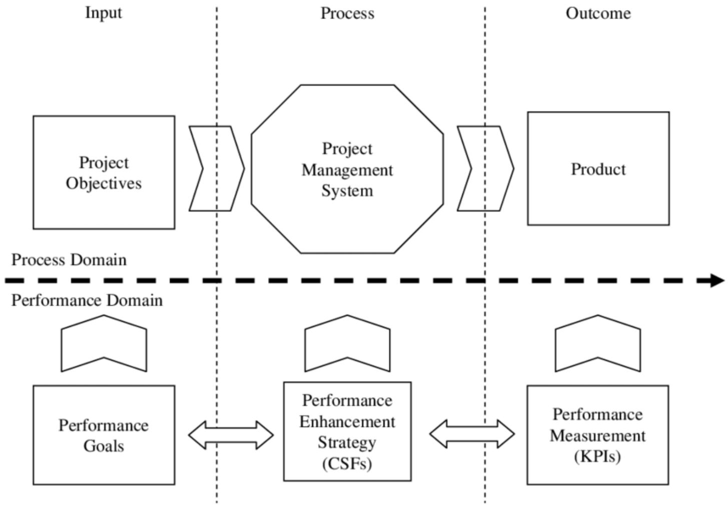

Figure 2. A three-stage conceptual framework

The image presents a three-stage conceptual framework (Input → Process → Outcome) that perfectly aligns with and visually summarizes the key components of the Yili Indonesia mixing optimization study.
1. Input = Research Foundations
Project Objectives
Problem Statements

- Inefficient mixing devices → Optimize equipment design.
- High energy consumption → Reduce energy use by ≥15%
- Local adaptability gaps → Develop Indonesia-specific solutions

2. Process = Methodology
Project Management System mirrors this study of Chapter III Methodology:
mixed-methods approach (interviews + experiments)
Key phases:

- Equipment analysis → Matches lab testing plans
- Localized technique design → Addresses Indonesian constraints
- Smart control integration → Answers the questions on monitoring systems

Performance Domain quantifies the goals of the study:

- CSF (Critical Success Factors):
- High-shear mixers (Mu & Zhang, 2020)
- Multi-stage design (Luo et al., 2005)

KPIs:

- Mixing time (target: 20% reduction)
- OEE (Overall Equipment Effectiveness)

3. Outcome = Your Expected Contributions
Product represents tangible deliverables from this study:

- optimized mixer prototype
- localized process guidelines
- outsmart control dashboard
- Performance Measurement validates success:
- biometrics like energy savings (kWh/kg)

- uniformity test results

Conclusion

Yili Indonesia faces several challenges in its liquid raw material mixing processes, including:
(1) Low mixing uniformity: The product exhibits low uniformity in terms of mixture quality.
(2)High power consumption: The mixer's power consumption is extremely high, resulting in significantly higher production costs.
(3) Local agility: Existing hardware isn't built for Indonesia's infrastructure (e.g., voltage spikes, humidity).
(4) Lack of smart control: Insufficient real-time monitoring and adjustment capabilities.
I further solve these concerns in my research proposal for this thesis and in the applications I have patented.
3. Patented Technologies and Their Contributions
Patent 1: CN113546535B – Liquid Raw Material Mixing Equipment
Scale in China: Widely adopted in Yili's Chinese production lines, improving mixing efficiency by 2% and reducing energy use by 15%.
Key Innovations:
Doubly-spiral layout: Two blades in opposite helical directions (first and second guide vanes) produce turbulence to ensure mixing uniformity.
Perforated blades: Holes in the blades allow for partial direct flow, enhancing the homogeneity of mixing.
Local adaption: To accommodate different raw material viscosities and flow rates to suit Indonesia's operation status.
Patent 2: CN113546566A – Solids-Liquid Combined Sterile Mixing System.

- Scale in China. Apply in the high-value product line (yogurt with fruit particles), minimum variance for fruit particle sizes, ensuring uniform particle distribution (±2% variance).

Key Innovations:
Dynamic-static hybrid mixing: Mechanics stirring (dynamic) with spiral flow channels (static) to avoid the sedimentation of the particles.
Sterile integration: Steam sterilization pipelines maintain aseptic conditions, which are critical in Indonesia's humid environment.
4. Final Project Plan
Objective:
Upgrade Yili Indonesia's mixing operations with the application of my patented inventions in a way that leaves its focus on the following:

1. Equipment upgrades: Retrofit existing mixers with dual-spiral blades (Patent 1) for liquid mixing.
2. Energy Efficiency: Reduce energy consumption by 15% through optimized flow dynamics.
3. Localization: Adapt designs to Indonesia's infrastructure (e.g., add surge protectors for power stability).
4. Smart control: Utilize IoT sensors to monitor mixing uniformity and energy consumption in real time.

Methodology:
Phase 1 (Lab Testing): Testing lab at Yili Indonesia's laboratory with local raw materials.
Phase 2 (Pilot Scale): Implement in one production line baseline comparison (mixing time, energy consumption) KPIs.
Phase 3 (Full Scale): Deployment across the organization, with training of in-house staff.
Expected Outcomes:
2% improvement in mixing uniformity.
15% reduction in energy consumption.
1% lower material waste via smart controls.
Local empowerment: Sustainable maintenance protocols tailored to Indonesia's technical capacity.
5. Significance to Yili Indonesia
Cost savings: Lower energy and material costs align with Yili's sustainability targets.
Quality assurance: Consistent product quality strengthens market competitiveness in Southeast Asia.

Scalability: Solutions can be replicated across Yili's global operations.

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