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Examining and Analyzing the Effectiveness of the Double Helical Spiral Mixer

Kanchan. K. Makune[1,*], I.I. Sayyad[2]

Abstract

Recent advancements in various mixing mechanisms are being leveraged in the food industry to enhance their success by ensuring product consistency fostering the development of new products and cutting down production costs the choice of mixing equipment is influenced by the types of phases being combined such as liquid–liquid solid–liquid or solid–solid and the physical properties of the final product including viscosity and density both traditional and innovative specialty mixing technologies are use in today but studies indicate that the efficiency of double helical mixers surpasses that of conventional mixers in traditional mixing methods metal oxide powder and vehicle are combined using a unidirectional stirring machine this machines stirrer rotates in a single direction creating a specific flow pattern in the fluids which causes particles to adhere to the container walls due to centrifugal force rather than mixing thoroughly in the paint mixture this results in a subpar quality of paint mixture and consequently a lower quality paint output to achieve homogeneous mixing it would be beneficial to have a stirrer shaft that rotates the blades in opposite directions with spiral blade applications in one cycle this would generate a turbulent flow pattern leading to an irregular flow pattern and a thoroughly mixed paint mixture ultimately producing high-quality paint additionally a pneumatic ram that dynamically moves the mixers drive head up and down would further enhance the mixing process.

Keywords: Bidirectional motion, periphery spiral blades rotation, homogeneous mixture, pneumatic ram, conical screw mixer

INTRODUCTION

Combining powders of various materials to produce a uniform product or powder mixture is a relatively simple process. However, challenges arise when attempting to mix powders in a fluid medium, particularly when the powder possesses a high density. Heavy particles tend to settle, necessitating the use of a bidirectional mixer designed to move in opposite directions within a single cycle. This motion is facilitated by a crank and fork mechanism that generates turbulence and results in a homogeneous mixture. Mechanical mixers are extensively utilized in processing industries, such as chemical plants, food processing facilities, and the paint industry, to mix powders and semisolid jelly fluids. Mixing involves combining powders or jellies into a uniform mixture, whereas stirring refers to the process of thoroughly dissolving powder in a fluid to achieve a consistent product. In both scenarios, thorough mixing is essential for producing high-quality, uniform output. Mixing is a crucial step in transforming raw ingredients into consumable food, with consistency being a key objective

***Author for Correspondence**
Kanchan. K. Makune
E-mail: ksmakune@gmail.com

[1]PG Student, Department of Mechanical Engineering, Sanjivani College of Engineering, Ahmednagar, Maharashtra, India
[2]Assistant Professor, Department of Mechanical Engineering, Sanjivani College of Engineering, Ahmednagar, Maharashtra, India

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shared by other food processing stages. In the food industry, maintaining consistency is vital not only from batch to batch but also across different facilities, as it underpins consumer loyalty [1–5].

Regardless of whether a recipe requires small-scale hand mixing or large-scale blending of multiple ingredients, both home cooks and process engineers recognize the importance of proper mixing. Even when the right ingredients and flavors are used, a recipe will not produce desirable results without proper mixing. The blending process plays a vital role in determining the taste, texture, color, and overall appearance. Consumers also expect consistency, wanting each product they purchase to match the quality and characteristics of their previous purchases. The selection and use of appropriate mixing equipment depend on the type of materials involved, e.g., liquid–liquid, solid–liquid, or solid–solid, and the physical properties of the final product, including its viscosity and density. In practice, many mixing technologies have overlapping uses and functions, allowing certain applications to be successfully produced by multiple types of mixing systems. In such situations, budget limitations may restrict the ability to invest in higher-cost equipment at the outset; however, efficiency differences must still be carefully evaluated. Choosing the right mixer and properly assessing its performance are essential steps in achieving an efficient and optimized process. After experimental analysis and study, the double helical spiral mixer was found to be the most effective and efficient for mixing all types of mixed ingredients [6–10].

Objectives

1. To design a screw mixer that delivers high efficiency and reduced processing time while accommodating a wide range of raw materials and particle sizes.
2. A double helical spiral mixer suitable for diverse industries, including pigments, dyes, pharmaceuticals, chemicals, food, cosmetics, batteries, pesticides, construction materials, and plastic granule production, was developed.
3. To ensure that the mixing operation is dependable and gentle, equipment wear is minimized, and maintenance requirements are reduced.
4. The performance of the planetary horizontal mixer and conical screw mixer was evaluated, highlighting the lower energy usage and advantages of energy efficiency and environmental sustainability.

Types of Mixers

Conical Screw Mixer

A conical screw mixer is a vertical mixing system designed for the efficient blending of powders and granules while consuming relatively low energy. It can effectively handle materials with varying particle sizes. The unit operates with screws and screw arms powered by a motor and gearbox, each moving at a different rate. The screws rotate on their own axes through a bevel gear mechanism, lifting the material from the bottom of the vessel upward, after which it descends naturally under gravity (Figure 1). Simultaneously, the screw arm rotates around the central shaft, promoting the continuous movement and thorough circulation of materials throughout the mixing chamber. A three-dimensional action involving the entire mix, wherein raw materials are sheared and diffused repeatedly in the vessel, occurs. Thus, the mixture achieves optimum homogeneity.

Planetary Mixer

The tooth count for each gear in a planetary gear set must be selected appropriately to ensure that all the components are properly connected (Figures 2 and 3). After identifying the required design, the set must be completed with other essential parameters to provide a functional system. For instance, one must specify a gear ratio of 5:1.

In this configuration, the sun gear must complete five rotations for each rotation of the output carrier. This assumes that the sun gear serves as the input, the planet gears transmit motion to drive the carrier as the output, and the ring gear is stationary. Other arrangements can be used based on the application. Another design limitation must be determined to complete the remaining calculations. The sun gear has 24 teeth.

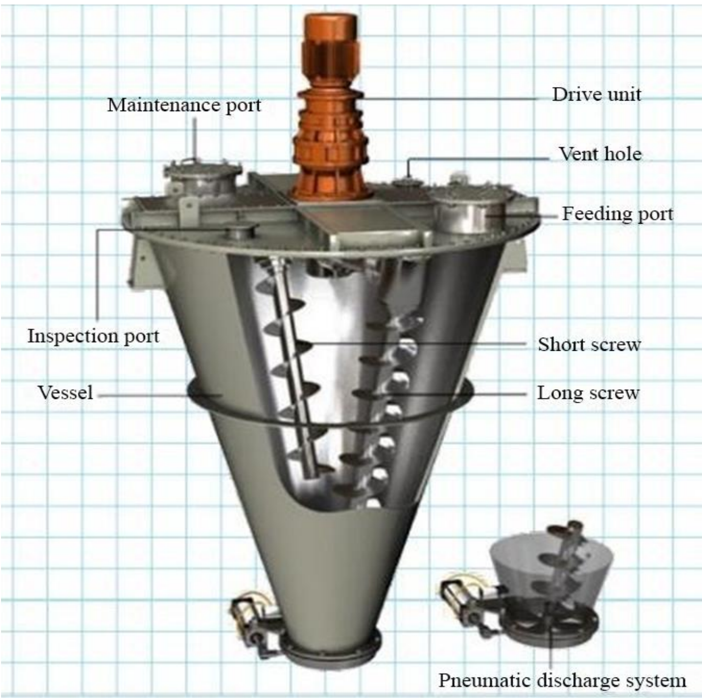


Figure 1. 2D view of conical screw mixer.

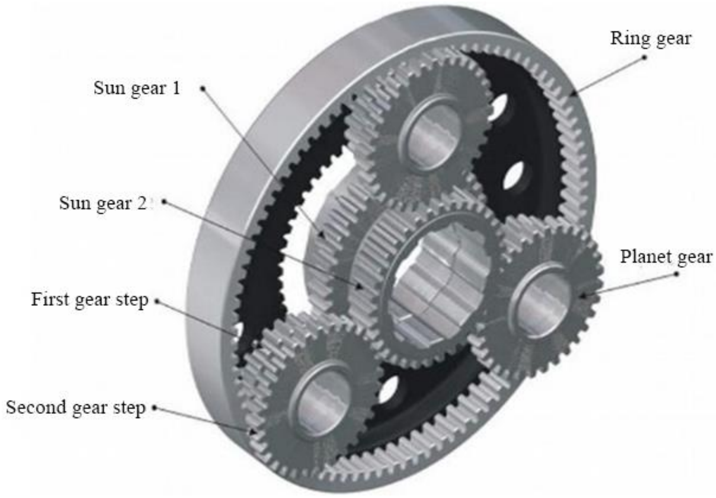


Figure 2. 2D view of planetary gear.

Figure 3. Planetary mixer.

By substituting the values into the formula, we concluded that the number of teeth required on the ring gear was 96. This allowed us to determine the number of teeth on the planet gear, which is expressed as Np.(s). By replacing the appropriate values, the number of teeth required for the planet gear is 36. The actual number of planet gears is irrelevant to this problem. It should be noted that the actual pitch of the gears has not yet been determined. These equations are valid regardless of the pitch, although a specific pitch must be chosen at some point in the design process of a planetary gear system.

The choice of pitch may either constrain the design or the physical size constraints may dictate the pitch that can be implemented. A planetary gear system, also called an epicyclic gear train, is composed of three main components: a central sun gear, multiple planet gears that rotate around it, and an outer ring gear. The torque is transmitted from the sun gear to the surrounding planet gears, enabling the system to distribute motion efficiently. Both are housed within the boundaries of the ring gear. The tooth patterns of the sun and planet gears are external, whereas that of the ring gear is internal. Planetary gear sets have a wide variation in size and shape, allowing the production of a broad range of speed ratios to meet varied design requirements. Planetary gear systems are used in a wide range of applications, including clocks, lunar calendar mechanisms, automotive rearview mirrors, toys, geared motors, and turbine engines.

CONSTRUCTION AND WORKING OF DOUBLE HELICAL SPIRAL MIXER

A mixer was designed that included a container, spiral impeller blades, an electric motor, a set of pulleys, pedestal bearings, pneumatic rams, a timer, a solenoid valve, and drive shafts. We used a container made of stainless steel, which was kept approximately 6 inches above the ground, so it was convenient to pour the material and prepare the chemical solution. A mixer was designed to efficiently blend cleaning solutions used for floor maintenance. The system comprises a container, spiral impeller blades, an electric motor, a pulley set, pedestal bearings, pneumatic rams, a timer, a solenoid valve, and a drive shaft. The motor was mounted vertically to align with the pulley and belt assembly on its shaft, ensuring smooth power transmission. Planetary gear systems, which include a central sun gear, orbiting planet gears, and an outer ring gear, are employed to distribute torque effectively. These gear sets are used in a wide range of devices, from clocks and lunar calendar mechanisms to automotive rearview mirrors, toys, geared motors, and turbine engines. The choice of gear pitch may either constrain the design, or physical size limitations may dictate the pitch that can be implemented. In an electrically driven system, an electric motor is used to rotate the shaft. When the motor shaft is rotated, the pulley fitted to the motor shaft also rotates.

The power is transmitted from the motor to the impeller shaft. When the impeller shaft starts rotating, the spiral blades also rotate in the same direction simultaneously. Simultaneously, the configurations of the pneumatic ram lift and lower the driver's head to achieve maximum efficiency in agitation, depending on the operation of the timer. Therefore, the mixing of chemical constituents was achieved. The theoretical and functional working models of the mixer are shown in Figures 4 and 5, respectively.

Benefits and Constraints

Benefits

1. Optimal mixing homogeneity.
2. Less mixing time compared with the conventional mixture.
3. Exceptional uniformity and quality in each batch of production.
4. Reduced wear and minimal maintenance requirements.
5. Easy access to a mixer/easy to clean.
6. Outstanding blending capabilities across all product tiers.
7. Low power consumption.

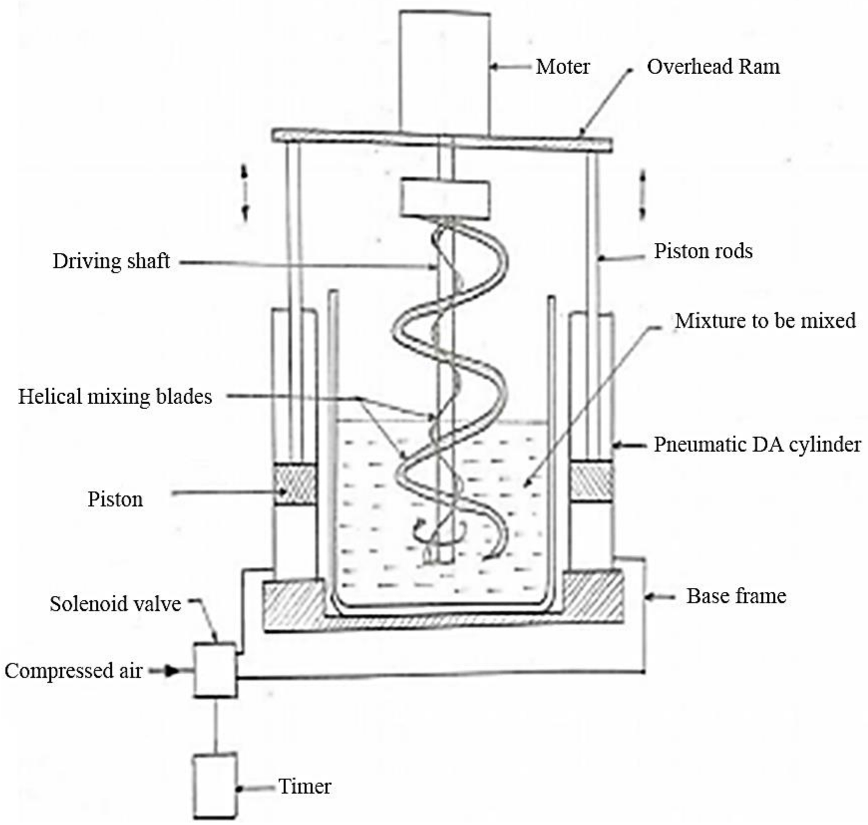


Figure 4. Proposed model of mixer.

Figure 5. Real model of mix.

Limitations

1. The machine we develop has a capacity of only 20 L. Although it is not intended for full-scale production, it meets all essential requirements. This prototype primarily serves to demonstrate the model's reliability and to test any functional changes during the development process.
2. The machine we develop has a small motor capacity; therefore, it cannot handle large quantities of chemicals or liquids.

Applications

1. Paint industry
2. Chemical industry
3. Construction material
4. Food industry
5. Animal feed
6. Metallurgy
7. Pharmaceutical industry
8. Ceramic powder
9. Minning industry

Figure 6 shows the mixing of multiple colors in the paint industry, whereas Figure 7 illustrates the mixing of metallic powders in pigments. Figure 8 shows the mixing applications in the pharmaceutical industry, and Figure 9 illustrates the skimming machine for creams, lotions, toothpaste, gels, ointments, etc.

Figure 6. Mixing of multiple colors of paint in the paint industry.

Figure 7. Mixing of metallic powders in pigment.

Figure 8. Mixing applications in the pharmaceutical industry.

Figure 9. Skimming machine for creams, lotions, toothpaste, gels, ointments, etc.

RESULT

The test was conducted using three liquids with standard viscosity ranges (measured in centipoises). The procedure involved the double helical spiral mixer, and the time required for each test was recorded on both the old machine and the double helical spiral mixer. The results were plotted for comparison.

Normal Viscosity Range

In the water and milk tests, 1 cps of water and 2 cps of milk were added, and readings were taken for both the old and new mixers (Figure 10).

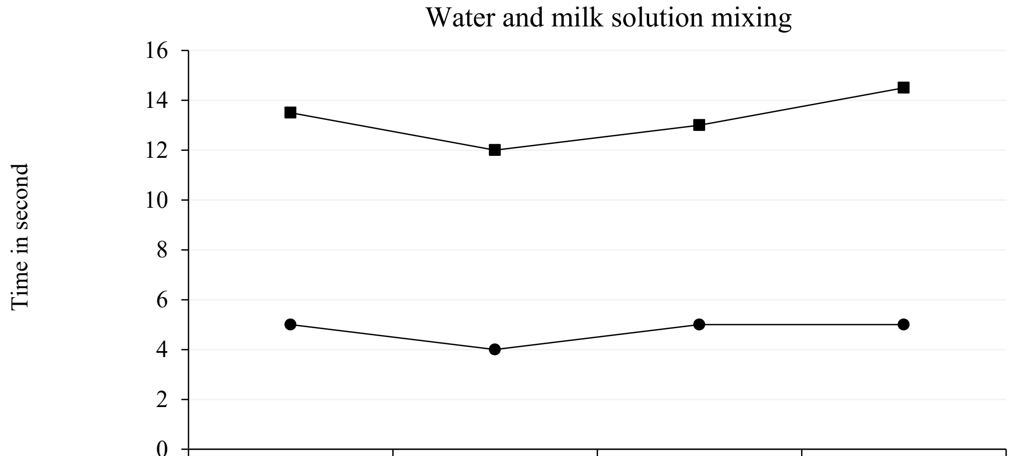
- Water = 1 cps
- Milk = 3 cps
- Take milk = 2 cps (cps = centi-poise)

From Figure 10, we can see that the time for effective mixing of milk and water is much shorter, approximately 14% shorter, in all the tests that were performed, than the older model mixer.

Normal Viscosity Range for Water and Ink

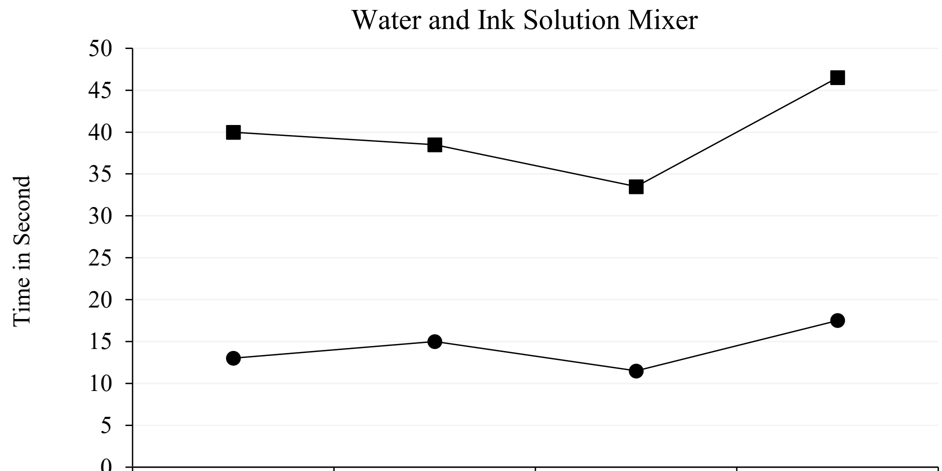
In the water and ink test, 1 cps of water and 500 cps of ink were added, and readings were taken for both the old and new mixers (Figure 11).

- Water = 1 cps
- Ink = 550–2200 cps
- Take ink = 500 cps



	1	2	3	4
Time of Old Mixer	8.5	8	8	9.5
Time of New Mixer	5	4	5	5

Figure 10. Required time to maintain the viscosity of milk up to 2 cps.



	1	2	3	4
Time of Old Mixer	27	23.5	22	29
Ttime of New Mixer	13	15	11.5	17.5

Figure 11. Required time to maintain the viscosity of ink up to 500 cps.

From Figure 11, we can see that the time for effective mixing of milk and ink is much shorter, approximately 44% shorter, in all the tests that were performed, than the older model mixer.

Normal Viscosity Range for Water and Soap Solution

In the water and milk test, 1 cps of water and 40 cps of soap solution were added, and readings were taken for both the old and new mixers (Figure 12).

- Water = 1 cps
- Soap solution = 82 cps
- Take soap solution = 40 cps

From Figure 12, we can see that the time for effective mixing of soap solution and water is much shorter, approximately 19 % shorter, in all the tests that were performed, than the older model mixer. The testing comparison of all three different mixtures is presented in Table 1.

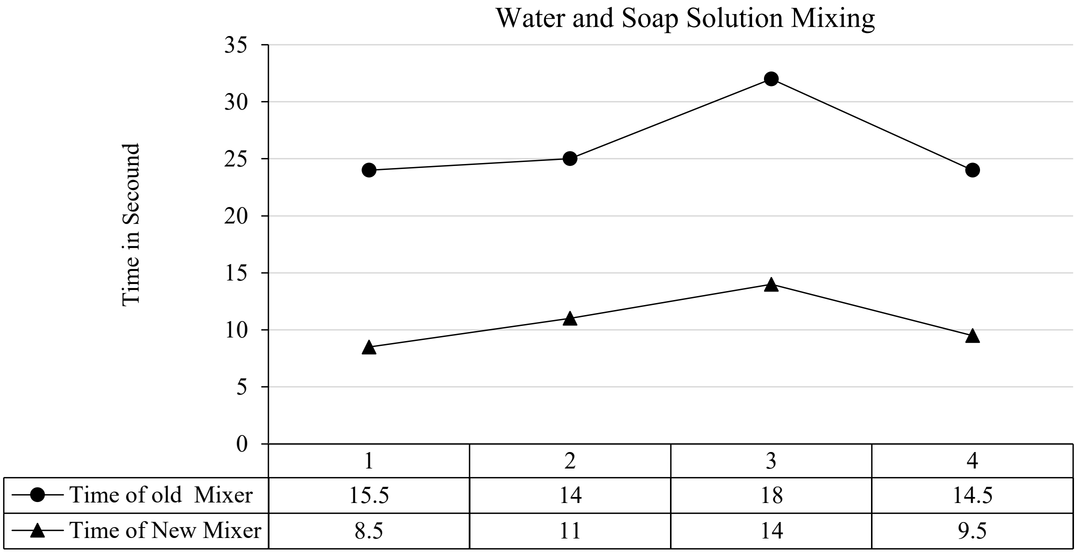


Figure 12. Required time to maintain the viscosity of the soap solution up to 40 cps.

Table 1. Testing comparison of all three different mixtures.

S. N.	Type of mixer used	Mixing 1 cps water and 2 cps milk				Mixing 1 cps water and 500 cps ink				Mixing 1 cps of water and 40 cps of soap solution			
		Test 1	*Test 2*	*Test 3*	*Test 4*	*Test 1*	*Test 2*	*Test 3*	*Test 4*	*Test 1*	*Test 2*	*Test 3*	*Test 4*
1	Old mixture time (sec)	9	8.5	11	8.5	27	23.5	22	29	15.5	14	18	14.5
2	New mixer time (sec)	5	4	5	5	13	15	11.5	17.5	8.5	11	14	9.5
3	Time effectiveness (%)		14%				44%				19%		

cps = centi-poise

CONCLUSION

This mixer uses two helical spiral blades for mixing, and it takes less time to mix than other mixer types. The model we developed had a 20-liter capacity and a 60-rpm motor. This mixer is used to mix liquid and semisolid products.

These models achieve the necessary goals of minimizing the time and human effort involved in the mixing procedures. In a similar vein, it maintains the accuracy of the chemical mixing procedure. High-speed chemical mixing in all types of liquids was carried out under the most rigorous conditions. The automation unit for the mixer was created after making specific modifications to the equipment to enable its incorporation into today's automated facilities.

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