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Enhancing efficiency in Panchagavya Preparation: Development and evaluation of a Crank-Operated mixer for small and marginal farmers

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Abstract

The historical use of chemical fertilizers and pesticides has significantly boosted crop yields but at the cost of soil health and human safety. This study aims to revive the use of panchagavya, a traditional Indian organic fertilizer made from cow products, which has proven benefits for soil enrichment and crop health. Panchagavya's manual preparation, although effective, is labor intensive and time consuming. This research focuses on the design and development of a crank operated panchagavya mixer to optimize the mixing process. Conducted at Vignan's Foundation for Science, Technology and Research, the study introduces a mixer with a capacity of 30 liters, reducing mixing time and physical effort. The new mixer, incorporating a crank mechanism, was tested in bapatla, Andhra Pradesh, demonstrating significant improvements in efficiency and consistency over traditional methods. The mixer design is detailed, including power calculations and mechanical design of the crank and cylindrical tank. The results indicate that the crank mechanism reduces mixing time from 10 days to 5-6 days, making it a viable option for small and marginal farmers.

Keywords: Panchagavya, crank mechanism, organic fertilizer, sustainable agriculture, mixing efficiency, smallholder farmers

Introduction

While chemical fertilizers and pesticides have historically increased crop yields, their overuse has resulted in unintended consequences. These include a decline in soil health and potential health risks for humans. As a response, there's a growing movement to revive organic farming practices. This traditional method prioritizes natural processes and minimizes reliance on external inputs. An ideal organic system promotes nutrient cycling within the farm itself, creating a more sustainable and potentially healthier food production system. (Natrajan, 2008) [1].

Ancient Indian farmers were pioneers in organic farming, using a combination of three natural amendments: panchagavya, vermicompost, and farmyard manure. Panchagavya, a time-tested recipe made from five cow products (milk, curd, ghee, dung, and urine), has been a cornerstone of Indian agriculture for generations. Traditionally revered for its ability to enrich soil and enhance crop health. The natural fertilizer is believed to work quickly, with positive results seen within a short period. While agriculture was reaped the most significant advantages from panchagavya, its potential benefits extend far beyond the farm (Math *et al*., 2013) [2]. The rise of Chemical fertilizers, a product of the industrial revolution, coincided with a decline in the use of panchagavya, a natural fertilizer. This decline may be linked to the adoption of chemical fertilizers during the industrial revolution. (Amalraj *et al*., 2013) [3].

Traditionally, panchagavya is made by thoroughly mixing cow dung and ghee in a clay pot. The mixture is stirred diligently every 12 hours for 3 days. Then, the remaining ingredients are added, followed by another round of thorough mixing. To accelerate the process, catalysts like sugarcane juice or jaggery can be introduced. The concoction is then stirred every 12 hours for another 15 days, reaching completion on 18th day. However, this manual method requires dedication, as it involves physical effort, managing unpleasant odors, strict adherence to a time schedule (Selvaraj *et al*. (2007)) [4]. In the view of above, a panchagavya mixer with a capacity of 30ltrs, reduced mixing time, labor cost and drudgery are required for small and marginal farmers. The present study was undertaken with the objective to design an improved motor operated maize sheller and optimise its operating parameters.

Materials and Methods

Location of study

The panchagavya mixer was designed and developed during the year 2023 at the Department of Agriculture Engineering, Vignan's Foundation for Sciences Technology and Research, Guntur, Andhra Pradesh. The Experimentation was carried out in at Kondabhotlavariapalem village, Bapatla, Andhra Pradesh.

Materials required for the preparation of panchagavya

Panchagavya, a traditional organic farming input, is a concoction derived from five products of the cow: cow dung, cow urine, cow milk, cow ghee (Clarified butter), and curd. The composition of panchagavya involves specific proportions of these ingredients to ensure its effectiveness in enhancing soil fertility and plant growth. The following are the recommended proportions for making 20 Liters of panchagavya, with corresponding adjustments for 10 Liters, 15 Liters, and 30 Liters to maintain the desired balance of nutrients and bio active compounds.

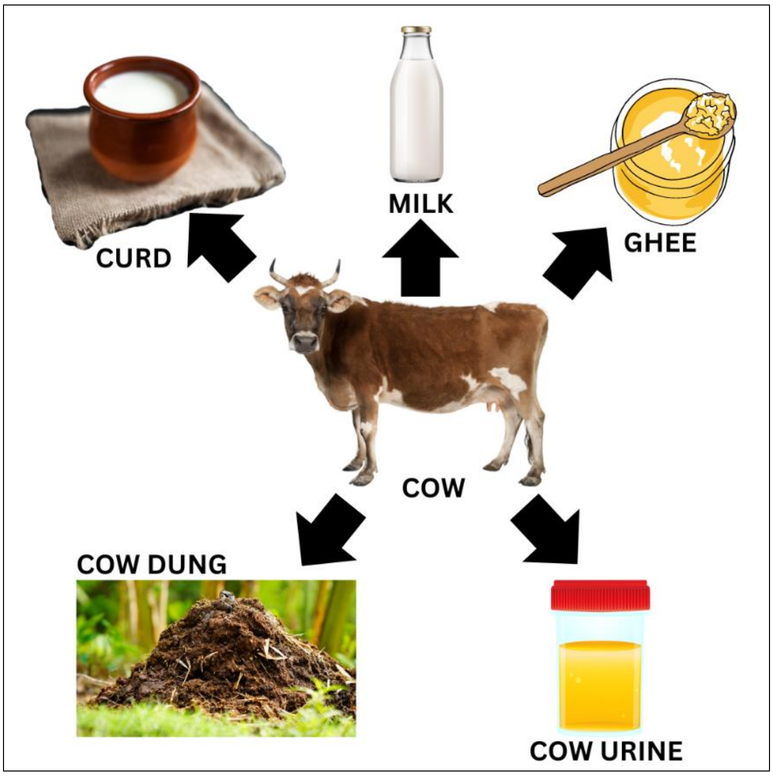

Fig 1: Key ingredients of Panchagavya

Table 1: Ingredients and Composition for Preparation of Panchagavya

S. No	Ingredients required for preparation of Panchagavya	Composition for making 10, 15, 20, 30 Liters of Panchagavya			
		10L	15L	20L	30L
1	Cow dung	2.5kg	3.75kg	5kg	7.5kg
2	Cow urine	1.5L	2.25L	3L	4.5L
3	Cow milk	1L	1.5L	2L	3L
4	Cow ghee	250gm	375gm	500gm	750gm
5	Curd	1L	1.5L	2L	3L

Physical Characteristics Panchagavya Mixture

When the five ingredients of panchagavya are combined and allowed to ferment, they form a dark brown, viscous liquid with a strong, earthy odour and slightly alkine pH of 7.0 to 8.0. (Selvaraj *et al* (2007) [4].

Table 2: Characteristics of Ingredients

S.no	Ingredients	Appearance	Odour	Density (g/cm³)	pH	Composition
1	Cow Dung	Semi-solid, fibrous texture	Strong, earthy	0.6 - 0.8	7.0 - 8.0	Contains organic matter, moisture content
2	Cow Urine	Clear, yellowish liquid	Pungent	~1.02	7.4 - 8.4	Urea, minerals, organic compounds
3	Cow Milk	White to off-white liquid	Mild dairy smell	~1.03	6.5 - 6.7	Fats, proteins, lactose, vitamins, minerals
4	Cow Curd (Yogurt)	Semi-solid, creamy texture	Mild, slightly sour	Varies	4.5 - 5.0	Water, proteins, lactic acid, probiotics
5	Cow Ghee	Semi-solid, yellowish colour	Rich, nutty, buttery	0.91-0.93	Neutral	Primarily fats, fat-soluble vitamins
6	Jaggery	Solid, golden brown	Sweet, molasses-like	~1.5	Neutral	Sucrose, glucose, fructose, minerals
7	Water	Clear, colourless liquid	Odourless	1	7	H_2O with trace minerals and impurities

Design of Panchagavya mixer

Power developed by the operator

The power developed by an operator using their hand to rotate a crank can be estimated based on the force applied by the operator, the speed of rotation, and the radius of the crank. The power developed by the operator using their hand to rotate the crank is approximately 31.4 watts at 50 newtons force, and with the crank radius of 0.1 meters and a rotational speed of 60rpm.

Torque (τ)

Force applied by operator (F): 50 Newtons
Crank radius (r): 0.1 meters
Rotational Speed (N): 60 rpm

$\tau = F \times r$

$\tau = 50N \times 0.1m$

$\tau = 5Nm$

Angular Velocity (ω)

$$\omega = \frac{2\pi N}{60}$$

$$\omega = \frac{2\pi \times 60}{60}$$

$$\omega \approx 6.28 \frac{rad}{s}$$

Power (P)

$P = \tau \times \omega$

$P = 5Nm \times 6.28 \frac{rad}{s}$

$P \approx$ 31.4 watts.

Design of cylindrical tank with a capacity of 30L
Volume of cylinder:

$$V = \pi \times (\frac{D}{2})^2 \times H$$

V = volume of cylinder, D = Diameter of the cylinder, H = Height of the cylinder.
Given V 0.03 cubic meters.

Diameter (D): Assumption is 30cm.
Height (H)

$$H = \frac{V}{\pi \times (\frac{D}{2})^2}$$

$$H = \frac{0.03}{\pi \times (\frac{0.3}{2})^2}$$

$$H = 42.4\ cm$$

Surface area of the cylinder
Lateral surface Area (A_L)
(A_L): $\pi \times D \times H$

$A_L = \pi \times 0.3 \times 0.424$

$A_L \approx 0.4\ m^2$

Top and Bottom Surface Area (A_{TB})

$$A_{TB} = 2 \times \pi \times \left(\frac{D}{2}\right)^2$$

$A_{TB} = 2 \times \pi \times 0.0225$

$A_{TB} = 0.141\ m^2$

Total surface Area (A_T)

$A_T = A_T + A_{TB}$

$A_T = 0.4 + 0.141$

$A_T \approx 0.541\ m^2$

Conical Bottom Volume (V_c):

$$V_c = \frac{1}{3} \times \pi \times (\frac{D}{2})^2 \times H_c$$

$$V_c = \frac{1}{3} \times \pi \times 0.0225 \times 0.1$$

$V_c \approx 0.00024\ m^3$

Height of Cylindrical Section (H_{cyl}):
$H_{cyl} = H - H_c$

$H_{cyl} = 0.424 - 0.1$

$H_{cyl} \approx$ 0.324 m

Design of Crank mechanism
A crank mechanism is designed and developed for the panchagavya mixer for converting rotational motion to linear motion. (Norton, *et al* (2009)) [7]
Components of the crank mechanism
1. Crank handle: the rotating part where manual force is applied.
2. Crank arm: the arm connected to the handle that rotates with it.
3. Connecting rod: the rod that connects the crank arm to the slider.
4. Slider: the part that moves linearly within the cylinder to mix the contents.
5. Cylinder: the container holding the mixture.

Design Parameters
Crank radius(r): the distance from the centre of rotation to the point of connection with the connecting rod.

Connecting rod length(L): the length of the rod connecting the crank arm to the slider.

Stroke length(s): the maximum linear travel distance of the slider, which is twice the crank radius (S=2r).

Crank angle (θ): the angle of rotation of the crank arm.

Slider (x): the linear displacement of the slider.

Velocity of slider (v):

$$v = -r\omega \sin(\theta)\,(1 + \frac{r\cos(\theta)}{\sqrt{L^2 - r^2\ sin^2\ (\theta)}})$$

(erdman, *et al* (2001)) [5]

For, $\omega = 10\frac{rad}{s}\ and\ \theta = 90°$

$$v = -0.1\ \times 10\sin(90°)\left(\frac{1 + 0.1\cos(90°)}{\sqrt{0.4^2 - 0.1^2 sin^2(90°)}}\right)$$

$$v = 1m/s$$

Acceleration of the slider(a)

$$\alpha = r\cos(\theta)\,(1 + \frac{r\cos(\theta)}{\sqrt{L^2 - r^2\ sin^2\ (\theta)}}) - \frac{r^2\omega^2 sin^2(\theta)}{L^2 - r^2\ sin^2\ (\theta)}$$

(erdman, *et al* (2001)) [5]

= for θ = 90°

$$\alpha = -7.14\,m/s$$

The paddle, attached to the connecting rod, has sufficient height to mix the contents effectively within the cylindrical section. The handle provides adequate leverage for manual operation, ensuring efficient mixing within the 30-litre cylinder

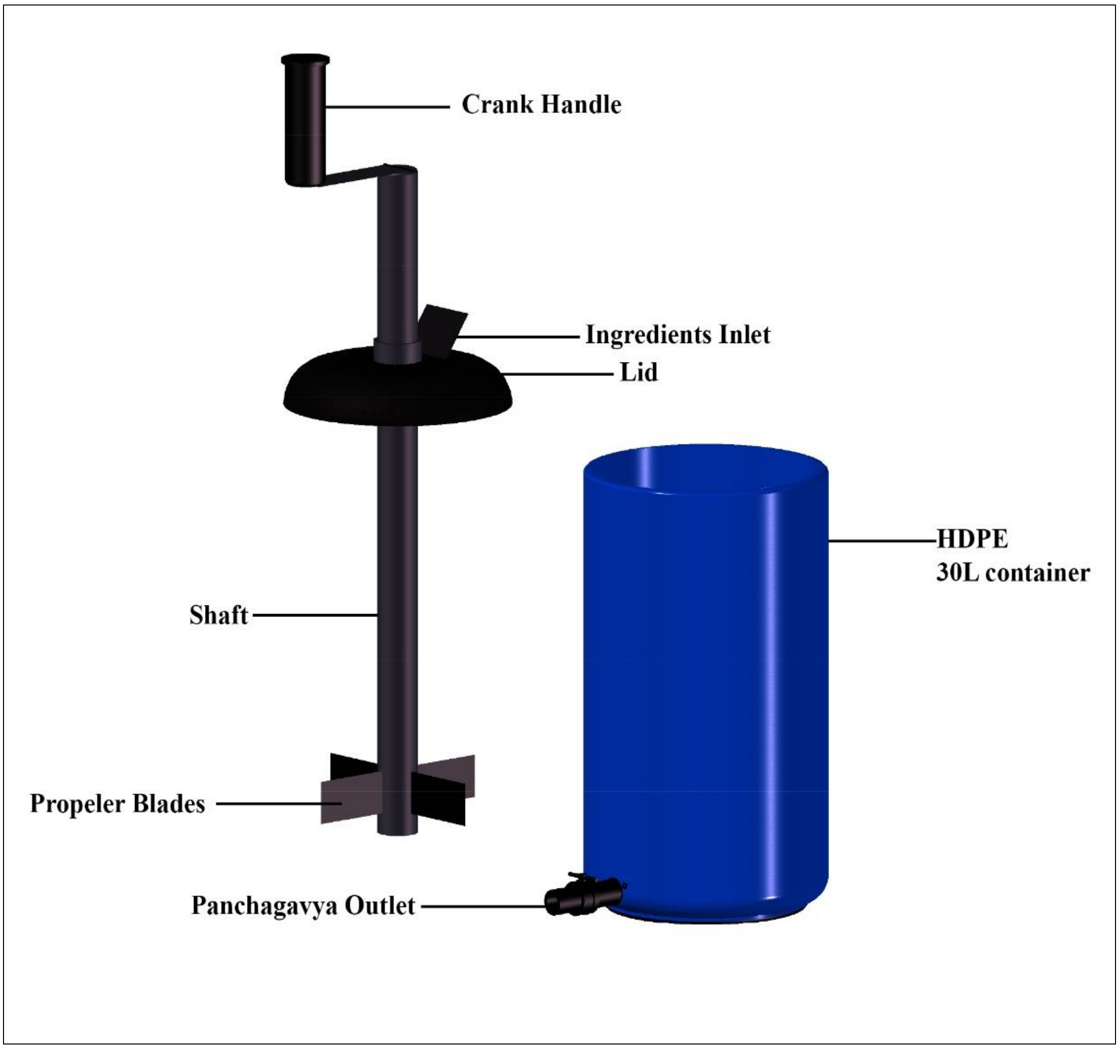

Fig 2: CAD model of Panchagavya Mixer

Table 3: Material used for making Panchagavya Mixer.

S. No	Parts of the Mixer	Material	Quantity
1.	Drum	HDPE(30lits)	01
2.	Shaft	Cast Iron	01
3.	Blades	Iron	01
4.	Handle	Iron	01
5.	Outlet	Brass valve	01
6.	Inlet	Plastic	01

Table 4: Specifications of Panchgavya Mixer

S.No	Particulars	Specifications
1	Shape of the mixer drum	Clyindrical with flat bottom
2	Capacity of mixer drum	25 liters
3.	No. of blades	1
4.	Type of blades	Pitch
5.	No. of Inlets	1
6.	No. of outlets	1
7.	No. of bearings	1
8.	Diameter of shaft (cm)	2.5
9.	Length of Handle (cm)	20 x 15 x 15
10.	Length of Shaft (cm)	30

Fig 3: Developed Panchagavya mixer.

Results and Discussion

The traditional hand – operated method of mixing Panchagavya using a stick takes approximately 10 days to complete. This method demands significant physical effort, as it involves continuous manual stirring. The consistency of the mixture can vary widely, depending on the operator's endurance and technique, often resulting in a homogeneous product. In contrast, using a crank mechanism significantly reduces the mixing time to about 5-6 days. The crank mechanism also alleviates the physical strain on the operator, making the process more manageable. The mechanical advantage provided by the crank leads to more consistent and through mixing, which enhances the overall quality of the panchagavya. The crank mechanism offers a moderate improvement in efficiency and consistency compared to manual stirring.

Table 4: Performance evaluation of hand operated and crank operated mixer

S. No	Mixing method	Mixing time (days)	Physical effort	Consistency
1	Hand operated (using stick)	10	high	Variable
2	Crank mechanism	5-6	moderate	Improved

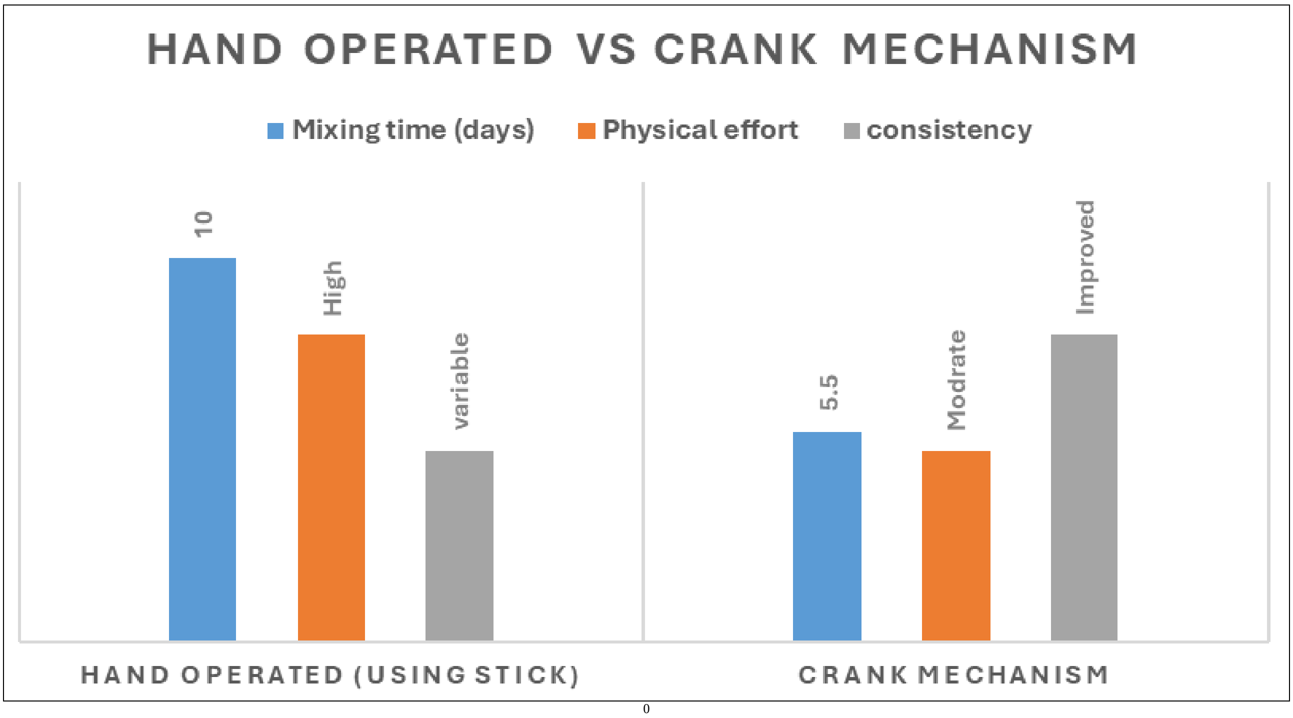

Fig 4: Graphical representation of Hand operated and crank mechanism

The graph shows that the crank mechanism not only reduces the mixing time and physical effort required but also improves the consistency of the mixture. The hand-operated method of mixing panchagavya is labour- intensive and time-consuming. It requires substantial physical effort and can lead to inconsistent results due to variations in the operator's technique and endurance. While this traditional method is accessible and cost-effective, its inefficiency and inconsistency make it less desirable for those seeking a more effective mixing process. The crank mechanism offers a considerable improvement over manual stirring. It reduces the physical effort required and almost halves the mixing time, making the process more efficient and yielding a more consistent product. This method is particularly beneficial for small to medium-scale operations.

Although not tested in this study, the use of a motor – operated mixer is projected to further enhance efficiency. A 0.25 hp motor can deliver continuous and thorough mixing, drastically reducing the time required to achieve the desired consistency. This method would be particularly beneficial for larger-scale operations or situations where time is a critical factor. The investment in a motorized mixer can be justified by the significant reduction in labor and time, leading to increased productivity and better control.

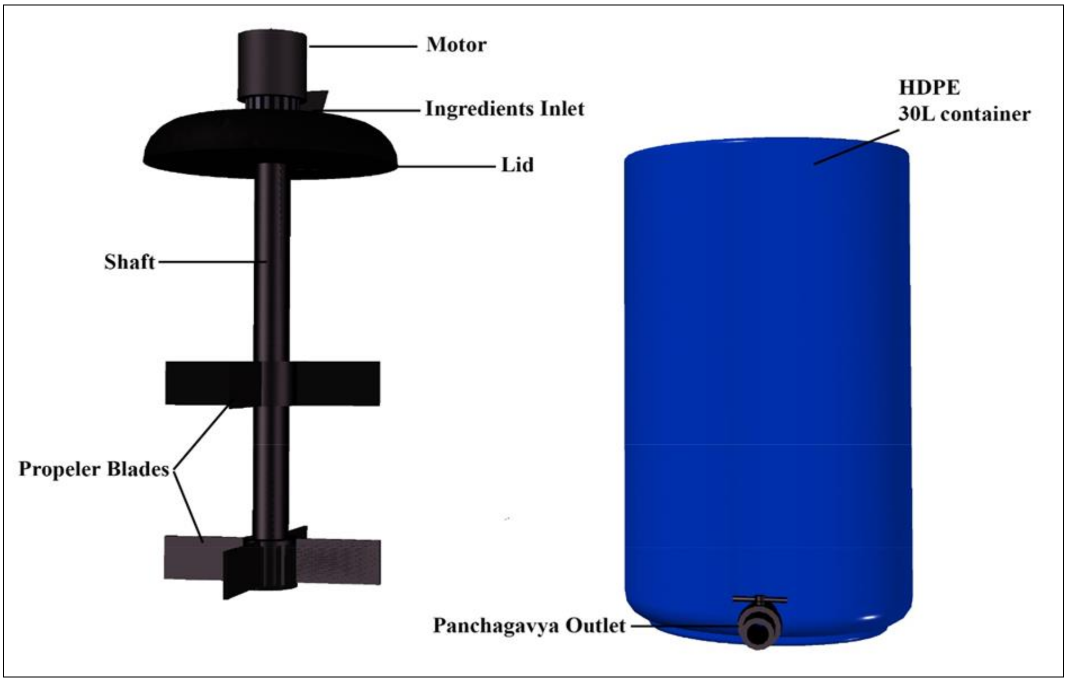

Fig 5: CAD model of motor operated Panchagavya mixer

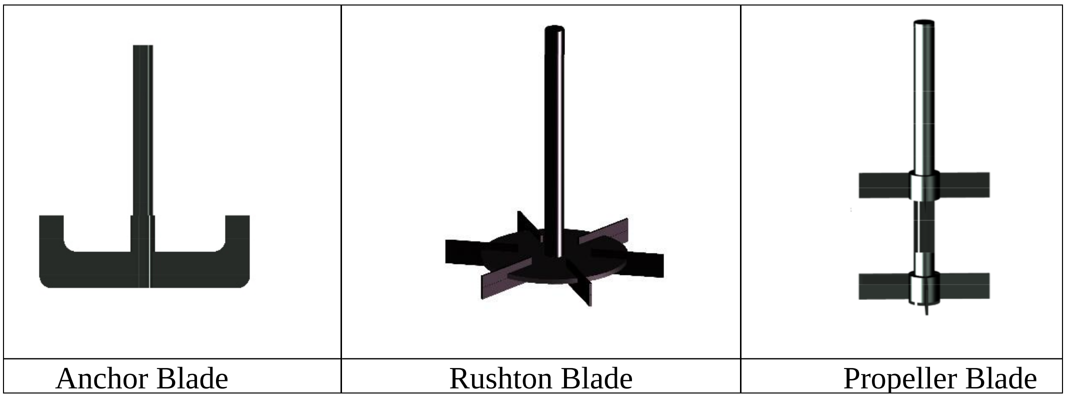

Fig 5: CAD model of different blades for motor operated Panchagavya mixer

Conclusion

The study successfully developed a crank-operated panchagavya mixer that significantly improves the efficiency and consistency of the panchagavya preparation process. By incorporating a crank mechanism, the mixer reduced physical effort and mixing time by almost half compared to traditional hand stirring methods. This advancement provides a practical solution for small and marginal farmers, enhancing their ability to produce high quality organic fertilizer with reduced labour and time investment. The crank operated mixer ensures a more consistent and homogeneous mixture, which is crucial for the effectiveness of panchagavya as a soil and plant health enhancer. The adoption of this improved mixing method can contribute to the broader revival of sustainable organic farming practices, promoting soil health and reducing reliance on chemical fertilizers. Further research could explore potential optimizations and the scaling the design for larger operations while maintaining the benefits observed in this study.

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