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Design & Development of Versatile Mixer

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Abstract: The aim of this work is to design a versatile mixer which model can satisfy the requirements; as it creates 3D motion it can rotate container in multi DOF and container is given V shape. This feature helps to create more turbulence than single DOF and cylindrical drum. Also multi DOF provide more path travelled by particles than single DOF with same size of container. These features help to reduce the number of revolution required for mixing up to 2.5 times and increases the mixing index to 0.9 for same mixing time. Also this mixer has 2 shafts to give rotation while currently available mixer has 1 shaft only. This increases safety against accident due to overload and impact load.
Keywords: Versatile Mixer, CAD model, Design, Paul Schatz Mechanism

I. INTRODUCTION

In industrial process engineering, mixing is operation that involves manipulation of a heterogeneous physical system with the intent to make it more homogeneous. Mixer is a device that uses a gear-driven mechanism to rotate a set of "beaters (blades)" in a bowl / container containing the stuff to be prepared by mixing them. The mixer with rotating parts was patented in 1856 by Baltimore, Maryland tinner Ralph Collier. U.S. Patent 16,267 This was followed by E.P. Griffith's whisk patented in England in 1857. Another hand-turned rotary egg beater was patented by J.F. and E.P. Monroe in 1859 in the US. U.S. Patent 23,694. In 1870, Turner Williams of Providence, R.I., invented another Dover egg beater model. U.S. Patent 103,811. The first mixer with electric motor is thought to be the one invented by American Rufus Eastman in 1885. U.S. Patent 330,829 The Hobart Manufacturing Company was an early manufacturer of large commercial mixers, and they say a new model introduced in 1914 played a key role in the mixer part of their business. The Hobart KitchenAid and Sunbeam Mixmaster (first produced 1910) were two very early US brands of electric mixer. Domestic electric mixers were rarely used before the 1920s, when they were adopted more widely for home use. Older models of mixers originally listed each speed by name of operation (ex: Beat-Whip would be high speed if it is a 3-speed mixer) they are now listed by number. Generally mixers are classified based on stuff and mixing effect. Based on mixing effect mixers are classified in convective mixer, Diffusive mixer, Shear mixer. Based on stuff used mixers are classified as: Solid-Solid mixer, Solid-Liquid mixer, Solid-Gas mixer, Liquid-Liquid mixer, Liquid-Gas mixer, Gas-Gas mixer.
Our focus is mixers that use diffusive mixing effect. Few examples of Solid-Solid mixers are: Drum mixer, V-shape mixer, Tabular mixer, Tumbler mixer, chopper mixer, stand mixer. These are the conventional mixers. Small purpose mixers don’t need more time to complete its operation. But mixers with heavy duty operation cannot be operated with high speed so it requires large time and more revolutions for mixing. This problem cannot be eliminated but it can be minimized. So based on modern researches and different mechanisms we have undertaken the project that can minimize the problem. We have undertaken the current work of “Design and development of versatile mixer”. We have used “paul schatz mechanism” to rotate the container. This mechanism rotates the container in 3D motion which gives better mixing index, lesser mixing time, multi degree of freedom.
In conventional mixers, mechanisms are used to rotate the container in only one degree of freedom (DOF). It causes less movement of particles than multi DOF also turbulence is less with simple rotating type mixers. Researches gave the size of blade, number of blade, number of baffles for proper mixing. It increases the quality of mixture but mixing time cannot be improved. To reduce the mixing time and increase the mixing index we need to increase the movement of particles that is possible by increasing the DOF. Paul schatz, an inventor and researcher, has suggested a mechanism that can rotate a component / vessel into multi DOF. This mechanism rotates the component in 3D motion. This effect increases the movement of particles per unit time than conventional mixers. So we can increases the mixing index and also reduce the mixing time. In mixing path travelled by particles, turbulence and size ratio is key factors affecting the mixing quality. Path travelled by particles depend on size and shape of container. Size ratio varies with ingredients. But turbulence is dependent on size and motion given to container. In drum type mixers to create turbulence baffles or blades are needed which increases the weight of machine and sometimes creates grinding effect. To reduce this problem cylindrical drum was replaced by V shape container which has increased turbulence due to its shape and also baffles are not required. So we have taken advantage of this v shape over cylindrical container. We used small v shape in the middle of cylindrical container. So use of 3D motion and V shape will increase the turbulence and path travelled by particles which result in better mixing quality in short time.

II. MECHANISM DESIGN

In conventional mixers single rotating motion is used. As discussed earlier this motion is time consuming and give less mixing effect with revolution. So as a solution we have used a principle derived by “Paul Schatz” and patent registered in Swiss patents number 500 000 after first world war.

This principle is also referred in his book “Rhythmusforschung and Technik" (Stuttgart 1975)” In this principle schatz has mentioned a shape that is used to create 3D motion. This shape is known as oloid. This oloid shape is driven by belt drive. In roller guided mechanism, more parts are needed to create 3D motion which increases complexity and make the machine more robust than oloid mechanism. The problem with the oloid shape is it needs proper surface finishing and require proper alignment of upper and lower portion of oloid shape also gripper attachment is complicated in fabrication. So oloid shape creates complication in manufacturing and designing which increases cost of product. Considering this points we are not using oloid shape. We are using a cylindrical container. We have also used advantage of V shape and placed V shape in middle of container.

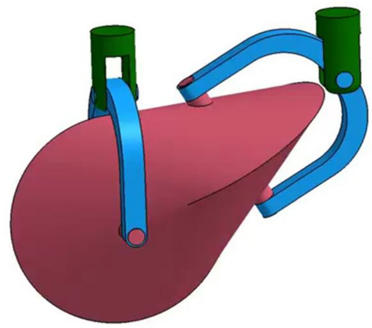

Fig. 1 Paul schatz principle

III.DESIGN OF MIXER

A. Container with V shape

It is the main component of product causes mixing of ingredients. Advantages of V shape is given earlier so we have placed a V shape in the middle of cylindrical container. Metals are heavy in weight and it may create chemical reaction with acidic material so we have used material “HDPE ASTM D638” Detailed dimensions of container is given in “section 3.2”. Creo model of this container is shown here.

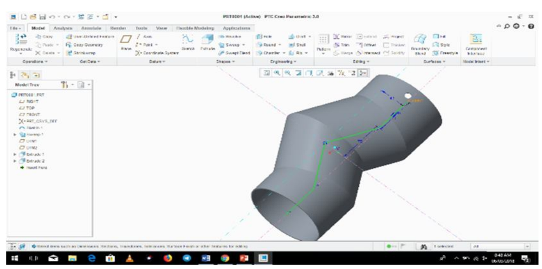

Fig. 1 Paul schatz principle

B. Gripper

This is the component which is connected to the container and shafts. This will transfer the motion from shafts to container. Gripper is made of M.S. material. 2 grippers are provided in model at each end of container. Detailed dimensions of gripper is given in “section 3.2”. Creo model of this gripper is shown here:

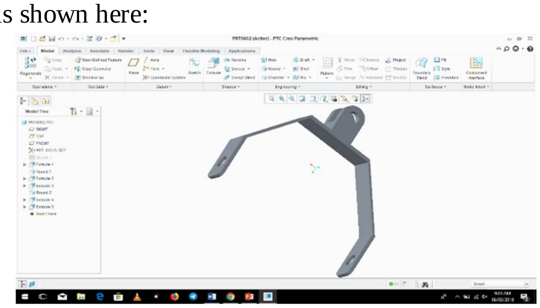

Fig. 2 Creo modelling of gripper

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C. Dimensions of Equipments

1) container dimensions

a) We are designing a mixer for 3L volume with 3.5 max. weight capacity.

b) To design the container for 3L volume length or dia. of container should be fixed. For that we have fixed diameter container.

c) According to paul schatz mechanism for oloid length of oloid should be equal to 3 times of its radius.

d) Volume of cylinder is given by,

$$V = \pi r^2 h \qquad \text{(r= radius of cylinder, h= length of container)}$$

e) We get the dia. of cylinder as around 140 mm and length as 210 mm.

f) Material used to make container is HDPE ASTM D638 (density 960kg/m^3 , σ_{ut} = 31.7 Mpa)

g) So container weight is given by M_c = volume of material* density = 0.304 kg

h) Centrifugal force on container is given by,

$F_c = MR\omega^2$ ($M=M_c + m$, m = max. mass of material R=radius of rotation=length of container)

= 15.65 N

i) Total force F = weight of components including mass of ingredients

We get F= 52.973N

j) We found that these dimensions are safe against shear failure of container for HDPE material.

2) Dimensions For Gripper Pin

a) Pin is used to connect the gripper to container and motor shaft to gripper.

b) Material used in pin is AISI 304 (SS material) , τ = 100 Mpa.

c) For pin design l=(1.25 to 1.5)d, (l= length of pin, d= dia of pin)

d) For us length of pin is required as 15mm.

e) So we get dia of pin as 10 mm

f) We found that pin dimensions are safe against shear failure and tensile failure.

3) Gripper

a) To make gripper metal strips are available with following c/s

t x b = 3 x 15, 3 x 25, 4 x 15, 4 x 25, 5 x 15. (t=thickness, b=width)

b) Metal strips are made of MS, σ_b= 100Mpa

c) Moment M = length x F/2 (as 2 grippers are provided)

We get M=3954 N mm.

d) Bending failure is given by σ_b = My/I (I/y= $bd^3/6$)

e) From above dimensions of metal strip we found that 4 x 25 mm strip is safe against failure.

f) Length of gripper should be greater than dia of container, including pin section we get min. length as 140 mm.

4) Shaft

a) Required torque on shaft T = F x L (L= length of gripper, F = total force)

Max torque is given by, T_{max} = T*(1.5 to 2) = 15816 Nmm

b) Max. RPM of motor is 50Rpm

c) So power required $P = \frac{2\pi N Tmax}{60000}$ = 82.81W

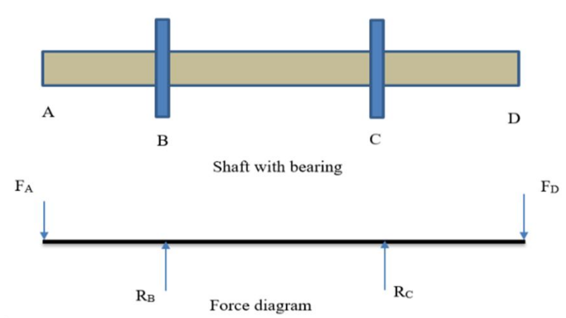

Fig. 3 Force Diagram of Shaft

d) Considering shaft length as 180 mm with 2 bearing support given as fig. distance AB= 50mm, BC=80mm, CD=50 mm (A is attached to gripper)
e) Using shear force and bending moment theory for beam we get R_c -8.505N and R_D= 39.77 N. and max. bending in shaft at point B M@B= 1318 Nmm

i) Now **case-1**
1. Equivalent twisting moment $T_e = (M^2 + T^2)^{1/2} = 1587.82$ Nmm
2. $T_e = \pi\tau d^3/16$, So we get dia of shaft d= 14 mm

ii) Now **case-2**
1. Equivalent bending moment $M_e = 1/2[M+(M^2 + T^2)^{1/2}] = 8594.41$ Nmm
2. $M_e = \pi\sigma_b d^3/16$, So we get dia of shaft d= 12 mm
3. So we have selected dia d= 14 mm

5) *V Shape Of Container*
a) In mixers generally V angle is provided as 90, 120, 150 degree.
b) 90 degree angle of V can block the path of mixture.
c) 150 degree creates turbulence effect at container surface only.
d) So we have preferred 120 degree as angle of V which uses advantage of both 90 and 150 degree angle.

D. Construction, Working & Fabrication

1) *Construction:* Paul schatz, inventor and researcher, has patented oloid shape as “ch-patent-5000 000” to create 3D motion. Using this principle we have designed this mixer. We have also taken advantage of V shape container over simple drum type cylinder. As discussed earlier we have designed components like V shape container, gripper and shaft. As shown in creo modeling container has holes at its peripheral surface at top and bottom side. Line joining the center of holes at top side is kept perpendicular to the line joining center of holes at bottom side as shown in fig. 6 (as per principle). Splitting end of grippers are attached at the both side of holes provided in the container. Common end of gripper is connected with one end shaft. Shaft is connected to motor on its other end. Bearings are mounted on shaft which provide support to mixer (motor, container, gripper and shaft). Bearings are fixed to stand. Load is transferred from bearing to stand. Wirings are connected to motor for power supply.
2) *Working:* When motor runs it transfer its motion to shaft. As shafts are connected to grippers motion is transferred to grippers but this motion is not transferred while complete rotation of shaft. When shaft 1 is rotated to 180 degree motion is transferred to gripper 1. At the same time shaft 2 doesn’t transfer motion to gripper 2 but supports the gripper only. When shaft 1 is rotated 180 degree to 360, this time shaft 1 is in idle condition and shaft 2 transfers motion to gripper 2. So, both shafts transfer motion alternatively for half rotation and remains in idle condition for another half revolution. Due to this motion grippers are rotated simultaneously container is also rotated.
3) *Fabrication:* Container is made by welding the cylindrical components. Grippers are also made by welding operation. Grippers are connected to container and shaft by fastening. Shaft is connected to gripper and motor by pin joint. Bearings are connected to stand by fastening process. Stand is made with welding process. Wirings are done using soldering process.The 2D and 3D models as shown in Figure 4 and Figure 5 are developed using AutoCAD 2009 software for the above calculated dimensions of fin tube heat exchanger [4].

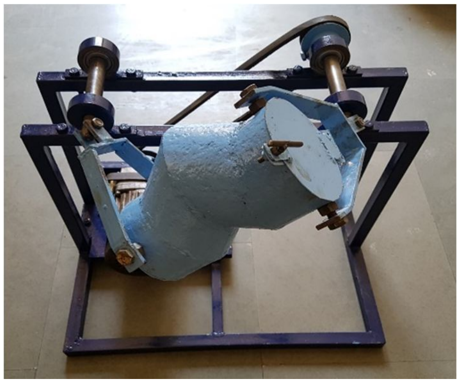

Fig. 4 Mechanism of Mixer fabricated

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From this mixer, we have found following results:

As we have used paul schatz mechanism we have achieved 3D oscillating motion of container. Also V shape of cylinder is used. Which has increased turbulence created in vessel.

By performing a mixing experiments we have achieved following comparisons:

a) To get same results in drum mixer, V shape mixer, Ribbon mixer and our mixer we found following results. This chart shows comparison of required revolution of different mixers for same results. (Fig 5)

b) After 45^0 rotation we get following mixing index for different mixers (Fig 6)

TABLE 1
Comparison Of Require Revolution For Different Mixer

Type	Revolution
V shape mixer	110
Drum mixer	120
Ribbon type mixer	90
Our prototype	60

TABLE 2
Mixing index after 450 rotation

Type	Mixing index
V shape mixer	0.53
Drum mixer	0.47
Ribbon type mixer	0.6
Our prototype	0.8

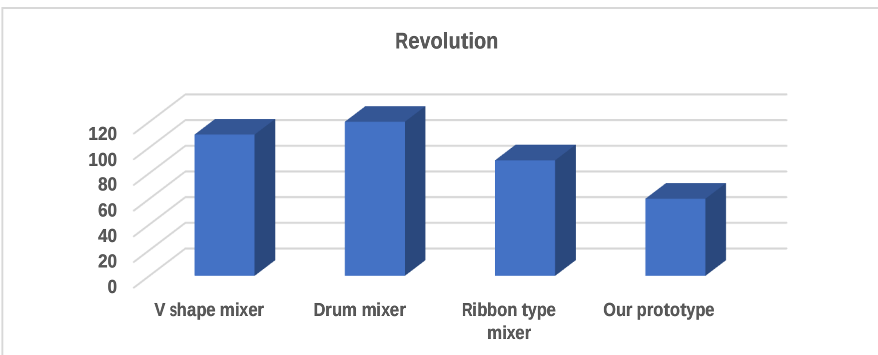

Fig. 5 comparison of require revolution for different mixer

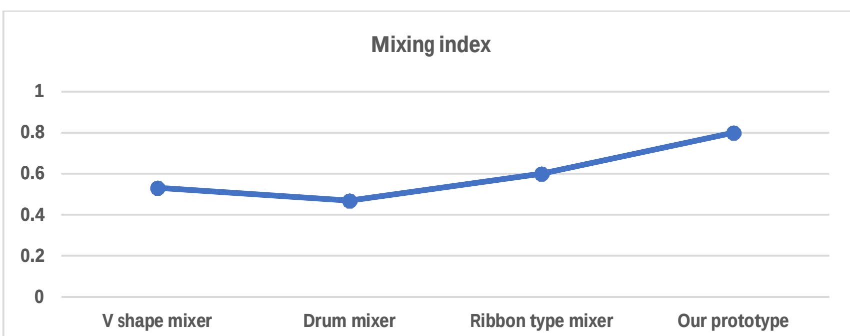

Fig. 6 Mixing index after 45 rotation

This model can satisfy the requirements; as it creates 3D motion it can rotate container in multi DOF and container is given V shape. This feature helps to create more turbulence than single DOF and cylindrical drum. Also multi DOF provide more path travelled by particles than single DOF with same size of container. These features help to reduce the number of revolution required for mixing up to 2.5 times and increases the mixing index to 0.9 for same mixing time. Also this mixer has 2 shafts to give rotation while currently available mixer has 1 shaft only. This increases safety against accident due to overload and impact load

IV. CONCLUSIONS

A Mixing focus on 3 terms: path travelled by particles, size ratio of ingredients and turbulence created in mixture. From our project we found that we have increased turbulence in mixture, increase the path travelled by particles for same size of container and can use this mixer for higher particle size ratio compared to other mixers. Using this prototype we can achieve same results 2-3 times faster than other mixers (like drum type mixers). This mixer can achieve mixing index of 0.8-0.85 with same revolution that required to get mixing index of 0.6-0.65 in drum type mixers. Also this mixer provide better safety compared to other mixers having one shaft for revolution of container.

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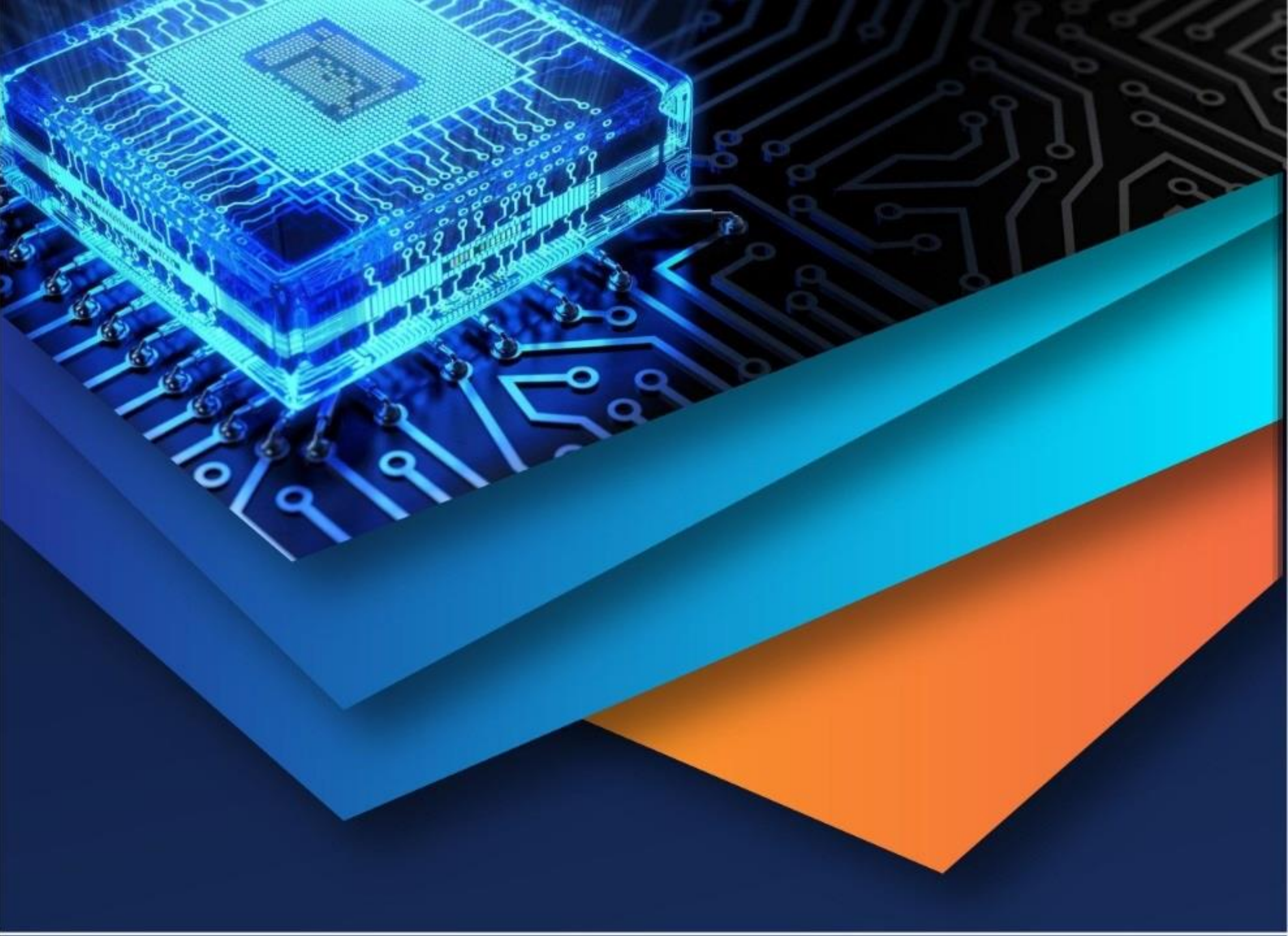

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