Design Development and Power Requirement Estimation of Conical Dual Blade Sinusoidal Mixer

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Abstract:

Stirring process is an integral part in manufacturing process of paints. Mechanical mixers are used largely in mixing of paints, semi-solids and jellies where in the suspended particles in form of powder or semi-solids are suspended uniformly to disperse the particles thoroughly to desired homogeneity .In cases predominantly where the specific weight of the powder is high the problem occurs the tendency to settle down poses a major problem in fixing such is the scenario in the case of production of ionic paint used for corrosion prevention , an thermal insulation in automobile silencers. These ionic paints require to mix metal powder rust (oxide) of heavy density in vehicles added with pigment base. Vehicle or base fluid is a low density evaporative fluid which is mixed with metal oxide powder to form thoroughly mixed applicant that can be applied by use of spray painting on to automobiles silencer to form a non-corrosive particle layer.

The project work is proposed to carry out the sizing, design development of conical dual blade sinusoidal mixer. The paper deals with estimation of the power requirements of the mixer and discusses over all constructional features of the mixer. The arrangement of the blades of the stirrer impeller is discussed along with the power train to drive the stirrer shaft

Keywords: *Ionic paint , dual balde sinusoidal cone mixer , power requirement , stirrer impeller , power train.*

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I. INTRODUCTION

Design of an efficient stirrer or mixing - blending system comprises of a balancing activity of product batch size, stirrer type and size, blade shear, motor horsepower, blade tip speed, viscosity of fluid to be mixed , energy costs , cycle time and the thermal capacity of the material ingredients of the product.. There is no universal mixer device that can handle all mixing conditions and tasks. A variety of different principles are applied for stirring of semi- solid materials in different based vehicles. Therefore, there are many different types of industrial mixing solutions

Common mixer types for powder processing include:

Paddle type mixers – These mixers have a horizontal rotating shaft with fixed mounting arms and paddles that translate, lift and rotate the mixture

Ribbon type mixers –An helix shaped blade arrangement with, counter-transport mechanism which scrubs product on product and attains desirable mixing

Screw type mixers -An rotating screw that moving around the periphery of a conical shape hopper is used in this type of mixer

V-cone type mixer - Inclined cylinders and employed that rotate, resulting bulk material to drop or fall and thereby converge during half of the rotation, and divide during the latter half rotation

Double cone type mixers - In these mixers the conical shape at either ends provides a subtle tumbling action due to gravity.

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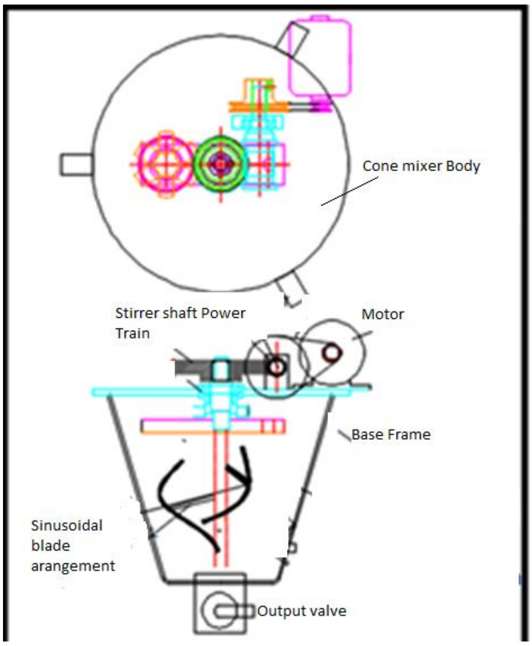
Drum type of mixers - In these mixers the continuously rotating drum is employed that,allows the product to be mixed from the entry point to the exit point of the mixer

Planetary type mixer – In this mixer two mixing blades that revolve around the centre axis and rotate around individual shafts and thereby stir ingredients of mixer

II. SCHEMATIC OF THE CONICAL DUAL BLADE SINUSOIDAL MIXER



A. Stirrer rotation speed (N) :

N_S =Drive motor speed / gear box reduction ratio=1200/60 =20rpm

B. Impeller or Stirrer blade Flow Number (Zq):

$Zq = Q_s / N_S * Ds^3$
Where,
Q = Stirrer primary flow (m3/sec)
[Capacity of Pumping of stirrer] = 0.25
Ds =Stirrer blade diameter (m) = 0.36 m
Zq = 0.25/ (20 * (0.36) i3) = 0.26

C. Stirrer blade or Impeller Power number (Zp) :

$Zp = P_s / Ns^{3*} Ds^5 * \rho$
Where,
P_s = Stirrer power (w)
Ns= Stirrer rotational speed (rpm)
Ds=Stirrer diameter (m) =0.36 m
ρ_s = Density of slurry (kg/m^3) =1.2400gm/cm3
$0.26 = P_s / 20^{3*} 0.36^5 * 1.24$
P_s = 15.59 watt.

D. Stirrer Reynolds Number (Re):

Re = Ds2*Ns*ρ_s /μ
Where,
Ns= Rotational speed of Stirrer (rpm) = 20 rpm
Ds =Stirrer diameter (m) = 0.36 m
ρ = slurry density (gm/cm^3) =1.24 gm/cm^3
ρ μ = Viscosity of the slurry (Ns/m^2) =0.042 Ns/m^2 given)
Re = 0.36 *20*1.24 / 0.042 = 211.5
As the Re <2300 ---flow is laminar

E. Tank area (A_t):

(A_t): = (π*Dt2) / 4
[Where Dt = Diameter tank] = 0.101 m^2

F. Bulk fluid Velocity :

Bulk fluid Velocity = Capacity of pumping of stirrer/ Area of Tank
Bulk fluid Velocity = 0.25/ 0.101 =2.47 m/min = 8.1 ft/min

G. Agitation degree of Stirrer :

Agitation degree of stirrer isthe optimizationparameter for degree of particle suspension that ranges between 1 to 10. For high intensity of mixing or stirring in any container or tank the calculated agitation degree can be worked out to greater than 10 but it is can assume a maximum value of 10 only
Agitation degree of stirrer = Bulk fluid Velocity/6
{For bulkvelocity of 6 ft./min ; Agitation degree of stirrer = 1
Agitation degree of stirrer = 8.1 / 6 = 1.35

III. STIRRER TANK ANNULUS AREA

A. Stirrer tank annulus area = [π*(Dt2 – Di2)^2 / 4]
Stirrer tank annulus area = [π*(0.45– 0.36)^2 / 4]
Stirrer tank annulus area = 0.00636m^2

Volume of Tank (Capacity of tank)

$V = \pi r^2 * H / 3 = \pi (0.225)^2 * 0.5 / 3 = 0.0265$ m3

B. Tank Delivery Rate

Tank Delivery Rate is the parameter that determines the rate of revolution of stirrer. The deposition velocity of particles of semi-solid or powder cannot be kept higher than the velocity of upward motion of particles in order to avoid sedimentation and accumulation of solids in tanks.

Tank Delivery Rate = Stirrer capacity of pumping / Capacity of Tank

Tank Delivery Rate = 0.25/ 0.0265

Pumping = 9.43 times/min

As the designed rpm of 20 rpm > tank delivery rate it is clear that the designed system will not allow sedimentation or settlement and thus homogeneity and well dispersion of particles is guaranteed.

C. Selection of Power train :

The stirrer is driven by a worm gear box of 1 :60 ratio , considering 50 percent transmission efficiency of the gear box the minimum motor power required is given by,

$P = P_{required} / 0.5 = 15.59 / 0.5 = 31.18$ watt

Considering factor of safety of 1.5

Moto power selected = 31.18 x 1.5 = 46.77 rounded up to 50 watt

IV. RESULT AND DISCUSSION

The following results for design of the Conical Dual blade sinusoidal mixer

1. Stirrer rpm is 20 rpm > tank turnover rate 9.4 --to avoid settling and sedimentation
2. The minimum power required is 15.39 watt considering worm gear box efficiency and factor of safety motor power selected is 50watt
3. The stirrer diameter is 360 mm the tank diameter is 450 mm cone with height of 450 mm and tank capacity is 0.0265 m^3
4. The Reynold Number (Re)= 0211.5 As the Re <2300 ---flow is laminar

V. CONCLUSION

The sizing, design of conical dual blade sinusoidal mixer is successfully done and the dimensions of the stirrer and the tank have being determined. Estimation of the power requirements of the mixer and discusses over all constructional features of the mixer have being decided and the motor power is selected with factor of safety of 1.5 . The arrangement of the blades of the stirrer impeller is discussed along with the power train to drive the stirrer shaft. As the designed rpm of 20 rpm > tank turnover rate it is clear that the designed system will not allow sedimentation or settlement and thus homogeneity and well dispersion of particles is guaranteed.

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