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A Review : Design Development, Analysis and Testing of Wobble Mixer Machine

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ABSTRACT

The mixing process is considered to be the most primary process in many industries like chemical, paint and pharmaceutical, etc. The conventional machinery used in the form of stirrers, cone mixer, paddle mixers, agitator mixers etc. The problem in use of conventional mixers mentioned above is in mixing of semi–solid or suspended solids in liquid vehicles.

The paper reviews the conventional mixers and the associated difficulty in application of these mixers in above said cases. The paper discusses the system design, mechanical design and analysis of the wobble mixer. The components of the system have been developed and the analysis has being carried out.

Keywords:— *Mixing, Process industry, Design, Analysis.*

I. INTRODUCTION

In case of process industries, process of mixing and stirring forms and integral and the important part of the total manufacturing process. Mixing is the process which determines uniformity and over all quality of product. Process industries like chemical plants, food processing plants, paint industry etc, largely employ mechanical mixers to carry out mixing of powders, semisolid jelly fluids etc. Mixing is a process where powder or jellies are mixed together through in the form of uniform mixture where stirring is the process to mix the fluid and powder to dissolve the powder thoroughly in given mixture and form a uniform product or output. In either of above cases through mixing of material is desirable to give and good and uniform quality output. Mixing of powders of different material in order to form a uniform product or a powder mix is quiet easy but when it is desirable to mix powder in a fluid matter specially when the density of powder is high the problem occurs due to heavy weight of particles of powder has a tendency to settle down.

II. LITERATURE REVIEW

Schrimpf, et al (1) (2019) For each application, various configurations and methodologies of the study are appropriate. In various processes, the overall efficiency and the final product quality depends on not only the physicochemical properties of all phases in mixing system, but also on the level of energy dissipation, and the impeller-tank configuration, in particular, on the detailed geometrical shape of impellers.

Major-Godlewska,et.al(2)(2018) Therefore, mixing processes optimisation, as one of the most energy-consumptive steps in many industrial processes, necessitates the reassessment of the existing knowledge and often lead to even the development of the high-performance system, as well as an experimental method [2].

Mishra, P.; Ein-Mozaffari (3)(2017) The location and mode of operation of the impeller (flow-pumping direction, clearance). The continuous-flow mixing operations in mechanically agitated vessels are going to play an essential role in industrial processes. Continuous mixing mat significantly speed-up mixing mixture production; however, it is still challenging to maintain final product constant properties.

Zych, M.;et.al (4)(2017) In a recent work, the authors evaluate single universal correlation that would be viable for mechanically agitated contactors in coalescent batch for any new impeller types with different diameters and their mutual position on a common shaft. Researchers have shown the correlation which can be used to predict transport characteristics in industrial-scale vessels for a wide range of operational conditions in the technological process.

Del Pozo;et.al, (5)(2020) In order to model the fluid flow, several assumptions have to be applied, including the assumption that, the hydrodynamics and fluid rheology are homogeneous in turbulent flow and referred the "perfectly mixed fluid" as the reference value in the mixing process.

Abdulrasaq, U.K.; Ayranci,(6)(2019) In analyse the Processes 2020, 8, 982 3 of 39 hydrodynamics of non-Newtonian flows at broad range Reynolds number generated by an axial impeller (A310) in a single-phase Carbopol fluid using CFD modelling and PIV measurement to validate results. The authors demonstrate that the flow field below the impeller is highly dependent on the rheological behaviour of the fluid.

Tsabet, È.;Fradette, (7)(2015) **[34],** Concerning the stability of Pickering emulsion (oil-water mixture with hydrophilic glass beads) in the baffled tank with Rushton turbine (RT) or pitched blade turbine (PBT). The authors found that the energy dissipated and the size of the high shear zone around the impeller are key information to create the emulsion with the desired droplet sizes.

Ali Sk et al.(8)(2020) **[35]** Reported that the heat transfer data for agitated Newtonian and non-Newtonian fluids related to Nusselt number depends on impeller diameter in the agitated vessel. The authors, by using experimental data, correlated viscosity with of Reynold, Prandtl number and Nusselt Number, which were evaluated at the impeller tip. In the literature, different research groups use various indexes to describe the effect of mixer geometry and mixture properties on degrees of homogeneity suspension.

Sher, F.; et.al;(9)(2016) Results obtained from an innovative approach which describe the behaviour of gas-liquid mixing, i.e., electrical resistance

tomography (ERT) were shown. The authors further used the dynamic gassing-out method in the tank with baffles during the input power measurement in order to find mass transfer coefficient k. They used selected working parameters to test the proposed methodology Processes 2020, 8, 982 6 of 39 by changing the number of baffles in the ERT system. Based on experimental results, it was shown that the optimum numbers of baffles, which reduced the energy input cost by as much as 54%, is four. Three-phases, the gas-liquid-liquid system configuration, may occur in many industrial processes with the chemical reactions.

Major-Godlewska (10)(2011) Confirm that the presence of additional phase positively impacts the mass transfer coefficient, but the authors do not explain the exact mechanism by which this improvement is obtained.

III. Research Gap

The careful literature review of mixers in single stirrer and multiple stirrer arrangement in mixing of fluids revealed that the suspension of the pigment particles greatly depends upon the action of the stirrer.

Several researchers have studied the cylindrical geometry of the container used for mixing along with the paddle type geometry of the with variations in the number of paddles used and the immersion depth of the paddles. Although this configuration was seen to prove ineffective for mixing of semi-solid gellies and fluids with high specific gravity. Other types of geometries with rotating drums was also studied by the researchers with fixed blade geometry although these configurations have found limitations in handling and were found to have suitability in solid to liquid mixing as in concrete mixers. The literature review also showed research on Dispersion Mixers, Paddle mixer, Jet Mixer, Mobile Mixers., Drum Blenders, Intermix mixer, Horizontal Mixer, Hot/ Cold mixing combination, Vertical mixer, and Turbomixer although these mixers were designed for specific industrial applications.

The viscosity of the paint, spreadability of paint and cycle time were found to be significant parameters of study. Variety of devices were found to be used in testing of the viscosity of the fluid or produce ranging for viscometers such as Ford cup viscometer, Saybolt viscosity tester etc. Some of the researchers studied the viscosity through the flow pattern observation through optical spectrometry.

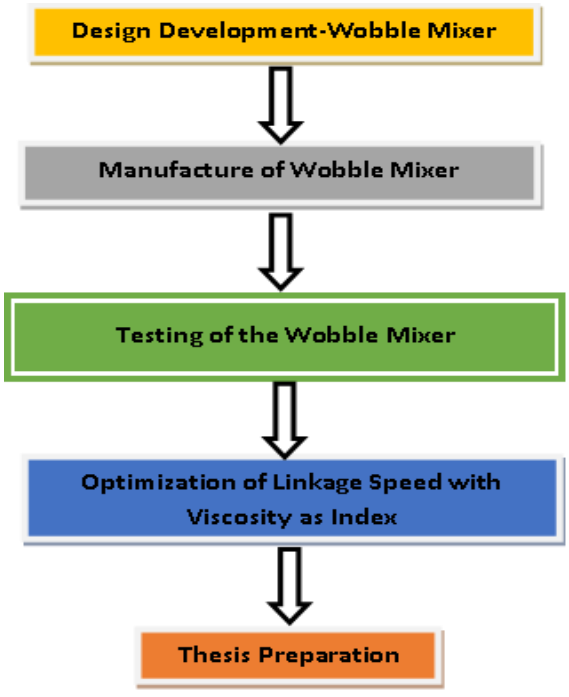

Figure 1 : Flow chart of Methodology

The literature review highlights the lack of research in development of mixers specially dedicated to production of heat resistant paint that use aluminum, or ferrous oxide powders mixed with paint vehicle, although nowadays the heat resistant coating on the automobile

silencers is becoming common and other applications of the heat resistant paint in process industry, chemical industry and agriculture equipment development shows the need of an dedicated mixing device with innovative stirrer action for the application.

Thus research work is focused on the domain of development of one mixer where in the arrangement of innovative kinematic linkage to stir the mixture.

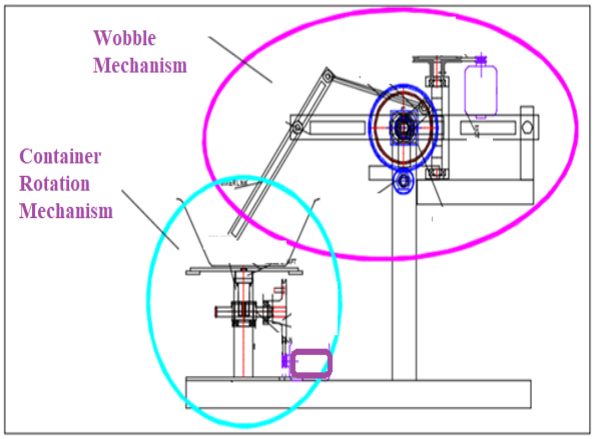

Figure 2 : Worm Shaft for wobble Mechanism

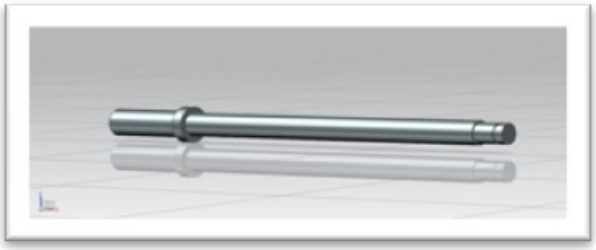

Figure 3: *Connecting rod*

Check for torsional shear failure of shaft

$Te = \Pi fs\ d^3$

16

fs_{act}= 2.94 N /mm^2As;

$fs_{act} < fs_{all}$

Worm shaft is safe under torsional load.

Maximum Stress induced in worm shaft :

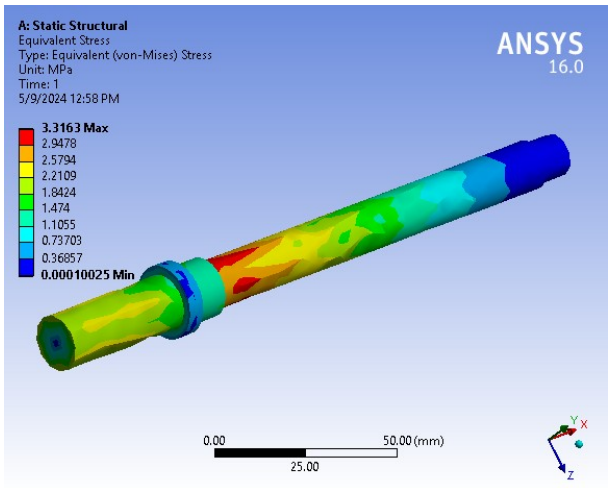

Figure 4: Maximum Stress induced in worm shaft

The maximum Von-misses stresses in the part are 3.3163 MPa which is far below the allowable value 104 MPa hence the part is safe under given loading conditions.

Design and Analysis of Worm :

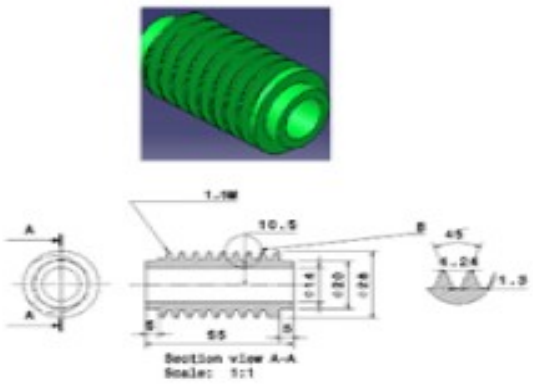

Figure 5: Analysis of Worm

Check for torsional shear failure of shaft.

$Td = \Pi/16 \times fs_{act} \times (D^4 - d^4) / D$

$\Rightarrow fs_{act} = 8.26\ N/mm^2$

As

$fs_{act} < fs_{all}$

$\Rightarrow$Worm is safe under torsional load

Maximum Stress induced in worm :

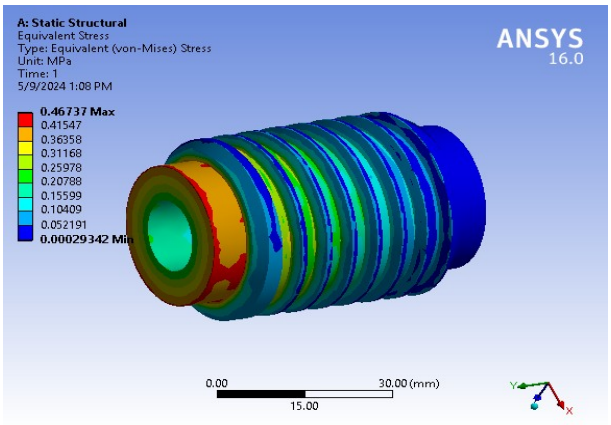

Figure 6: Maximum Stress induced in worm

The maximum Von-misses stresses in the part are 0.46 MPa which is far below the allowable value 104MPa hence the part is safe under given loading conditions.

Maximum Stress induced in worm gear :

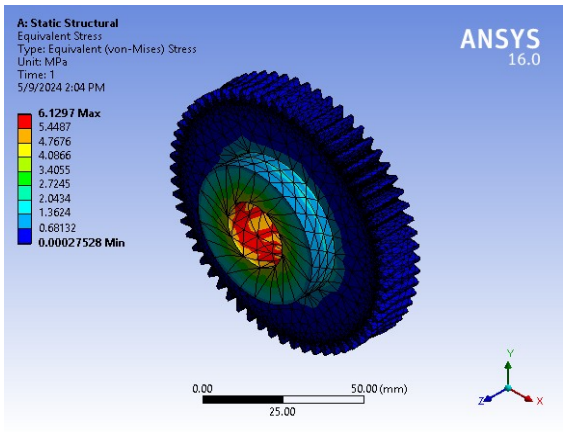

Figure 8: Maximum Stress induced in worm gear

Maximum stress induced in worm gear in torsion mode. Maximum stress indued in the worm is 6.1297 which is well below permissible limit hence it is safe.

Design and Analysis of Worm Gear:

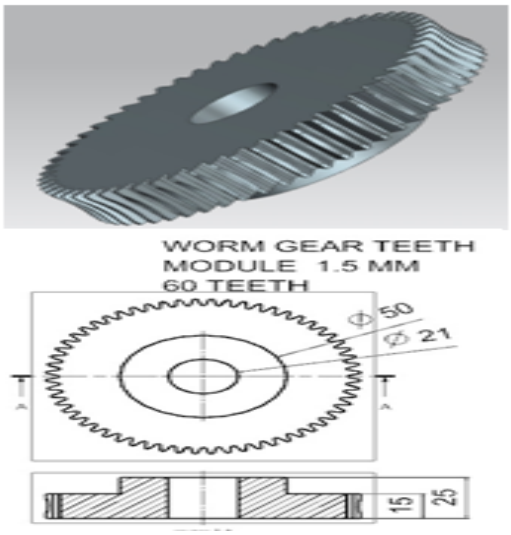

Figure 7: Worm Gear

Check for torsional shear failure of worm gear

$Td = \Pi/16 \times fs_{act} \times (D^4 - d^4) / D$

$\Rightarrow fs_{act} = 24.9\ N/mm^2$ As

$fs_{act} < fs_{all}$

$\Rightarrow$ Worm gear is safe under torsional load.

Design and Analysis of crank

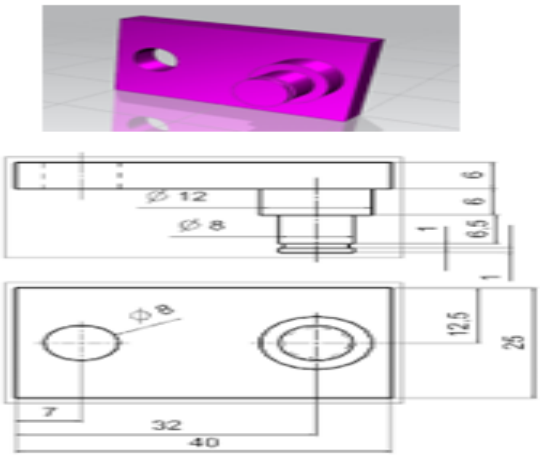

Figure 9: Crank

Check for direct shear failure of crank

Shear stress = Shear Force/ Area

Shear force = 230 N

Area = $\pi \times 8^2 / 4 = 50.2\ mm^2$

Shear Stress = 230/50.2 = 4.58 MPa

As the maximum stress 4.58 Mpa< Allowable stress …hence the crank is safe

Maximum Stress induced in crank :

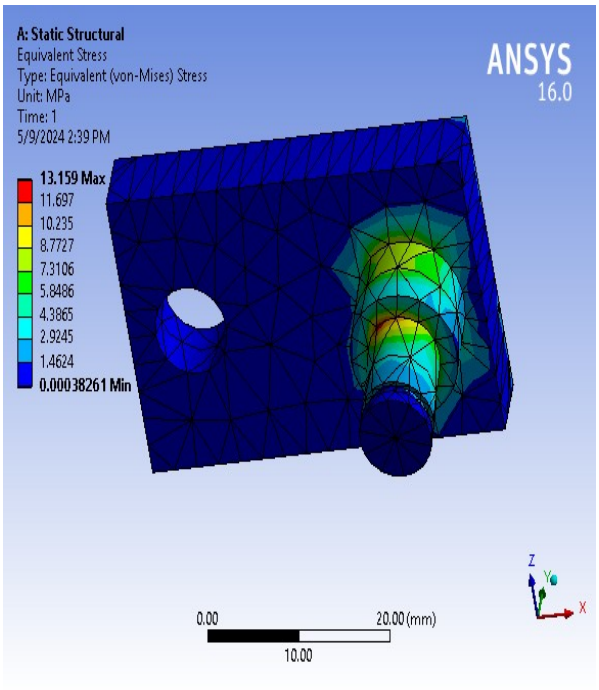

Figure 10: Maximum Stress induced in crank

As the maximum stress induced in the crank 13.15 N/mm2 < allowable stress shows that the crank is safe under given system of forces.

IV. Result and Discussion

- Literature review revealed that the conventional mixer prove ineffective in case of mixing of semi-solids and suspended solids.
- The design and analysis of the input worm shaft showed that the input shaft is safe under given system of loads.
- The design and analysis of the input worm showed that the input shaft is safe under given system of loads.
- The design and analysis of the worm gear showed that the input shaft is safe under given system of loads.
- The design and analysis of the crank showed that the input shaft is safe under given system of loads.

V. Conclusion

The literature review brought forward the lack of research in development of mixers specially dedicated to production of suspended solids in vehicle mixture. Thus research work is focused on the domain of development of one mixer where in the arrangement of innovative kinematic linkage to stir the mixture. The design and analysis of the components of mixer was done and it revealed the components are proven to be safe.

The future work would focus on development and fabrication of the unit. The developed unit will be tested for performance evaluation of the same.

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