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Analysis and Performance Evaluation of Twin Crank Agitator Machine

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Abstract

Mixing process is a simple yet critical process used in almost field of applications ranging from mechanical, chemical and pharmaceutical industry. A wide spectrum of machines and method are available in market to achieve a good quality of mixture. The most common being a stirrer attached to a geared motor that rotate freely in the container carrying the fluids to be mixed, rate of mixing can be varied by changing the speed of the stirrer. But in process a powder is too mixed with a fluid and if the specific gravity of powder is slightly higher than the vehicle fluid, then the above mentioned stirrer proves ineffective due to effect of centrifugal force on the particles of the powder. In such cases an entirely different approach to mixing is needed where in the stirrer should also have an up-down or to-from motion to ensure that the particles do not settle down in container and there is an enough agitation and turbulence to carry out uniform dispersion of the powder particles all over the mixture. The paper introduces to twin crank agitator mixing mechanism coupled to a rotating container mechanism. The object is to carry out design and analysis of critical components of the twin crank mechanism and also to carry out the productivity test of the machine under consideration.

Keywords: - *Powder, Vehicle fluid, Agitator, To -from motion*

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INTRODUCTION

Mixing of powders in fluids is a common operation in any industry. Most powders are known to be cohesive, many te spontaneously when exposed to humid atmosphere or elevated storage temperature. Mixing or Agitation of the powder (especially powders with different specific gravity) may result in migration of smaller particles downwards and of larger ones upwards. Another problem is segregation whose main cause is the difference in particle size, density shape and resilience there are standard mixing devices, such as drum tumblers or Turbula mixers. Alternate device type used is the static mixer of Kenics type. Static mixers save energy, disable segregation and effect particle migration.

LITERATURE REVIEW

Allen Edgar Bryson has studied the control of quality in the manufacture of paint. He had given the brief introduction about composition of paint and its quality. He further presented the manufacturing process of paints which consist of essential steps like Mixing, Grinding, Thinning, and Tinting. Straining and canning operations takes place after the paint batch has been tested and accepted as meeting the prescribed standard. Further he focused on the Testing of paints, Measurement of quality of paints and controlling factors in manufacturing of paints.

Ronal J. Weetman worked on the mechanical design of mixer with the emphasis on the fluid forces that are imposed on the impellers by the fluid continuum in the mixing vessel. According to them forces are the results of transient fluid flow asymmetries, acting on the mixing impeller. These loads are dynamic and are transmitted from the impeller blades to the mixer shaft and gear reducer. Fluid forces acting on the mixer that is bending loads on the shafts caused by an effective force and torque can be calculated and same can be analyzed with the help of CFD that is Computational Fluid Dynamics.

O. S. Galaktionov applied the mapping approach to study the distributive mixing in the industrial mixer. They have taken the Kenics Static mixer for study which is widely used in industrial applications. According to them mapping method makes it possible to study and compare thousands of different mixer layouts and perform optimization with respect to macroscopic homogenization efficiency and interface generation. Mapping technique comprises of computational domain, mixing modules and mapping matrices. They studied the

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mixing efficiency in terms of blade twist angle.

David W Kammel has focused on design, selection and use of Total Mixed Rations (TMR) mixers. According to him mixer design is still primarily a trial and error process with due consideration given to prior experience. The manufacturer selects a specific mixer design that is expected to perform, and field tests determine design changes and their effect on the mix. He highlighted on major aspect like Mixer design and options, Mixer testing, Batch mixing, Mixing time, Safety, Mixer sizing, Mixer costs etc. He further said that since „Perfect mix" is impossible, there will likely be some difference in the test results. The test results should be looked at to determine the statistical significance of the variability.

Rafique A. Memon has evaluated the numerical predictions for contra rotating mixing flow within a cylindrical container. The behavior of fluid is compared against previously simulated numerical results. According to them two dimensional incompressible complex flow of Newtonian fluid is relevant to the food industries. The numerical method adopted by them was finite element semi-implicit time – Stepping Taylor-Galerkin/pressure correction scheme, posed in a cylindrical coordinate system.

PROBLEM STATEMENT

Mixing process is a simple yet critical process used in almost field of applications ranging from mechanical, chemical and pharmaceutical industry. A wide spectrum of machines and method are available in market to achieve a good quality of mixture. The most common being a stirrer attached to a geared motor that rotate freely in the container carrying the fluids to be mixed, rate of mixing can be varied by changing the speed of the stirrer. But in process a powder is too mixed with a fluid and if the specific gravity of powder is slightly higher than the vehicle fluid, then the above mentioned stirrer proves ineffective due to effect of centrifugal force on the particles of the powder. One such mixer is shown in image below.



Fig.1 Conventional method

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SOLUTION:

In such cases an entirely different approach to mixing is needed where in the stirrer should also have a up-down or to-fro motion to ensure that the particles do not settle down in container and there is a enough agitation and turbulence to carry out uniform dispersion of the powder particles all over the mixture. The two twin crank agitator mixing mechanism coupled to a rotating container mechanism is proposed to be as per mechanism shown below, and the work motions are also depicted in the graphic below.

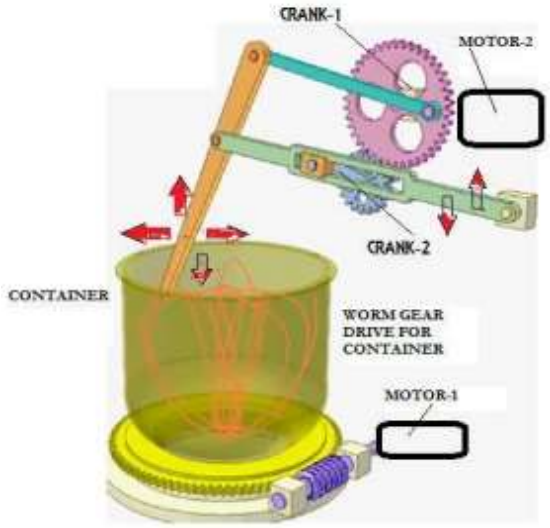

Fig 2: Modified method over conventional

Thus the entire machine can be divided into two parts:

a) The twin crank link to produce updown and to-fro motion of the agitator.

b) The container rotation mechanism.

Actual working diagram of the machine with details of the above two mechanisms are as below:

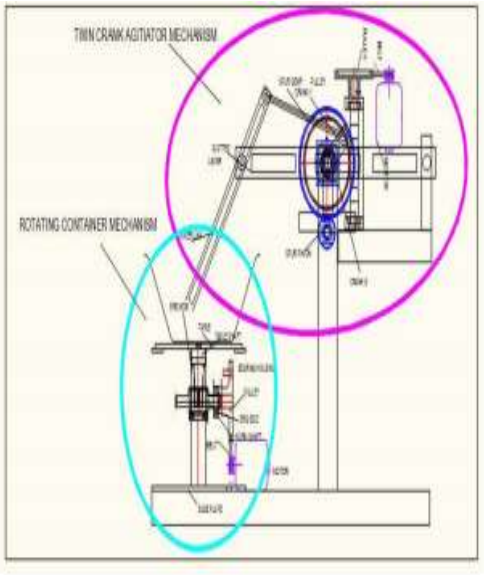

Fig.3: Mechanism of model

Specifications for motor for both linkages are same Details of Drive:

Motor: Single phase AC motor, 85 watt, 0 to 6000 rpm variable speed. Open belt drive with ratio of 1:5 reductions

Gear box: Single start worm, 1.5 module, worm gear 60 Teeth Spur gear pair between Crank -1 and Crank 2 shafts Pinion 1.25 module 2 teeth

Gear 1.25 module 96 teeth

Thus Torque @ Crank -1 shaft = 8.1 N-m

Torque @ Crank -2 shaft = 8.1/4 = 2.02 Nm

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ANALYSIS OF CRANK-1

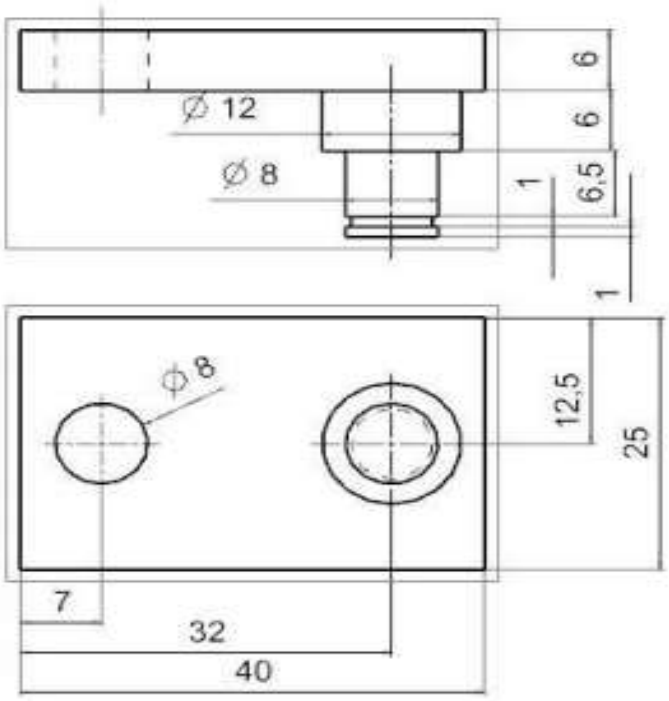

FIG.4: 2-D drafting of crank-1

MATERIAL SELECTION: -Ref: - PSG (1.10 & 1.12) + (1.17)

DESIGNATION	ULTIMATE TENSILE STRENGTH N/mm^2	YEILD STRENGTH N/mm^2
I. C45	600	480

fs allowable= 0.18 X 600 =108N/mm^2⇒

FORCE ANALYSIS: Torque = Force x radius

Thus , Force = Torque / radius = 8100 /25= 324 N

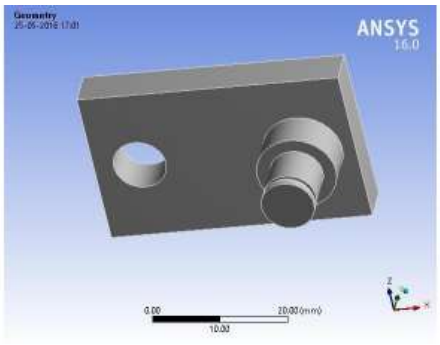

Fig.5: CAD model of crank

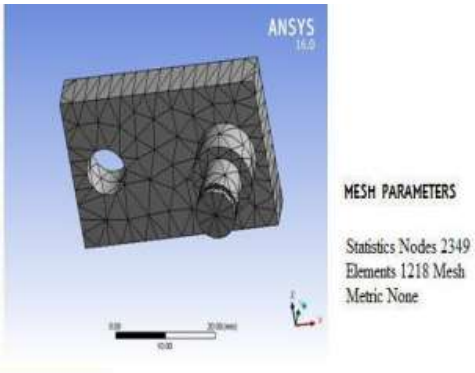

Fig.6 meshing of crank

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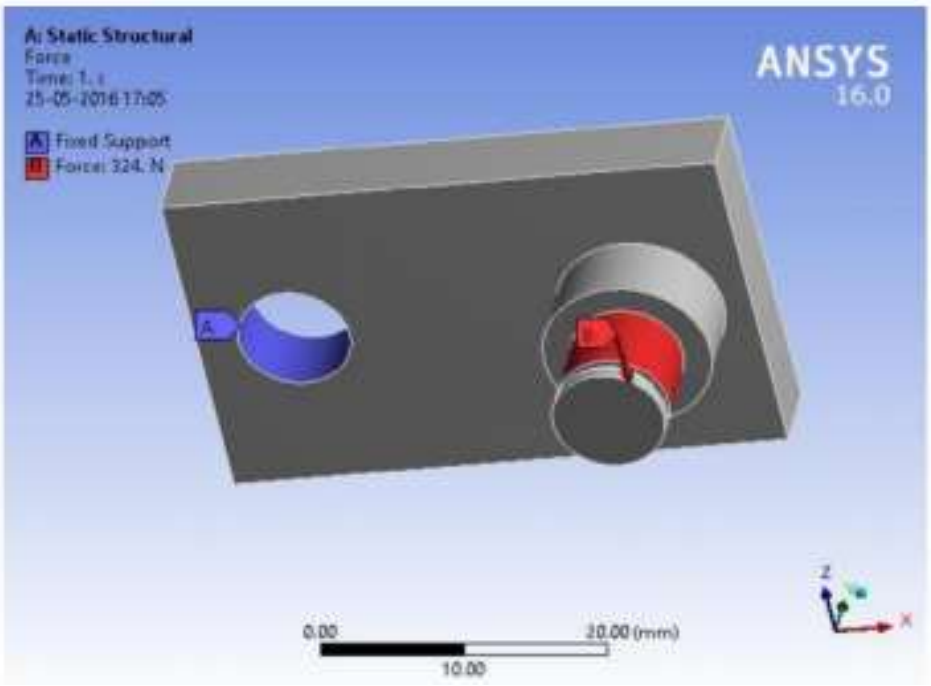

Fig.7: Application of boundry condition

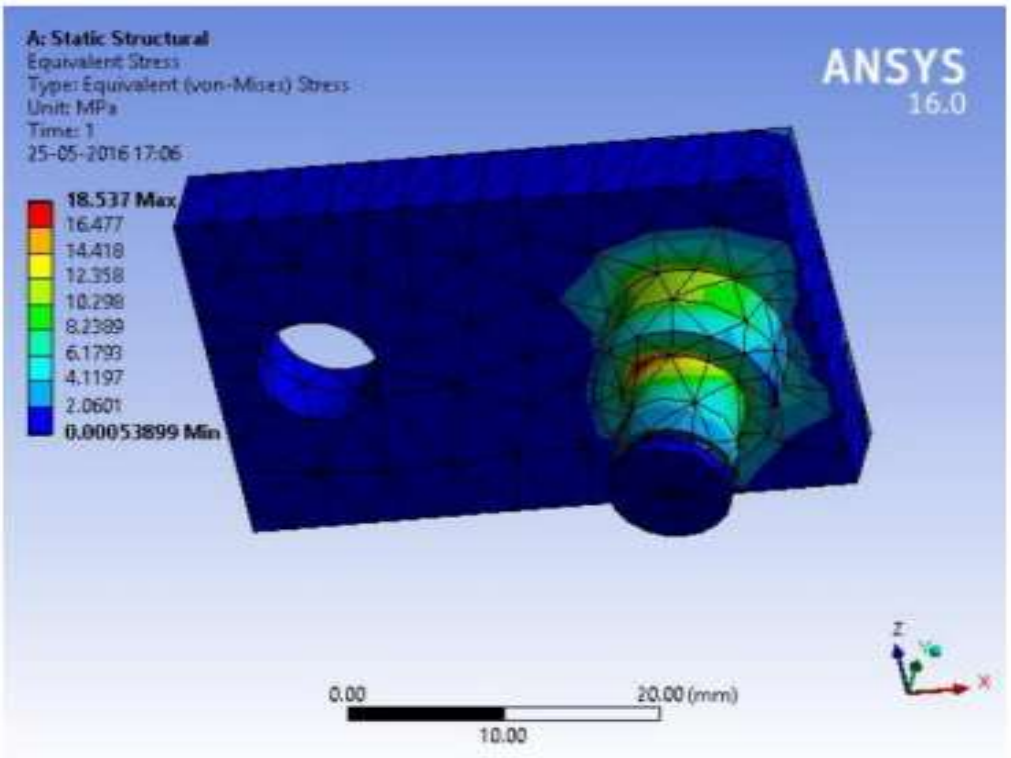

Fig.8: As the maximum stress induced in the crank-1 18.51 N/mm2 < allowable stress shows that the crank-1 is safe under given system of forces.

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ANALYSIS OF CRANK-2

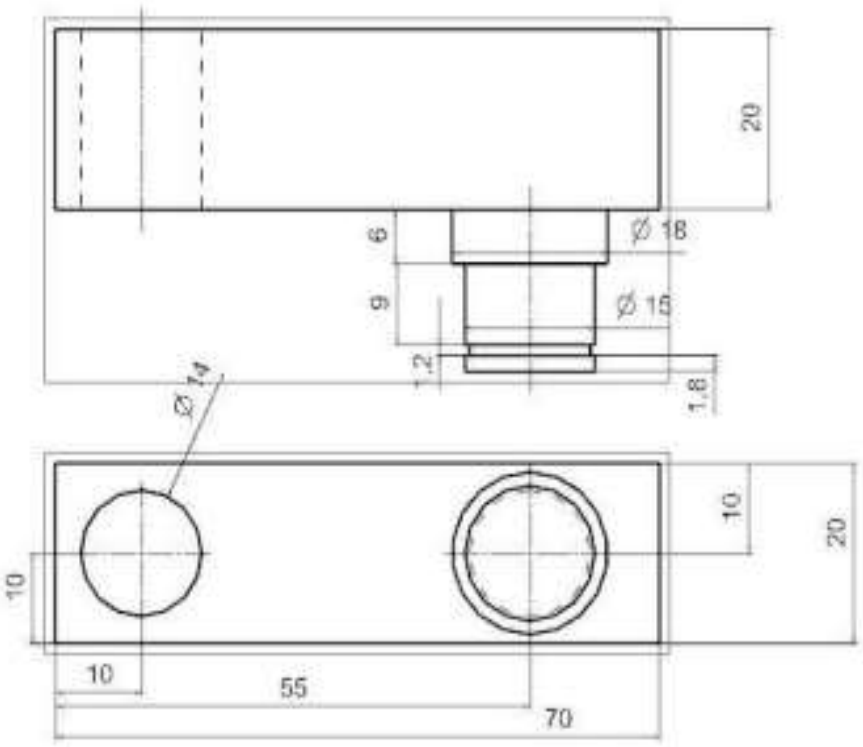

Fig.9:2-D drafting of crank-2

MATERIAL SELECTION: -Ref :- PSG (1.10 & 1.12) +(1.17)

DESIGNATION	ULTIMATE TENSILE STRENGTH N/mm^2	YEILD STRENGTH N/mm^2
II. AL	480	380

fs allowable = 480/2 = 240 N/mm2

Torque @ Crank -2 shaft = 8.1/4 = 2.02 N-m

FORCE ANALYSIS:

Torque = Force x radius

Thus, Force = Torque / radius = 2020/45= 44.8 N

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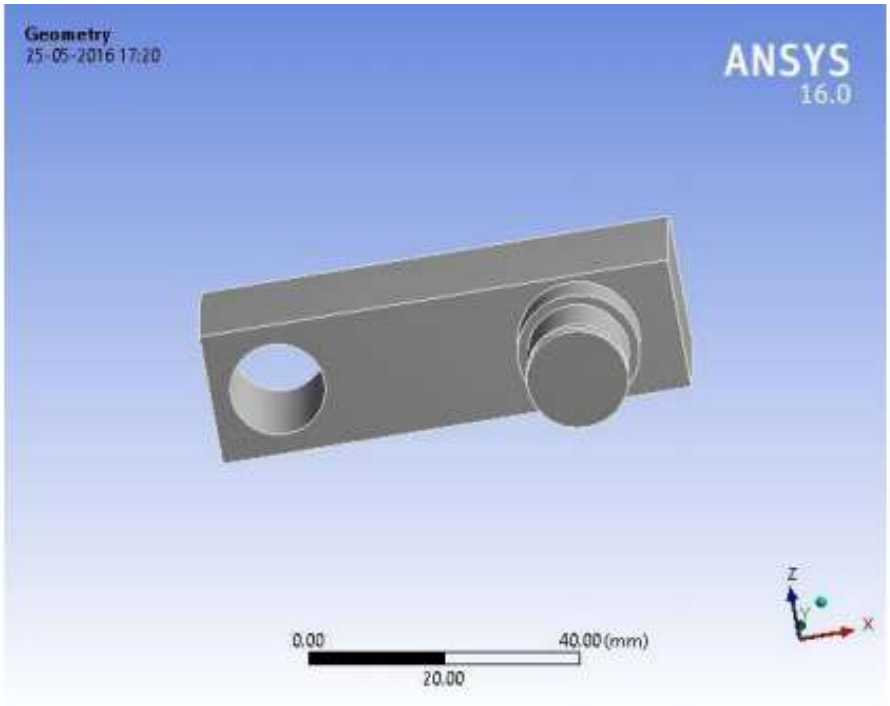

Fig.10: CAD Model

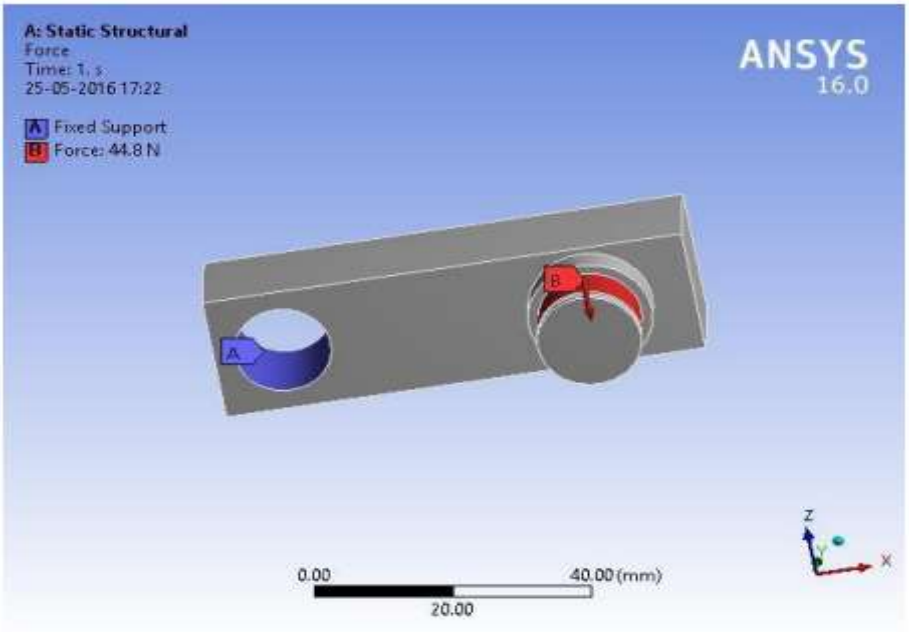

Fig.11: Boundary Condition

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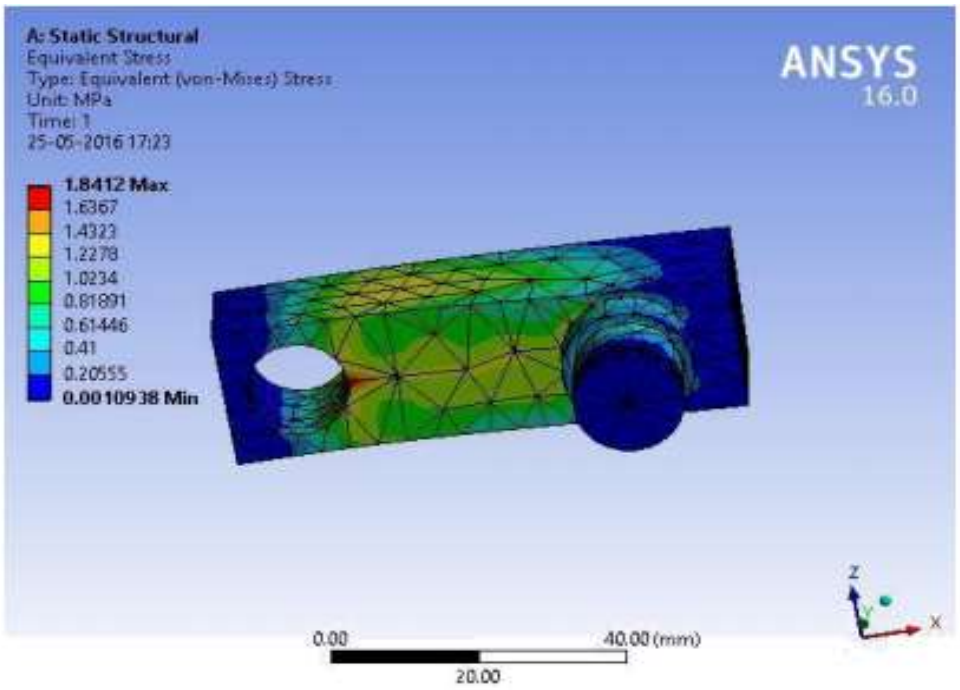

Fig.12: As the maximum stress induced in the crank-2 is 1.8 N/mm2 < allowable stress shows that the crank-1 is safe under given system of forces.

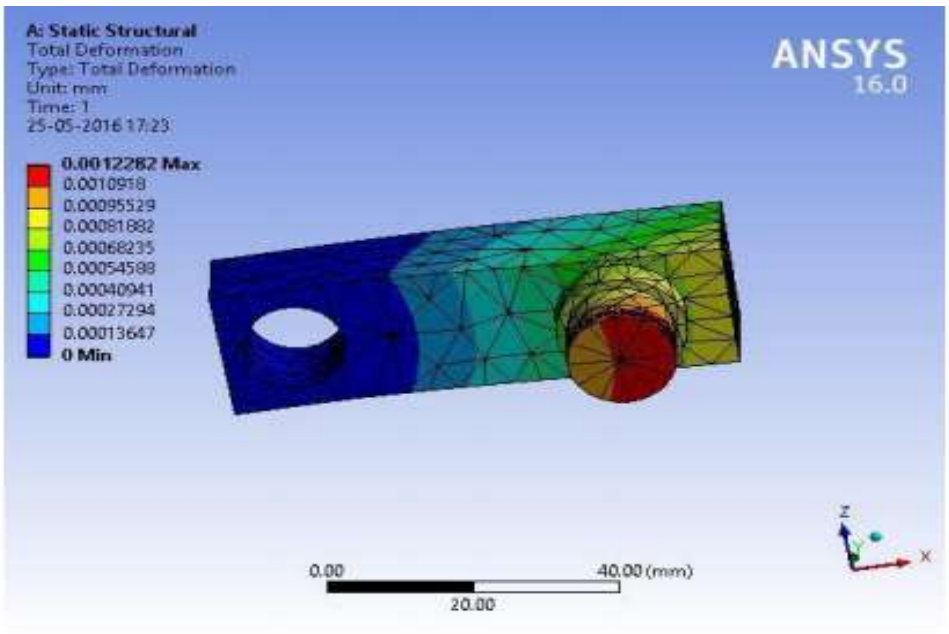

Fig13: Maximum deformation in the crank-1 is 0.024 mm which is considerably negligible

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ANALYSIS OF CONNECTING ROD

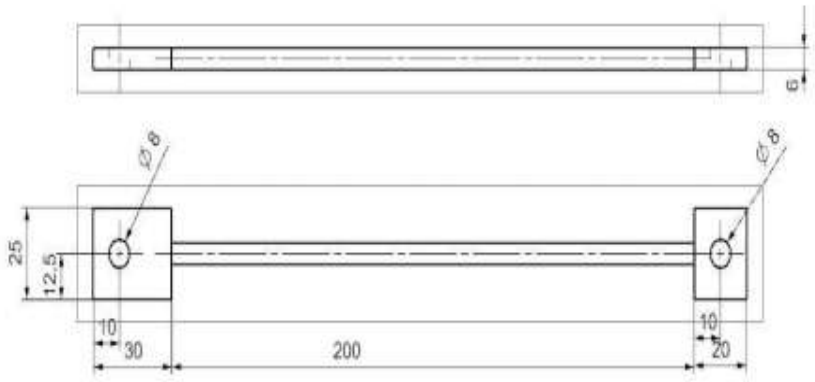

Fig.14: 2-D drafting of connecting Rod

MATERIAL SELECTION: -Ref: - PSG (1.10 & 1.12) + (1.17)

DESIGNATION	ULTIMATE TENSILE STRENGTH N/mm^2	YEILD STRENGTH N/mm^2
III. C45	600	480

FORCE ANALYSIS:

Torque = Force x radius

Thus, Force = Torque / radius = 8100 /25= 324 N

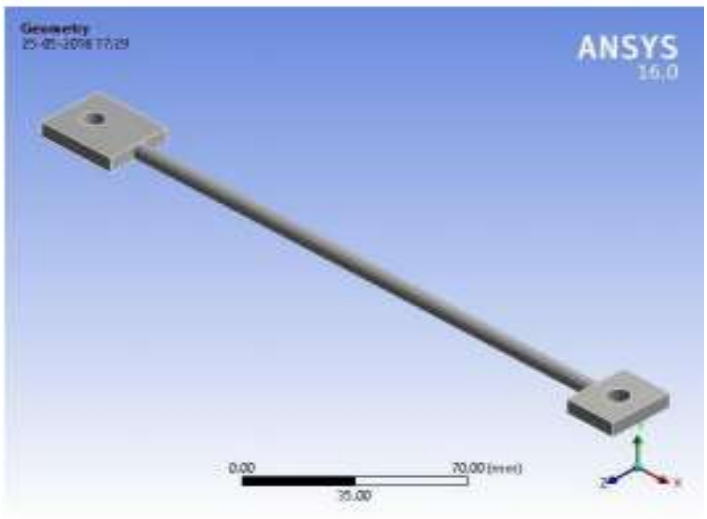

Fig.15: CAD Model

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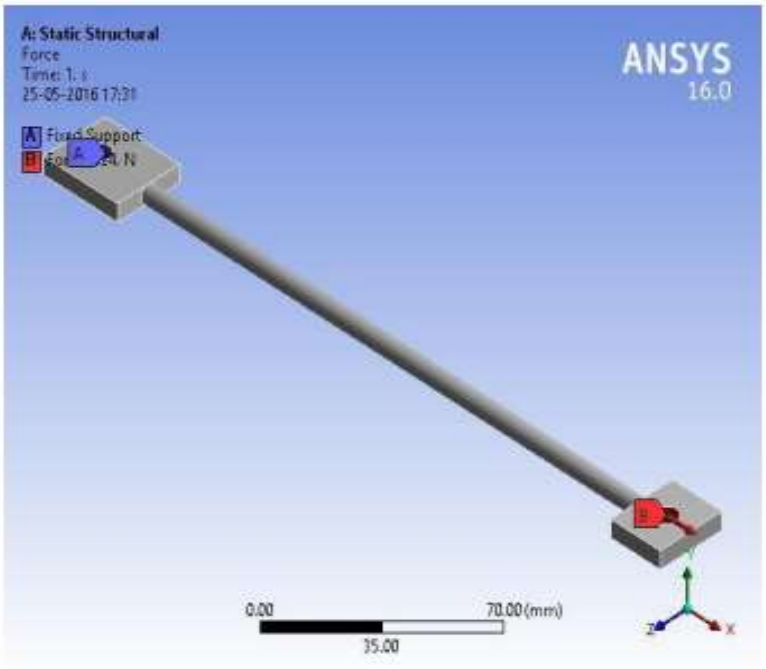

Fig.16: Boundry Condition

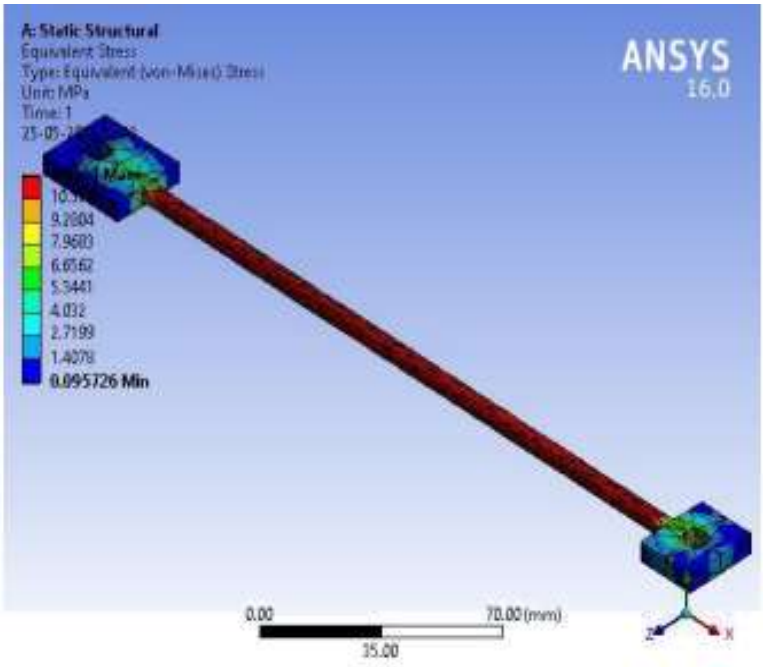

Fig.17: As the maximum stress induced in the CONNCECTING ROD is 11.9 N/mm2 < Allowable stress shows that the crank-1 is safe under given system of forces.

Maximum deformation in the CONNECTING ROD-1 is 0.024 mm which is considerably Negligible.

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ANALYSIS OF SLIDER LINK

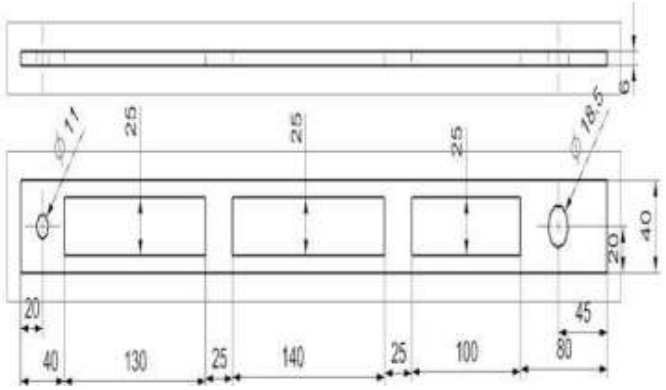

Fig.18: 2-D drafting of slider crank

MATERIAL SELECTION: -Ref:- PSG (1.10 & 1.12) +(1.17)

DESIGNATION	ULTIMATE TENSILE STRENGTH N/mm^2	YEILD STRENGTH N/mm^2
IV. C45	600	480

FORCE ANALYSIS:

Force at the TOP locations is 324 N

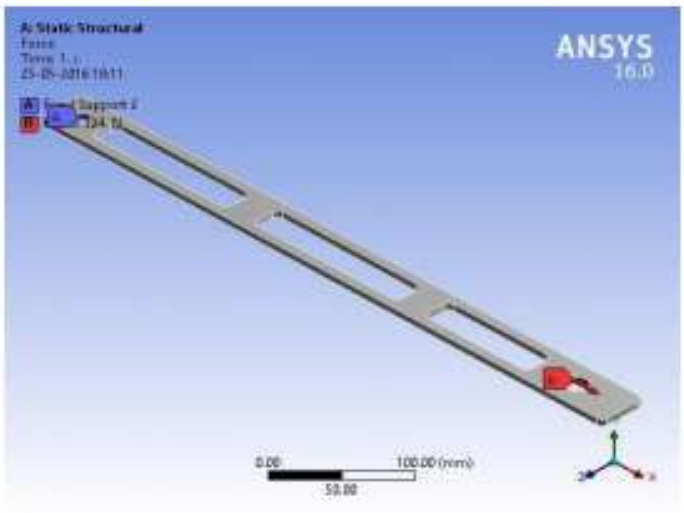

Fig.19: Boundry Condition

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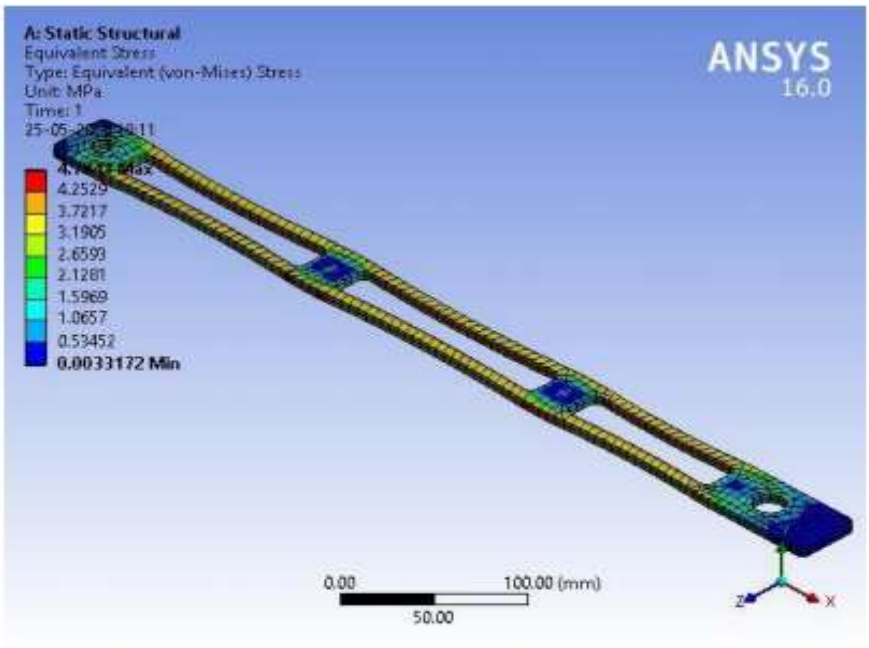

Fig.20: As the maximum stress induced in the SLIDER LINK is 4.78 N/mm2 < allowable stress shows that the crank-1 is safe under given system of forces.

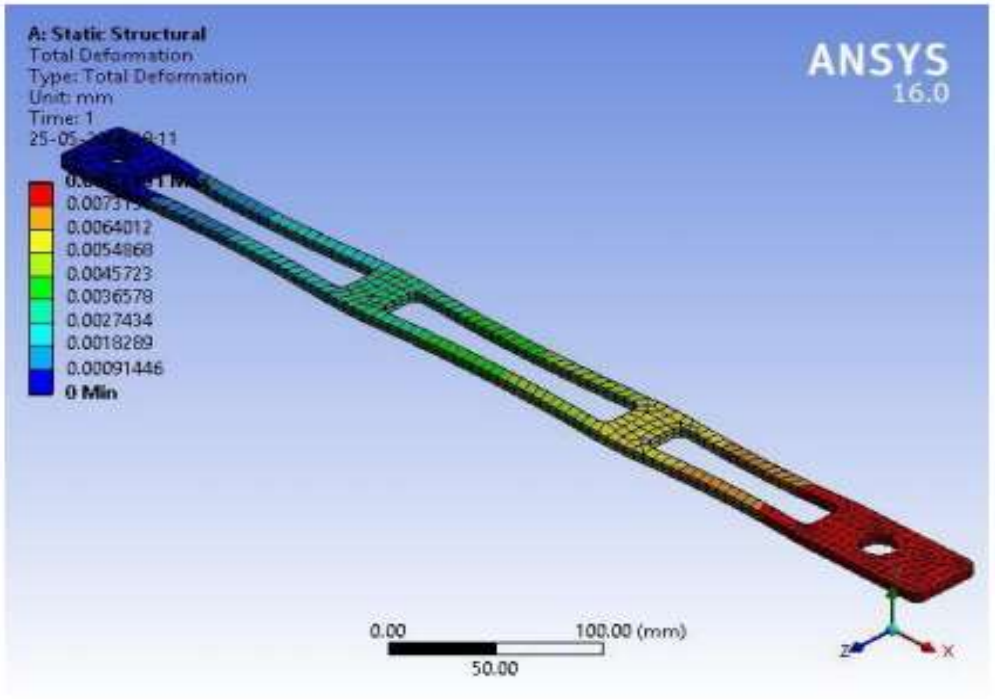

Fig.21: Maximum deformation in the SLIDR LINK -1 is 0.08mm which is considerably negligible.

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Testing of the Twin crank link Mixer

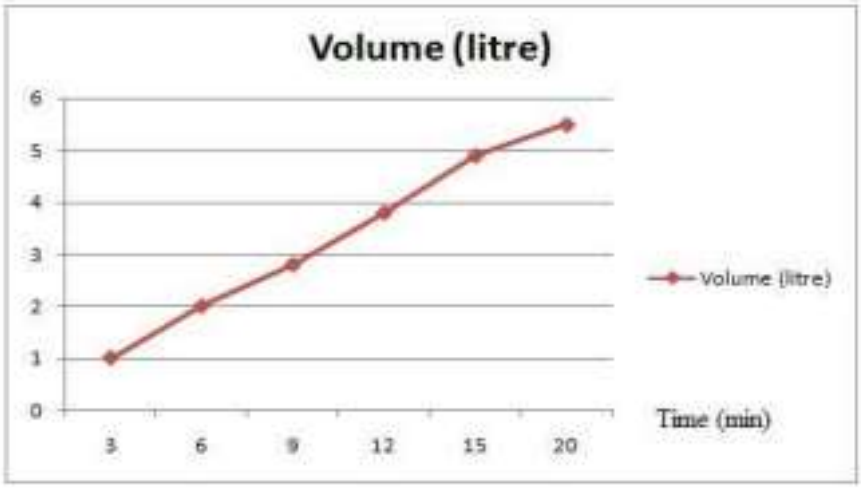
Procedure:

1. Pour the vehicle fluid (water) in the container
2. Add powder to container
3. Start machine
4. Check consistency after every min and for index mark.
5. Note time for every litre of paint produced
6. Conventional mixer production volume is 3litre @ end of cycle of 20 min

OBSERVATIONS

Sr.No	Time min	Volume Litre	Productivity index
01	3	1	0.333333333
02	6	2.0	0.666666667
03	9	2.8	0.933333333
04	12	3.8	1.266666667
05	15	4.9	1.633333333
06	20	5.5	1.833333

GRAPHS



Volume of paint produced increases with increase in time

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Productivity index of machine improves with time

CONCLUSION:

1. The Analysis of the Crank-1 shows that the maximum stress is well below safe limit and the deformation is negligible indicating the full safety of the part.

2. The Analysis of the Crank-2 shows that the maximum stress is well below safe limit and the deformation is negligible indicating the full safety of the part.

3. The Analysis of the Slider link shows that the maximum stress is well below safe limit and the deformation is negligible indicating the full safety of the part.

4. The Analysis of the Connecting rod shows that the maximum stress is well below safe limit and the deformation is negligible indicating the full safety of the part.

5. Volume of paint produced increases with increase in time and maximum paint produced in cycle time of 20 min is 5.5 litres

6. Productivity index of the machine improves with time and is maximum of 1.833 indicating that the machine is 1.83 times more effective than the conventional machine.

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