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"Design Development And Application of 3-Dimensional Schatz Geometry Kinematic Linkage For Uni- Directional Motion Mixer Machine"

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Abstract :*Powder/semisolid jellies mixing as demonstrated previously is an important step in the manufacturing process of many industrial products such as pharmaceuticals, foodstuffs, plastics, fertilizers, and ceramics. With the continuous improvement in methods, the course is open for the development of coherent chemical engineering research in particle technology and more specifically in Paint mixing. Paint mixing is conventionally done in a mixing machine with fixed container and a rotating blade. This method generates a vortex type action where in the particles of paint either move towards the periphery of container and tend to stick to walls of container that is stirrer of conventional mixer rotates in one direction only which create a particular flow pattern hence particles tend to stick to the wall of container due to centrifugal force or keep rotating in a regular a pattern of generator of cone resulting in a poor quality mixture. This paper searches the limitations of the conventional mixer & developed by the schatz geometry theory. The exceptional efficiency of the schatz geometry shaker-mixer arises from the use of rotation, translation and inversion according to the Schatz geometric theory also this mixer is possible to mix wetand dry components or different wet components in which production process is hygienic and dust-free; making the schatz geometry easy to clean. It isdesign, development, and analysis of driving system of Schatz mechanism with 3D-motion mixer to produce desired motion pattern, increase mixing rate and quality*

Keywords : *Conventional mixer, Schatz Mechanism, Rotation, Translation, Inversion, Oxide Paint application.*

Introduction

Mixing of powders is a common operation in any industry. Most powders are known to be cohesive, many agglomerate spontaneously when exposed to humid atmosphere or elevated storage temperature. Agitation of the powder 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.[2,3]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 overall 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 thorough 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.[6,1,12]

1.1 Conventional Method

In conventional method of mixing the metal oxide powder and vehicle mixing is carried out on a vertical shaft mixer with a static mixer blade at the bottom, this machine the motor is driven on reduction gear box through coupling the output shaft of gear box is coupled to stirrer shaft to which the blades are connected, when the motor rotates output shaft of gear box rotates at slow speed. There by driving the stirrer.The stirrer rotates in one direction to agitate the mixture to prepare paint.

Problem Statement- The stirrer of conventional machine rotates in one direction only which creates a particular flow pattern in the fluids hence the particles tend to stick to the walls of container owing to the centrifugal force rather than mixing thoroughly in mixture of paint , ultimately results into poor quality mixture of paints there by poor quality output of paint.[6]

Fig.1 & Fig.2 shows the blade profile of conventional mixer, the other prominent issue is the vibrations, thrust and bending forces that create noise and high maintenance of machine. The variability of powders arises from the many ways in which their flow properties may be changed such as: physical properties of the powder particles such as their size, size range, shape, hardness, elasticity, porosity, mass, interactions between particles, texture, angularity and so on. These factors modify the physical distribution and arrangement of the particles in the powder mass. Individual particle changes in conventional method of mixing the metal oxide powder and vehicle mixing is carried out on uni-directional stirring machine. [6]

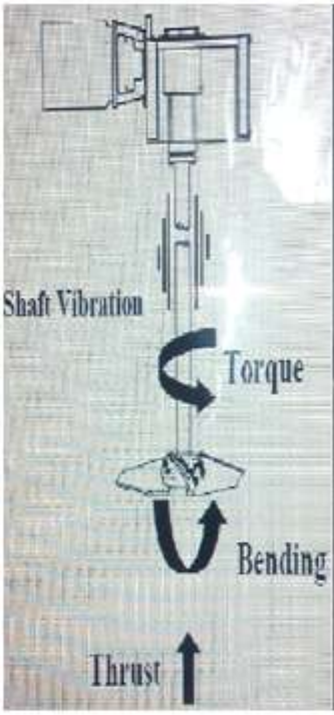


Fig1: Conventional Mixer Fig2: Blade Profile

Solution **-** The Schatz Geometry shaker-mixer is used for a homogeneous mixing of powdery substances with differing specific weights and particle sizes. The product is mixed in its own closed container. The exceptional efficiency of the Schatz Geometry shaker-mixer arises from the use of rotation, translation and inversion according to the Schatz geometric theory. The mixing container is set into a three-dimensional movement that exposes the product to continuously changing, rhythmically pulsing motion. It operates by tumbling the solids inside a revolving vessel, at speeds up to about 40 rpm (about half the critical speed at which the centrifugal force on the particles exceeds the pull of gravity). [1, 3]

It is also possible to mix wet and dry components or different wet components. The production process is hygienic and dust-free, making the Schatz Geometry easy to clean .The results fulfil the highest requirements and are achieved in a minimum of time as shown in fig 3.

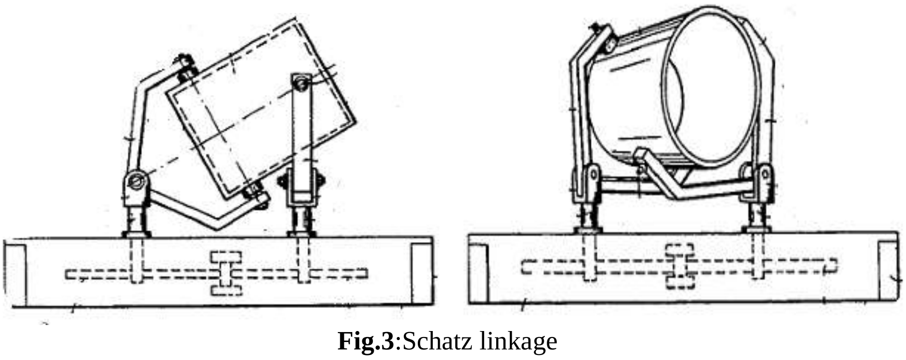


Fig.3:Schatz linkage

Literature Review

C-C Lee[1] have investigates different configurations of the Schatz linkage which is based on the analysis of areciprocal screw and relationship between the reciprocal screw and its stem-screw system, which consists of twists of freedomlocated at six revolute joints of the linkage. A new method of using cofactors of an augmenting screw is used to obtain thereciprocal screw. The stem-screw system of order 5 of the linkage is developed from the special geometry of the six revolutejoints and closed-form displacement solutions are provided based on the stem-screw system. The special relationship between the reciprocal screw and the stem-screw system is analyzed and used tocharacterize the constraint wrench and configurations created by the changes of the constraint wrench with a non-zero pitch.Consequently, a set of configurations are presented in conjunction with a ruled surface produced by the progression of theconstraint wrench when the linkage drive joint rotates from 5˚ to 85˚.

Ingrid Bauman et. al,[2]have work on,static mixers which is to be used for mixing of powders, but their shape, number of mixing elements and the mixer length should be adapted for each mixture separately, experimentally and mathematically, through modelling of the system.

P.S.Jadhav et.al, [3] has studied mixing device according to the material mixed; therefore, it focuses on the particle size as well as their flow properties. So study on the apparatus having the combination movements of a material in a container which has a closed and constrained invertible kinematic link-work of which at least one link serves as receptacle for the container.

Mr.Raghunath Rajaput et. al,[6] has investigated conventional method of mixing the metal oxide powder and vehicle mixing which is carried out on 'Unidirectional Stirring Machine' The stirrer of conventional machine rotates in one direction only which creates a particular flow pattern in the fluids hence the particles tend to stick to the walls of container owing to the centrifugal force rather than mixing thoroughly in mixture of paint, ultimately results into poor quality mixture of paints.In order to have a homogeneous mixing would be appropriate to have directions of rotation of stirrer shaft which will rotate stirrer blades in opposite directions in one cycle.

P.S.Kulat et. al, [11] has studied Industrial Mixers and Blenders used to mix or blend a wide range of materials used in different industries including the food, chemical, pharmaceutical, plastic and mineral industries. To mix different materials using mixers range from laboratory to production line scale, investigate different types of V-blender for batch operation. This mixer rotated about a horizontal axis, with mixing resulting from the tumbling motion of the particles.

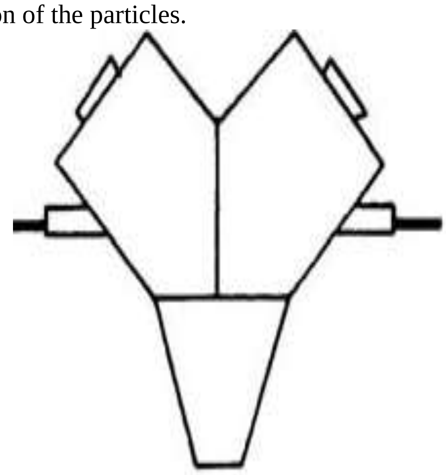


Fig.4:V-shaped drum mixer

S. N. Waghmare et. al,[12] has studied a electrically operated bidirectional mixer, which is a chemical mixing machine which rotates both in clockwise direction as well as the anticlockwise direction. This paper Proposed work of a chemical mixer. This work was undertaken considering reducing human efforts in small scale and institutional level.

Objective

1) Design development & kinematic analysis of 3-dimensional Schatz geometry linkage to produce desired motion pattern to achieve desired mixing rate and quality
2) Estimation of the torque and power requirements of mixer for mixing of specified viscous fluids for given volume of mixture.
3) Design development & kinematic analysis to drive the Schatz geometry linkage for Strength analysis of components like the driver shaft, universal link, fork arm, container, locking bracket.
4) Design development of locking mechanism of mixing container inside bracket such that container has single degree of freedom.
5) Fabrication& experimental test on the schatz geometry mixer for derivation of result as to viscosity, spread-ability and quality of paint and its comparison over the conventional mixer.

IV. Methodology

4.1 Theoretical Work:

Literature review study for various configuration of Schatz geometry linkage, different driver technology for Schatz geometry linkage, using various Handbooks, United State Patent documents, Technical papers, etc.

4.2 Design & Development

In this attempt to design a special purpose machine that adopted a very a very careful approach, the total design work has been divided into two parts mainly;

- System design
- Mechanical design

System design mainly concerns with the various physical constraints and ergonomics, space requirements, arrangement of various components on the main frame of machine no of controls position of these controls ease of maintenance scope of further improvement; height of m/c from ground etc.

In Mechanical design the components are categorized in two parts like design parts and parts to be purchasedFor design parts detail design is done and dimensions thus obtained are compared to next highest dimension which are readily available in market this simplifies the assembly as well as post production servicing work.The various tolerances on work pieces are specified in the manufacturing drawings. The process charts are prepared & passed on to the manufacturing stage .The parts are to be purchased directly are specified &selected from standard catalogues.

V. Experimental Setup

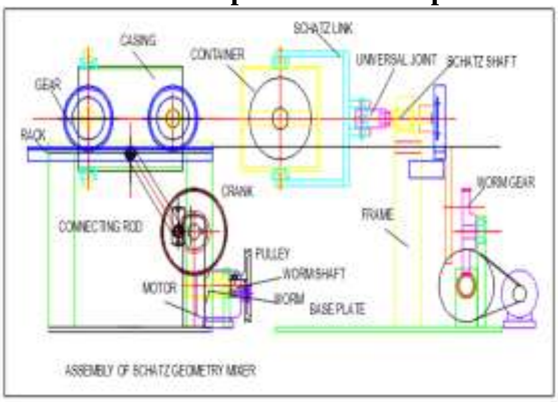


Fig.5: Experimental set up of Schatz Geometry Mixer

VI. Theoretical And Fe Analysis

6.1. Design of schatz geometry linkage shaft:

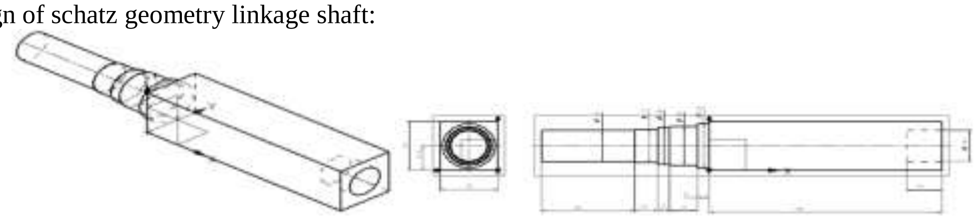


Fig. 6: Schatz Geometry Linkage Shaft

➢ **Theoretical analysis of Schatz Geometry Linkage Shaft-**

Material Selected from Ref. - PSG (1.10 & 1.12) as,

- Designation :- EN24
- Ultimate Tensile Strength :- 800 N/mm^2
- Yield Strength:- 680 N/mm^2

fs allowable = 0.18 X 800=144 N/mm^2

T design = 15.12 Nm

This is the allowable value of shear stress that can be induced in the shaft material for safe operation.

Check for torsional shear failure of shaft

$$Te = \frac{\Pi fs_{act}\ d3}{16}$$

➢ **FE analysis of Schatz Geometry Linkage Shaft-**

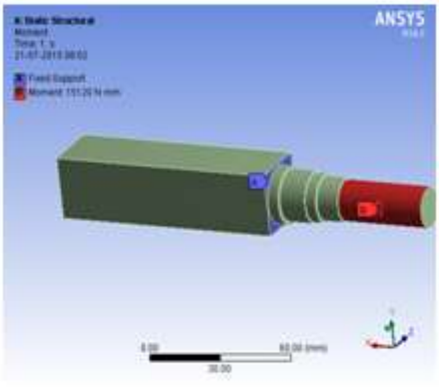


Fig. 7:Loading and boundary condition

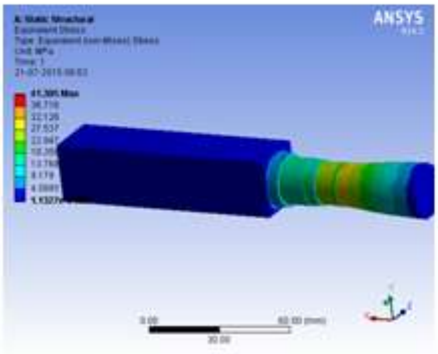


Fig.8: Von-mises stress

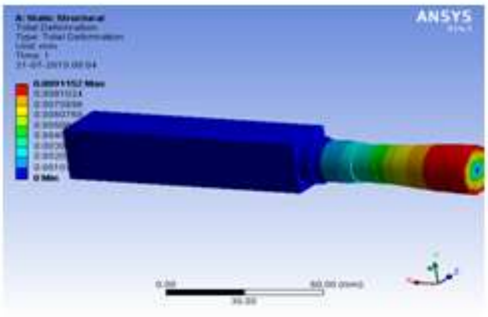


Fig.9: Maximum Deformation

Table1: Analysis result table for Schatz Shaft

Part Name	Maximum theoretical stress (MPa)	Von-mises stress (MPa)	Maximum deformation mm	Result
Schatz Shaft	18.8	41.3	0.009	Safe

Result:

- Maximum stress by theoretical method and Von-mises stress are well below the allowable limit, hence the Schatz Shaft is safe.
- Schatz Shaft shows negligible deformation under the action of system of forces.

6.2. Design of schatz bracket

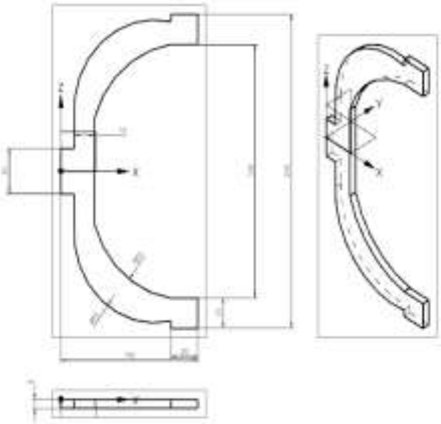


Fig 10: Schatz Bracket

➢

Theoretical analysis of Schatz Bracket-

Direct SHEAR stress due to a pull load:-

Load = Torque / radius = 15120 /25 =604 N

$fc_{act} = \frac{W}{A}$

$fc_{act} = \frac{604}{15x6}$

fs_{act} = 6.71 N/mm^2

As $fc_{act} < fc_{all}$; Schatz bracket is safe under shear load.

➢ **FE analysis of Schatz Bracket-**

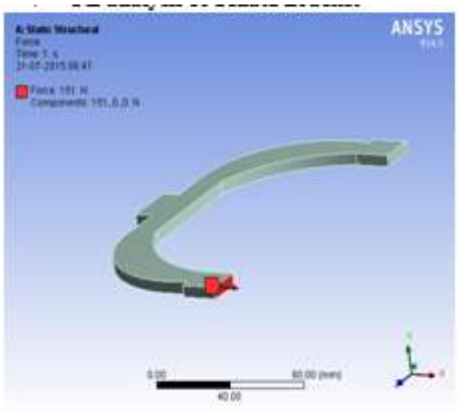


Fig 10: Loading and boundary condition

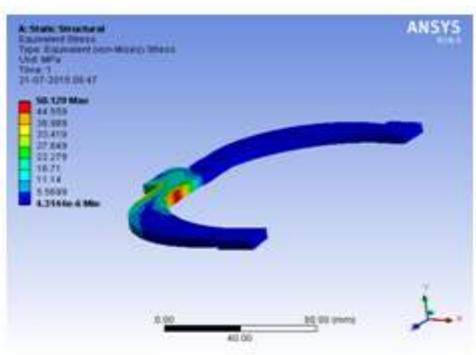


Fig.11: Von-mises stress

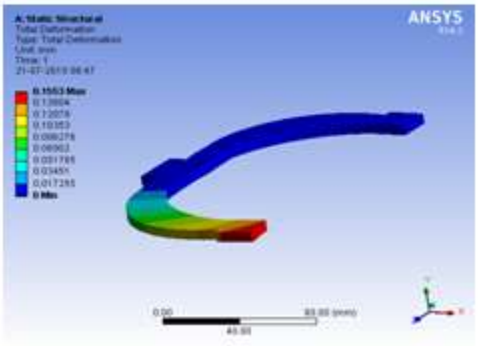


Fig. 12: Maximum Deformation

Table 2: Analysis result table for Schatz Bracket

Part Name	Maximum theoretical stress (MPa)	Von-mises stress (MPa)	Maximum deformation mm	Result
Schatz Bracket	6.71	50.129	0.1553	Safe

Result:-

- Maximum stress by theoretical method and Von-mises stress are well below the allowable limit; hence the hinge pin is safe.
- Hinge pin shows negligible deformation under the action of system of forces

6.3Design of Container Casing

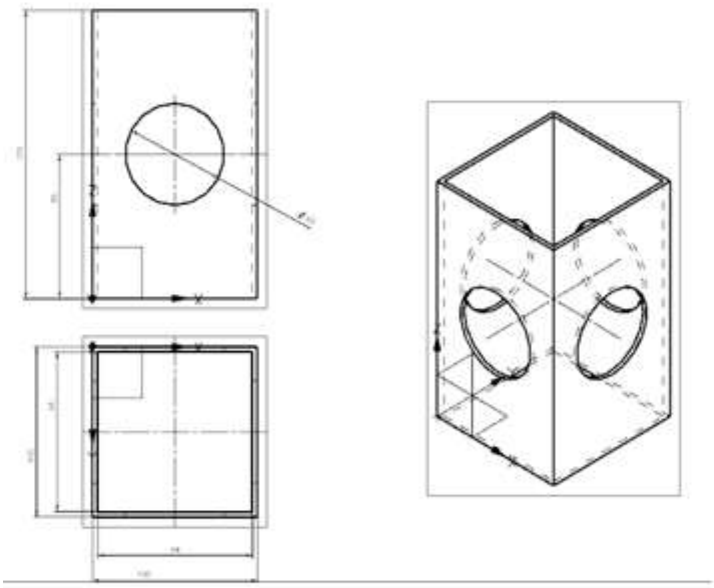


Fig13: Container Casing

Theoretical analysis of Container Casing -

Material selected from Ref :- (PSG – 1.12)

- Designation:- AL
- Tensile Strength:- 400 N/mm^2

- Yield Strength :- 320 N/mm^2

Direct tensile stress due to a pull load:-

Load = Torque / radius = 15120 /25 =604 N

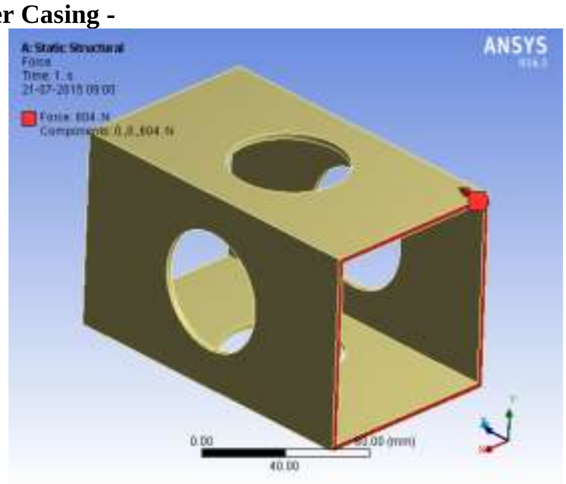
$$fc_{act} = \frac{W}{A}$$

$$fc_{act} = \frac{604}{(100x100 - 94x94 - 360)}$$

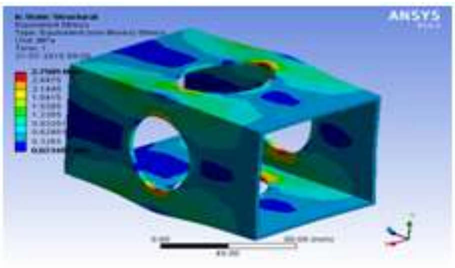
fs_{act} = 0.75 N/mm^2

As $fc_{act} < fc_{all}$; Casing is safe under shear load

- **FE analysis of Container Casing -**



- Fig. 14:Loading and boundary condition



- Fig.15: Von-mises stress

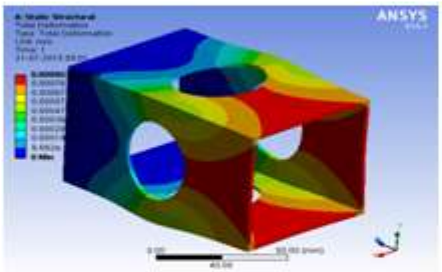


Fig. 16: Maximum Deformation

Fig. 16: Maximum Deformation

Table 3: Analysis result table for Casing

Part Name	Maximum theoretical stress (MPa)	Von-mises stress (MPa)	Maximum deformation mm	Result
CASING	0.75	2.75	0.0086	Safe

Result:-

- Maximum stress by theoretical method and Von-mises stress are well below the allowable limit, hence the CASING is safe.
- CASING shows negligible deformation under the action of system of forces

VII. Observations

Table 4. Observations: Conventional mixer

Sr. No	Time min	Viscosity	Spread ability mm
01	3	4.1	146
02	6	3.5	152
03	9	3.2	164
04	12	3.1	176
05	15	3.0	190
06	20	3.0	208

Sr. No	Time min	Viscosity	Spread ability mm
01	3	4.6	130
02	6	4.4	132
03	9	4.4	136
04	12	4.2	140
05	15	4.1	146
06	20	4.1	148

VIII. Results

8.1 Comparative Graphs of Resultant Viscosity Vs time

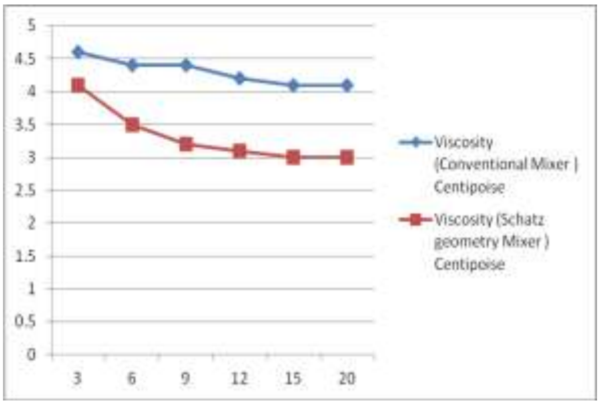


Fig.17: Graph of Viscosity vs. Time

Fig.17 shows graph indicates the viscoisty against time in which viscosity of paint reduces with increase in time that lower viscosity of paint is desirable characteristic. The Schatz geometry mixer shows better performance and better quality as compared to conventional mixer. Schatz geometry mixer shows minimum paint viscoity up to 3 centipoise during the period of 20 minutes as compared to conventional one, which is best desirable for maximum lustre and better application of paint along with least quanity of paint required per unit area of application.

8.2 Comparative Graph of Spreadablility of Paint Vs Time

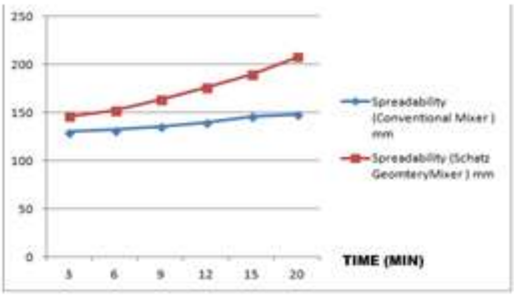


Fig. 18: Graph of spread ability of paint vs. Time

Fig. 18 shows graph indicates spreadablity against time. The Schatz geometry mixer shows better performance and better spreadability as compared to conventional mixer. Maximum paint spreadability obtained by the Schatz geometry mixer is close to 200 mm during period of 20 minutes compare to conventional one, which is best desirable for maximum lustre and better application of paint along with least quanity of paint required per unit area of application.

IX. Conclusion

The testing of the machine with ferrous oxide paint results in lower viscosity, higher spread ability and more homogeneous mixture as compared to the existing mixing machines. The time required for mixing the mixture is also reduced substantially.

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