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FINITE ELEMENT ANALYSIS OF SCHATZ GEOMETRY MECHANISM

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Abstract –

Mixing of two or more materials or compounds i.e. heavy density metal powder in the fluid is a complicated task. In traditional mixing method the metal powder and fluid mixing is carried out on uni-directional stirring machine. This paper investigates the limitations of the traditional mixer. The stirrer of traditional mixer rotates in one direction only which create a particular and limited flow pattern in the fluid hence particles tend to stick to the wall of container due to the centrifugal force. Most of the materials are settle down at the bottom of the container due to high density. In traditional mixer, the other main issue is the vibrations, thrust and bending forces that create too much noise and high machine maintenance. The research work is based on the Schatz geometry shaker mixer mechanism which is used for a homogeneous mixing of powder substances with differing specific weights and particle sizes. The product is mixed in its own closed container. The mixing container is set into a three dimensional (3D) movement that used for rotation, translation and inversion according to the Schatz geometric mechanism theory. It is design as well as Finite Element Analysis (FEA) of driving system of Schatz mechanism with Three Dimensional motion mixer to produce desired motion pattern, increase mixing rate and quality by finding productivity effectiveness by using CATIA V5R20 and ANSYS.

Keywords- ANSYS, traditional mixer, Powder, Schatz Geometry mechanism, Shaker Mixer, CATIA V5R20

I. INTRODUCTION

Mixing of powders is a common operation in any industry. Agitation of the powder (especially powders with different densities) 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.

Mixing is the process which determines uniformity and overall quality of product. Mixing of powders of different types of materials in order to form an uniform product or powder mixture is quiet easy, but when it is required to mix powder in a fluid matter especially when the density of powder is high the problem occurs due to heavy weight of particles. Heavy particles has tendency to settle down.

Industrial Mixers as well as Blenders are used for mixing or blending a wide range of materials or compounds used in different industries such as food-processing, chemicals, pharmaceuticals, plastics and mineral industries. They are mainly used to mix different materials by using different types of the blades to make good quality homogeneous mixtures. This included dry blending devices, paste mixing designs for high viscosity products and high shear models for emulsification, particle size reduction and homogenization.

In traditional methods of mixing the metal powder and fluid mixing is carried out on unidirectional stirring machine. The stirrer of traditional machine rotates in one direction, which creates a particular flow pattern in the fluids hence the particles tend to stick to the wall of container owing to the centrifugal force; ultimately it results into poor quality mixture. Most of the materials having high density will settle down as compared to low density materials.

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. Exceptional efficiency of Schatz geometry shaker mixer generated from the application of rotation, translation and inversion as per the Schatz geometry theory. The mixing container is set into a 3D movement which exposes the product continuously changing, rhythmically pulsing motion.

Fig.1. Schatz Geometry Shaker Mixer

The Three-dimensional (3D) movement of a cylindrical container could be achieved in Turbula mixer as shown in Fig. 1. This is the laboratory scale mixer which is mostly used in industry for the purpose of development or testing of new products.

II. LITERATURE REVIEW

A. LITERATURE REVIEW OF THE KINEMATIC ANALYSIS OF SCHATZ LINKAGE

Lei Cui, Jian S Dai and Chung Ching Lee

Lei Cui, Jian S Dai and Chung Ching Lee applied Euclidean invariants from differential geometry to kinematic properties of the ruled surfaces generated by the coupler link and the constraint-screw axes. Starting from investigating the assembly configuration, the work reveals two cycle phases of the coupler link when the input link finishes a full rotation. This leads to analysis of the motion ruled surface generated by the directrix along the coupler link, where Euclidean invariants are obtained and singularities are identified. This work further presents the constraint ruled surface that is generated by the constraint screw axes and unveils its intrinsic characteristics.

Michele Marigo

Michele Marigo explained about the discrete element method modelling of complex granular motion in mixing vessels: evaluation and validation will be explained. A three-dimensional movement of a cylindrical container can be achieved in the Turbula mixer. This is a laboratory scale mixer that is largely used in industry for the development or testing of new products. The model T2F considered in this work has a mixing chamber that can hold a container with a capacity up to 2 L. The rotational speed can be 21 varied from 22 to 100 rpm. The mixing container, located in the mixer chamber, is subjected to intensive, periodically translational and rotational pulsating movements, which simulate the pattern of agitation achieved by manual shaking. This extremely complicated movement is composed of two rotations of the container and a horizontal translation. In addition to these traditional principal motions of rotation and translation there is a third fundamental motion of inversion based on the Schatz inversion principle. This particular motion subjects the contents to two alternating, rhythmic pulsating motions, which have the effect of continuously compressing and thinning material. Hence the particle bed moves within the vessel with a periodical nature.

Jingfang Liu, Xiaoou Huang, Yueqing Yu and Zhen Huang

Jingfang Liu, Xiaoou Huang, Yueqing Yu and Zhen Huang explain structure modelling of Schatz linkage. Schatz linkage has been applied as a main component in a mixed machine “Turbula.” To further understand this mechanism, the structure analysis and modelling of the Schatz linkage in “Turbula” is given. From the analysis and modelling, a novel type of Schatz linkage is designed and the parameter conditions are modified, which can be regarded as a variant of Schatz mechanism. It can further extend the key linkage selection of mixed machines.

Ferdinand Freudenstein

Ferdinand Freudenstein gives the explanation of approximate synthesis of four-bar linkages. Formulas are presented for obtaining the characteristics of a four- bar linkage, designed to generate an arbitrary function approximately over a finite range. A number of methods of varying degrees of accuracy and complexity have been developed, enabling a designer to select the one best suited to his requirements.

B. LITERATURE REVIEW OF THE SCHATZ MECHANISM AND THEIR DRIVE SYSTEMS

TeunKoetsier, Marco Ceccarelli

TeunKoetsier, Marco Ceccarelli elaborates the explanation of Schatz linkage. This linkage was discovered and patented by Schatz in 1942, also known by the name Turbula. It is used for mixing fluids and powders. It was considered as a derivation of a special trihedral Bricard linkage.

Donald I. Cruse

Donald I. Cruse have discussed about the apparatus which were producing a combination of rotating, tumbling and shaking movements of material in a container has a closed and constrained invertible kinematic link-work of which at least one link serves as receptacle for the container and motive power for driving the link-work is provided by imparting thrusting power, rather than rotating power.

Reinhold C.

Reinhold C. invents the electric drive for the mixing machine. According to the invention, the drive for the inversion kinematic Paul Schatz type mixing machine consists of two electric motors (11, 12) in series powered at a constant current via a shared regulator. The current which determines the torque at the spindles (4, 5) is set by an adjuster. The voltage drop across the motors determines the mean revolution speed of shafts (4, 5) which rotate differentially owing to the design of the machine. The mixing machine, which is consist of a support (1) having two bearings (2, 3) in which the two parallel shafts (4, 5) can rotate. At their upper ends the shaft (4, 5) takes the form of swivel bearings (6) for two forks (7). Axis bolts for rotation (8) run through the forks (7) which are perpendicular to each other and to the respective swivel axes (6). The two axis bolts for rotation (8) are secured to a cage (9) receiving a mixing container (10).

C. LITERATURE REVIEW OF VARIOUS POWDER MIXING DEVICES

I. Bauman explained about the static mixers were in-line devices, which consist of motionless mixing elements, inserted in the given length of the pipe. Homogenization was attained by using the flow energy of the material to be mixed. The mixing effect depends on the continuous separation, distribution, and reunion of particles in the stream of material. There were various element designs available for mixing liquids and they were widely spread for use in industry. For mixing solids there was hardly any industrial usage of static mixer types, therefore, various experiments with solids have been done. The number of elements and their shape required in any application depend on the complexity of the mixing process, more elements being necessary for more complex tasks. I Bauman discussed about the solid-solid mixing with static mixer. The aim of this work was used for the mixing powder materials, in different batches and then put together in one tank before packing. He gives information about different parameters like shape of the mixing elements played a significant role. He gives the investigation about the real materials such as, food powders, pharmaceutics.

Dr. Bhawna Bhatt explains the concept of pharmaceutical mixing. Mixing is one of the most common pharmaceutical operations. It is difficult to find a pharmaceutical product in which mixing is not done at one stage. Mixing may be defined as the process in which two or more components in a separate or roughly manner mixed condition are processed in such a manner that each particle of any one ingredient lies as nearly as possible to the adjacent particles of other ingredients. This process may involve the mixing of gases, liquids or solids in any possible way for the combination and in any possible ratio of two or more components or ingredients. Mixing of a gas with other gas, mixing of miscible low viscosity liquids and mixing of a highly soluble solid with a low viscosity liquid to effect dissolution are comparatively simple as compared to the mixing of gases with liquids, mixing of liquids of high viscosity , mixing of two immiscible liquids such as aqueous and oily solutions to form emulsions, mixing of solids with liquids when the proportion of solids is high and mixing of solids with solids, specialized equipment's are required for these operations.

D. LITERATURE REVIEW OF THE MIXTURE QUALITY

Benjamin Ivorra, Juana L. Redondo, Juan G. Santiago, Pilar M. Ortigosa and Angel M. Ramos

Benjamin Ivorra, Juana L. Redondo, Juan G. Santiago, Pilar M. Ortigosa and Angel M. Ramos have performed the experimental setup on Two Dimensional (2D) and Three Dimensional (3D) modelling as well as optimization for the design of a fast hydrodynamic focusing micro fluidic mixer. They have verified the robustness of the optimized result by performing a sensitivity analysis of its various parameters. They achieved a design with a predicted mixing time of 0.10 µs, approximately one order of magnitude faster than previous mixers which they have used.

Ronald J. Weetman

Ronald J. Weetman explained about the mechanical design of a mixer with the emphasis on the fluid forces that were impacted on the impellers by the fluid continuum in the mixing vessel container. The analysis describe that the forces were a result of transient fluid flow asymmetrically acting on the mixing impeller. These loads were dynamic and have transition movement from the impeller blades to the mixer shaft and gear. A generalised result for the form of the fluid force equating could be developed. The significance of the mechanical interaction of the mixing process with the mixing vessel and impeller is stressed.

III. CONCLUSION

From above literature review it is clear that there are many researchers who have performed various analyses on Schatz profile geometry of mixer and various components by considering 2D, 3D and Optimization factors for Kinematic analysis of schatz linkage, schatz mechanism and their drive systems, mixture quality, various powder mixing devices for solid, liquid and gaseous compounds. So, I have decided to perform Finite Element Analysis of Schatz Geometry by designing the components in CATIA V5R20 and performing static Structural Analysis in ANSYS for finding productivity Effectives by considering the ratio of volume of schatz geometry mixture to the volume of traditional mixer for achieving best mixing quality mixture so that effectiveness can be enhanced. It is design as well as Finite Element Analysis (FEA) of driving system of Schatz mechanism with Three Dimensional motion mixer to produce desired motion pattern, increase mixing rate and quality by finding productivity effectiveness.

IV. REFERENCES

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