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STATIC AND DYNAMIC ANALYSIS ON THE MIXER BLADES

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Abstract
PVC (polyvinyl chloride) is a solid plastic made from vinyl chloride. It is made softer and more flexible by the addition of phthalates and bisphenol-A PVC is used to make pipes, sliding, medical devices and automobiles parts etc. The PVC mixtures are used for mixing, drying, stirring and cooling of plastics for a daily usage. The temperature of the PVC mixture is maintained around 120ºC and mixing the different chemical powders uniformly. The highspeed stainless steel mixer blades are used in PVC mixer. These blades are arranged in 3 series with different angles. Blades angle play an important role for uniform mixing. The aim of this project work is to increase blade efficiency by designing a mixer blade with new profile. In this work, the modelling of the blade will be done using Space claim software package and analysis viz., static, dynamic and model analysis will be carried out using ANSYS software package. The proposed new design ensures longer life and uniform mixing in lesser time.

Keywords: PVC granules, Mixer Blades, High-Speed Cutting Steel, ANSYS, Chemical Powders, Efficient Mixing.

Introduction

Mixer blades are an essential component of industrial mixing equipment, used in a wide range of applications across various industries, such as chemical processing, food and beverage, and pharmaceuticals. The proper design and operation of mixer blades are critical to achieving efficient mixing, uniform blending, and proper dispersion of materials. Static and dynamic analyses are two methods used to evaluate the performance of mixer blades. Static analysis involves examining the structural integrity of the blades under static loading conditions, such as the weight of the materials being mixed. Dynamic analysis, on the other hand, focuses on the dynamic response of the blades to external forces, such as the rotational speed of the mixer. Static analysis involves determining the stress and strain distribution in the blades, identifying potential areas of failure, and optimizing the design for improved performance. Dynamic analysis helps to identify the natural frequencies and mode shapes of the blades, allowing for the prediction and prevention of resonance and fatigue failure. By conducting both static and dynamic analyses, engineers can design mixer blades that are both structurally sound and capable of withstanding the dynamic loads and vibrations generated during mixing. This helps to ensure efficient and safe operation of industrial mixing equipment, resulting in improved product quality and increased productivity.

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Statement of the Problem

Mixer blades are subject to several problems that can impact their performance and the efficiency of industrial mixing equipment. Some of the problems like wear and tear, Fatigue failure, resonance, Insufficient mixing are quite common in the blades. To overcome these problems, it is crucial to select the correct design and material for the mixer blade for the specific application. In this Analysis Five different designs are Analyzed under the same Boundary conditions in the systems like Static Structural A nalysis, Modal Analysis, Fluid Flow

(Flu ent) Analysis System and Optimum results giving Design is obtained as the result which gives theleast deformation when subjected to the loads statically, Dynamically and least Eddy viscosity and Turbulence Kinetic Energy.

Objectives of the study

- To Determine the Total Deformations in Blades under same Boundary conditions.
- To Determine the Total Induced Stresses on the Blades under same Boundary conditions.
- To Determine the Eddy viscosity and Turbulence Kinetic Energy acting on the Blades.
- To find the Optimum Design for lesser deformations, Eddy Viscosity and TKE which ultimatelyleads to better Mixing and efficient grinding of the Mixture.

Review of Literature

Ch Tirumala Rao [1] Observed the results for high-speed tool steel material gives good efficiency and uniform mixing of PVC elements and durability is more compare to existing material that is SS304. DONALD W. BOYD [2] Produced Systems Analysis and Modelling A Macro-To-Macro Approach with Multidisciplinary Applications. O. Balkan et al. [3] Investigated morphological and mechanical properties of hot gas butt-welds on polyethylene (PE), polypropylene (PP), and polyvinyl chloride (PVC) sheets for four different procedures, which are single and double Vwelds with and without a welding shoe. Design/methodology/approach: Welding energy (Ew), which is transferred onto weld surfaces, was calculated to evaluate weld quality. Liu Bowen et al. [4] In this study, the effect of tempering conditions on microstructure, grain size, and carbide phase compositions of spray-formed high-speed steel after quenching at 1180 °C was studied. The influence of carbide phase, size of carbides, and retained austenite content on secondary hardening of the steel was analyzed by field emission scanning electron microscope (FESEM), transmission electron microscope (TEM), electron backscattered diffraction (EBSD), and differential scanning calorimetry (DSC); the hardness, microhardness of carbide, and bending strength were tested. The results show that M_3C, M_6C, M_7C_3, and MC carbides may precipitate at different tempering temperatures and the transformation of the retained austenite can be controlled by tempering. The phase composition of carbides. Zhukov, Ivan

[5] The article expounds the design technique of parametrical three-dimension model of the mixer which is a part of the automated power generating complex, used for coal-water fuel preparation. The possibility of the kinematic characteristics analysis of the mixer based on engineering calculations in T-Flex CAD is shown. Ch Tirumala Rao DONALD BOYD BalkanLiu B Zhukov,

Research Methodology:

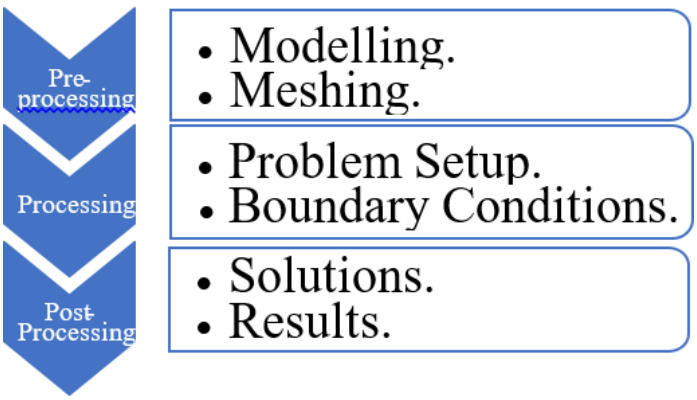

Figure 1: Research methodology

The entire Analysis is done by the above shown Figure 1 methodology, the models as shown in the figure 2 are designed in the designing software space claim 18.0 and meshed in the Mechanical System of the ANSYS 18.0. The processing of the Analysis is done in the ANSYS 18.0 by setting up the Boundary conditions. For the determination of the Total deformation and Total Induced Stresses on the blades the Analysis is done in the "Static Structural Analysis" System. For the determination of the Modal Deformations due to the natural resonance the analysis is done in the "Modal Analysis" System. For the determination of the Eddy viscosity and Turbulence Kinetic Energy the analysis is done in the "Fluid Flow (Fluent) Analysis" System.

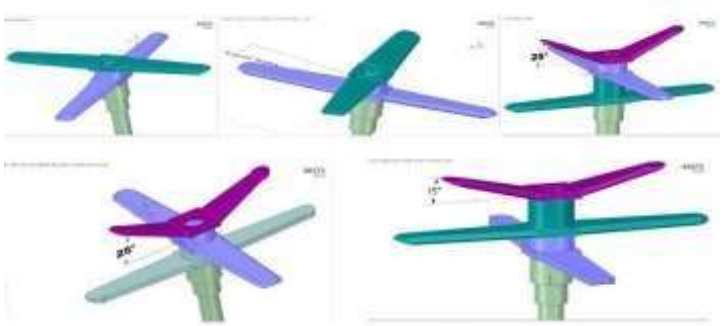

Figure 2: Design Models for the static and dynamic analysis of the Mixer Blades.

Results and Discussions:

The Blades are subjected to a mass of 100 kg's and rotated with a uniform rotational motion. Under these Boundary conditions the blades are analyzed in the Static Structural and Modal Analysis Systems. Then the Blades are analyzed Dynamically in the Fluid Flow (Fluent) System by applying some boundary conditions. The below figures show the parameters that are analyzed by using ANSYS 18.0 System.

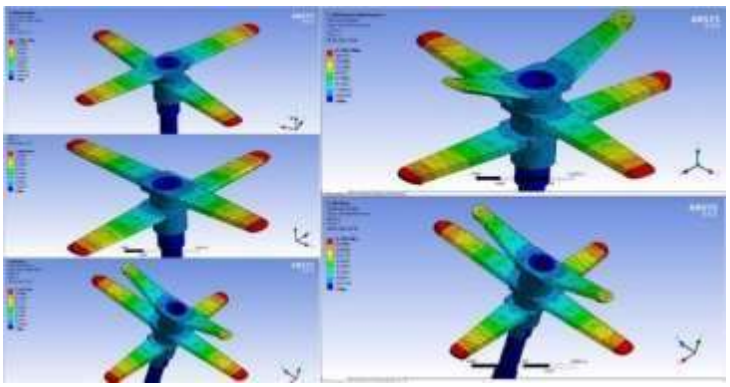

Figure 3: Total Deformations on the blades under Static loads**.**

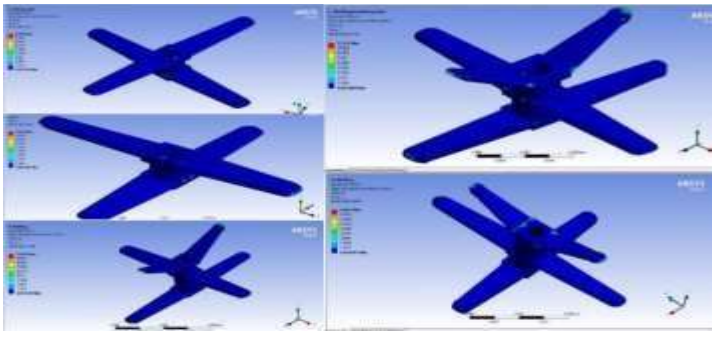

Figure 4: Equivalent Stresses (Von-Mises) on the Blade Designs.

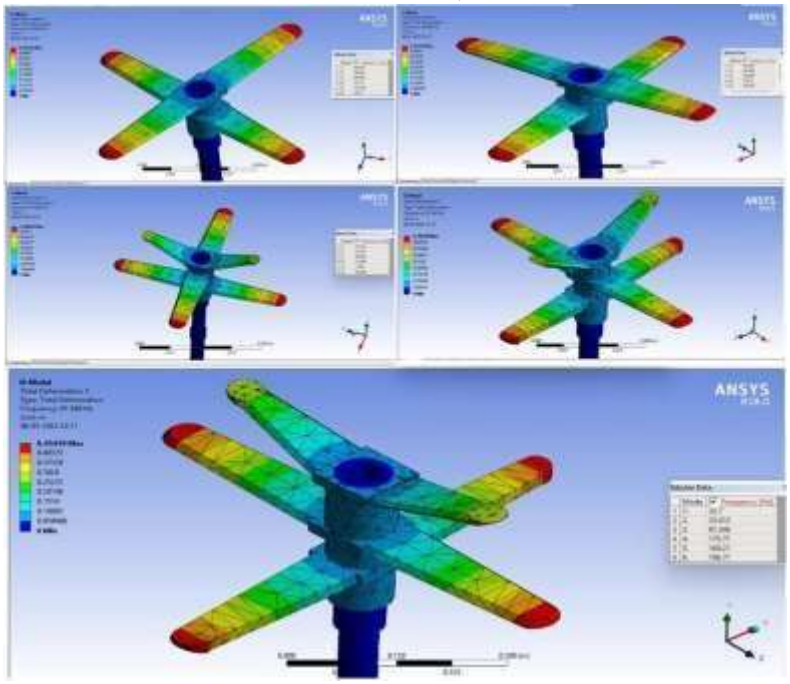

Figure 5: Total Deformations due to Natural Resonance

The Figure 3, Figure 4, Figure 5, shows that the blade designs are analyzed under the boundary conditions of the mass load of 100 kg's and one degree of freedom i.e., Rotational motion. The tumbler is fixed and the analysis is done in the Mechanical System in ANSYS 18.0. Then the Blades are tested by Modal Analysis system to find the deformations occur due to the Natural Resonance.

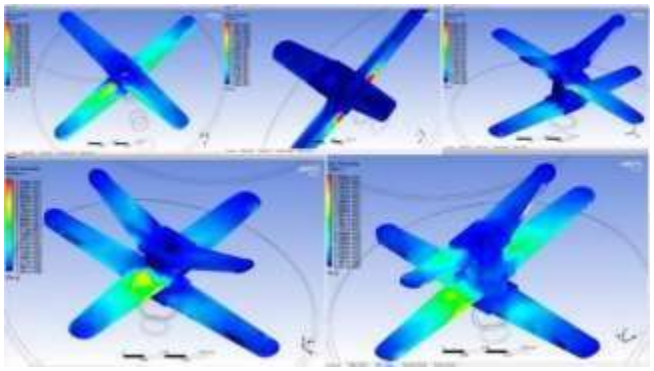

Figure 6: Eddy Viscosity on the blade designs in CFD.

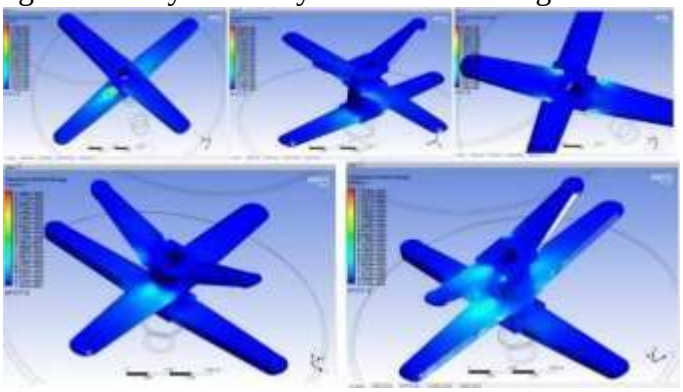

Figure 7: Turbulence Kinetic Energy on the blade designs in CFD**.**

Figure 6, Figure 7 showing the Eddy Viscosity and Turbulence Kinetic Energy generated on the blades when subjected to the Dynamic loads.

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RESULTS:

Material: HSS(M35)	**2 Set Blade Aligned**	**2 Set Blade Straight**	**3 Set Blade 25^0 Bent Top, two side Chamfered**	**3 Set Blade 25^0 Bent Top, One Side Chamfered**	**3 Set Blade 15^0 Bent Top, One Side Chamfered**
Turbulence Kinetic Energy **(m2/s2)**	1.47E+05	1.21E+04	6.82E+03	2.13E-03	1.14E-03
Deformation **(m)**	0.3848	0.38017	0.38239	0.3792	0.37542
Stress **(Pa)**	8.4	8.86	6.165	5.6587	3.8
Modal Deformation (80Hz) **(m)**	0.4546	0.4577	0.44088	0.456	0.4542
Eddy Viscosity **(Pa-s)**	1.66	1.67E+00	3.57E-01	2.15E-01	1.34E-01

Table 1: Results of the different analysis of the Mixer Blades

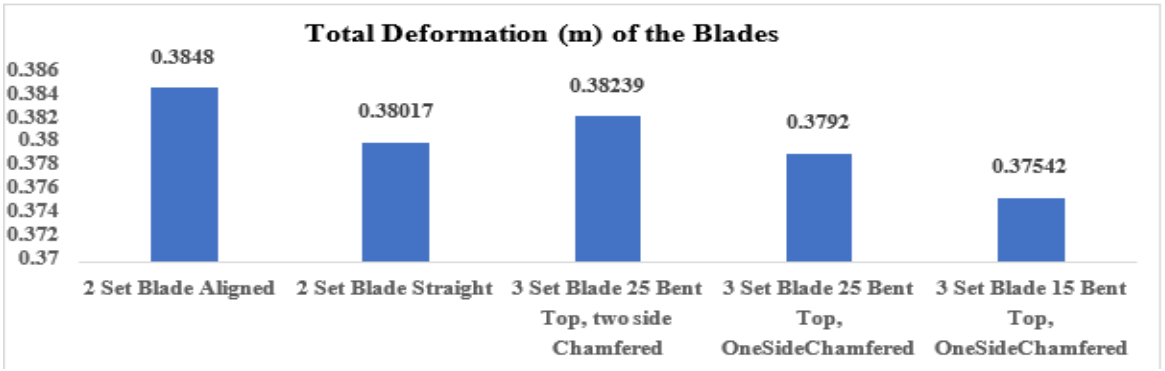

Chart 1: Total Deformation of the Blade in the Static Structural Analysis

The chart 1 represents the Total Deformation results of the blades when analyzed in the Static Structural Analysis system. The 3 Set Blade of 15^0 Bent top, one side chamfered edge gave the least results.

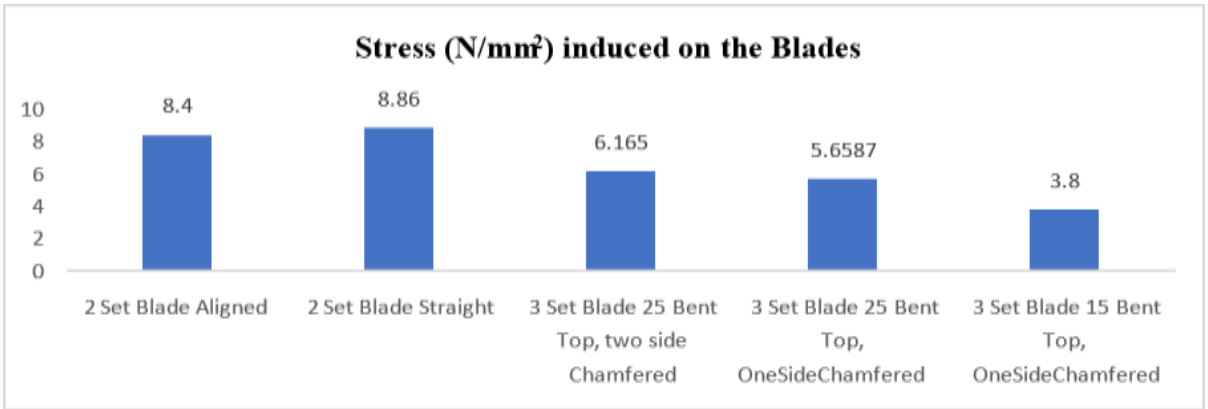

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Chart 2: Total Induced Stresses on the Blades

The chart 2 represents the Total Induced Stresses on the Blades when subjected to the Static load of 100 kilograms. The 3 Set Blade of 15^0 Bent top, one side chamfered edge gave the least results.

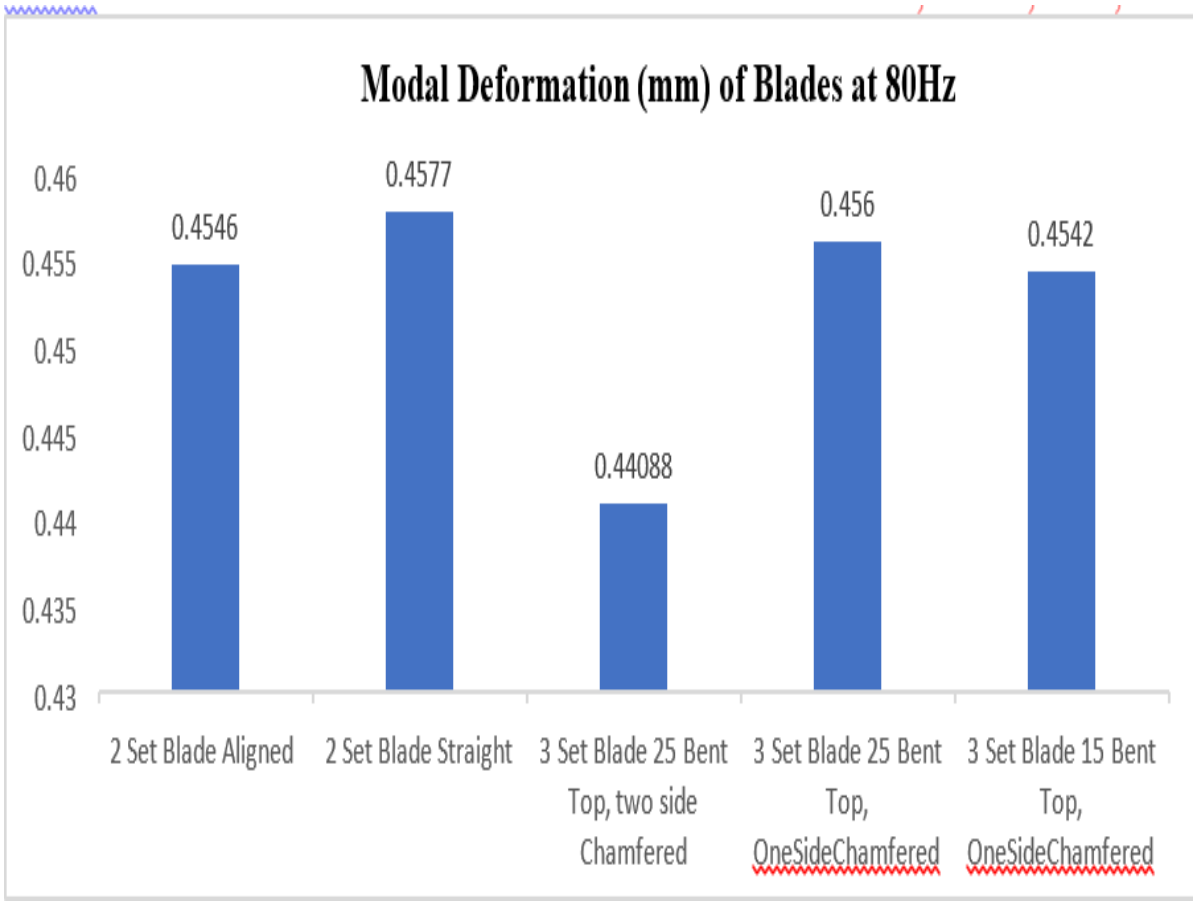

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Chart 3: Modal Deformations on the blade due to Natural Resonance

Chart 3 represents the results of the Blades under the same boundary conditions in the Modal Analysis showing the same deformations for the Natural Resonance because all blades are made of the same material i.e., High-Speed cutting Steel (M35).

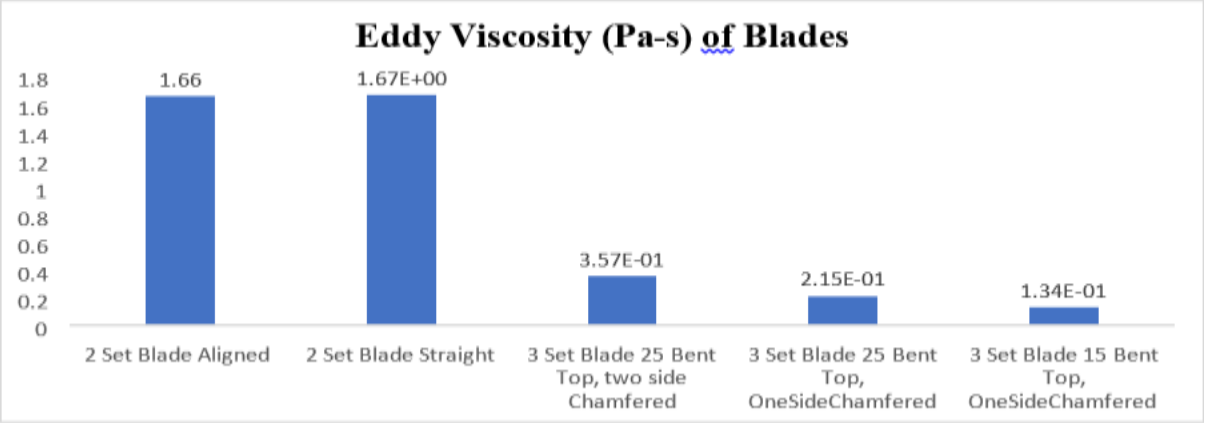

Chart 4: Eddy Viscosity on the Blades

Chart 4 represents the Eddy Viscosity results shows that the A 3 Set Blade of 15^0 Bent top set, one side Chamfered gave the optimum result. So, the mixture doesn't stick on the blade often and provide the better mixing.

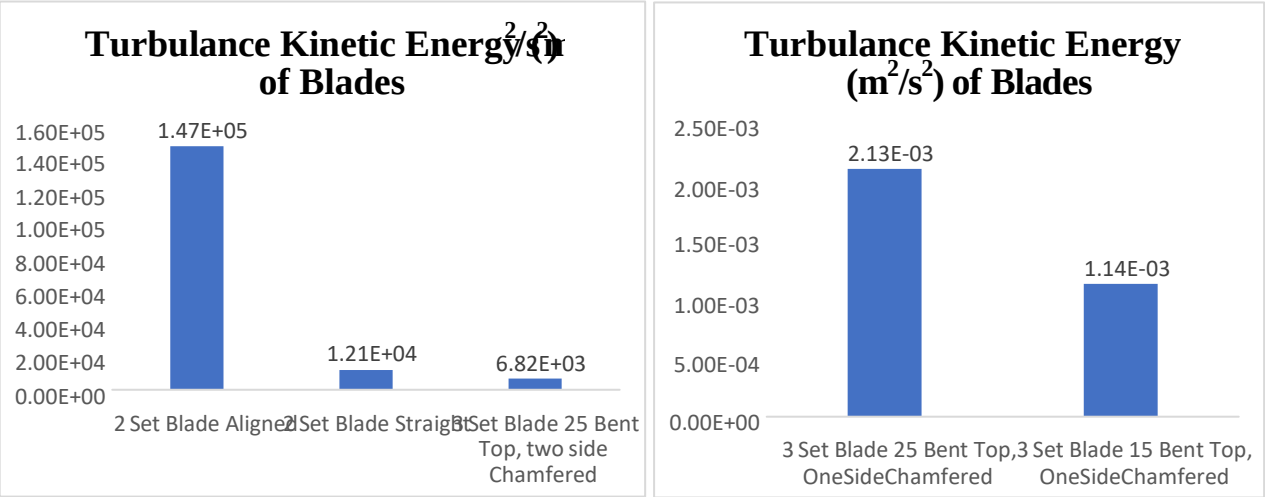

Chart 5: Turbulent Kinetic energies Results on the Different Blade Designs.

From the Above chart 5 the Turbulence Kinetic Energy results it states that the 3 Set Blade of 15^0 Bent top set, one side Chamfered gave the optimum result.

Conclusion:

From the above done analysis we conclude that, A Blade consists of 3 Sets designed with a 15^0 Bent top and one side chamfered edge give the optimum results for the efficient mixing of the PVC granules with the least possible deformations occurred by the Static and Modal loads and the least Possible Eddy Viscosity and Turbulence Kinetic Energy when subjected to the dynamic parameters while mixing of the mixture. By this Design efficient mixing is achieved in the least time.

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