DESIGN AND DEVELOPMENT OF WELDMENT BOTTOM SCRAPER AND ITS STRENGTH

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Abstract: In wooden pulp production multiple types of machinery and equipment are used for refining, cooking and bleaching process. This scraper is made for pressure diffuser to make separation and pulp feeding bottom scraper is a component for outlet device in pressure diffuser. The new design is weldment based technological development which is to be replaced before this scraper was very bulky and by casting made. Few modifications and hub design to this rotary assembly new design give a compact and optimized solution with its validation. Sheet metal components are majorly used to assemble its material selection is based on the medium of pulp and ASME pressure vessel standards.

Index Terms **- Bottom scraper, Hub design, Pressure diffuser, Pulp production, Sheet metal etc.**

I. INTRODUCTION

The mixing of fluids and effective agitations are among two main characteristics on which most of the operations of processing industries as well as chemical industries are dependent. A scraper impeller, which is installed internally, is used to mix the volumes of liquid batches. Generally, the process of agitation represents that fluid is forced to flow in a specific pattern such as a circulatory motion or another pattern in a vessel by using an agitator. As in today's industry, the agitators are very effective but there are various other issues that are affecting the process of agitation. Usually, an impeller is consist of a single turbine blade or propeller which is connected to a shaft which is further run by an electric motor that worked on a fixed speed. The impeller agitators are basically classified into two classes: radial-flow and axial-flow, along with this the mixing characteristics of axial-flow impellers produce the currents which are parallel to the impeller shaft's axis. Whereas the currents produced by the radial-flow impellers are in the radial or tangential direction to the impeller shaft's axis. These two impeller classes contain the three impeller design types. There are three types of impellers: paddle, turbine, and propeller. In agitation systems, nearly 95% of batch liquid uses these three primary types of impellers. These propellers can be either two-bladed, four-bladed but standard propeller is having three-blades that are covered by a circular guard.

Fig. 1: Small bottom scraper vessel installed in the outfield unit

A helix is traced out in the fluid by the revolving propeller. In a complete revolution, a fixed distance is moved by the liquid. Further, the ratio of distance moved to the diameter of the propeller is called pitch. Propellers are termed as the impeller agitators' axial class members. At the end of the agitator shaft, there are mounted six or more blades of the turbines. Turbines are said to be the impeller agitators' radial class members. Normally, the diameter of the turbine is 30%-50% of that of vessel diameter. The process of inducing motion in a specific way in the material is called bottom scraper. The mixing of fluids and effective agitations are among two main characteristics on which most of the operations of processing industries as well as chemical industries are dependent. Generally, the process of agitation represents that fluid is forced to flow in a specific pattern such as a circulatory motion or another pattern in a vessel by using an agitator. The process of agitation states that the phase mixing can be achieved as well as the heat and mass transferred among external surfaces and phases during this process can be enhanced.

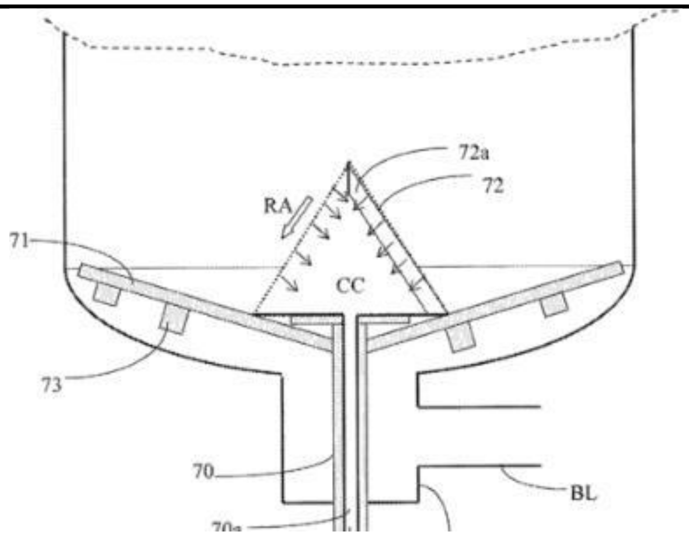

Fig. 2: Proposing geometry

Bottom Scraper operates under relatively more severe conditions on account of higher stresses involved. A Bottom Scraper is subjected to designing the factors that are basically "safety factors" which allows others to design reliable, safe agitator scraper material. The design factor purely depends on the operators, their experience and the raw material condition that they have used. Here in this project creating a scraper unit with welded plates and avoiding casting process.

II. LITERATURE SURVEY

B. Kumar et al [1] suggest a new design on wiper and agitator modification for milk machine. The current agitator isn't appropriate for manageable functioning of tasks hence creating issues in the result of the various efficiency parameters of the business such as workforce capacity, delivery schedule, quantity as well as quality. This particular project indicates a new agitator design. By thorough research of 3 diverse versions in most elements environment is considered for the last fabrication. Simulation is utilized for the needed experiments for finalizing the design. The various literature survey is used for all the required necessary input along with discussion with experts of that particular area as well as actual time analysis continues to be performed to obtain the actual necessity of the consumer [1].

Daennis Beatty et al [2] reviewed the side entry agitator test stand. It has been created at RIT along with Lightnin Mixers, SPX Corporation. The product is necessary to pervade a void in the market, and also shall be built of metal, using welded as well as bolted connections. A Lab View interface, a variable frequency drive, and load cells along with appropriate data acquisition devices are used to provide the sensing. Information is going to be output in a text file for simple integration with Matlab or Microsoft Excel [2].

Joelle Aubin et al [3] reviewed the highly viscous fluids are mixed using stirred tanks that uses multiple impellers along with CFD. Lagrangian particle tracking is used for assessing the connections among the impeller compartment and stages. It was observed from the results that when Intermit impeller is rotated at 45° rather than 90° as per producer's recommendation, with respect to the sided thing, the Reynolds number flow is decreased, the large operating condition range is enabled for handling. Moreover, by lessening the distance in between the lower 2 impellers, fluid exchange in between the impellers is guaranteed down to Re = 27 [3].

Ronald J. Weetman et al [4] explains the mechanical design of the mixer for fluid forces. Mixer's mechanical designs were represented by him along with emphasizing on the fluid continuum's fluid forces that were actually resisted on the impellers in a mixing vessel. The evaluation demonstrates that these forces are a consequence of the flow of transient substance that acts as equilibriums on the blending impeller. The specific dynamic loads are transferred to gear reducer and mixer shaft from impeller blades. An overall consequence for the kind of the substance pressure equation may be designed. The significance of the physical interaction of the blending practice with the mixing vessel as well as the impeller is emphasized [4].

Saeed Asiri [5] designed and implemented an innovative type of agitators known as a differential agitator. It is an electro-mechanic set comprises of 2 shafts. Understanding the components prosperities as well as the loading time circumstances, the FEM applying ANSYS11 was utilized to obtain the maximum geometrical details designs of the differential agitator components while the experimental check was conducted to verify the benefits of the differential agitators to offer an impressive agitation functionality of lime in the bath like a good example.

Tomas Jirout et al [6], "Impeller design for mixing of suspensions" has examined the result of impeller variety on off bottom particle suspension. Depending on the many suspension dimensions there was suggested correlations for computation just suspended impeller velocity of 11 impeller geometries and kinds in the number of levels as well as particle diameters. The suspension effectiveness of examined impellers was when compared by ways of the energy ingestion necessary for off-bottom suspension of reliable allergens [6].

Julian B. Fasano et al [7] examine the flow of fluids in stirred chests. Nevertheless, many efforts concentrated on the computation of flow patterns in lab scale tanks built with leading putting in impellers. Manufacturing issues are generally much more difficult to deal with. Complicating variables would be the usage of fluids with complicated non-Newtonian conduct, using edge typing agitators rather than leading putting in agitators and also the reality that the agitator might be operated in the transitional routine.

III. OBJECTIVES OF PROJECT

The bottom scraper is a vital component of agitation industry. Therefore, studying the bottom scraper both theoretically and experimentally would help in:

a) Design of concept model.
b) Design of multiple variants of drive hub and selection of the best one.
c) The shape and weight optimization. Manufacturing easiness.
d) Analysis of dismantling possibility
e) Material selection of raw material availability and boundary conditions.
f) Sizes and materials are finalized according to the strength behavior analysis.
g) Once the higher strength is obtained, weight and size reductions can be performed.
h) Sheet metal bending and weldability to be check.
i) For the final optimized solution, the metal flame cut design, as well as multiple joint options, should be made.

IV. DESIGN AND DEVELOPMENT

[1] New Design formulation:

- Sheet metal scraper body formation
- The external authority will do the changes
- The large capacity cylindrical vessel is used, and their height is limited to 300 mm more than the existing one.
- The shape of the new product is kept flat rounded scraping and collecting process having changes in casting to flat weldment techniques.

[2] Scraper Plate:

The first concept with flat body scraper
Component 1: BASE PLATE BENDED (thick 12 mm)

Base plate working as a platform for holding the whole assembly. This part will play an important role to execute scrapping application as all the boundary conditions will affect this body along with the vertical axle.
Gusseting will be providing stiffening.

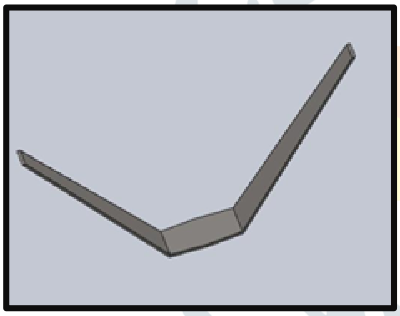

Fig. 3: Scraper blades

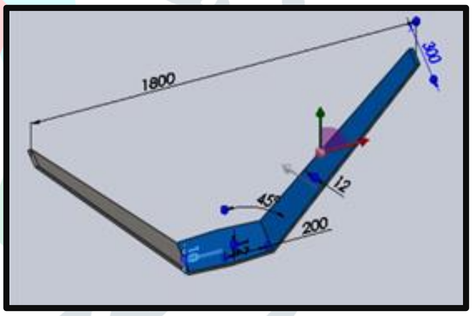

Fig. 4: Initial assumption for scraper body

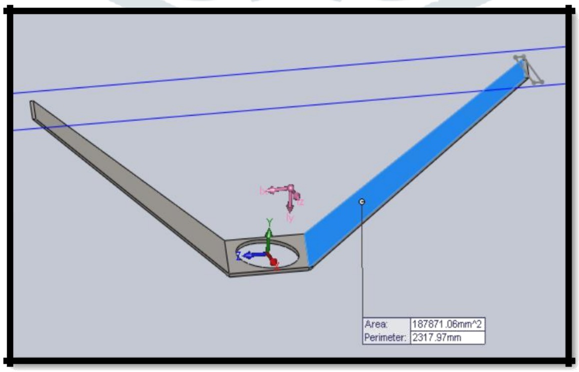

Fig. 5: CAD model of a base plate of the agitator

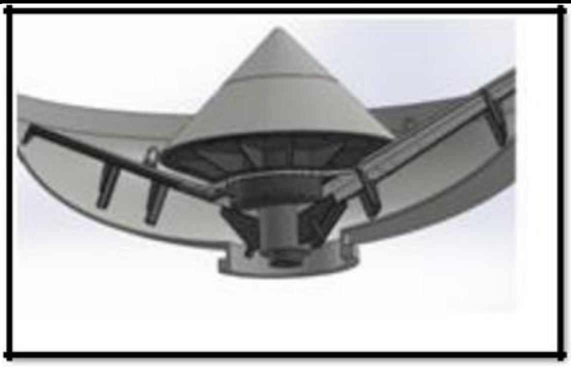

Fig. 6: Attachments on the base plate

[3] Axle Design:

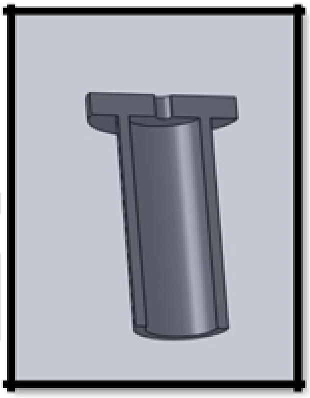

Fig. 7: Cut section of the axle

V. EXPERIMENTAL SETUP

[1] Experimental Method:

The analytical method is an approximate method. Therefore, for ensuring the component safety and working requirements the numerical results will be compared with either experimental results or with FEA results. Universal testers are the most commonly used testing machines that are used for testing the materials in bending, compression, or tension. Machines are tested either hydraulically or electromechanically.

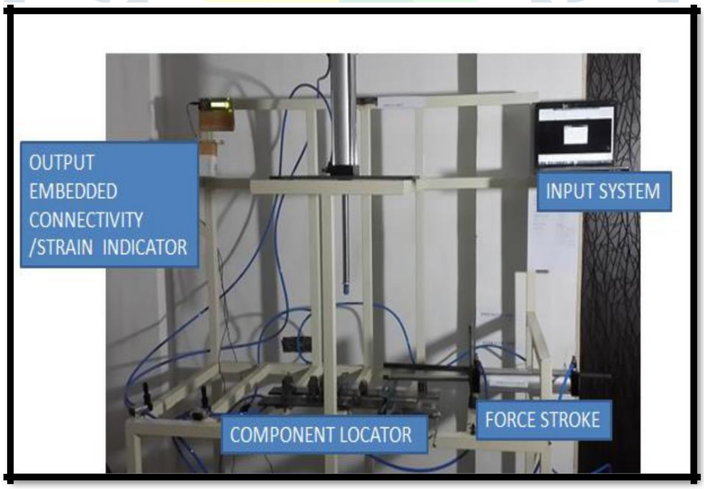

Fig. 8: Experimental setup

This is the Semi-Automated Strain Gauge Output Analogue on which actual testing is carried out. Soldering process is used for fixing the strain gauges on the specimen to be tested. After this, the strain developed on the specimen is calculated by the loading machine. For calculating the induced stress in the components stress-strain relation is used. And for loading the Hydraulic or Pneumatic bars are used.

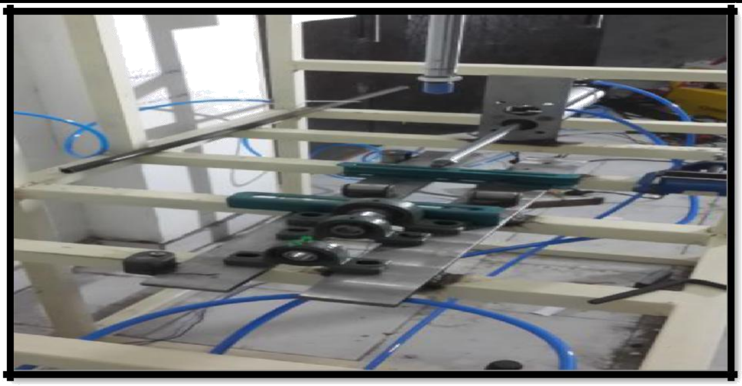

Fig. 9: Blank machine setup

This is the photograph of Blank machine setup. Some of the fixtures are presented in these photographs. For performing the actual testing the specimen is fixed into the particular fixture. The pneumatic pipelines are shown by the blue pipes in the given picture. There are several fixtures types that were available in the lab. As per our requirements, these fixtures can also be built.

[2] Hub Drum Validation:

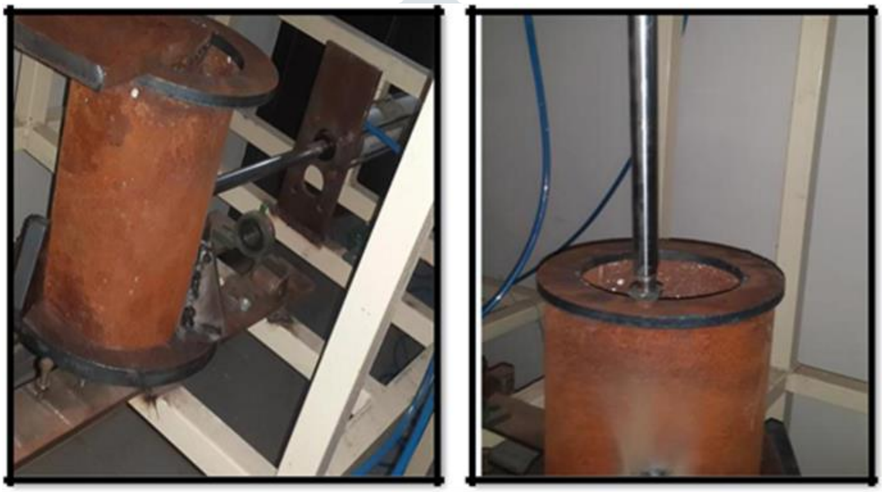

Fig. 10: Components loaded for experimental validation

Fig. 11: Strain gauge value for hub drum

From the diagram Maximum Strain developed is 133.5 that is in micro strain.
Hence,
Young Modulus = Stress / Strain
Therefore,
Stress = Young Modulus X Strain
Where,
Young modulus= 200 GPa
Stress = 26.7 Mpa

[3] Gussets

Fig. 12: Components loaded for experimental validation

Fig. 13: Strain gauge value for gusset

From the diagram Maximum Strain developed is 1005 that is in micro strain. Hence,

Young Modulus = Stress / Strain

Therefore,

Stress = Young Modulus x Strain

Where,

Young modulus= 200 GPa

Stress = 201 Mpa

[4] Scraper Body

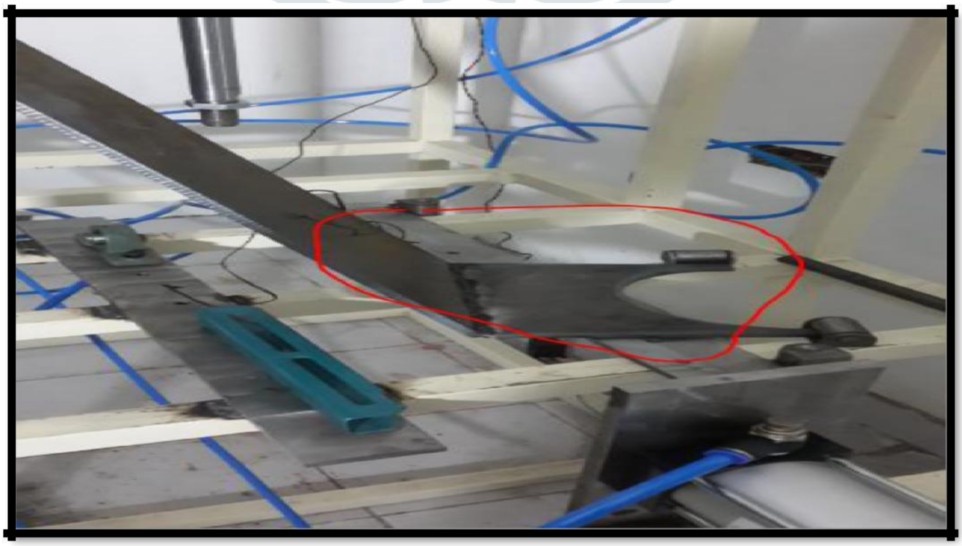

Fig. 14: Fabricated model component loaded to get strains values

Fig. 15: Strain gauge value for scraper body

From the diagram Maximum Strain developed is 305 that is in micro strain. Hence,

Young Modulus = Stress / Strain

Therefore,

Stress = Young Modulus x Strain

Where,

Young modulus= 200 GPa

Stress = 61 Mpa

VI. RESULTS AND DISCUSSIONS

Thus % deviation in stress obtained by using FEA and experimental analysis is within the acceptable limits. Thus numerical as well as an experimental result shows that the Stresses developed on Scraper body, Hub Drum and Gussets by analytical, experimental and CAE validation are near about same. The result of stress analysis done by analytically, by using CAE tool (Ansys) and testing are tabulated as below.

[1] Result Table

Parameter	Engineering	CAE	Testing
Cylindrical Hub			
Stress Mpa	34.87	46.64	26.7
Deflection mm	0.04	0.016	NA
Gussets			
Stress Mpa	208	178	201
Deflection mm	0.18	0.1	NA
Scraper Body			
Stress Mpa	78.43	74	61
Deflection mm	4.33	5.46	NA

[2] Graph of Results

Scraper Body

The graph is showing the stress values on the scraper body calculated by Analytical, CAE, and Experimental.

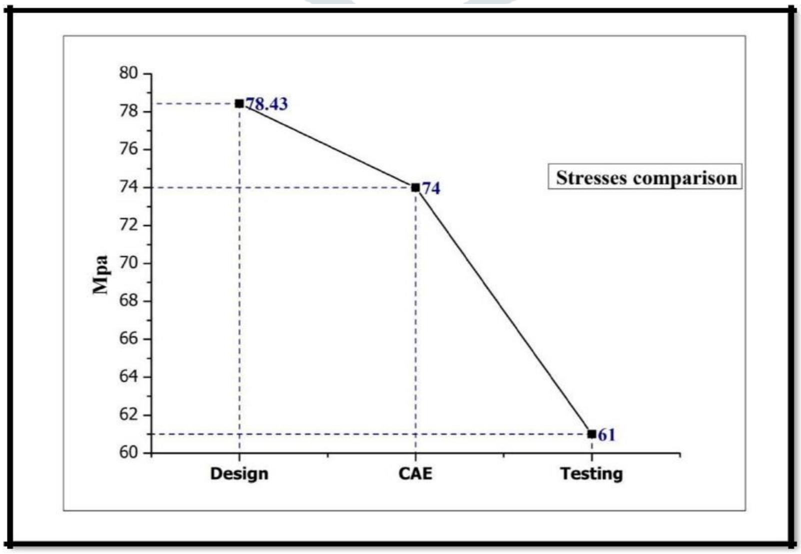

Fig. 16: Comparison of Stresses in Scraper Body

Cylindrical Hub

The graph is showing the stress values on the scraper body calculated by Analytical, CAE, and Experimental.

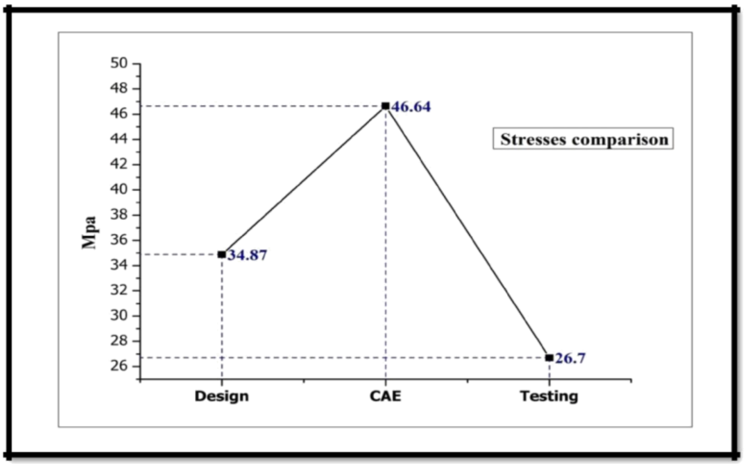

Fig. 17: Comparison of Stresses in Cylindrical Hub

Gussets

The graph is showing the stress values on the scraper body calculated by Analytical, CAE, and Experimental.

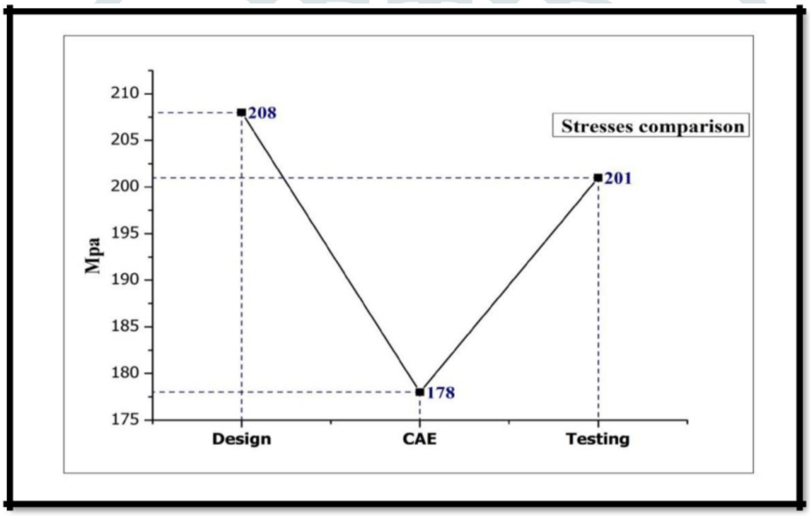

Fig. 18: Comparison of Stresses in Gussets

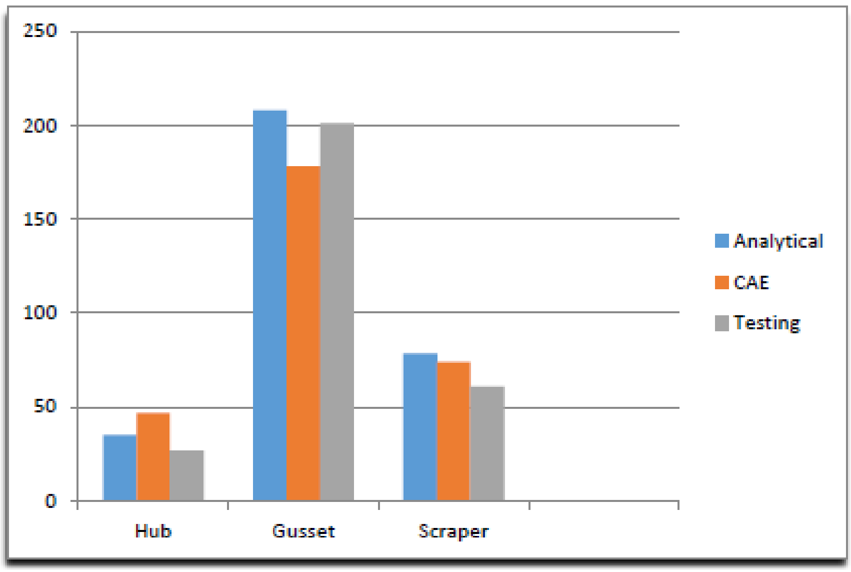

Fig. 19: Comparison of Stresses in All Components

VII. CONCLUSION AND FUTURE SCOPE

Assembly behavior of the bottom scraper in pressure diffuser is found safe in structural working. These kinds of scrapers can be used in multiple applications of food processing plants, mixing of pulp, etc. Hub designed for scraper is very suitable to make rotary operation in the machine. The old scraper was too heavy and non-removable from the assembly. Old scraper body is too expensive and bulky compared to this new one. Hub-based stirrer and scraping are ultimately using for agitation use here and it's good to build in easy steps of simple machining and welding bodies. No dedicated molds or preparation cavities required to form a shape as the typical shape of scraper also simple and straight flange sheet metal body.

For a mixture of low RPM requirements, it can be implementing. For making feeding application also it can be used as only need to change the end structure of flanges made for scrapping. The vessel can be conically optimized in new development. More feasible work of assembly with pressure diffuser body and vessel can be designed. Bottom scraper body can be increased in application areas if RPM variations developed using variable frequency drive or other electromechanical components.

VIII. REFERENCES

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