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Static and Dynamic Analysis of Impeller of Centrifugal Blower

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ABSTRACT

Blowers are providing air for ventilation and industrial process requirements. Blower generates a pressure to move air and gases against a resistance caused by ducts, dampers, or other components in a system. The blower rotor receives energy from rotating shaft and transmits it to the air. Blowers are widely used in industrial and commercial applications from shop ventilation, material handling and boiler applications to some of the vehicle cooling systems.

This project deals with the study of impeller design of centrifugal blower manufacturing company. In this study operating mechanism of impeller and analyze the static and dynamic design. The company is facing many problems regarding centrifugal blower. They are using centrifugal blower used for ventilation purpose, also they are using blower to maintain the temperature of food storages (Pulp storage).The present centrifugal blower is made up of from M.S. material here corrosion is a major problem. Due to the corrosion life of blower is less. The corrosive ingredients of the same are mixing with fruit pulps, which are harmful, also weight of the present blower is high and vibrations produced by the given centrifugal blower is more.

The above problem solve by using changing the blower material. The present centrifugal blower is formed from M.S. material here corrosion could be a major problem; this will be reduced by changing blower material i.e. during this project work SS316L is employed to avoid corrosion of the blower. Weight of the centrifugal blower is reduced beside increase its strength, by optimization of static analysis and dynamic analysis by using FEA for the MS, SS, and SS316L (Food Grade Steel). During this project work modal analysis is finished for the MS, SS, SS316L that could be a food grade material and natural frequency of the blower is compared with frequency of external excitation so as to cut back vibrations and failure of the centrifugal blower fan.

Keywords: ***I****mpeller of centrifugal blower, CATIA V5 R20, ANSSYS 14.5, Material SS316L*

1. INTRODUCTION

Most manufacturing plants uses fans and blowers for ventilation and for industrial processes that need an air flow. Fan systems is essential to keep manufacturing processes working, and consist of a fan, an electric motor, a drive system, ducts, piping, flow control devices, and air conditioning equipment (filters, cooling coils, heat exchangers, etc.).

Fan and blower selection depend on the volume flow rate, pressure, type of material handled, space limitations, and efficiency. Fan efficiencies are different from design to design and also by types. Fans fall into two general categories: centrifugal flow & axial flow. In centrifugal flow, airflow changes direction twice - once when entering and second when leaving (forward curved, backward curved, inclined, radial). In axial flow, air enters and leaves the fan with no change its direction (propeller, tube axial, vane axial). The major types of centrifugal fan are: radial forward curved and backward curved. Radial fans are industrial workhorses because of their high static pressures (up to 1400 mm WC) and ability to handle heavily contaminated air. Because of their simple design, radial fans are well suited for higher temperatures and medium blade tip speeds. Forward-curved fans are used in clean environments and operate at lower temperatures. They are well suited for lower tip speed and high-airflow work - they are best suited for moving large volumes of air against relatively low pressure. Backward-inclined fans are more efficient than forward-curved fans. Backward-inclined fans reach their peak power consumption and power demand drops off well within their useable airflow range. Backward-inclined fan are known as "non-overloading" because changes in static pressure do not overload the motor.

2. PROBLEM STATEMENT:

The present centrifugal blower is formed of from M.S material here corrosion could be a major drawback. Due to the corrosion life of the bower is reduced. The corrosive ingredients are mix with an equivalent with food, that is harmful for human life, conjointly weight of this blower is high and vibrations created by the given centrifugal blower is a lot of.

3. OBJECTIVES OF THE PROJECT

a) To study operations of blower

b) To develop solid model of impeller with static part CATIA

c) To analyse static and dynamic stability of impeller

d) To validate the simulated results with experimental results

4. SOLUTION PROCEDURE

4.1) To Reduce Corrosion Problem Of Centrifugal Blower and increase life of blower:

The present centrifugal blower is formed of from M.S material here corrosion could be a major drawback. Due to the corrosion life of the bower is reduced. The corrosive ingredients are mix with an equivalent with food, that is harmful for human life, conjointly weight of this blower is high and vibrations created by the given centrifugal blower is a lot of. In this project work to avoid corrosion downside of centrifugal blower SS316L (Food Grade Steel) material is employed rather than MS material because of its corrosion resistance properties and this material is food grade steel. Stainless-steel offers outstanding resistance to corrosion. There are, however, environments that may cause permanent breakdown of the protecting metallic element compound passive layer on the steel, resulting in corrosion on the unprotected surface. Adding alloying components like Mo and N creates high-alloyed or superior unsullied steels with improved resistance to corrosion. The Outokumpu Corrosion vade mecum addresses the complete scale of corrosion connected problems with intensive articles and technical descriptions covering totally different industrial sectors. The recently updated vade mecum contains a wealth of information concerning the comparatively new duplex family of low-nickel unsullied steels and therefore the made kind of new product and applications. Additionally enclosed is a special target industry with demanding applications like chemical process, pulp and paper and oil and gas business. the knowledge ought to be are available handy for anyone seeking answers to corrosion issues: designers, engineers, metallurgists and different specialists.

4.2) **Static Analysis of Centrifugal Blower To Optimize the Weight and enhance the strength**

Commonly brought up as 3D Product Lifecycle Management package suite, CATIA supports multiple stages of development (CAx), as well as conceptualization, style (CAD), producing (CAM), and engineering (CAE). CATIA facilitates cooperative engineering across disciplines, as well as egression & form style, engineering science, and instrumentality and systems engineering. CATIA provides a collection of egression, reverse engineering, and mental image solutions to form, modify, and validate advanced innovative shapes, from subdivision, styling, and sophistication A surfaces to mechanical purposeful surfaces. CATIA allows the creation of 3D elements, from 3D sketches, sheet, composites, and moulded, cast or tooling elements up to the definition of mechanical assemblies. It provides tools to finish product definition, as well as purposeful tolerances likewise as mechanics definition.

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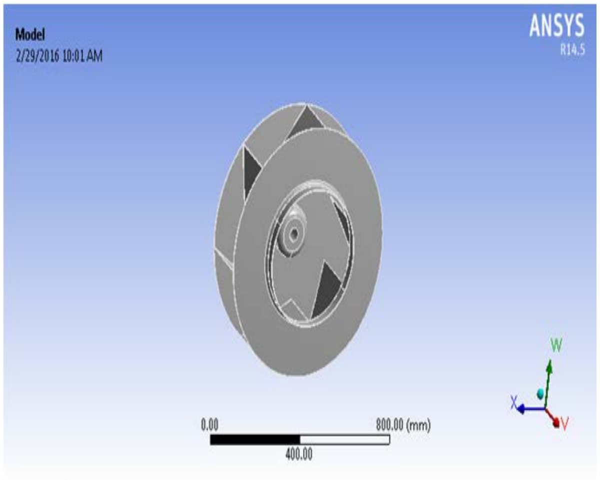
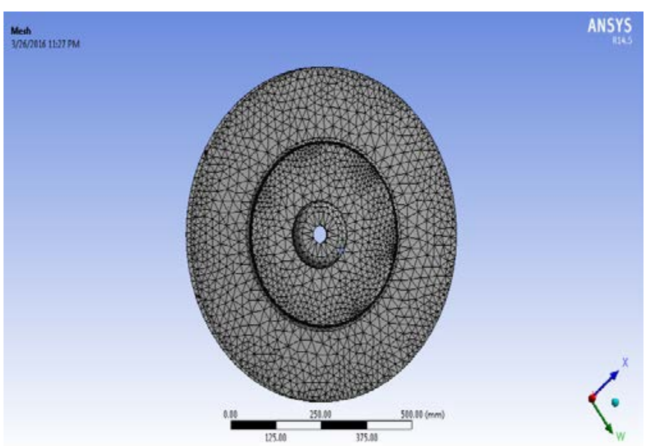
Fig.1 Blower Model



4.3) MESH GENERATION

In order to hold out a finite part analysis, the model we tend to area unit victimisation should be divided into variety of little items called finite parts. Since the model is split into variety of separate components, FEA will be delineated as a discretization technique. In straightforward terms, a mathematical web or "mesh" is needed to hold out a finite part analysis. If the system beneath investigation is 1D in nature, we tend to might use line parts to represent our pure mathematics and to hold out our analysis. If the matter will be delineated in 2 dimensions, then a 2nd mesh is needed. Correspondingly, if the matter is complicated and a 3D illustration of the time is needed, then we tend to use a 3D mesh.

Fig.2 Meshing



Statistics	
Nodes	78135
Elements	38286

4.4) ANSYS 14.5:

ANSYS Work bench may be thought of as a computer code platform or framework wherever you perform your analysis (Finite component Analysis) activities. In different words, bench permits you to arrange all of your connected analysis files and databases underneath same frame work. Among different things, this implies that you simply will use an equivalent material property set for all of your analyses. The ANSYS bench platform permits users to form new, quicker processes and to expeditiously move with different tools like CAD systems. during this platform acting on philosophy simulation is straightforward. Those playacting a structural simulation use a graphical interface (called the ANSYS bench Mechanical application) that employs a tree-like navigation structure to outline all components of their simulation: pure mathematics, connections, mesh, loads, boundary conditions and results. By victimisation ANSYS bench the user will save time in several of the tasks performed throughout simulation. The two-way links with all major CAD systems provide a really economical thanks to update CAD geometries alongside the look parameters.

Fig.3 Defomation of MS blower

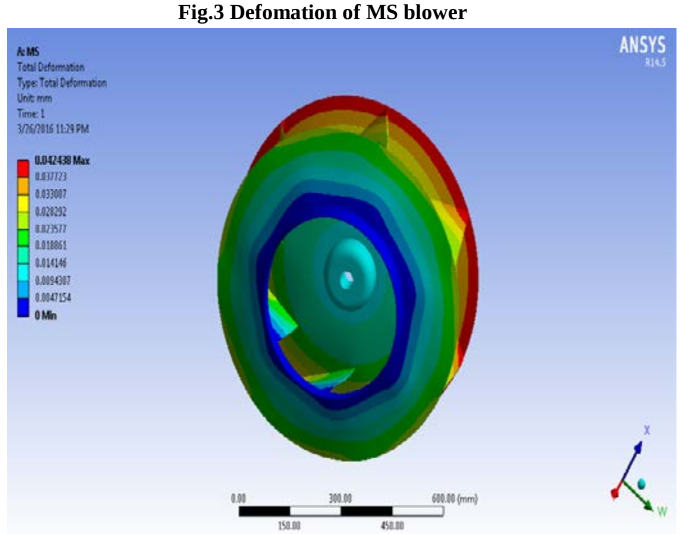


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Fig.4 Stress of MS blower

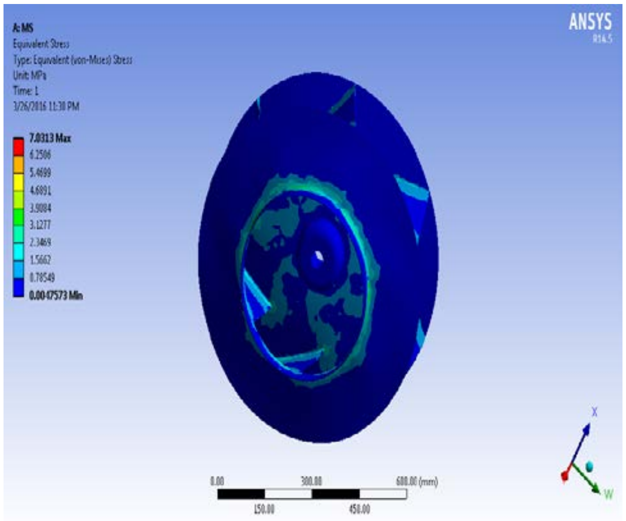
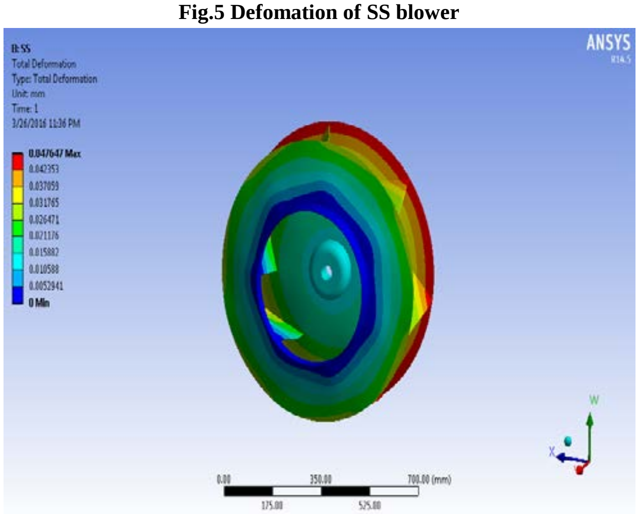


Fig.5 Defomation of SS blower



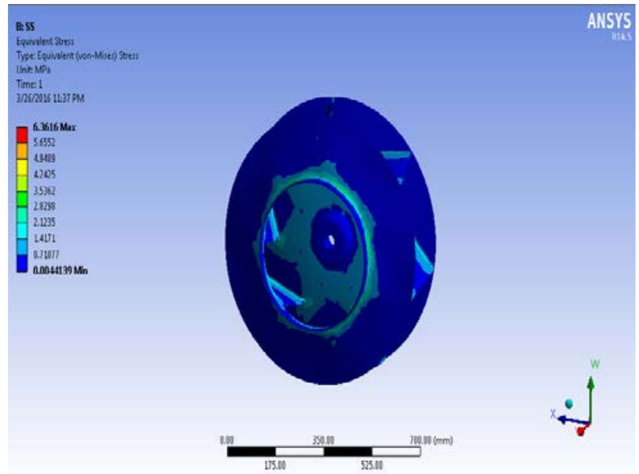


Fig.6 Stress of SS blower

Fig.7 Defomation of SS316L blower

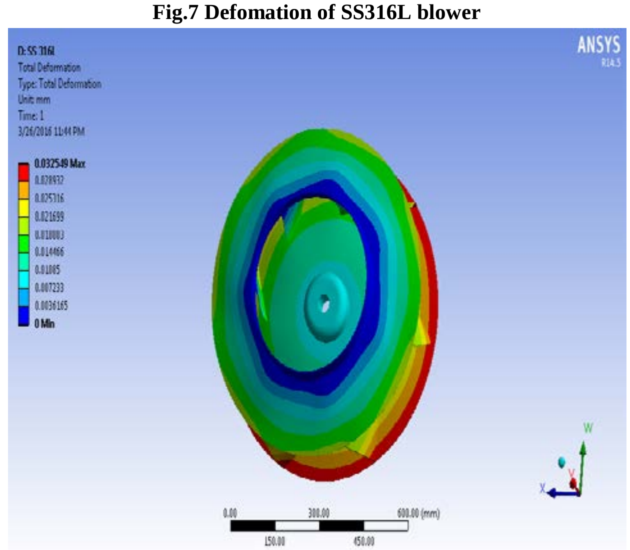


Fig.8 stress of SS316L blower

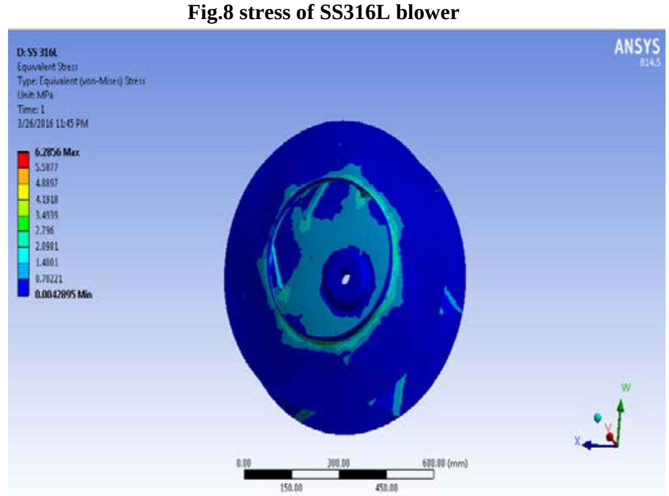


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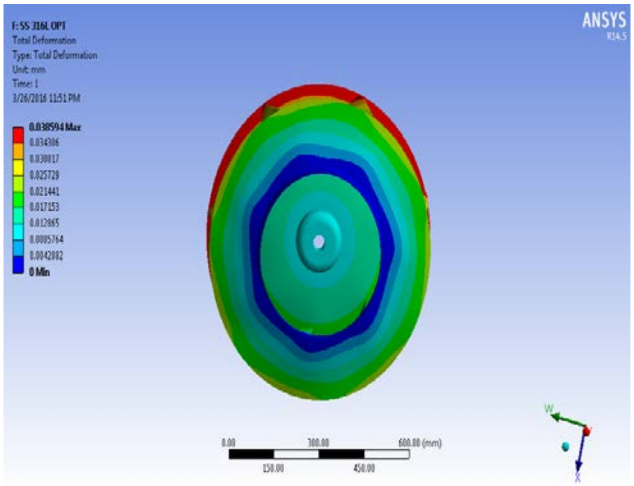
Fig.9 Defomation of SS316L blower(opti)



The maximum deflection induced in SS316L material is 0.038594 mm, which is in safe limits. Hence based on rigidity the design is safe. The maximum induced stress for the same material is 7.7023 Mpa which is less than the allowable stress (120 Mpa).Hence the design is safe based on strength. If we compare corresponding deformation of the material MS, SS on above results SS316L material having minimum deformation therefore there are less chances of failure of the blower fan as compare to other two materials. Hence the strength of blower gets increased because of the SS316L material. From the above result table it is clear that weight of the SS316L blower fan material is minimum as compared to other material, hence weight of the blower fan optimized.

Fig.10 stress of SS316L blower(opti)

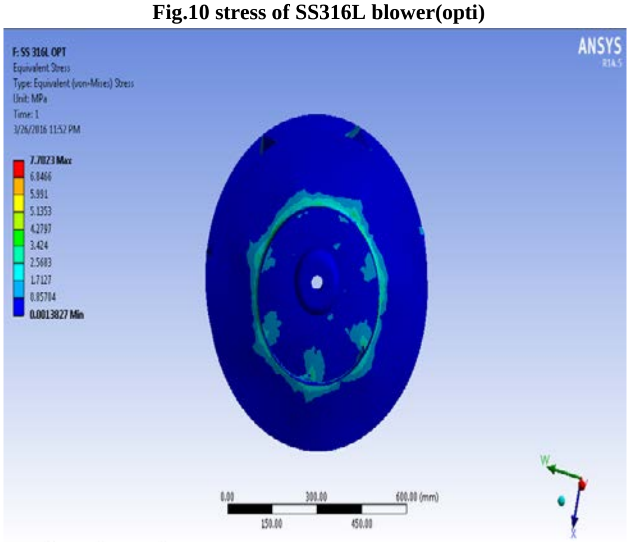


Table 1.Result and discussion

Sr. No	Material	Stress (MPa)	Deformation (mm)	Weight (Kg)
1	MS	7.0313	0.042438	36.394
2	SS	6.3616	0.047647	35.93
3	SS316L	6.2856	0.032549	35.93
4	SS316L Optimized	7.7023	0.038594	32.93

5.0) MODAL ANALYSIS OF CENTRIFUGAL BLOWER FAN:

Eigen value analysis results show that the first critical speed of MS blower is 64.209 Hz and that of SS316L blower is 31.843 Hz the reduction in natural frequency of MS blower is due to the high stiffness of the MS blower as per the equation below. This shows that both MS and SS316L blower are running with in the safe limits. The natural frequencies of the experimental results match with the natural frequency in the table.

$$F_1 = \sqrt{\frac{\lambda 1}{2\pi}}$$

Fig.11 MS blower mode shape table

Tabular Data

	Mode	Frequency [Hz]
1	1.	64.209
2	2.	64.296
3	3.	78.011
4	4.	148.21
5	5.	222.6
6	6.	224.7

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Fig.12 MS blower first mode shape and its deformation

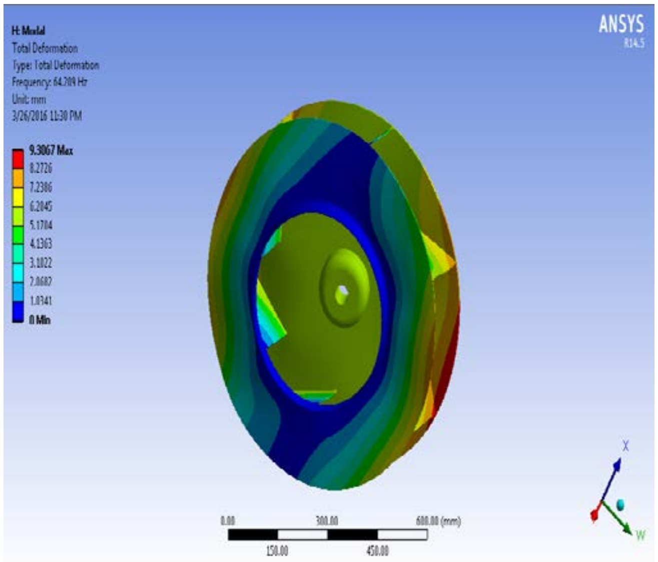

Fig.13 SS316L blower mode shape table

Tabular Data

	Mode	Frequency [Hz]
1	1.	31.843
2	2.	32.226
3	3.	55.958
4	4.	155.22
5	5.	186.33
6	6.	187.15

Fig.14 SS316L(opti) blower first mode shape and its deformation

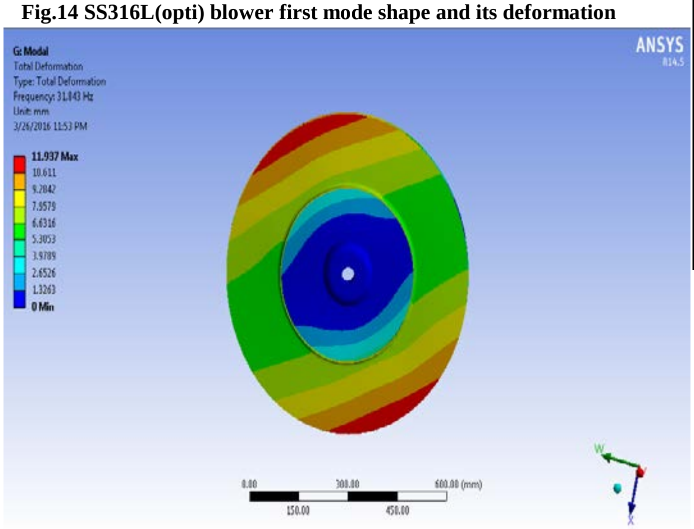

Table2. Comparison of first five natural frequencies of MS and SS316L (opti) blower

No. of Modes	Natural frequencies of MS blower fan in Hz	Natural frequencies of SS316L(opti) with1mm reduced thickness blower fan in Hz
1	64.209	31.843
2	64.296	32.226
3	78.011	55.958
4	148.21	155.22
5	222.6	186.33
6	224.7	187.15

Table3. Comparison of Deformations of MS and SS316L blower

Mode	MS Deformation	SS316L(opti)-1mm reduced thickness Deformation
1	9.3067	11.937
2	9.1647	11.937
3	9.8699	8.8338
4	10.403	11.878
5	62.19	18.074
6	47.01	16.792

From above table it is clear that SS316L with 1mm reduced thickness have less deformation for different modes. Therefore there are less chances of failure the material, also from table 2 it is clear that the natural frequency of SS316L with 1mm less thickness blower is reduced because of high stiffness and the layup sequence in the blower.

7. 0) Conclusion

a) Corrosion issue of the radiating blower is decreased (93.7%) by utilizing material SS316L (Food Grade Steel), which is very erosion safe. Thus there won't be any blending of elements of erosion in natural product pulps as talked about in issue definition. Weight of the Centrifugal blower is optimized by using SS316L material (i.e.32.93 Kg which is less as compared to MS material i.e. 36.394Kg).

b) SS316L material having least deformation subsequently, there are less chance of failure of the blower fan as contrast with ms materials.Consequently the quality of blower increase.

C) From above result we reason that SS316L steel is the best material for blower fabricating according to modern prerequisite.

d) Vibration issue of divergent blower decreased by utilizing SS316L material as a result of its high firmness and layup succession in fan.

8.0) FUTURE SCOPE:

The present work gives only static and dynamic analysis of critical parts of centrifugal blower in order to optimize the weight & enhance strength of the blower, to reduce vibration problems; also this works provides solution to the corrosion problem by suggesting alternative material. However this paper does not gives the Harmonic analysis of centrifugal blower as the fan is rotating member so it produces vibrations, in future there is always scope of harmonic analysis and CFD analysis of the blower fan, using CFD simulation tool in order to increase performance of the given centrifugal blower.

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