DESIGN AND ANALYSIS OF CENTRIFUGAL BLOWER IMPELLER USING STEELS AND ALUMINIUM ALLOY

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Abstract
Blowers are one of the types of turbo machinery which are used to move air continuously with in slight increase in static pressure. Blowers are widely used in industrial and commercial applications from shop ventilation to material handling, boiler applications to some of the vehicle cooling systems. The main aim of this project is to increase the life period of centrifugal blower impeller by considering different types of materials, designs and by varying the thickness of base plate of centrifugal blower impeller. Using Ansys software implemented static analysis under different boundary conditions also implemented Taguchi optimisation technique to grab the best material, design and thickness. Total deformation under static analysis considered for Taguchi optimisation technique and using Anova method obtained best results were Stainless steel, 12 Blades impeller and 8 mm as base plate thickness provides very less deformation under static analysis.
Keywords: Centrifugal Blower Impeller, Taguchi Optimisation Technique, Deformation

Introduction:

Blowers are one of the instruments utilized frequently in submarines. They are introduced in wind stream and aerating and cooling structures in every single submarine compartment. Ventilation structures for the most part provided by methods for significant structures incorporate supply and fumes fans, serve for wind current of cabin and other than hotel ranges with barometrical air with synchronous wind current of carport batteries and for air cooling and refinement from perilous and noticing polluting influences.

The centrifugal fan uses the centrifugal power generated from the rotation of impellers to increase the pressure of air/gases. When the impellers rotate, the gas near the impellers is thrown-off from the impellers due to the centrifugal force and then moves into the fan casing. As a result the gas pressure in the fan casing is increased. The gas is then guided to the exit via outlet ducts. After the gas is thrown-off, the gas pressure in the middle region of the impellers decreases. The gas from the impeller eye rushes in to normalize this pressure. This cycle repeats and therefore the gas can be continuously transferred.

Rotating blower is comprised of from M.S material. When blower works under wet environment it may corrode and formation of scale on it. This corrosion and scale formation may lead to affect life & performance of blower. In this project corrosion is a problematic undesired chemical ingredients cumulatively to add pollute ingredients in the food and pharmaceutical Industries process. Due to the corrosion life of the bower is reduced.

PRESENT WORK:

Designing of Impeller:

Table 1. Design parameters for Impeller design

Parameters	Dimensions(mm)
Impeller outlet diameter	260
Impeller inlet diameter	600
Thickness of blade	4
Thickness of base plate	4
Impeller inlet width	43
Impeller outlet width	22

Modelling of impeller:

Modelling of impeller is carried out using CATIA v5 software. CATIA is a robust application that enables you to create rich and complex designs. The goals of the CATIA course are to teach you how to build parts and assemblies. Using CATIA V5 Software 3 models developed with same inlet and outlet diameter and by varying the number of blades on the impeller and also by changing thickness of base plate of centrifugal blower impeller.

The first model designed with 6 blades with 4,6,8mm as thickness of base plate and 260mm,600 mm as inlet and outlet diameter of impeller , the thickness of base plate varied to conduct Taguchi optimisation technique. Catia software provides very good features to design very complex design also. This model is named as D1 in this paper.

The second model is designed with 7 blades with same 4,6,8 mm as base plate thickness and same inlet and outlet diameters , design with 7 blades one is complex one as compared to design of 6 blades, the inlet and outlet angle consideration and the connection of focus of points to design impeller blade is an complex job. This model is named as D2 in this paper.

The Third model is designed with 12 blades with same 4, 6, 8 mm as thicknesses and design of 12 blade impeller is complex because equal space should be maintained between each blade. Most of industries use this type of centrifugal blowers impeller because the pressure output of this blower is more and discharge rate is more for same input. In the design of 12 blades impeller the complex job in modelling of blade because the thickness varies from inner hub to outer. In this paper model is named as D3.The model is analysed using ANSYS 16.0 software.

The above 3 models named D1, D2, D3 are imported into Ansys software. And for the analysis of 3 models selection of material also very important ,In this paper for static analysis of D1,D2,D3 the selected material are Structural steel(S312), Aluminium alloy (A356), Stainless Steel (SS304) ,In this paper above 3 materials named as M1,M2,M3 , under static condition applied force on each impeller blade is 2000N , Boundary conditions also concerned depends on material, For the static analysis under different boundary conditions we obtained von-mises stress , Elastic equivalent strain and total deformation , results are tabulated as per requirement of Taguchi optimisation technique

Procedure for static analysis in Ansys:

Build the FE Model, Define the material properties such as young’s modulas , density , poisons ratio etc , next step is to apply boundary conditions and pressures to tabulate the von-mises stress, Equivalent elastic strain and total deformation.

Taguchi Optimisation Technique

Dr.Taguchi of Nippon Telephones and Telegraph Company ,Japan has developed a method based on OA experiments which gives much reduced variance for the experiment with optimum settings of control parameters. Taguchi technique is applied to plan the expirements,in a tree step approach namely system design, parameter design, and tolerance design. In system design the most influenced process parameters were identified taking with minimum trails into consideration. Secondly Signal-to-Noise (S/N) ration to analyze experiment data for determining the quality characteristics implemented in engineering design problems. Thirdly estimates individual parameter contributions.

This study is to minimize total deformation under static analysis; lesser the deformation of material under required conditions increases the life of the component.

The three most influenced identified parameters (A) Material, (B) Design of impeller, (C) Thickness of base plate of centrifugal blower.

Design of Experiments

Design of Experiment (DOE) is a powerful statistical technique for improving product/process designs and solving production problems.

Table 2. DOE Table for Taguchi optimisation Technique

S.NO	Material	Design	Thickness
1	M1	D1	T1
2	M1	D2	T2
3	M1	D3	T3
4	M2	D1	T2
5	M2	D2	T3
6	M2	D3	T1
7	M3	D1	T3
8	M3	D2	T1
9	M3	D3	T2

Results and Discussions

Static Analysis implemented using ANSYS 16.0 Software, with the patterns explained in DOE and results obtained for Total deformation under static analysis with different boundary conditions are tabulated below.

Table 3. Results table of static analysis for different Taguchi patterns

S.NO	Material	Design	Thickness	Deformation under Static Analysis (mm)
1	M1	D1	T1	0.087266
2	M1	D2	T2	0.032456
3	M1	D3	T3	0.02874
4	M2	D1	T2	0.18974

5	M2	D2	T3	0.091195
6	M2	D3	T1	0.090541
7	M3	D1	T3	0.061442
8	M3	D2	T1	0.031065
9	M3	D3	T2	0.020993

1. Main effects of the factor :

Qualitek software is used for optimisation process which is best software for taguchi optimisation technique to optimise the results and to grab out the best pattern for more life period of component .The results obtained by taking DOE 9 patterns into consideration, the result pattern with values are tabulated below .

Table 4. Table of Main effects of the factor

Level	Material	Design	Thickness
1	0.048	0.11	0.07
2	0.04	0.05	0.08
3	0.03	0.04	0.06

From above table we can conclude that 0.03(M3), 0.04(D3), 0.06(T3) are less compared to previous values, so the pattern obtained after Taguchi optimisation technique M3 + D3 + T3.The results also shown in graphs .

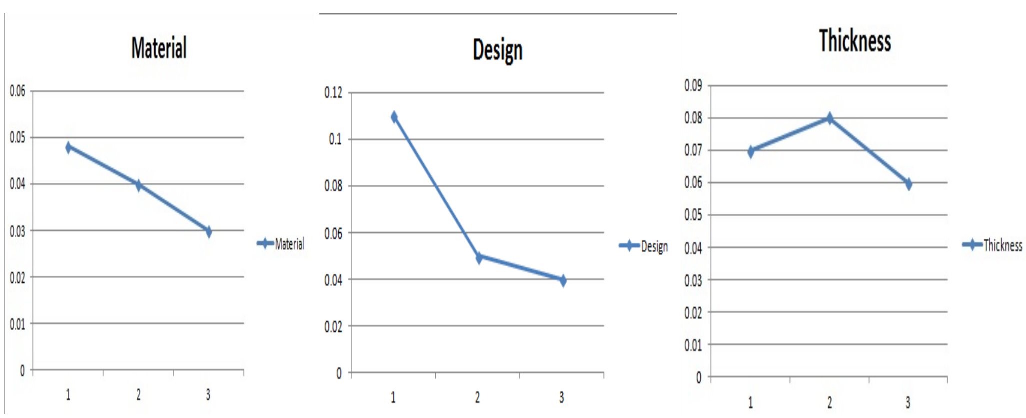

Figure .1 Graph diagrams for Main effects of the factor

2. ANOVA Method :

ANOVA is a statistically based, objective decision making tool for detecting any differences in the average performance of groups of items tested. ANOVA helps in formally testing the significance of all main factors and their interactions by comparing the mean square against an estimate of the experimental errors at specific confidence levels. Using ANOVA method percentage contribution of each parameter can be calculated in the process of optimisation technique, In this paper for the parameters Material, Design and Thickness of impeller base plate, The percentage contribution calculated and shown in follows pi-chart

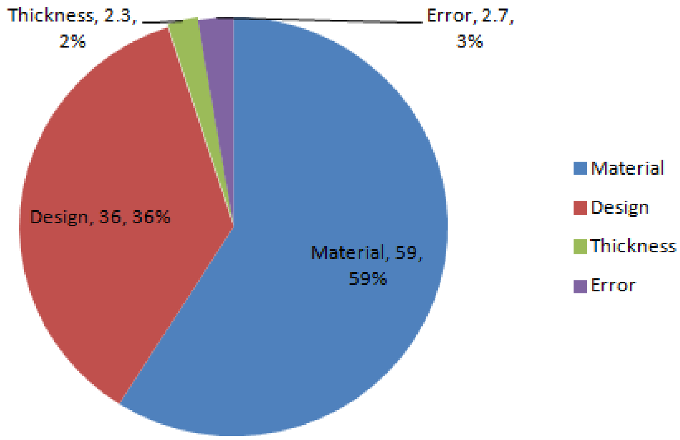

Figure .2 Percentage contributions of Material, Design, and Thickness

3. Static Analysis for optimised pattern : Static Analysis conducted for the optimised pattern M3 ,D3 and T3 ,the result total deformation under static analysis is obtained and compared with previous 9 patterns which are mentioned in DOE table , observed that total deformation value is less for the pattern M3+D3+T3 i.e., **0.020145,** so that we can conclude the results obtained from optimisation technique gives more life for a component ,for the pattern M3+D3+T3 model analysis also conducted , the results are tabulated in table

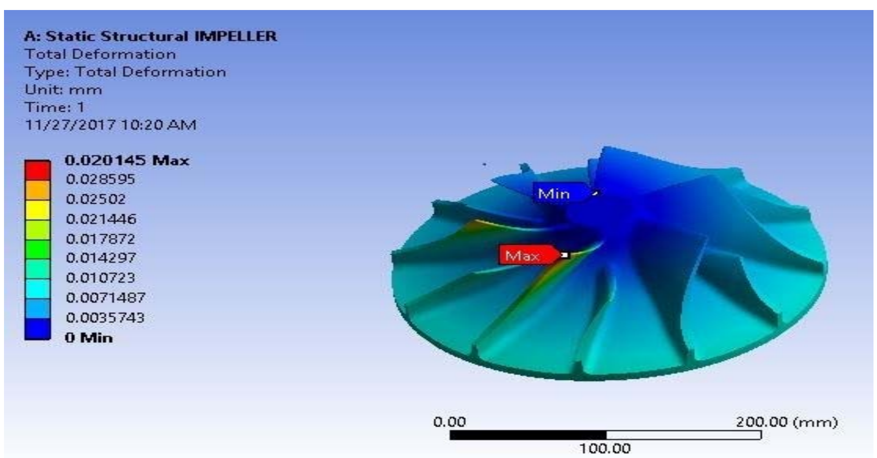

Figure .3 Percentage Total Deformation Diagram for M3+D3+T3 under Static Analysis

Table. 5 Static and Model Analysis Results for optimised pattern

No	Material	Design	Thickness	Von-Mises Stress (MPa)	Equivalent -strain	Deformation under Static Analysis (mm)	Frequency (Hz)	Deformation under Model Analysis (mm)
1	M3	D3	T3	33.334Max	0.00018033	**0.020145**	818.46 853.05 853.32 3385.3 3401.2 3401.6	0.47201 0.53258 0.52961 0.58125 1.8951 1.8303

CONCLUSION:

In this paper Design and Analysis of centrifugal blower carried out for different materials like Stainless steel, Aluminium alloy, Structural steel, Designs and Thicknesses. The Total deformation for the pattern M3+D3+T3 (Stainless steel, Impeller with 12 blades and 8 mm base plate thickness) which is obtained by Taguchi optimisation techniques results very less deformation **0.020145** as compared to other 9 patterns which are shown in DOE table.

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