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Design of Mixed flow Fan with Rapid Prototyping Method for Acoustics Performance

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Abstract

Objectives: In this work Rapid prototype model is used to reduce the noise of an axial cooling fan. **Methods/Analysis**: Reverse engineering is considered for modeling the fan and computational fluid dynamics methods are applied to the existing fan to evaluate the noise levels. Changed the existed axial fan blade profile with NACA 63-006 airfoil to decrease noise levels. The local flow field of the fan was computed with rapid prototype model. The flow patterns throughout the fan are visualized using numerical techniques. **Findings**: By decreasing the no. of blades with airfoil cross section, noise is reduced and also increased fan performance. The overall sound intensity levels are observed for modified fan a series of NACA Airfoil and it has been observed that the minimum noise level of NACA 63-006 RPT fan is 60.5 dB. **Novelty/ Improvement:** Large broadband noise reduction is obtained due to RPT fan a NACA 63-006 airfoil profile of blade geometry.

Keywords: Axial Cooling Fan, CFD, Noise Evaluation, NACA Series, Rapid Prototyping

1. Introduction

Noise of level intensity reduction at cause is very essential for sea water pumping in submarines. Cooling fan of ten blades in a radial shape driven by 20 HP induction electric motors. Once the preliminary detection of characteristic noise sources in the fan, an endeavor has been made to condense the soundintensity level of fan by changing of geometrical parameters of the equipment.

In the present paper, noise of axial fan has been streamlined by NACA 63 arrangement airfoil edge segment. Numerous instruments have been hypothesized and examined both tentatively and hypothetically to survey their possible immensity as the noiseof axial flow fans. In[1] was effectively predictable the extent of the tones created at the initial pair of blades passing sounds by the persistent stacking (both push and torque powers) on a propeller. Afterward trial results, by[2], showed that such stacking couldn't represent the greatness of the higher sounds noticed in the range. From that point forward, in[3] investigations of unsteady optimal design and collaboration noise of streamlined bodies.

In[4] covered a trial and numerical examination planned to disclose the tone, creating mechanism. In[5] studied the expectation of the commotion emanation delivered by the rotors of axial fans, helicopters, and so on. In[6] concentrated on the noise produced components in hub flow fans. In[7] study is to apply reproduction procedures to a motor fan structure and utilize the accepted model to assess information outline parameters. Reproduction comes about and measured information at different fan speeds demonstrated brilliant similarity between CFD results and the test information. In[8] presented a hypothetical investigation of axial fan comprises of two sections: 1. A streamlined methodology in view of the eddy surface strategy and 2. An air acoustic methodology which primarily concern the expectation of the tonal noise utilizing the Ffowcs Williams and Hawkings (FW–H) condition. In[9] introduced multiplication on simply the radiator fan working with the condenser fan adjusted. Condenser

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and radiator heat exchangers were joined into the multiplication, regardless of the way that the radiator heat exchanger tank was definitely not a permeable media was utilized to speak to the heat exchanger. In[10] contemplated a car HVAC sub module made out of both blower and air admission. The test noise level was measured downstream of the module in a shut channel with an anechoic end. In[11] studied noise emitted by a vacuum cleaner suction unit has aerodynamic, mechanical and electromagnetic noise origins. In[12] presented a controlled experimental study of the noise emission of a typical model of computer cooling fan. In[13] studied on a numerical forecast of the collaboration noise transmitted from an axial fan. In[14] investigated probability of admittance noise of a car engine in keeping running up condition. In[15] Rapid Prototyping (RP) technologies are reviewed. In[16] discussed about the RP technology and application of basic principles and methods through case studies.

2. Importance of Noise Evaluation

In considering the design of the fan, designer must first take into account the limitations imposed by standards on the geometry of the motor. This leads to a severe restriction on the geometry of the fan and for the flow path of the cooling air. Compared to cover, the blades are the essential source to sound characteristics of the stream field. Embracing airfoil shape, noise happening because of strengths going ahead the blade because of an isolated stream at the inlet can be reduced. A cooling fan create a pressure difference by exchange the energy from the blade to the vaporous liquid. The amount of the inbuilt energy exchange ability relies on upon blade design. Outline of the fan is fundamental for better execution of the motor by diminishing its overheating, subsequently developing its existence and unwavering quality. In this work different airfoils are studied in the design of axial cooling fan.

Major sound sources concerned in the motor fan noise era:

- Rotational frequency and fan BPF. These two are generally the governing sources of noise.
- The cooling fan produced Broadband noiseAt the inlet and outlet.

Underwater application equipments noise reduction is very important. Total investigation is made at a single operating point. The aim of the work is to new geometry of the fan keeping in mind the end goal to minimize the sound produced without diminishing the fan working point.

For low noise fan inner and outer shrouds radius is optimized. Table 1 shows the specifications of Existed fan. Table 2 shows the specifications of Rapid prototype fan.

Figure 1 shows the CAD model of original fan, which have created model by using CATIA software.

Figure 2 shows the CAD model of redesigning fan.

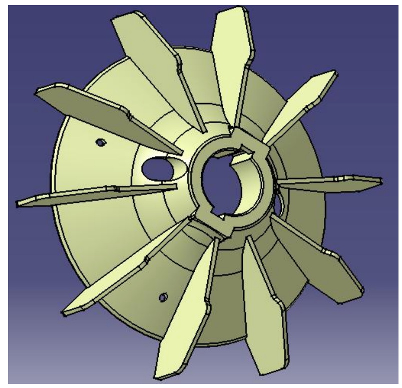

Figure 1. CAD model of original fan.

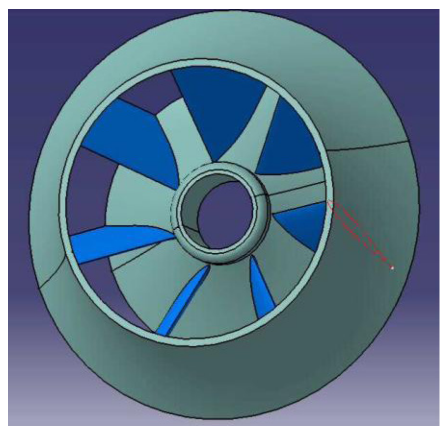

Figure 2. Cad model of fan with 7 blades in aerofoil.

Table 1. Specifications of existed fan

Type of Fan	Axial Flow Fan
Total no. of blades	10
Blade Orientation	Radial
Profile	Rectangular
Spacing of Blade	Even
Internal diameter	40 mm
External diameter	234 mm
Speed	2920 rpm
Material	Plastic
Thickness of shroud	4mm

Table 2. Specifications of RPT fan

Type of Fan	Axial
Total blades	Seven
Direction of blades	Backward inclination
Profile of blade	NACA, 63-006
Inner diameter	43 mm
Outer diameter	236mm
Material	Nylon 11 (SLS)

3. RPT Fan Building Process

Computer aided design model of planned fan changed over to STL group, which can be comprehended by a 3D printing device.

SLS are made with nylon powder material, which are scattered in a slender layer on top of the manufacture stage in the SLS machine (Figure 3).

Figure 3. SLS machine.

A laser, following a cut of the fan onto the powder (Figure 4). The laser warms the powder and consolidates the particles together into a strong form (Figure 5). Once the essential layer is framed, the stage of the SLS machine drops by 0.1 mm and afterward uncovering another layer of powder for the laser to follow and consolidate together. These processes continue over again until the whole fan has been created.

3.1 SLS Process

The procedure starts through a 3D computer aided design document of fan which contain numerous segments. The thickness of each layeris 0.10 mm to 0.15 mm.

Within the laser sintering machine, a heater is utilized to warm the nylon material to a couple of degrees underneath liquefying. This almost softened powder is then "specifically" liquefied, or sintered, by an overhead laser to converse to one cross-segment layer of fan.

The machine stage brings down a couple of thousandths or one layer, and instantly subsequently the recoated, or roller, conveys another layer of material over the construct stage. This flimsy layer of almost softened powder is on the other hand specifically liquefied to speak to the following cross area which is somewhat not the same as the last. Following 4.36 hours, several layers are sintered together to frame a whole fan (Figure 6). After that powder cooled from 178^{0}C to room temperature in 14 hours. It has been brushed away, uncovering strong fan. The fan is then dab impacted to expel any powder adhering to the surface and is then prepared to utilize.

Figure 4. Nylon powder.

Figure 5. SLS adhesive.

Figure 6. RPT fan model.

4. Experimentation of RPT Fan

Anechoic chambers are used to evaluate the sound properties of acoustic instruments. The main features of an anechoic chamber are sound pressure level measurements, sound source levels, recognition and receiver of noise source. Computed the 1/3 octave band SPL by using A microphone receiver and Dewetron software.

Figure 7. RPT fan testing set-up.

Table 3. Summary of the sound levels of RPT fan

Location (m)	x	y	z	Sound level [dB(A)]		Reduction dB(A)
				Original Fan	Redesigned RPT Fan	
Inlet	1	1	0	85.6	56.68	28.92
Outlet	1	1	0	97.8	57.93	39.87

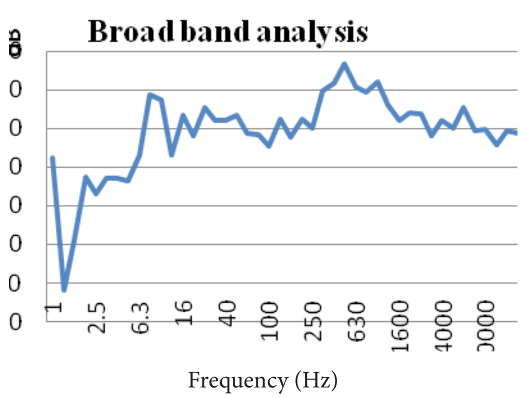

Figure 8. Sound pressure level of fan at inlet.

Figure 7 shows the testsetup for RPT Axial fan to measure the noise inside the chamber. In this experiment RPT fan was fitted to the motor shaft and measured the RPM with tachometer set the required speed of the fan. Marked the microphone receiver locations from the rpt fan inlet in the directions of x, y and z. recorded the broadband noise waves of fan with the help of a computer. Broadband sound results are plotted to a frequency of 0–10 kHz. The same procedure was applied at the fan outlet noise and then 1/3 octave band, narrow band sound analyzed by using software and plotted the values.

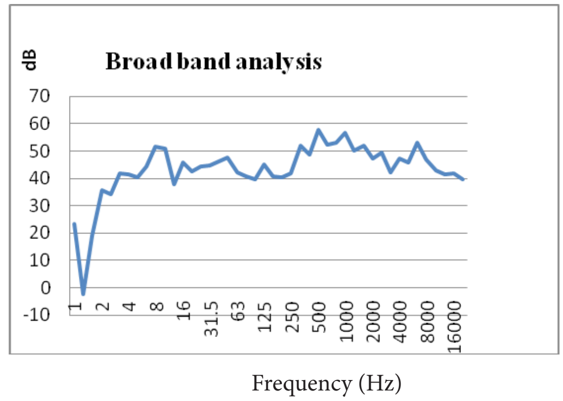

Figure 9. Sound pressure level of fan at outlet.

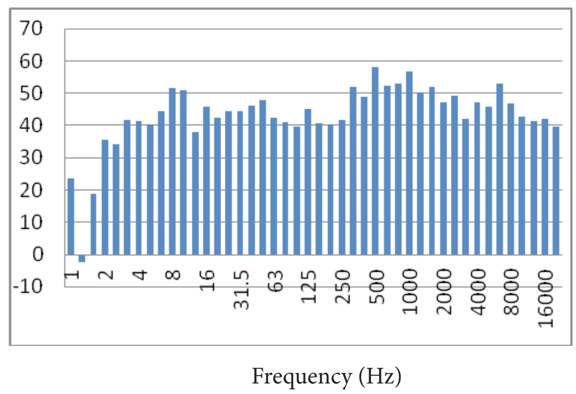

Figure 10. 1/3 octave band SPL spectrum of fan at location 1.

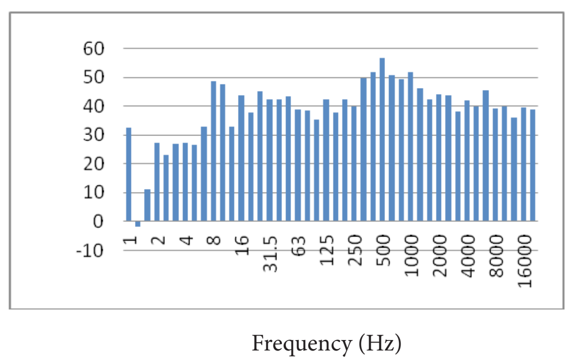

Figure 11. 1/3 octave band SPL spectrum of fan at location 2.

5. Results and Discussion

The total sound pressure levels are obtained from the Experiment is 56.68 dB at inlet and 57.93 dB at outlet. It is observed that cooling fan blade is the major role to the noise characteristics of the flow field. It has been observed noise levels, experimentally at inlet and outlet. The following graphs Figure 8, Figure 9, Figure 10 and Figure 11 shows the Broad band and one third octave band analysis, noise levels for RP fan. Observed that redesigned fan sound pressure levels are very low when compared to original fan. Finally concluded that the rapid prototype fan of airfoil blades will generate low noise.

6. Conclusions

The overall sound intensity levels are observed for modified fan a series of NACA Airfoil and it has been noticed that the lowest amount of noise intensity of NACA series 63-006 RP fan is 60.5 dB. Large broadband noise reduction is obtained due to RP fan with a 63-006 aerofoil profile of blade geometry. This can be used for underneath water applications for marine water pump.

7. Acknowledgement

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