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EXPERIMENTAL INVESTIGATION ON ENERGY SAVINGS IN CENTRIFUGAL FANS USING DIFFERENT INLET GUIDE VANES

SHAIK KHAJANAWAZ[1], Dr.K.NARYANA RAO[2], Dr.A.V. SITARAMARAJU[3]

Associate professor, Dept. of Mechanical Engineering, Deccan College of Engineering &Technology, Dar us salam, Hyderabad-500001. India[1]

Professor (Rtd), Dept. of Mechanical Engineering, University College of Engineering,OsmaniaUniversity,Hyderabad-500007, India[2]

Professor, Dept. of Mechanical Engineering, JNTU College of Engineering. Kukatpally, Hyderabad-500072, India[3]

Abstract: The current study of fitting the inlet guide vanes at the entrance of centrifugal fan impeller is to resolve the non uniformity of the flow and to get rid of the vortices that are generated by the existence of inlet distortion. The main purpose of this work is to evaluate the use of the inlet guide vanes (IGV) made of sheet metal and fiber reinforced plastic to improve the fan performance and saving of energy. For this purpose the ring of blades in radial direction i.e. Radial cascade, with different exit blade angles of impellers is used. Comparison with free inlet (without IGV) fans is performed. Measurement of static head, shaft power and energy savings at different loads are made for dissimilar cases. The study of these measurements gives some information concerning the operating range and how energy could be saved in V.A.V. (variable air volume) system in air conditioning. By using the above method the overall size of the fan could be reduced.

Keywords: Centrifugal fan, VAV, FRP, IGV.

I. INTRODUCTION

By the aerodynamic principles, due to inlet guide vanes (IGV), the centrifugal fan operates with stable enough characteristic pressure curves which do not tend to surge because of the turbulence created by the vanes in the inlet eye in running condition. The centrifugal fan (CF) with inlet guide vanes are used in V.A.V. (variable air volume) systems mainly in the industrial field. The resulting operating system characteristic is considerably the basic square law relation ship. Centrifugal fans are used in HVAC system is to create more powerful, efficient, smaller and quieter among different types of rotors. Centrifugal fans are extensively used because they accomplish high pressure ratio in a small axial distance compared to axial fans. Flow in a centrifugal fan is complex, three dimensional phenomenons, involving boundary layer separation, secondary flow, and turbulence etc. Centrifugal fans are operated with pressure ratio not over 1.15 and 1.2 kg/m^3 flow density. When Centrifugal fan integrated with inlet guide vanes are used in V.A.V. system in the comfort air-conditioning, energy savings are made by the flow modulation.

Inlet guide vanes are commonly used with CF having fan wheels with back ward inclined aerofoil or flat blades. The inlet vanes impart a whirl to the air such that it enters the fan wheel in the direction of rotation. These results in decreasing air flow, lower static discharge pressure, and decreased brake horse power requirements. The inlet vanes are designed to control gas flow by changing the amount of gas or air admitted to the fan inlet and reduces fan energy usage due to their ability to affect the airflow pattern in to the fan. They may be installed at the suction side, at delivery side of the fan or both.

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II. TEST FACILITIES AND INSTRUEMENTATION

Experimental investigations were conducted in Turbo Machinery Laboratory. The test rig consists of a low pressure commercial CF of radial type, a test inlet duct and a delivery duct. The fan wheel consists of 16 straight blades of 3mm thickness with constant blade width of 60 mm welded to a black plate and a shroud. The impeller inner and outer diameters are 250mm and 394mm respectively. The scroll casing is of constant rectangular width. The fan is driven by an electric motor of shaft power 3HP at a constant speed of2800rpm. The test inlet duct is 160mm in diameter and 300mm long. The exit circular duct of 100mm diameter is connected to the rectangular outlet of the fan through a conical connection and fitted at the end with a throttle valve. Fig.1 illustrates the test rig layout equipped with the measuring devices.

The shaft power of the fan is measured by a digital Wattmeter with accuracy of 0.09% while the rotational speed is measured by a digital tachometer with accuracy 0.05%. Investigations of the effect of the sheet metal and FRP (Fiber reinforced plastic) IGV on centrifugal fans with different exit blade angles are made.

This purpose, three types of impellers ,one backward, one forward and radial facing with different exit blades angles have been constructed using the original scroll casing. In this investigation, the cross sectional inner diameter and outer diameter are 100mm and 200mm respectively with 8 vanes of 3mm thickness made of sheet metal. It is mounted at the suction side of the impeller as shown in Fig1. The two impellers one backward and one forward facing with different exit blade angle have been constructed using the original scroll casing. More details about the different impellers are tabulated in table 1.

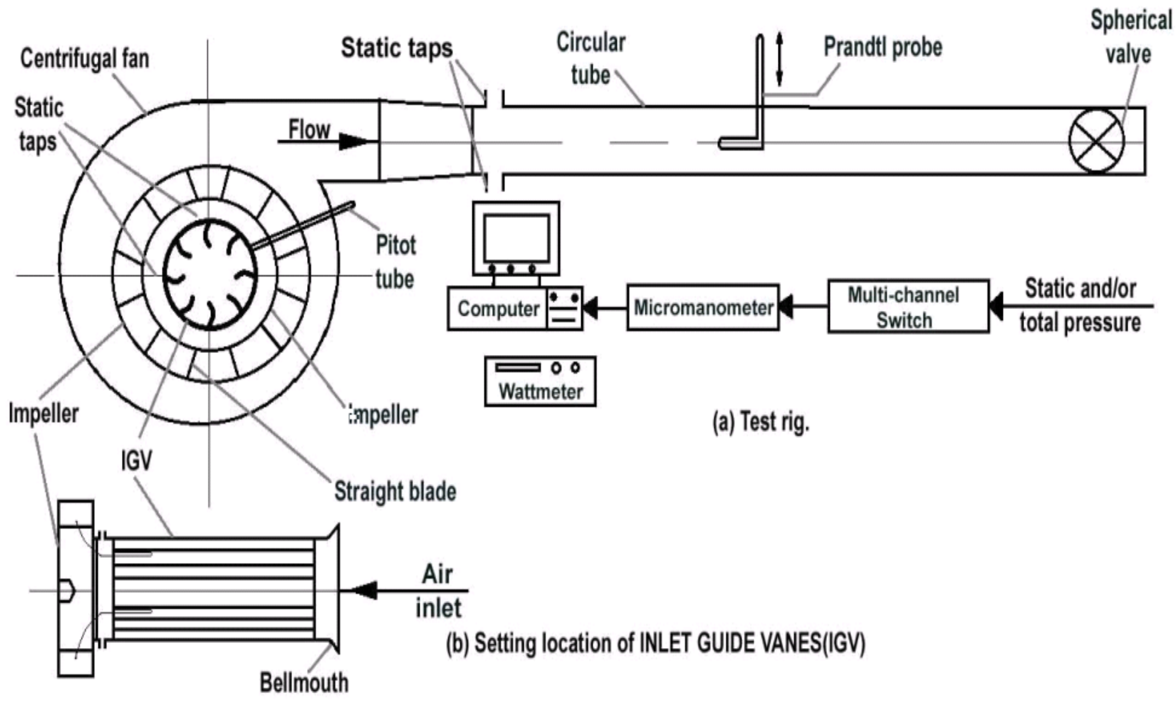

Fig. 1 Test rig measuring devices layout

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Table1: Characteristics of the different impellers

Parameters	Original impeller	Impeller I	Impeller II
Outlet angle; β_2	90^0	60^0	105^0
Inlet angle; β_1	90^0	25^0	125^0
Blade length (mm)	80	86	84

III. EXPERIMENTAL RESULTS AND DISCUSSION

The characteristics curves of the three different impellers tested are shown in fig2(a),(b)(c), 3(a),(b),(c) and 4(a),(b), (c). The measured delivery static head with calculated static efficiency and the shaft power are plotted versus the volume flow rate for each fan with different IGVs .Comparisons with the free inlet condition are performed on the same plots as shown in fig .2 (a), (b) &(c)

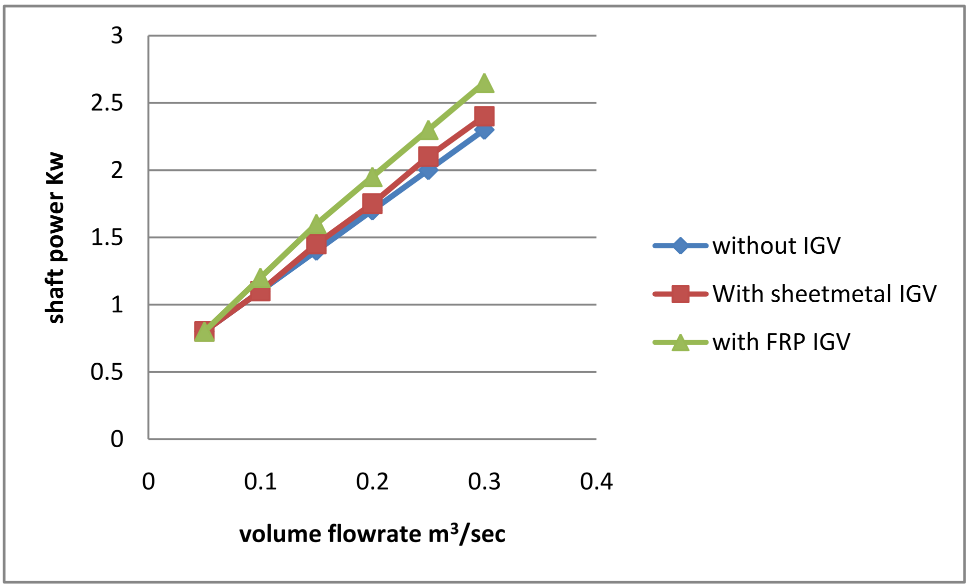

Fig.2 (a) Fan performance for radial vane impeller (β_2=90^o)

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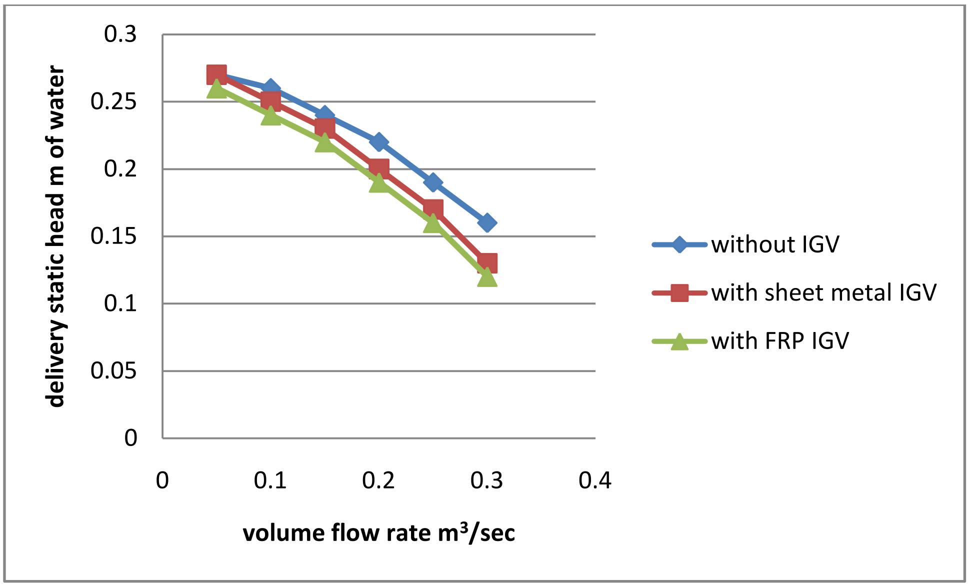

Fig. 2(b) Fan performance for radial vane impeller (β_2=90^o)

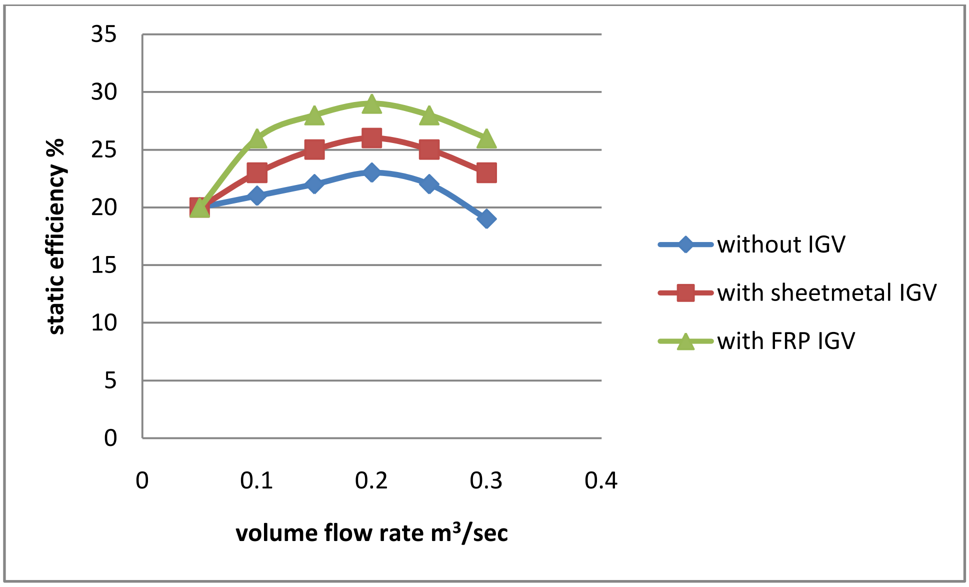

Fig. 2 (c) Fan performance for radial vane impeller (β_2=90^o)

At large flow rate, a remarkable increase in static head due to the sheet metal, FRP IGV can be noted after 0.15 m^3/ sec. Compared to sheet metal IGV the FRP IGV is shows an appreciable improvement in the fan efficiency.

The performance of the backward fan with 60^0 exit blade angle is as shown in fig.3 (a), (b) &(c) .A small drop in the static head associated with an increase in shaft power is observed. As the blade angle increases a lower efficiency is obtained all over the operating range at the free inlet condition. The use of inlet guide vanes leads to decrease in the flow rate. The FRP IGV leads to decrease in the maximum flow rate.

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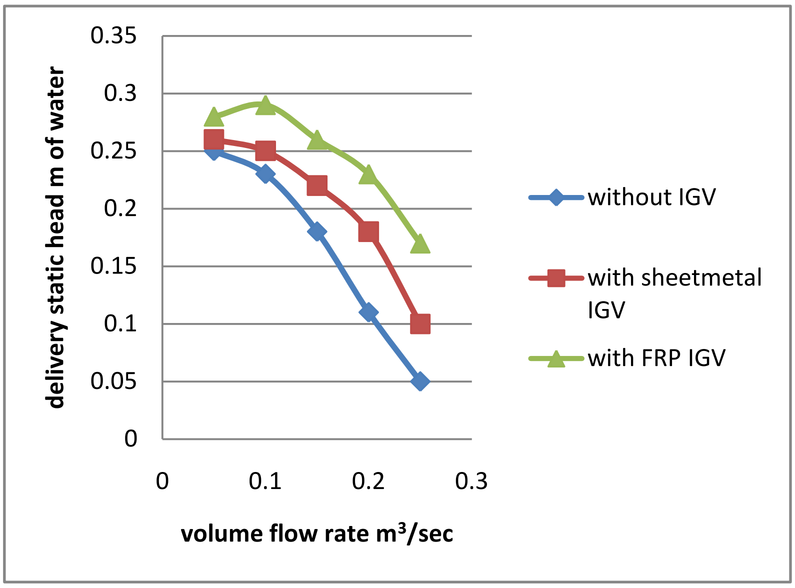

Fig.3 (a) Fan performance for backward vane impeller (β_2=60^o)

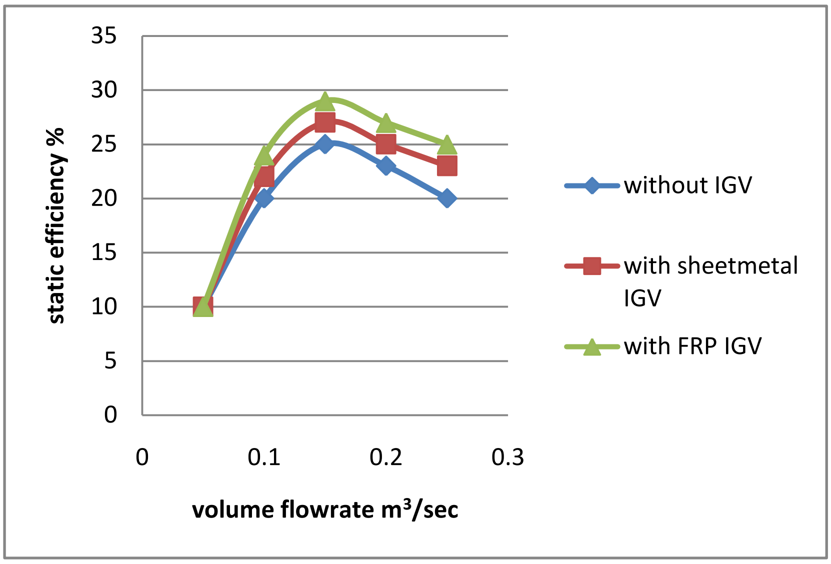

Fig.3 (b) Fan performance for backward vane impeller (β_2=60^o)

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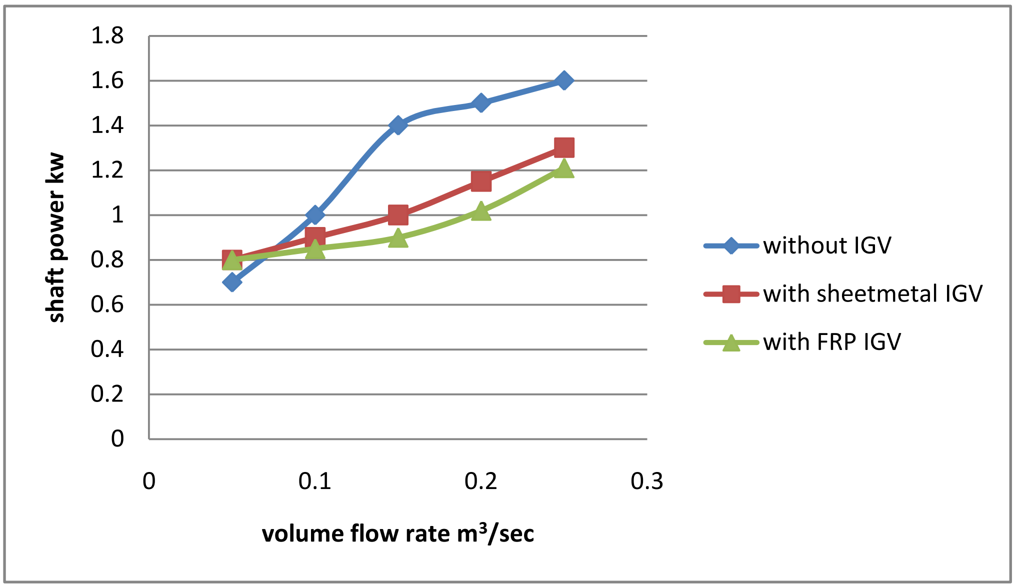

Fig.3(c) Fan performance for backward vane impeller (β_2=60^o)

Fig.4 (a), (b) &(c) shows the performance of the forward fan with exit blade angle 105^0. The use of different IGVs gives small increase in static efficiency on account of the appreciable drop in static head at the free inlet conditions. The fan efficiency is very low. This is due to separation of the flow inside the impeller passages.

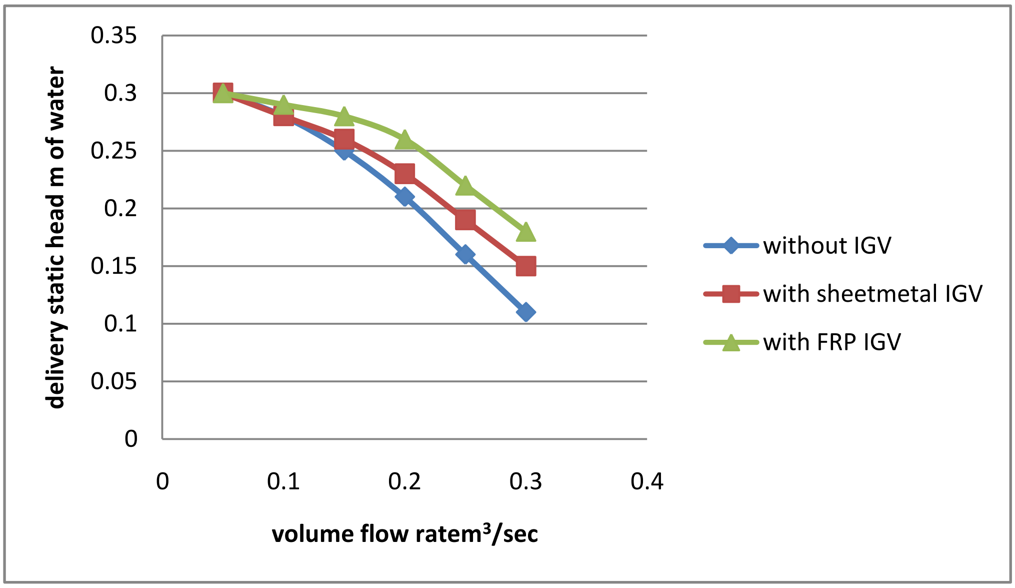

Fig. 4(a) Fan performance for forward vane impeller (β_2=105^o)

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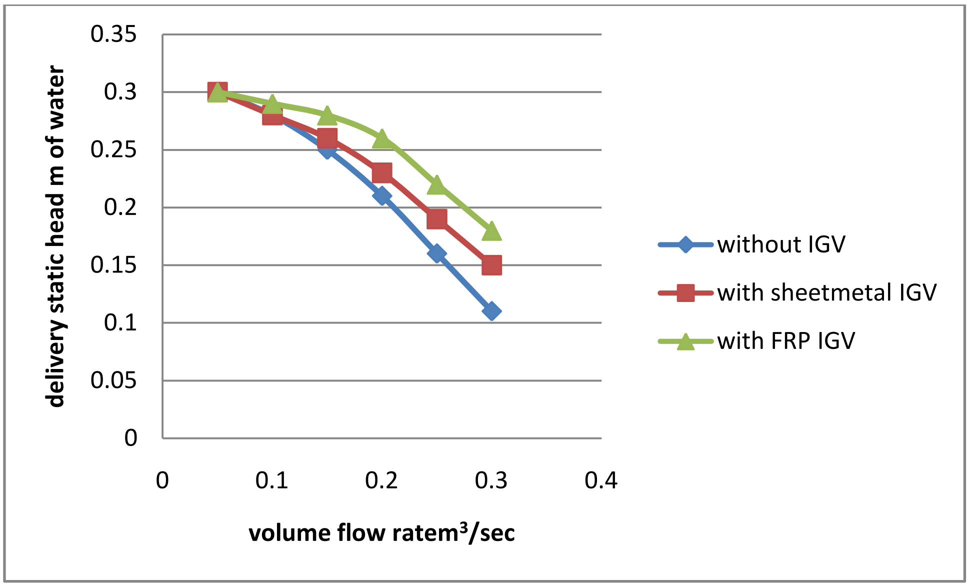

Fig .4 (b)   Fan performance for forward vane impeller (β_2=105°)

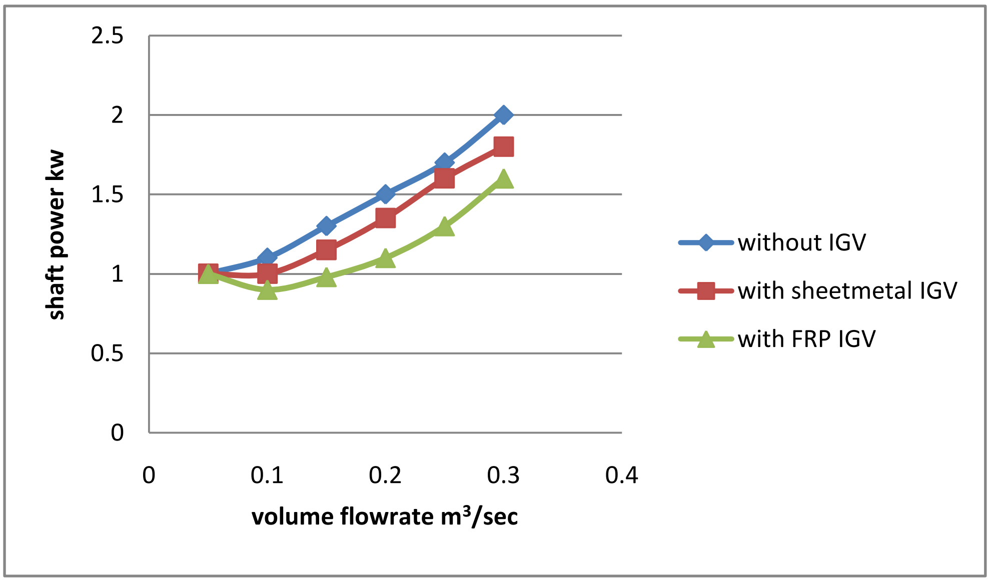

Fig. 4 (c)   Fan performance for forward vane impeller (β2=105°)

From the above results it can be noted that the effect of different IGVs on the fan performance varies according to the exit blade angles. From the results the FRP IGV with radial and backward blades are advisable for V.A.V. system in air conditioning.

IV CONCLUSION

The present paper investigates the effects of different type inlet guide vanes on the performance, operation range and energy savings of CF in V.A.V. System. Experimental investigations concerning radial cascade internal guide vanes with radial, forward, and backward impellers are conducted.

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1. The effect of IGV on the fan performance is mainly found to depend on the exit blade angle.
2. The flow margin increases for backward and radial impellers
3. The effect of IGV on energy savings varies with exit blade angle, for the backward impeller with angle 60^0 as well as for radial blades.
4. The modulation of flow by use of IGV with centrifugal fans increases the static efficiency as well as the consumption of energy saved.

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