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Design and Development of a 2hp Electric Motor Driven Blower for Local Blacksmith as a Substitute for Bellows

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ABSTRACT; *Poor supply and control of air are the main causes of failures in providing a complete combustion in furnaces. Lack of adequate number of blowers as well as the use of unsuitable type of blower also lead to the total collapse of foundry shops Blowers provides energy to the air, system, to assists to increase the pressure flow takes place from the low pressure side to high pressure side, this is not obtainable from bellows are used by the local blacksmith. This paper discuss the design of a centrifugal blower which will replace the bellows and give the required manometric efficiency that will aid adequate combustion as required. The blower was designed to convert 'driver' energy to kinetic energy in the fluid by accelerating it to the outer rim of the revolving device known as the impeller. The numbers of blades, capacity of electric motor ,manometric head were determined through a related and adopted mathematical formula the calculated parameters were accommodated to ensure optimal performance of the blower with an efficiency of 74.6%.*
KEYWORDS: *Blowers, centrifugal, efficiency, electric motor, manometric,*

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I. INTRODUCTION

The principles involved in the design of a blower is similar to that of a centrifugal pump except for the fact that the term "centrifugal pump" is often associated with liquid as its working fluid, while the blower is meant to work on air. The blower can therefore be described as a device, which converts „driver‟ energy to kinetic energy in a fluid by accelerating it to the outer rim of a revolving device known as an impeller. The impeller, driven by the blower shaft adds the velocity component to the fluid by centrifugally casting the fluid away from the impeller vane tips (Adekunle et al., 2008).

The stator and rotor magnetic cores are made of thin silicon steel laminations with non grain-to reduce hysteresis and eddy current losses. The stator and rotor laminations are packed into a single stack which is shown in Fig 1 or in a multiple stack shown in Fig 2.The latter has radial channels (5-15 mm wide) between elementary stacks (50 to 150 mm long) for radial ventilation. Single stacks are adequate for axial ventilation. Single-stack induction motors have been traditionally used below 100 kW but recently have been introduced up to 2 MW as axial ventilation has been improved drastically. The multistack concept is necessary for large power (torque) with long stacks. The multiple stacks lead to additional winding losses, up to 10%, in the stator and in the rotor as the coils (bars) lead through the radial channels without producing torque. Also, the electromagnetic field energy produced by the coils (bar) currents in the channels translates into additional leakage inductances which tend to reduce the breakdown torque and the power factor. They also reduce the starting current and torque. Typical multistack Induction motor are shown in For induction motors of fundamental frequency up to 300 Hz, 0.5 mm thick silicon steel laminations lead to reasonable core losses 2 to 4 W/Kg at 1T and 50 Hz. For higher fundamental frequency, thinner laminations are required. Alternatively, anisotropic magnetic powder materials may be used to cut down the core losses at high fundamental frequencies, above 500 Hz (Daut, K.2009)

II. METHODODLOGY

This design is made based on the following assumptions for maximum efficiency
Air enters the impeller eye in radial direction which makes the whirls component at inlet zero.
No loss due to shock at entry base on the above mentioned assumptions the design parameters are fairly estimated, these are:

- Blade inlet and outlet diameter
- Blade width
- Number of blades
- Number of blade revolutions per minute
- Manometric head
- Analysis of the various velocities during he blades operation
- The Motor horse power required
- The pressure rise across the impeller
- The overall efficiency and power developed by the blower.

2.1 DESIGN SPECIFICATION

This blower is expected to have the following ratings:
$Q = 6.77m^3/min$ (R.K Rajput 2008)
P = 2 – 10Kpa
Where Q= volumetric flow rate
P= pressure developed

a) Blades Diameters

From the optimum performance specification it is stated that the ratio of the internal diameter to the external diameter is to fall between 0.4 to 0.7 as stated in the ASME code.

That is $0.4 < D_1/D_2 < 0.7$, for this design

The ratio $D_1/D_2 = 0.65$ is taken;

If $D_1 = 182mm$

$$D_2 = \frac{D_1}{0.65} = \frac{182}{0.65} = 280mm$$

Therefore, $D_1 = 182mm$, $D_2 = 280mm$

b) Number of Blades

From ASME code, for optimum performance the number of blades is given by

$$C = \frac{8.5\,Sin\beta_2}{1 - D_1/D_2}$$

Where β_2 is the outlet vane angle which has a range of $20^0 < \beta_2 < 90^0$

For this design $\beta_2 = 81^0$ and $D_1/D_2 = 0.65$

$$C = \frac{8.5\,Sin\beta_2}{1 - D_1/D_2}$$

$$= 11 \text{ Blades}$$

c) Blade Width

It is given from ASME code specification that, the blade width is given by the formula. [Adejuyigbe, S.B. (2006).]

$$W = \frac{6(D_1/2)}{C+1}$$

Where C is the number of blades
W = 22mm

d) Number of revolution per minute

For a centrifugal blower to deliver an air, the centrifugal head must be equal to the total head [Edward, H.S. (1995)].

Thus, $\frac{U_2^2 - U_1^2}{2g} = H_{man}$

Where U_1 and U_2 are he respective impeller velocities at inlet and outlet.

$$U_1 = \frac{\pi D_1 N}{60} \qquad \text{and} \qquad U_2 = \frac{\pi D_2 N}{60}$$

So,

$$U_2^2 - U_1^2 = 2gH_{man}$$

Where, H_{man} is the manometric head
N = 1800Rev/min

e) The Manometric Head

This is head which the blower needs to overcome before it delivers and it is given as (Rajput 2008)

$$H_{man} = \frac{U_2^2 - U_1^2}{2g}$$

$$U_1 = \frac{\pi D_1 N}{60} H_{man} == 10m$$

f) Horse power required by the motor

This is given by the formula **(Addison et al 1995)**

$$\rho = \frac{Q\gamma H_{man}}{550}$$

Where, Q = volumetric flow rate m^3/s
$\gamma = \rho g$
ρ= density of air Kg/m^3

$$P = \frac{6.77 \times 1.002 \times 9.8 \times 10}{550}$$

$$P = 2hp$$

g) The pressure through the impeller

By applying the energy, equation from the entrance to exit of the impeller including the energy head.

$$\frac{P_2 - P_1}{r} = H_{man} - \frac{V_2^2 - V_1^2}{2g}$$

$$P_2 - P_1 = r\left[H_{man} - \frac{V_2^2 - V_1^2}{2g}\right]^2$$

$$P_2 - P_1 = 9.8 \times 1.002\left[10 - \frac{11.6^2 - 9^2}{2 \times 9.8}\right]$$

$P_2 - P_2 = 71Pa$

(h) Efficiency of the blower (Adekunle 2018)

The efficiency of the blower is given by

$$\int_m = \frac{\text{manometric head}}{\text{Head imparted by imepller to liquid}}$$

$$H_{man} = 10m$$

$$\text{Head imparted by impeller} =$$

$$\frac{V_{w2}U_2}{g} = \frac{7.3 \times 18}{9.8} = 13.4$$

$$\int_m = \frac{10}{13.4} = 74.6\%$$

This is the manometric efficiency developed by impeller

2.2 Production of the Blades

The number of blades were obtained mathematically to be 11,the production was done through casting of the blades in a mould using 100kg aluminum scraps heated to its melting point in a furnace.

FIG1 Casing showing the casted aluminium scrap blades

FIG 2 Assembled blower with housing

Fig 3 Assembled blower with housing and electric motor

III. DICUSSIONS AND CONCLUSION

A blower was designed, developed and tested to be used by local blacksmith to replace bellows. The development of this design will ensure a near-complete standardization of the 50kg capacity blacksmith furnace setup by ensuring uniformity in design since the blowers used are of various designs and most of them needed repair/modifications before they can perform satisfactorily. For optimum performance the ratio of internal diameter to external diameter falls between 0.4to 0.7(ASME).The diameter of the blade is a design parameter which others depend upon, The total energy imparted to the fluid as the diameter increases goes up by the square of the diameter increase. This can be understood by the fact that the fluid's energy is a function of its velocity and the velocity accelerates as the fluid passes through the impeller . The blower was specifically designed for blacksmith operation (50kg capacity) but it can equally be adapted for use in operations that needed air supply system for its smooth running, most especially in combustion-related operations.

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