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NEWLY DESIGNED TRACTOR MOUNTED AIR CARRIER CENTRIFUGAL SPRAYER: A STUDY

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ABSTRACT

The computer aided design of the wind tunnel setups used in the performance evaluation of blowers, and a new tractor mounted air carrier centrifugal blower for cotton crop. A computer aided design was prepared according to the AMCA (The Air Movement and Control Association) guidelines to obtain the specifications of the wind tunnel setup for the different blowers. The wind tunnel setup consists of the transition section, flow straightener and the tunnel. This paper deals with the fabrication of the various parts of the newly designed tractor mounted air carrier centrifugal sprayer. The techniques and equipment used for the performance evaluation of the centrifugal blower assemblies in the laboratory are also discussed.

Keywords: *Computer Aided Design, Wind Tunnel, Performance Evaluation, Centrifugal Blower, AMCA.*

Introduction

The basic parts of the sprayer were first fabricated and were then assembled and mounted on the frame. In this section, the fabrication of various diameter of 177 min and 600 apart from each other, the newly designed tractor mounted air carrier centrifugal sprayer are discussed.

The sprayer consists of the following parts:

- Impeller,
- Blower casing,
- Bearing block
- Frame for mounting blower casing,
- Power transmission unit,
- Horizontal triplex pump,
- Tank,
- Nozzles,
- Distributor, and
- Frame for mounting nozzles.

Impeller

The impeller consists of the central plate, blades and rings. It had sixty forward curved blades on one side of the central plate.

- **Central Plate**

The central plate was cut out of 3 mm thick aluminium sheet. It had the diameter equal to the outer diameter (53.31 cm) the impeller. At the centre of this plate, a hole of 73 mm was cut to fit on the plate of the bearing holes of diameter 12.5 mm were drilled at the pitch circle diameter of 177 mm and 600 apart from each other, for fixing the impeller on the plate which was keyed to the blower shaft.

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- **Blades of the Impeller**

The blades of the impeller were fabricated aluminium sheet of 1.5 mm thickness. The sheet was first cut into rectangular pieces of size 4 cm x 7.5 cm. Then these rectangular pieces were kept on the die and were punched to obtain the blade curvature. On the two side walls of blades, holes of 2 mm diameter were drilled for riveting. These holes coincided those made on the central plate.

- **Blade Shape**

The flow of air through the blade passage of a centrifugal fan impeller is often far from ideal, and the object of design of blade curvature should be to provide the minimum flow separation. In the absence of experimental information in such a term as to permit prediction of flow pattern to be easily made, most sheet metal blades join inlet angle B1 to outlet angle 32 as smoothly as possible with either a curve or a straight line.

A circular arc was convenient to manufacture for which a simple geometrical construction. After laying out inner and outer diameters of the impeller, line AB drawn from the outer circle at an angle B2 to the radius OA, and line OC was drawn at an angle B1+ B2 to OA to cut the inner circle at C.

Line AC (extended if necessary) would also cut the inner circle at D. Line AD was now bisected at right angles, the bisector meeting line AB at E. With radius AE (or DE) the circular blade profile was drawn. The justification for this construction is as follows.

$OAD = 900\ (\beta 2 + \delta)$

$ODA = 900 + (\beta 1 - \delta)$

$AOD = 1800\ (OAD + ODA)$

$1800 - (900 - \beta 2 - \delta + 900 + \beta 1 - \delta)$

$= \beta 2 - \beta 1 + 2\delta$

also $ODC = 1800 - ODA$

$= 1800 - (900 + \beta 1 - \delta)$

$= 900 - \beta 1 + \delta$

and $DOC = 1800 - 2\ ODC$

$= 1800\ (1800 - 2\beta 1 + 2\delta)$

$= 2\beta 1 + 2\delta$

$AOC = AOD + DOC$

$= \beta 2 - \beta 1 + 2\delta + 2\beta 1 - 2\delta$

$= \beta 2 + \beta 1$

- **Outer Ring**

The outer annular ring was cut out of 1.0 mm thick aluminium sheet. The outer diameter of the ring was 15 mm more than that of the impeller outer diameter and the inner diameter of the ring was 10 mm less than the impeller inlet diameter. This ring was then curved outwards at inner and outer diameter of the impeller. This gave strength to the ring. Sixty holes coinciding with those on the central plate were drilled.

- **Blower Casing**

The blower casing was designed to suit the impeller SO as to get the required discharge and velocity at the blower outlets. The circular shape of the casing was assumed to be best for delivering uniform and equal amount of discharge in the equally spaced eight outlets. The number of outlets i.e., eight, were selected based on previous work done and keeping in mind the cotton crop on which the sprayer is to be used. To direct the spray from the outlets onto the crop, flexible PVC pipes were used. The blower casing was made of 1.5 mm thick GI sheet.

In the frame side face of the casing, a circular hole of diameter 490 mm was made. To the inside of this face a circular ring of GI sheet was welded. On this ring six nuts each at 600 apart were welded and on the cut GI sheet six matching holes were drilled, so that the blower could be bolted to the bearing block. On the other face of the casing a circular hole of 45 cm diameter was cut to provide the inlet for air.

- **Frame**

The overall dimension of the frame was 830 X 630 mm. The blower assembly, water tank and the HTP pump assembly were mounted on the frame. An arrangement was made to bolt the bearing block on the back side of the frame. The water tank was positioned in the central space and was fixed to the frame with the help of clamps. At the bottom on the central line of symmetry the one-piece shaft of diameter 40 mm was mounted on the universal bearing. A pulley of 152 mm diameter was keyed to supply power to HTP pump on the tractor side of this shaft.

On the tractor side of the frame, two pins were provided 730 mm a part to fix the lower links of the tractor. One arm was provided on the frame at the top in between these two pins. This arm was fixed in place of the upper link. Two V- clamps supported the whole frame. The clamps were bolted to the frame at the bottom.

Power Transmission Unit

With the help of a universal coupling shaft, the power to drive the blower and the HTP pump was taken from the PTO shaft. At one end of this shaft, the inner splines were provided to fit on the PTO shaft and on other end the universal coupling was provided. This shaft was bolted to the pulley on the tractor side of the frame. Two belts transmitted the power from this pulley to the pulley on HTP pump. A sprocket with 90 teeth was keyed at the other end of the shaft. The power was transmitted from this shaft to blower shaft by means of chain and sprocket arrangement. On the blower shaft a sprocket with suitable number of teeth was keyed to get the required r/min. An idle sprocket was provided to keep the chain at required tension. The chain and the sprocket assembly along with the tensioner were enclosed with a cover. At the bottom of this cover an oil sump was provided to lubricate and cool the chain continuously.

HTP Pump

HTP or horizontal triplex pump (having 3 pistons) working in an oil bath has a free discharge capacity of 36 litres per minute. It consists of a crank case (oil bath chamber) and an assembly of three chambers, namely suction chamber at the bottom, valve chamber at the centre and the delivery chamber at the top. Pressure vessel to stabilise pressure and by-pass cone pressure regulator valve are mounted on the above assembly side by side. The valve drains off the extra quantity of liquid as well as it regulates the pressure. At the outlet of the delivery chamber, a cut off valve is provided. Piston and valves are made of stainless steel.

Tank for Chemical Solution

A cylindrical FRP tank was used for the storage of chemical solution. It had a capacity for 400 litres of solution. On the top centre of the tank an inlet was provided for filling in the chemical solution. The inlet was covered with a lid. The suction hose was connected to the bottom of the tank through the strainer. A strainer was also provided at the inlet of the tank. The by-pass hoses were connected to the tank from the top. An agitator was also provided inside the tank.

Nozzles

Eight nozzles were mounted on flexible PVC hoses at one end, while the other end of the hoses was connected to the eight outlets of the blower. Spraying Jet Nozzles were used. The nozzles contain the following parts:

- Housing AB41,
- Dosage Sleeve AB45 with 'O' Ring, AB46, and
- Nozzle, Tube, AB44.

The dosage sleeve has 4 apertures of different sizes on its periphery to give 4 different discharge rates. On the knob of the dosage sleeve there are 4 marks I, II, III and IV indicating the size of the holes in the dosage sleeve. Hole I is for the lowest rate of discharge and hole IV is for the highest rate of discharge. Table 1 gives the discharge rate of different apertures

Table 1: Discharge Rate of Different Apertures in a Nozzle

Aperture No.	I	II	III	IV
Discharge, 1/min	0.5	1.0	1.5	2.0

Distribution

The spray solution after being pumped from the HTP pump of is then directed to the distributor. The distributor was made of brass. The distributor distributes the spray solution uniformly to the eight nozzles of the sprayer.

Frame for Mounting Nozzles

The frame for mounting nozzles was made of angle iron. It was U-shaped and the base of which was bolted to the frame used for mounting the casing. The nozzles were attached frame with the help of thin strips of cast iron.

Assembling of Air-Carrier Sprayer

With the help of nuts and bolts, the HTP pump was mounted first on its plat form. It was 50 situated on the platform pulley that the pulley on the bottom shaft and the pulley on the HTP pump were aligned with each other in the vertical plane. Both are V-grooved pulleys and are driven by two V-belts. The FRP tank was then mounted in the central space allocated for the same. It was held in position with the help of two clamps. the suction hose was connected to the suction pipe of the HTP pump and the other end of the hose was connected to the strainer which in turn was connected to the outlet of the tank at the bottom. The by-pass hoses were connected to the by-pass valve and the other end were put in the hole made on the top of the tank.

On the back side of the frame, the bearing block was then mounted by means of six bolts. To the other end of the shaft, a sprocket of appropriate number of teeth was keyed and fixed in position by means of Allen screw, so that this sprocket and the sprocket on the bottom shaft are aligned with each other in the vertical plane. On these sprockets a chain was mounted. After mounting the chain, a tensioner was set in position to ensure the tightness of chain. The chain and the sprockets were then enclosed with a chain cover. Oil was then filled in the sump at the bottom. After this, the casing was mounted on the bearing block with the help of a ring having six holes. These six holes were then matched with the holes made on the casing and tightened in position by means of six bolts.

The impeller was then fixed to the plate on the blower shaft by means of six bolts. After this the cover plate of the casing was screwed in place. The frame for clamping nozzles was bolted on the blower assembly frame. Then one end of the 8 flexible PVC pipes of diameter 5 cm was clamped over the 8 outlets of the blower, while on the other end of each a CI sleeve diameter 4.5 cm was inserted. The nozzles were clamped over the sleeves. Then with the help of 8 thin strips of CI the nozzles were screwed to the frame. Their direction of spray was adjustable.

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