AN INVESTIGATION OF THE PERFORMANCE OF PROCESSING EGYPTIAN COTTON YARNS ON AIR JET WEAVING MACHINES

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ABSTRACT

To determine the air drag force on different Egyptian cotton yarns a test-stand is built to insert the weft yarn with air stream through a closed tube. The measurements are carried out by means of an electronic tensiometer and recorder. From the equation of air drag force, a theoretical term is delivered, which is named in this work as a form resistance. Different cotton types for different yarn counts and twist factor as well as different spinning system, ring and open end are examined. Single, plyed and core spun yarns are also inserted by air stream and air drag force are measured on stationary yarn at different inserted lengths. It was found that, spun yarns with coarser and short fibers as well as coarser spun and plyed yarns showed higher air drag force and form resistance. Yarn structure and amount of twist have an effect on the air drag force. The best distance for the closed tube from the nozzle was 25 mm and the diameter of the closed tube 20 mm to draw the yarn with higher air drag force.

NOTATIONS

dF	= air drag force on small yarn element	[CN]
ρ_{air}	= air density = 1.293	[kg/m^3]
d	= effective yarn diameter	[mm]
V_a	= air velocity	[m/sec]
V_y	= yarn velocity	[m/sec]
C	= air friction drag coefficient	
F.R	= from resistance = ratio of air drag forces	
υ	= dynamic viscosity of air	[kg/m.sec]

INTRODUCTION

On air jet weaving machines, the weft yarn is transported across the loom through an air stream. The transmission forces between air stream and yarn surface is not only influenced by the effective air stream but also very strongly by the air effective structure of the yarn surface (1,2). For filament yarns the effective yarn surface increases with lower yarn twist and higher number of filaments and by that also the force transmission by frictional resistance (2). Higher air effective yarn surfaces reduce the force acting in opposite direction of the weft insertion, caused by yarn balloons of the drum storage (3). Spun yarns have a higher hairiness and are transported more quickly due to higher air drag force given to the yarn (4). Furthermore the yarn velocity and consequently air drag force is influenced by fibre properties, such as cross-section, the substantial density and the crimp of the fibres, also the yarn properties depending on the spinning system (5).

The value of air drag coefficient, for a given yarn count, is dependent on the form of the yarn, twist factor, hairiness and yarn diameter as well as the fibres used. So that both the fibre properties as well as the spinning system will affect the air drag force. From the previous work (6), considering the fibre properties, the value of the coefficient of air drag is found to be dependend on Reynold's number Vd/υ, and if the fibres are combed or carded. As it was proved by El-Messiery et al [7] that the number of hair per cm will depending mainly on the number of fibre ends in a known weight of yarn, it is expected to have different air drag coefficient depending on the cotton fibre used.

The spinning system affect the packing density as well as the yarn diameter. Open end yarns were found [4] to have higher diameter and lower packing density than ring yarns.

The twist inserted in the ring spinning yarns increase the

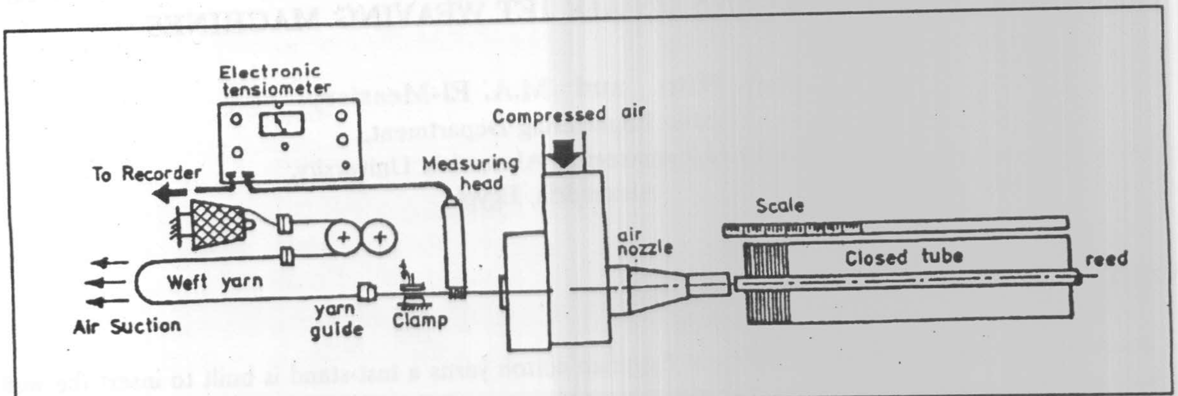

Figure 1. Shematic drawing of the experimental testing stand for weft insertion with air jet.

Type of fibres	yarn count Ne	Twist factor	Spinning system
Giza 75 carded Giza 80 carded	18 18	5 5	OE OE
Giza 80 carded	11 15 18	5 5 5	OE OE OE
Giza 80 carded	18 18 18	4.5 5.0 5.5	OE OE OE
Giza 80 carded	15 15	5 5	R.S OE
Giza 76 + Continous filament	36 36/2 36/3	767 T/m 767 T/m 767 T/m	core spum yarn

compact density of the yarn as well as the angle of laying of the fibres with respect to the yarn axis.

So that both the value of twist and the direction S or Z are expected to affect the air drag coefficient.

SCOPE OF WORK

In this work, the effect of two types of Egyptian cotton, spinning parameters, i.e, yarn count, yarn twist, spinning system, ply and core spun yarn as well as machine parameters on the air drag force and air drag friction coefficient when the inserted yarn by air blow on stationary and at a different yarn lengths through a closed tube is studied.

EXPERIMENTAL WORK

Measurement of Air Drag Force

In order to carry out this work a test stand was built Fig. 1. This test stand consists of main nozzle, a closed tube as a confusor and is connected to a reed, package carrier, air suction storage device and a compressor to feed a compressed air to the nozzle. The process of opening and closing the nozzle is carried out by means of cam and lever.

The air drag force was measured on a stationary yarn with different inserted lengths by means of an electronic-tensionmeter " Rotschild" model R 1092. The output of the tensionmeter is connected to a recorder for recording the value of tension obtained during air blow on the yarn. The reading of tensionmeter and the movement of the pin on the recorder was calibrated daily before getting any reading. Different spinning and yarn parameters were examined to study its effect on the air drag force. Experimental conditions are given in table (1).

The machine parameters which were investigated, were the distance between the nozzle and the closed tube as well as the diameter of the closed tube. Four distances, 15, 20, 25 and 30 mm were chosen and two tubes with a diameter of 20 and 25 mm were studied.

Air Friction drag coefficient

Air drag force dF acting on small yarn element dl was studied by many workers (8,9), where

$$dF = \tfrac{1}{2}\,\rho_{air}\,C\,\pi\,d\,.\,(V_a - V_y)^2\,.\,dl \qquad (1)$$

The air drag force acting on a stationary yarn can be written as

$$dF = \tfrac{1}{2}\,\rho_{air}\,C\,\pi\,d\,(V_a)^2.\,dl \qquad (2)$$

where V_y = zero

The yarn diameter d as well as the air density can be put to be constant, then

$$dF = K.C.\,V_a^2.\,dl \qquad (3)$$

where $K = \tfrac{1}{2}\,\pi\,d\,\rho_{air}$

To study the effect of the mentioned parameters on the behaviour of the yarn in air stream, let KC V^2_{air} as a new term named as form resistance "F.R". then the ratio of two air drag force for two examined parameters

$$\frac{dF_1}{dF_2} = \frac{(K.C.V_a^2)_1}{(K.C.V_a^2)_2} = \frac{(F.R)_1}{(F.R)_2} \qquad (4)$$

where $[(F.R)_1/(F.R)_2]$ is the form resistance ratio.
This ratio can be calculated from the measured air drag force, and gives acceptable prediction for the air drag friction coefficient.

RESULTS AND DISCUSSION

Following are the results of studied parameters and also the discussion of each effect on the form resistance value.

Effect of Cotton Type

Fig. 2 shows the relation between the stationary length of the inserted yarn and the measured air drag force for two yarns of the same count and different cotton type. It is clear that the yarn made from Giza 80, which is shorter in fibre length and coarser than Giza 75, has higher air drag force. The difference in air drag force increases as the stationary yarn length increases. This is because the value of form resistance KCV^2 in equation (3) for the yarn spun from short and coarser fibres, Giza 80, is higher than Giza 75. The value of the ratio of form resistance against the stationary length of the yarn is plotted in Figure 3. It is seen that the ratio of the form resistance at short stationary lengths very small because the average air velocity V_a approximately the same, while the difference in air drag friction coefficient is only the factor which has increased the form resistance ratio greater than 1. This

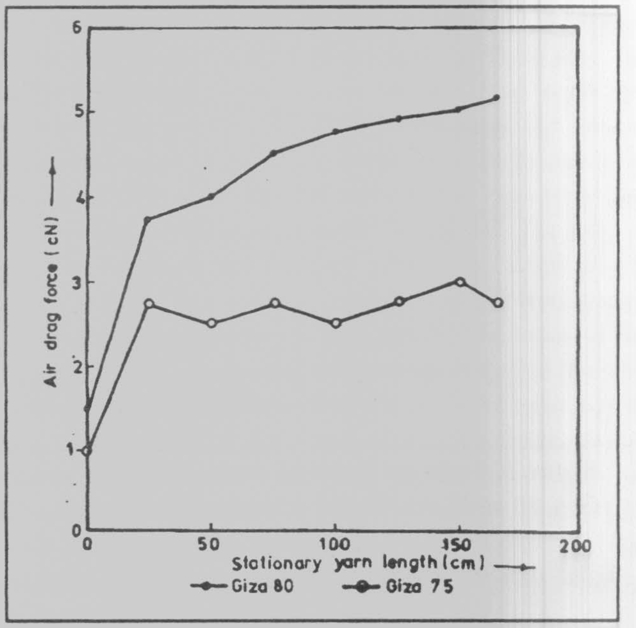

Figure 2. Effect of cotton type on air drag force pof O.E.yarn.

means that, the air drag friction coefficient for Giza 80 is higher than Giza 75. This behaviour, as expected due to higher yarn hairiness.

Among 25 cm increases the form resistance ratio as the stationary yarn length increases. This increase is actually due to the increase in average air velocity for Giza 80 than Giza 75. as a result to the difference in yarn structure and air drag friction coefficient.

Effect of yarn Count

The effect of yarn count on air drag force is shown in Figure 4. It can be seen that the air drag force is affected by the yarn linear density. An increase in the air drag force is due to increase in the outer surface of the yarn i.e. the yarn diameter "d". The ratio of air drag force plotted in Figure 5 against the stationary yarn length showed that an increase in the form resistance of yarn Ne = 11 than that Ne = 15 is equal to 1,17 which also equal to the ratio of $\sqrt{15}/\sqrt{11}$, the ratio of the roat of yarn count (Ne). This value is constant whatever is the yarn length. It is also clear from Figure 5 that, the ratio of form resistance for yarn 18^5 and 15^5 equals to 1.09 and 11^5 and 18^5 is 1,27. which is also proportional to the roat of Ne.

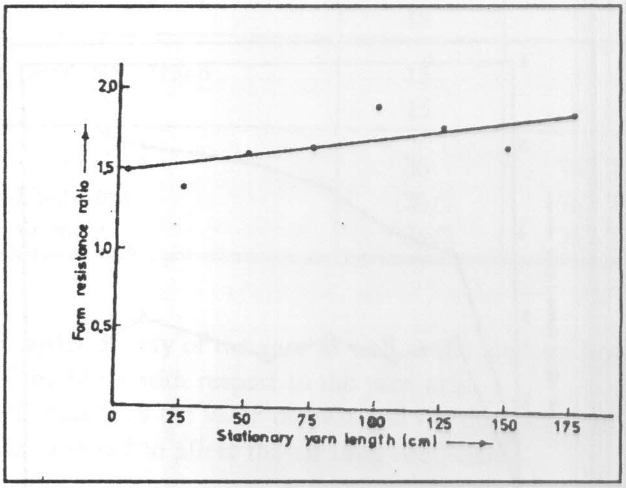

Figure 3. Relation between form resistance ratio of Giza 80 and Giza 75 and stationary yarn length.

Effect of Yarn Twist

Wahhoud (2,4) was found that, as the yarn becomes closer, i.e, highly twisted, the weft insertion time increases. This increase in weft insertion time had registered at the end of the yarn passage when the yarn becomes slower in its movement. This means that, the twist given to the yarn affect on its speed as the width of the weaving machine is increased. The results shown in Figure 6, show that after a length of 150 cm an increase in air drag force is registered for low twisted yarn, i.e. the form resistance showed lower value after 150 cm for highly twisted yarn.

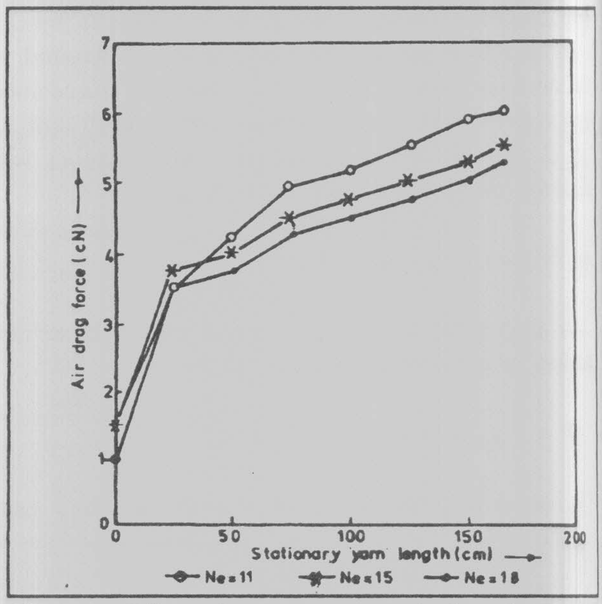

Figure 4. Effect of yarn count on air drag force.

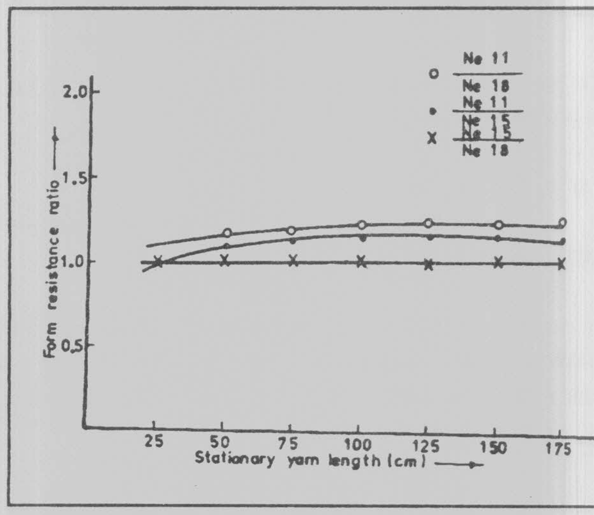

Figure 5. Relation between form resistance ratio for different yarn count and stationary yarn length.

These results ful- fill the same result of the workers (2,4) and also as expected due to the compactness of the highly twisted yarn.

Effect of Spinning System

As the yarn structure of OE varies than that ring spun yarn, the behaviour on air jet weaving machines may also be vary. It is clear from fig. 7 that the OE yarn has higher air drag force than that ring spun yarn. At the start of movement the air drag force was equal, but as the length of the yarn increases a higher value of air drag force for OE yarn was registered. The ratio of form resistance is shown in Figure 8. From the result, we found that the gain in form resistance was equal to 2 at a distance 25 cm from the nozzle and behind this length the value was decreased to 1.25. This means that, the increase in form resistance for OE yarn is higher than ring spun yarn by 25 % as a result of the lower packing density of OE than ring yarn.

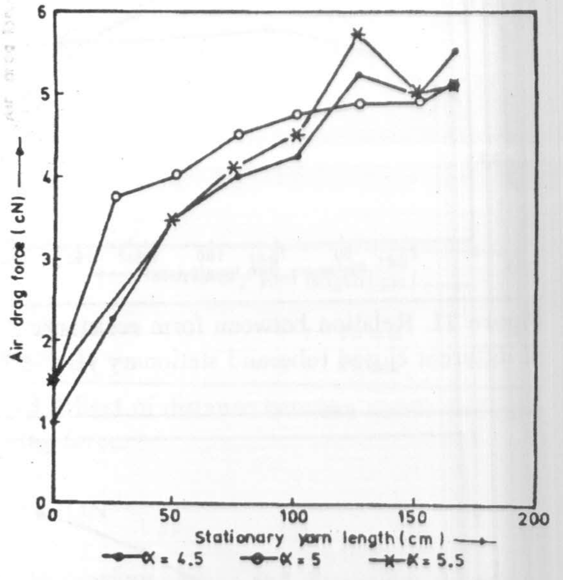

Figure 6. Effect of twist factor on air drag force.

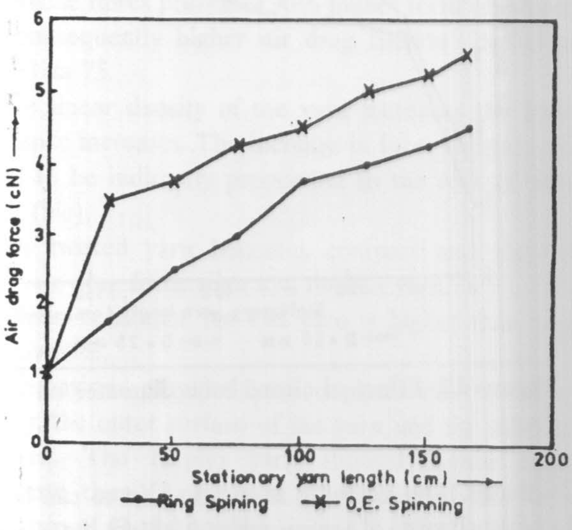

Figure 7. Effect of spinning system on air drag force.

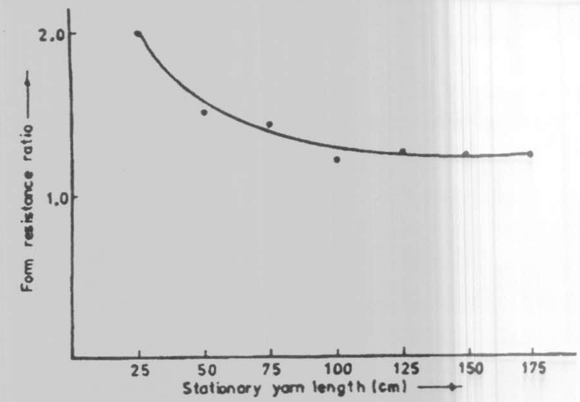

Figure 8. Relation between form resistance ratio of O E and ring yarn and stationary yarn length.

Effect of Yarn Plying

The difference in linear density and surface characteristics of single to plyed yarns showed a difference in air drag force. Figure 9 shows that the plyed yarn, (n) folds, which has higher linear density, had registered higher air drag force than that of single yarn. The ratio of form resistance of 36/2 to single yarn 36 is shown in Figure 10. It is seen that, the value of the form resistance at start was 1.6 and at the whole length 1.2. The ratio of the outer yarn surface of plyed yarn to the single yarn is equal to 2 and this value is registered at the start when

The stationary length is very small. The cause of the difference at a longer stationary length is due to the twist given in the played yarns. For yarn 36/3 the ratio may be less than 3 because the area of contact between yarn decreases the outer surface area as shown in Figure 10. The form resistance ratio of 36/3 to 36/2 is equal to 1.25. This value is the maximum value and can be, experimentaly, less than 1.25 due to amount of twist imparted to the yarn.

It is clear from Figure 13, that the max. air drag force measured on the yarn is when the distance between the closed tube and the mouth of the nozzle is 25 mm. When

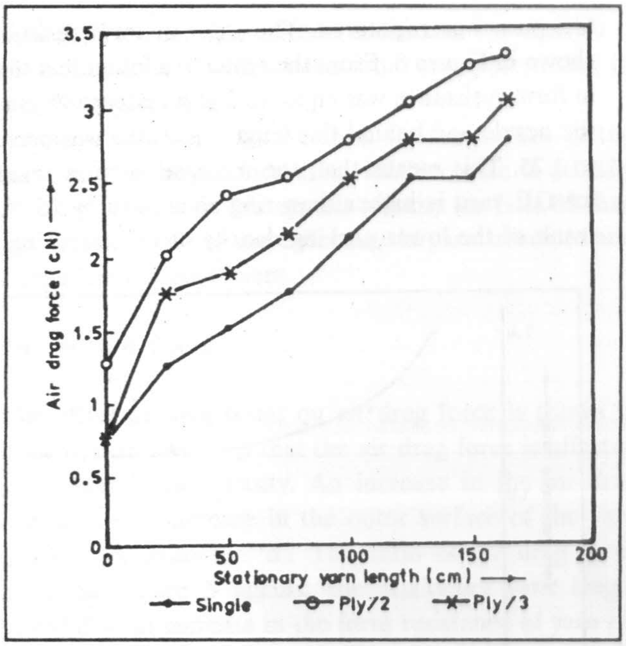

Figure 9. Effect of ply on air drag force.

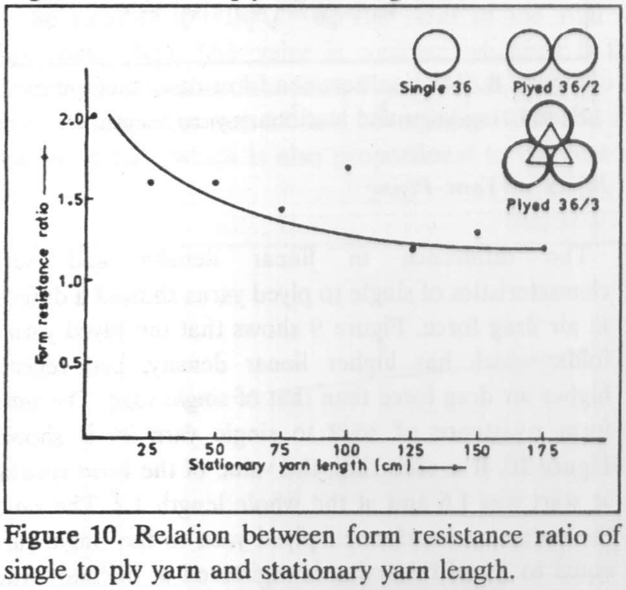

Figure 10. Relation between form resistance ratio of single to ply yarn and stationary yarn length.

this distances decreases the measured air drag force

Effect of Machine Parameters

Some machine parameters affect the air drag force such as the distance between the closed tube and the mouth of the nozzle as well as the diameter of the closed tube. Figure 11 shows the effect of two tube diameters 20 mm and 25 mm on the air drag force. It is seen that, as the diameter of closed tube decreases the air drag force had increased. The increase in air drag force is due to the increase in the form resistance KCV^2 Figure 12 and actually due to the increase in the axial air velocity imposed to the yarn.

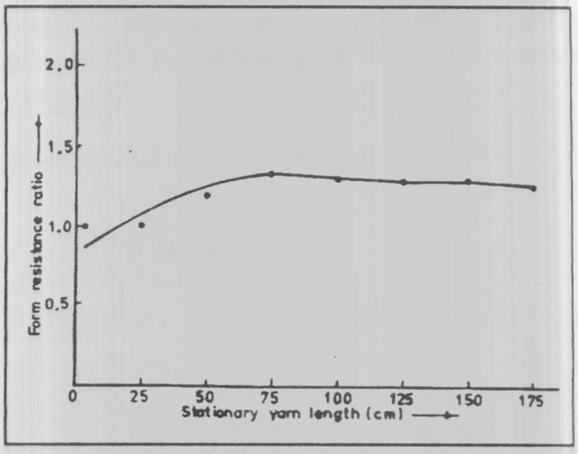

Figure 11. Relation between form resistance ratio of different closed tube and stationary yarn length.

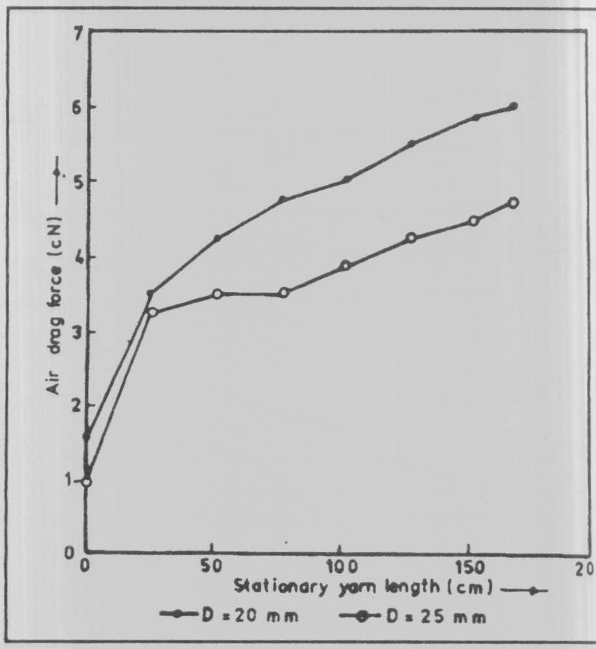

Figure 12. Effect of closed tube diameter on air drag force.

decreases. The decrease in air drag force can be due to the disturbance of the air when it enters the closed tube. Above 25 mm distance had not the measured air drag force any other increase. This means that, the optimum distance to set the closed tube, or in practice the confusor, is 25 mm from the tip of the nozzle.

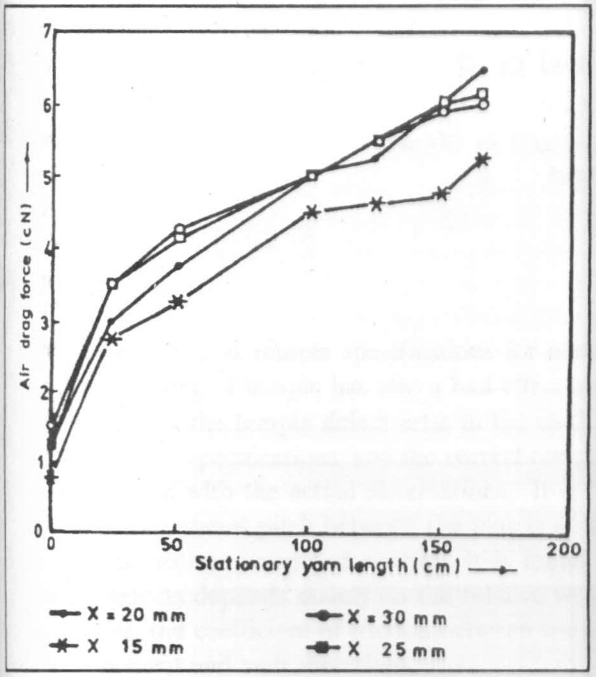

Figure 13. Effect of distance between nozzle and tube on air drag force.

CONCLUSION

From the previous results and discussions the following conclusion can be deduced:

1. Yarns spun from Giza 80 which has relatively short and coarse fibres possesses 70% higher form resistance and consequently higher air drag friction coefficient than Giza 75.
2. As the linear density of the yarn increases the form resistance increases. The increase in form resistance is found to be indirectly proportion to the roat of yarn count (Ne).
3. Highly twisted yarn becomes compact and showed lower air drag force than low twisted yarn.
4. The form resistance for OE yarn is higher than ring yarn by 25%.
5. The behaviour of plyed yarn depends on the linear density, the outer surface of the yarn and the amount of twist. The (2-ply) yarn showed higher form resistance than (3-ply) yarn. The ratio of the form resistance of (2-ply) to the single is 2 and (3 ply) to (2 ply) is 1.25.
6. The best distance for the air guide or closed tube on air jet weft insertion system 25 mm. Also small diameter air guide, confuser or closed tube increases the axial air velocity than large diameter tube.

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