A REVIEW OF AIR CONSUMPTION ON AIR JET WEAVING MACHINES

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Abstract – *Air-jet is one of the leading and successful highest productive weaving machine. However, due to addition of charges of compressed air, manufacturing cost on air-jet weaving machine is higher as compared with rapier and projectile weaving machines. This is making air jet less preferable where energy cost is the problem, despite their high production speeds. In this regard, several researchers and machine manufacturers have continuously been working to improve the efficiency of air-jet weft insertion. Studies which have been taken to reduce air consumption, included manufacturing of different parts i.e. researches have been taken place on the manufacturing levels. Although some effort have been made to improve the efficiency of compressed air usage, the effort has not been uniform. There is still a critical need to understand the energy loss or consumption in filtration, distribution and machine usage in the textile industry. Due to technical barriers, reducing energy consumption by compressed air systems has been viewed as a complicated task. Intensive efforts have been made by researchers and air-jet loom makers to overcome this problem and achieve a dramatic reduction in air consumption without any decrease in loom performance and fabric quality, but due to faulty mill practices and ignored settings, air consumed by looms is on higher side. By improving work practices, we could save the compressed air.*

Key Words: Air-jet weaving machine, yarn, weft, count, reed, nozzle.

1. INTRODUCTION

In Textile industry, Air-Jet is one of the leading and successful highest productive weaving machine. However, due to addition in the charges of compressed air, manufacturing cost on air-jet weaving machine is higher as compared with Rapier and Projectile weaving machines. This leads to energy issues. Therefore several researchers and manufacturers have continuously been working to improve the efficiency of air jet weft insertion. The aim is to investigate the air consumption of air jet weaving on industrial practice.

Main reasons for difference of air-jet consumption on air jet weaving machines are - distance between compressor and weaving machine, number of joints, unnecessary valve opening and pipe leakages etc. which leads to an increase in compressed air consumption. This is making air jet less preferable due to energy cost problem, despite their high production speeds. The Table – 1 below shows the power consumption on various weaving machines.

Table -1: Power consumption on various machines.

Types of Looms	Power Consumption/ Loom shift of 8 hrs (Units)
Non-Auto	5.9
Auto	8.8
Auto High Speed	11.8
Projectile	14.7
Rapier	17.6
Air-jet	20.6 + 30 (For Air Compressor)

The air consumption varies with almost all machines, though machines are of same manufacturers and model. The air is filtered and compressed before using in machine. Due to significant compressed air consumption and extra cost of electricity, the manufacturing cost on air jet weaving increases.

Air jet weaving machines belong to the set of intermittent-operation weaving machines. The energy resulting from air pressure directed from the central air tank to the weaving machine changes into kinetic energy in the nozzle, which accelerates and delivers the weft in the differently formed air channels. The speed of air exiting the nozzle is near or sometimes over the local sonic speed. The air leaving the nozzle mixes with the still air, it disperses, and the speed of the axis of the flow drops quickly as it moves away from the nozzle, therefore in order to reach bigger reed width the air speed must be kept high in the line of the weft course.

The forces which are required to move and accelerate the weft yarn are produced by the air jet. These forces have to be higher than the combination of the force of the inertia and the resistance forces of the yarn bobbin and the reserve system. The carrier and the resistive force characteristics are defined by the consideration of weft yarn properties and physical properties of the air flow. Air velocity and yarn structures have complex interrelations due to their properties, such as turbulent and laminar air flow, yarn diameter, linear density (count) and elasticity.

Air flow is important to increase weft velocity and productivity, therefore it must always be controlled, due to the change in the yarn count and the coefficient of twist. When the coefficient of twist increases, the weft velocity decreases. Also when the yarn count (Tex) increases, the average velocity increases. Weft yarn velocity for the Toyoda type weaving machine has been studied by Hasegawa et al. This velocity achieves a certain average value along the weft insertion. It reaches constant speed at a certain time which is such a function of the weft diameter that it increases due to the increase in diameter.

2. LITERATURE REVIEW

According to Uno, the insertion force at a constant diameter weft increases due to the increase in air velocity. With the decrease in weft diameter, the insertion force also decreases. For this reason, it was observed that the velocity of the weft yarn has a smaller value. Some researchers studied various loom parts such as nozzle, reed, and valves to improve the filling insertion and reduce air consumptions and thus developed an optimum main nozzle design.

Picanol developed the air-index as a measure of weft yarn suitability for air-jet weaving and also introduced a new relay nozzle design with 16 holes to reduce air consumption. Dornier developed a PIC (Permanent Insertion Control) system for permanent monitoring of the most important filling insertion elements. Similarly, Sultex claims outstanding results with regard to compressed air consumption on L5500 looms with the new AWC (Active Weft Control) system. Other loom makers also claim substantial reductions in air consumption following new developments in their designs.

In air jet weaving machines weft is accelerated and taken through the shed by the flow impedance between the flowing air and the weft. The energy resulting from air pressure directed from the central air tank to the loom changes into kinetic energy in the nozzle, which accelerates and delivers the weft in the air channels which are of different shape according to loom types.

M. M. Islam studied the nature of air leaving the nozzles. In his research, he states that air leaving the nozzle mixes with the still air, it disperses and the speed of the axis of the flow drops quickly as it moves away from the nozzle. Different systems have mainly been used to reduce air consumption on commercial air jet loom viz. air pressure, main valve drive time and relay valve drive time, pick insertion and pick arrival time, multiple nozzles with guides, multiple (relay) nozzles with tunnel reed etc. By maintaining the air pressure of the air jet loom along the main valve and relay valve drive time, low air will be consumed without hampering product quality.

Corrado Grassi and Achim Schröter researched on performance and cost effectiveness of air-jet machine. The air-jet weaving machine combines high performance with low manufacturing requirements, because they are different from rapier and projectile machines. The filling medium here is just air and no mechanical parts are directly involved in the weft insertion process. It has an extremely high production rate up to 1,100 weft insertions per minute and it covers a wide range of processing yarns like spun and continuous filament yarns. However, the main drawback of the technology is the very high energy required in the usage of compressed air during the weft insertion process. Since the cost of energy has increasing trend, power consumption is still a challenging issue. Air-jet weft insertion systems are currently used in all kinds of fibers and yarns. The weft is moved by the friction created by the high speed flow of the air jet loom. The air jet force is required to move and accelerate the weft yarn. These forces should be higher than the inertia and resistance. It is defined in consideration with the characteristics and physical properties of the air flow, and its concerned resistance properties.

Jin Hyeon Kim, Toshiaki Setoguchi and Heuy Dong Kim studied the numerical study of sub-nozzle flows for the weft transmission in an air jet loom. In that they state that the actual air speed depends on the properties such as turbulent air flow or laminar flow, a constant thread diameter, linear density and elasticity. The complex relationship between the air flow speed and productivity of weft is important. It is controlled so as to change the count and twist factor at all times. If the twist coefficient increases, and the speed of the weft is reduced then the average speed goes up.

The combination of low manufacturing requirements and high performance of air-jet loom has many advantages, such as inserting a very high speed, high productivity and low initial expenditure, a simple operation of moving parts, reduced risk, low noise and vibration levels. The weft yarn speed is mainly affected by air guides. In air jet weaving machines weft is accelerated and taken through the shed by the flow impedance between the flowing air and the weft. The movement of the inserted yarn in weft passage is a complex motion. It is not a positively controlled process. Three different systems have been used on commercial air jet looms - single nozzle, confusor guides and suction on the other side, multiple nozzles with guides, relay nozzles with profile reed.

M. Cengiz Kayacan studied velocity control of weft insertion on Air Jet Looms. The working principles of air jet weaving machines are based on carrying the yarn by the friction of the air jet. During the yarn's forward movement by the air in the sheds, the velocity of the weft yarn decreases because of the decreasing pressure and the disturbance on the air flow direction. The air jet must provide a constant speed to the weft yarn along the weaving wideness. However, weft yarn of a certain mass is carried by a single jet at a limited distance. That is why the relay nozzles are installed at certain distances, in order to prevent a decrease in yarn velocity. These are implemented on a movable hollow-needle or slay system. The basic function of the main jet is to load the weft yarn into the shed, and then to carry it to the first relay nozzle at a certain speed. The weft yarn suddenly reaches high velocity by means of the main jet. To prevent weaving defects and asynchronous beat-up movement, the weft yarn position and the instant velocity of the weft yarn must be fully controlled during the weaving process.

3. CONCLUSION

Use of Air-jet weaving machines, despite of high production speeds and highest successful productive weaving machines is being limited due to addition of compressed air charges as compared with other conventional & unconventional weaving machines. Researchers and machine manufacturers are continuously working to improve the efficiency of air-jet weft insertion on manufacturing levels.

Air consumption is also due to some wrong settings, ignorance, etc. which can be reduced without any investments which may lead to increase the profits. Mill workers adopt hit and trial practice in weaving industry including air pressure setting which leads to variation of nozzle pressure. Intensive efforts have been made by researchers and air-jet loom makers to overcome this problem and achieve a dramatic reduction in air consumption without any decrease in loom performance and fabric quality, but due to faulty mill practices and ignored settings, air consumed by looms is on higher side. Savings in the compressed air can also be achieved by improving work practices and optimising main nozzle and relay nozzle settings.

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