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# Air Consumption Analysis of Air-Jet Weaving

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## ABSTRACT

In Textile industry, production is mostly key concern for Industry owner. This always has attracted researchers and machines manufacturers to make new developments in process and machines. Air-jet is one of the leading and successful highest productive weaving machines. However, it is now well established that due to add of charges of compressed air, manufacturing cost of air-jet weaving machine is higher as compared with rapier and projectile weaving machines. This is why countries having energy issues do not prefer air-jet weaving machines comparing projectile weaving machines. In this regard, several researchers and machine manufacturers have continuously been working to improve the efficiency of air-jet weft insertion. However, industry practice is as important as design made by researchers. The aim of this research is to investigate the air consumption of air-jet weaving on industrial scale practice. In this study, five weaving machine of same manufacturer and model were selected. It was observed that despite of manufacturing same quality of fabric, air consumption was varying almost in all weaving machines. Conventionally, mill workers adopt hit and trial practice in weaving industry including air-pressure setting which leads to variation of nozzle pressure. Main reason of disparity of air consumption in air-jet weaving machines may be variation of distance from compressor to weaving machines, number of joints, un-necessary valve opening and pipes leakages cause an increase of compressed air consumption.

**Key Words:** Air-Jet Weaving, Compressed Air, Main and Sub Nozzles.

## 1. INTRODUCTION

**A**ir-Jet weaving machine is one of the successful and high productive shuttle less weaving machine in Textile industry [1]. An air-jet is device used to insert the weft yarn by using high air pressure. The air is filtered and compressed before using in air-jet weaving machine. Due to significant compressed air consumption and extra cost of compressor electricity, the manufacturing cost of air-jet weaving increases. This is making air-jet weaving less preferable where energy cost is the problem despite their high production speed.

Though air-jet weaving machines manufacturers and researchers have been continuously working on reduction of air consumption in their new design to overcome this drawback. Yet, there is still deficiency of reliable information on energy efficiency of compressed air for industries [2-7]. Adanur and his team analyzed the use of compressed air for weft insertion process and investigated the effect of yarn characteristics and compressed air [8-12]. Beside the researchers air-jet weaving machine manufacturers put several efforts to improve the weft

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insertion by compressed air. Picnol developed air-index system to measure the weft yarn suitability for air-jet weaving [13]. Donier introduced PIC (Permanent Insertion Control) for monitoring of insertion element [14].

Despite the efforts made by researchers and machines manufacturers, it is observed that efficiency and air consumption has not been achieved at industrial scale. This study aims to analyze the air consumption of air jet weaving at industrial scale practice. Focus was made on important parameters such as air consumption on main nozzles, sub nozzles, opening and closing of nozzles with respect to degrees etc where significant percentage of compressed air is consumed.

## 2. MATERIALS AND METHODOLOGY

**Selection of Weaving Machines:** Five Air-Jet weaving machines were selected to analyze the air consumption at different stages of weaving. All five air-jet weaving machines were made by Toyota Company Model JAT 710. The details of air-jet weaving machines are given in Table 1.

**Material:** Following is fabric quality made on each air-jet weaving machine.

Fabric Construction:  $75 \times 30 / 100 \times 72 = 106''$

Where Warp count (English) =75, Weft count (English) =30, Ends/Inch= 100, Picks/inch=72, Width of Fabric (Inches)=106.

**Methodology:** Air flow meter is a device used to measure overall compressed air consumption of Air-Jet weaving machine. The device may be installed at different parts of weaving machine to check the air-pressure as well as air-pressure required for whole machine as shown in Fig. 1. The input (air connection) for part of weaving machine may be connected with air flow meter and out-put (air connection) of air flow meter may be connected to part of weaving machine in order to measure the air-pressure. In

this study, the air flow meter is digital and measures the air consumption of Air-Jet weaving in cfm (Cubic Feet Per Minute).

## 3. RESULTS AND DISCUSSION

### **Air Consumption at Main Nozzle of Air-Jet Weaving:**

Every nozzle (Main or sub) require certain pressure of air to accomplish its job. The pressure of air for main nozzle is set according to the count of weft yarn; coarser weft yarn requires high pressure as comparative to the finer weft yarn. Therefore, the settings on all following Air-Jet weaving machines were set by machine operators according to the count of weft yarn. However it is not possible to set same pressure for all weaving machines. There are various factors involved to set the air pressure such as distance from compressor to weaving machine, elbows etc.

TABLE 1. AIR-JET WEAVING MACHINES USED FOR AIR CONSUMPTION

Air-Jet Weaving Machine No.	Width (cm)	Speed (ppm)
1.	360	600
2.		
3.		
4.		
5.		

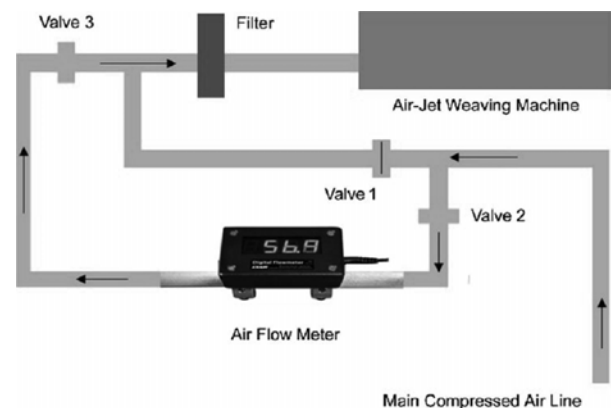


FIG. 1. LINE-DIAGRAM OF AIR CONSUMPTION MEASUREMENT BY AIR FLOW METER

Fig. 2 presents analysis of air pressure of main nozzles of different air-jet weaving machines. Air pressure is directly proportional to air consumption therefore high air pressure leads to higher air consumption. Conventionally several main nozzles (normally up to 8) are used for different colored yarn insertion. In this research, two main nozzles were used in all air-jet weaving machines. It is observed from Fig. 2 that air pressure for Air-jet weaving machines number 1 is set lowest pressure for main nozzles whereas Air-jet weaving machine number 3 used higher pressure for both nozzles. This may be due to distance of main compressor to weaving machine, elbows and joints involved in air pipe lines. Trend of air consumption for both nozzles is almost same; however air pressure for second nozzles is slightly low which is mainly to support the main nozzle 1 pressure for weft yarn.

**Air Consumption at Sub Nozzle of Air-Jet Weaving:**

Sub nozzles are the main component for compressed air consumption for air-jet weaving machines. Highest percentage of compressed air is consumed at sub nozzles. Fig. 3 presents the air pressure of sub nozzles on different air-jet weaving machines. In Air-jet weaving machine number 4, it is observed that the sub nozzles pressure is set at lowest level 2.8 bar where as Air-jet weaving machine number 3 used higher sub nozzles

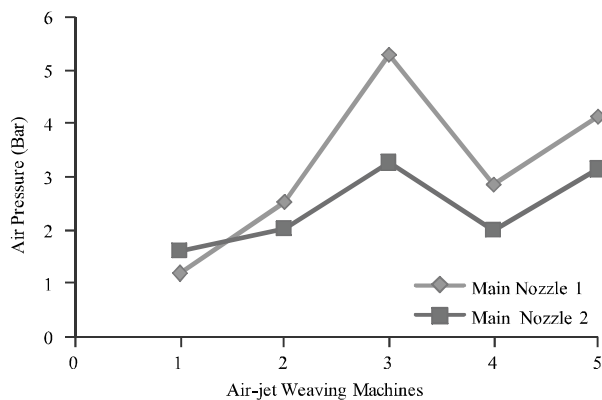


FIG. 2. AIR CONSUMPTION AT MAIN NOZZLES OF DIFFERENT AIR-JET WEAVING MACHINES

pressure 5.33 bar. This variation shows that the Air-jet weaving machines are not working on optimize pressure. It is not possible to keep same air pressure in all weaving machine even though their weaving machine model number, yarn count and fibre types are same because humidity and air duct efficiency cannot be same in all weaving machines under same roof. Moreover, conventionally air-pressure is directly related to number of warp yarns in working width of fabric. In this study, it is observed that distance from compressor to weaving machine, joints and elbow have played key role. It is clearly visible in weaving machine 4 which consumes air less quantity with low pressure as compared with other weaving machines.

**Air Consumption with Relation Pick Insertion Cycle in Degrees:**

Fig. 4 presents the pick insertion position in (TO) and pick arrival position (TW) of different looms. In air-jet weaving machine number 5, pick insertion beginning to pick arrival cycle is short whereas air-jet weaving machine number 4, pick insertion beginning to pick arrival is high. This observation validates the Fig. 3 where air pressure of sub nozzles of air-jet weaving machine 5 is greater as compared with air pressure of sub nozzles of air-jet weaving machine 4. It is found that higher pressure is required to minimize the insertion time or increase in picking speed, however higher pressure may lead to high consumption of air.

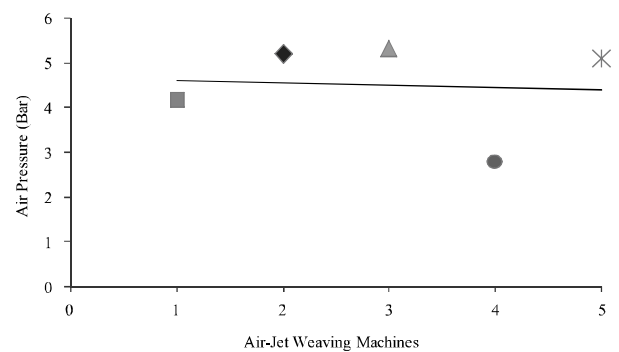


FIG. 3. AIR CONSUMPTION AT SUB NOZZLES OF DIFFERENT AIR-JET WEAVING MACHINES

**Air Consumption of Air-Jet Weaving Machines at Stop and Running Position:** Fig. 5(a) presents the air consumption of Air-Jet weaving machine at stop position. Though there is no any primary or secondary motion active. Yet, it is clearly visible that compressed air is continuously consumed by air-jet weaving machine. Air-jet weaving machine number 2 consumed lowest quantity of air (110cfm) and air-jet weaving machine number 5, consumed higher quantity of air 470cfm which is quite surprising and it may be because leakages in machine pipes and long distance from air compressor.

Fig. 5(b) shows the air consumption of Air-Jet weaving machine at running position in which fabric is manufacturing. While manufacturing of fabric, picking, cutting process and nozzles are the key parts requires compressed air is required. Air-jet weaving machine number 2 consumed lowest quantity of compressed air 1380cfm, whereas air-jet weaving machine number 5 consumed higher quantity of compressed air 1860cfm. Results of both machines are almost at similar trend Fig. 5(a). However, its consumption rate is different because of various parameters such as main nozzles pressure variation, sub nozzles pressure variation, opening and closing timing of sub nozzles, main nozzles and pick insertion timing variations. It is also visible that as the number of air-jet weaving machine increases, the air consumption increases. This may be due to distance increases from air compressor to the air-jet weaving machine location.

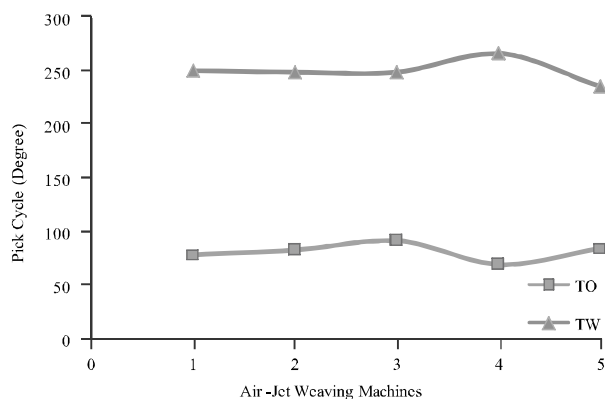
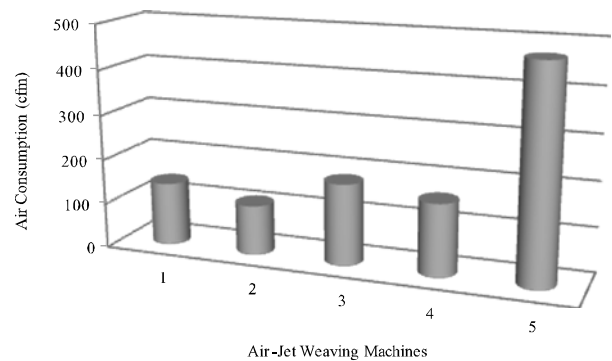
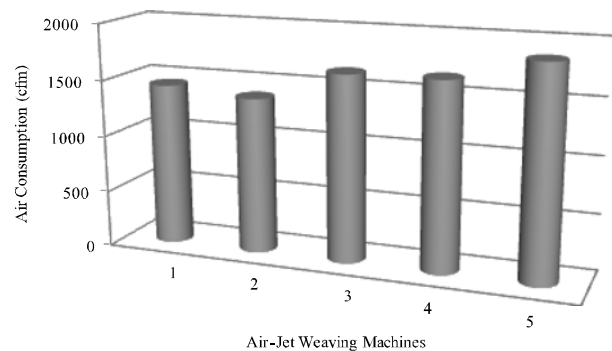


FIG. 4. PICK INSERTION CYCLE OF DIFFERENT AIR-JET WEAVING MACHINES

**Air Consumption of Air-Jet Weaving Machines with Relation of Opening Duration of Sub Nozzles:** Sub nozzles are the main air consumers of compressed air where 80% of compressed air is consumed [1]. Thus its operation should be optimized. However, no machine manufacture recommends any pressure with respect to yarn type. Hit and Trial experiment is common practice of all weaving industry workers. Table 2 shows open and close position of sub nozzles in degree which clearly illustrates the hit and trial practice. In Air-jet weaving machine number 4, we found that the opening to closing time of sub nozzles is higher than others four machines that is why it consumes higher amount of compressed air whereas air-jet weaving machine number 1 which consumes less air as its opening to closing period is short. The imperfect opening to closing time of sub nozzles required high time for opening to closing valves which causes high quantity of air consumption.



(A) STOP POSITION



(B) RUNNING POSITION

FIG. 5. AIR CONSUMPTION OF AIR-JET WEAVING MACHINE

**TABLE 2. OPENING DURATION OF SUB NOZZLES OF AIR-JET WEAVING MACHINES**

Serial Number	Air-Jet Weaving Machine-1 Open-Close	Air-Jet Weaving Machine-2 Open-Close	Air-Jet Weaving Machine-3 Open-Close	Air-Jet Weaving Machine-4 Open-Close	Air-Jet Weaving Machine-5 Open-Close
Sub-1	85-135	74-139	71-141	71-131	71-141
Sub-2	98-148	96-161	94-154	88-148	88-158
Sub-3	108-158	107-173	106-183	100-160	100-170
Sub-4	117-167	121-186	128-195	111-171	112-182
Sub-5	126-176	129-194	138-205	123-183	124-194
Sub-6	136-186	138-203	143-218	135-195	135-205
Sub-7	144-194	148-213	155-230	146-206	147-217
Sub-8	154-204	159-225	167-242	158-218	159-229
Sub-9	163-253	170-253	179-285	169-260	171-270
Sub-10	173-263	182-262	191-295	181-260	183-280
Sub-11	182-273	192-273	204-305	193-270	194-290
Sub-12	191-293	204-293	216-325	204-300	206-310
Sub-13	201-293	214-293	228-325	216-300	218-310

#### 4. CONCLUSIONS

Compressed air is the today’s main issue in Air-Jet weaving machines Industry. This leads to expensive cost to produce fabric comparing to conventional ways. In this regard, several efforts are made by machines manufacturing industries as well scholars. In this study, we have focused on air consumption of air-jet weaving machines. Five air-jet weaving machines (Toyota JAT710) were selected which were manufacturing same quality of fabric. Following are the key observation found during air-consumption analysis and inspection of key areas of weaving shed.

- (i) Air consumption may be reduced by utilizing proper pressure setting of main nozzles, sub nozzles according to the required quality of fabric construction.
- (ii) Higher air pressure is required to minimize the insertion time or increase in picking speed, however higher pressure may lead to high consumption of air.

- (iii) Un-necessary valves opening, leakages at different air pipes at different location and lack of awareness causes the increase in air consumption.
- (iv) Distance between loom to compressor department should be reduced.
- (v) Compressor delivers high pressure to the looms but due to junctions or elbows the pressure slow down at the looms.
- (vi) Untrained workers and lack of professional knowledge causes variation of pressure and air consumption for even same part and fabric manufactured.

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