GOVERNMENT POLYTECHNIC, BHADRAK

ADVANCE TEXTILE MANUFACTURE (Th-04)

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Air-Jet Loom:

Air-jet weaving is a type of weaving in which the filling yarn is inserted into the warp shed with compressed air. We can define air-jet loom in different ways. A loom in which the weft yarn is propelled through the shed by means of a jet of air. OR, A shuttleless loom capable of very high speeds that uses an air jet to propel the filling yarn through the shed. OR, A loom using a jet of air to carry the yarn through the shed. Air-jet loom is one of the two types of fluid jet looms where another one is water jet loom.

Air-jet loom have become very popular in recent years. The air-jet weaving machine was selected as one of the top innovations of the last decade by the Textile World magazine. The number of air-jet weaving machine manufacturers has increased considerably over the past several years. Intensive research and development on air-jet weaving machines have continued. As a result, air-jet looms are getting wider, faster and more economical than before.

Brief Description of the Drawings of Air Jet Weaving Machine:

The construction designed to carry out the invention will be hereinafter described, together with other features thereon.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings forming a part thereof, wherein an example of the invention is shown and wherein:

A nozzle 27 of vacuum system is located in the carriage. It is moved into position automatically when buffing is performed, and out of the way when measuring is performed. Its purpose is to clean the reed and constantly remove any particles created during the buffing process. Thus, apparatus has been provided for measuring air flow for all types of air jet reeds for all known air jet looms.

The measuring of air flow by pressure drop from a known pressure can be performed anywhere in the cross section of the tunnel and at any distance from the Pitot tube to the nozzle. A variety of nozzles can be used and the nozzle location is variable relative to the tunnel and the Pitot tube. The number of nozzles is also variable.

Air pressure to the nozzles can be set at variable pressures. Once air flow measurements are taken with potentially a variety of methods, the air flow can be recorded in any suitable way. Adjustments in air flow throughout the cross section of the air jet reed tunnel and over the full length of the air jet reed tunnel are possible. Variations in air flow can be produced in both cross sections and over the length of the air jet reed to accommodate optimum filling stop arrangements, different fillings, air consumption and resulting power conservation, loom speed as measured in picks per minute, and cloth quality. These adjustments are accomplished by removing or creating slight burrs on the metal profile dents, varying the surface finish of the metal profile dents, modifying the shape of the metal profile dent to increase or decrease air flow and to increase or decrease turbulence, varying nozzle location relative to air jet tunnel, and changing nozzle design.

While a preferred embodiment of the invention has been described using specific terms, such description is for illustrative purposes only, and it is to be understood that changes and variations may be made without departing from the spirit or scope of the following claims.

Air-jet weaving machines are under constant development. Current research is mainly focused on the air and yarn interaction as well as the guide system to increase the yarn velocity and reduce the compressed air consumption. Widening of the application range is another topic of the current developments.

Different Parts of Air-jet Loom:

I already published an article on **Different Parts of Air Jet Loom and Their Functions**.

Working Principle of Air-Jet Loom:

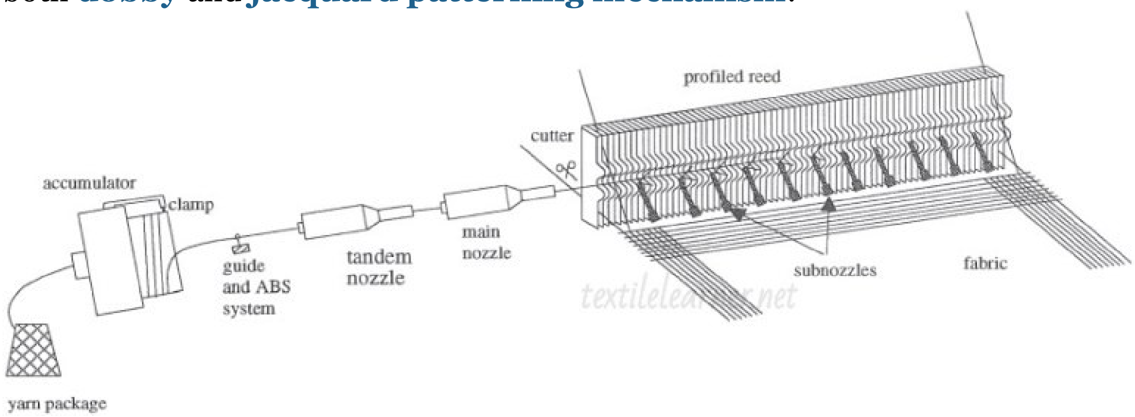
We already know that air-jet loom is a shuttleless loom that uses a jet stream to pull the weft yarn across the shed. The working principle is to use air as the weft insertion medium, and the compressed airflow is used to pull the frictional traction force of the weft yarn, and the weft yarn is taken through the shed, and the jet generated by the jet is used to achieve the purpose of weft insertion. This weft insertion method enables the weaving machine to achieve high speed and high yield.

The major components of the insertion system are the tandem and main nozzles, ABS brake system and relay nozzles which are relatively simple in design. The insertion medium mass to be accelerated is very small, relative to the shuttle, rapier or projectile machines, which allows high running speeds.

Unlike rapier or projectile insertion systems, there are not many mechanically moving parts to control and insert the filling yarn.

Below figure 5 shows a schematic of air-jet weaving utilizing a multiple nozzle system and profiled reed which is the most common configuration in the market.

Air-jet loom use a jet of air to propel the weft yarn through the shed at rates of up to 600 ppm. Date from manufacturers indicate that air-jet looms operate at speed up to 2200 meters of pick inserted per minute. They can weave multicolored yarns to make plaids and are available with both **dobby** and **jacquard patterning mechanism**.



Different advantages of air-jet loom have pointed out in the following:

1. High productivity.
2. Low initial outlay.
3. High filling insertion rates.
4. Weft insertion performance is too much here (normally 600pm).
5. Simple operation and reduced hazard because of few moving parts.
6. Reduced space requirements.
7. Normally, standard width of air jet loom is 190cm.
8. Low noise and vibration levels.
9. In case of air jet loom, noise level is lower than rapier loom and missile.
10. low spare parts requirement.
11. It consumes very low power.
12. Reliability and minimum maintenance.

Disadvantages of Air-Jet Loom:

The disadvantages of air-jet loom are-

1. Broken pick or miss pick has occurred due to excess air pressure of main nozzle.

2. In case of air jet loom, pile up and buckle tip of yarn formed due to air resistance.
3. Double pick may occur in air jet loom.
4. Loom of weft yarn along weft direction formed due to variation of air pressure.

Water Jet Loom:

Jet weaving looms are divided into **air-jet loom** and water jet loom according to the medium of **weft insertion**. The weft thread is transported through the shed with the help of air or water jets. Secondary jets located in the shed assist the main jet in transporting the thread. This technology can only be used for lightweight fabrics. Jet looms have the highest weft insertion speeds of all looms, but they are limited with regard to suitable weft materials. Water-jet loom can produce superior high quality fabrics that have good appearance and feel.

A water jet loom is similar to an air jet loom but uses water instead of air to transport the yarn around the shed. A water jet loom inserts the filling yarn by highly pressurized water. The tractive force is provided by the relative velocity between the filling yarn and the water jet. If there is no velocity difference between the water and yarn, then there would be no tension on the yarn which would result in curling and snarling of the yarn. The tractive force can be affected by the viscosity of the water and the roughness and length of the filling yarn; higher viscosities cause higher tractive forces. The viscosity of water depends on the temperature.

Water-jet weaving machines are produced only by few companies and are used for the manufacture of light and medium weight fabrics with standard characteristics and in water repellent fiber materials, primarily multi-filament synthetic yarns. Water jet machines are extensively used in East Asia, but have limited importance in other countries. They are characterized in particular by high insertion performance and low energy consumption.

Water jet loom is not used as frequently as air jet, but they are preferred for some **types of fabrics**. The process is unsuitable for yarns of hydrophilic fibers because the fabric picks up too much moisture. Water-soluble warp sizings are used on most staple warp yarns. Therefore, the use of water jet loom is restricted to filament yarns of acetate, nylon, polyester, and glass; yarns that are non absorbent, and those that do not lose strength when wet. Furthermore, these fabrics come off the loom wet and must be dried. In this technique a water jet is shot under force and, with it, a weft yarn. The force of the water as it is propelled across the shed carries the yarn to the opposite side. This machine is economical in its operation. A water jet of only 0.1centimeter is sufficient to carry a yarn across a 48 inch shed. The amount of water required for each weft yarn is less than 2.0 cubic centimeters. Water jet loom can reach speeds of 2,000 meters of picks per minute.

Both air and water jet weaving machines weave rapidly, provide for laying different colors in the weft direction, and produce uniform, high quality fabrics. They are less noisy and require less space than most other **types of loom**. They cause Minimal damage to warp yarns during the weaving operation, because the air or Water jets are less abrasive than moving metal parts.

The speeds of shuttle less weaving machines can be compared by measuring the picks per minute (ppm) or the yards laid per minute (ypm) in weft insertion. In 1990, the top speed for a projectile weaving machine was 420 ppm with between 1000 and 1203 ypm weft insertion. Flexible **rapier weaving machine** operated at 524 ppm and rigid rapiers at 475ppm, laying weft at up to 1404 and 930ypm, respectively. Air jets could lay as many as 1200 ppm and water jets up to 1500 ppm, laying 2145 and 2360 ypm, respectively.

If a fabric 60 inches wide is woven on each machine at a density of 50 picks per inch, approximately 84 yards of weft yarn would be needed to produce an inch of fabric. In theory, the **projectile loom** would produce approximately 8.4 inches of fabric per minute; the flexible rapier, 10.5 inches; the rigid rapier, 9.5 inches; the air jet, 24 inches; and the water jet, 30 inches. The slowest of the new machines could produce a yard of fabric in 4.3 minutes, and the fastest would take just 1.2 minutes. Seldom do weaving machines operate at full capacity, but even at 50% efficiency such machines could produce a yard of fabric every 2.5 minutes.

Working Principle of Water Jet Loom:

Water-jet weaving machines have the same basic functions of any other type of weaving machines. The principle of filling insertion with a water-jet is similar to the filling insertion with an air-jet: they both use a fluid to carry the yarn. However there are some differences that affect the performance and acceptance of water-jet weaving machines. For example, the yarn must be wettable in order to develop enough tractive force.

The flow of water has three phases: 1) acceleration inside the pump prior to injection into the nozzle, 2) jet outlet from the nozzle, 3) flow inside the shed. The water flow inside the shed has a conical shape with three regions: compact, split and atomized.

Compact and split portions are better for yarn insertion. Due to water weight, the jet axis forms a parabola which necessitates adjusting the axis of the nozzle upward by some angle. The flow of water then follows the motion of angular projection.

Unlike the air-jet weaving machines, the pump and picking system is fixed firmly to the machine frame to ensure that the beat-up mechanism moves the reed only. Due to the viscosity of water and its surface tension, a water-jet is more coherent than an air-jet. As a result, the water-jet does not break up that easily and has a longer propulsive zone. There are no varying lateral forces in a water-jet to cause the filling yarn to contort. Besides, since the wet moving element is more massive, there is less chance for the filling yarn to entangle with the warp. The braking of the filling yarn is provided by the reed.

The width of a water jet loom machine depends on the water pressure and diameter of the jet. Since water is not compressible, it is relatively easy to give enough pressure to the water-jet for insertion. The diameter of the jet is around 0.1 cm and the amount of water used for one pick is usually less than 2 cc. Double pump system, with two nozzle at will filling insertion, is suitable for weaving fabrics with two different fillings.

The wastewater after insertion is usually removed into a drainage system.

Advantages of Water Jet Loom:

The main advantages of water jet loom are in the below:

1. Water jet loom machine consumes less power than others.
2. This type of loom is suitable for producing synthetic fabric.
3. Here, production rate is higher.
4. It creates less noise than rapier loom and missile.
5. Flexibility during the use of multiple water jet looms may allow operators to continue to operate efficiently on fewer drives.
6. Lowest downtime and easy maintenance routines.
7. There is no vibration during looming.
8. It produce faultless fabric.

Disadvantages of Water Jet Loom:

A few disadvantages of water jet loom are-

1. By using hard water, here may form rust on the yarn.
2. It is not perfect for absorbent fiber such as cotton.

Rapier Loom:

Rapier loom is a shuttleless weaving loom in which the filling yarn is carried through the shed of warp yarns to the other side of the loom by finger like carriers called rapiers. Rapier weaving machines are known for their reliability and performance. Since 1972, the rapier weaving machine has evolved into a successful, versatile and flexible weaving machine. A very wide range of fabrics can be woven on a rapier weaving machine which is typically from very light fabrics with 20 g/m^2 to heavy fabrics with around 850 g/m^2. Rapier machines are widely used for household textiles and **industrial fabrics**. Designed for universal use, the rapier weaving machine can weave not only the classic wool, cotton and **man made fibers**, but also the most technically demanding filament yarns, finest silk and fancy yarns.

The rapier loom is emerging as weaving machine of the future. It is not far off from **air-jet loom** in production (Speed) rate (up to 1,500 mpm or 600–800 rpm) without scarifying their special status of flexibility.

In rapier weaving, a flexible or rigid solid element, called rapier, is used to insert the filling yarn across the shed. Rapiers are two hooks which carry the weft picks across the warp sheet. The first giver hook takes the weft pick from the yarn feeder and carries it to the center of the warp width. Meanwhile, the taker hook moves from the other side of the weaving machine to the centre. There, the two hooks meet and the weft pick is transferred to the taker hook. After that, the giver hooks returns vacant to the side it came from, and the taker hook carries the weft to the opposite side. As in the projectile loom, a stationary package of yarn is used to supply the weft yarns in the rapier machine. One end of a rapier, a rod or steel tape, carries the weft yarn. The other end of the rapier is connected to the control system. The rapier moves across the width of the fabric, carrying the weft yarn across through the shed to the opposite side. The rapier is then retracted, leaving the new filling in place.

In some versions of the machine, two rapiers are used, each half the width of the fabric in size. One rapier carries the yarn to the center of the shed, where the opposing rapier picks up the yarn and carries it the remainder of the way across the shed. A disadvantage of both these techniques is the space required for the machine if a rigid rapier is used. The housing for the rapiers must take up as much space as the width of the machine. To overcome this problem, looms with flexible rapiers have been devised. The flexible rapier can be coiled as it is withdrawn and will therefore require less space. However, if the rapier is too stiff, it will not coil; if it is too flexible, it will buckle. The double rapier is used more frequently than the single rapier. Rigid and flexible rapier machines operate at speeds of up to 1,300 meters of weft per minute. These rapier looms are efficient. They operate at speeds ranging from about 200 to 260 ppm at about the noise level of projectile looms. They can produce a wide **variety of fabrics** ranging from muslin to drapery and upholstery materials.

Newer rapier machines are built with two distinct weaving areas for two separate fabrics. On such machines, one rapier picks up the yarn from the center, between the two fabrics, and carries it across one weaving area; as it finishes laying that pick, the opposite end of the rapier picks up another yarn from the center, and the rapier moves in the other direction to lay a pick for the second weaving area, on the other half of the machine. Figure 2 shows the action on a single width of fabric for a single rigid rapier system, a double rigid rapier system, and a double flexible rapier system.

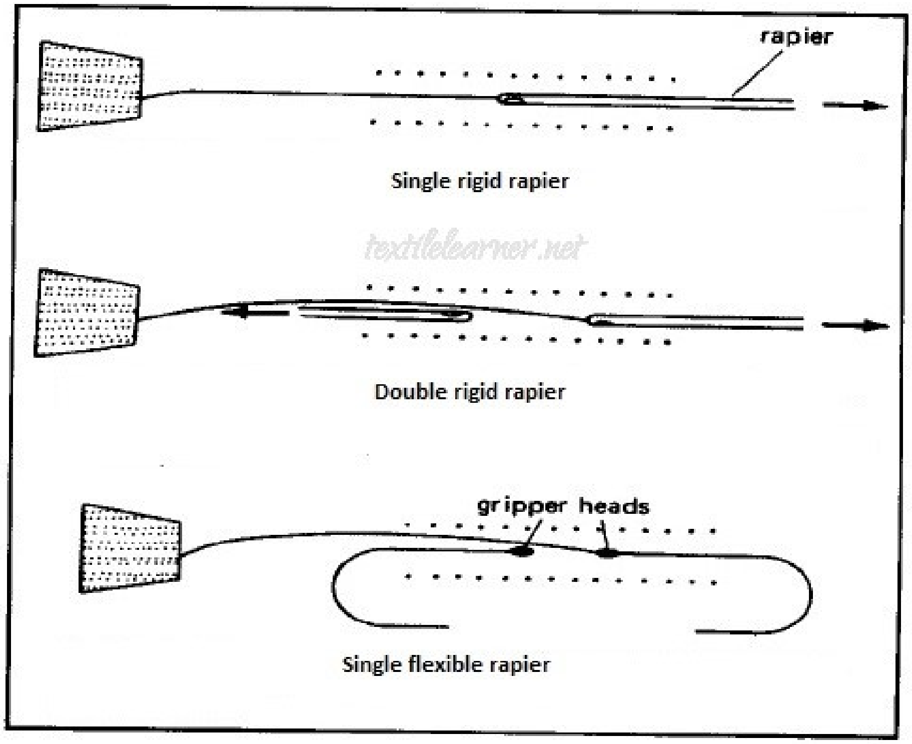


Figure 1: The operation principle of three rapier systems

Rapier machines weave more rapidly than most shuttle machines but more slowly than most projectile machines. An important advantage of rapier machines is their flexibility, which perm it's the laying of picks of different colors. They also weave yarns of any **type of fiber** and can weave fabrics up to 110 inches in width without modification. Rapier loom is popular in the production of terry cloth because of the flexibility they offer for production.

Types of Rapier Loom:

Rapier loom may have various types according to the weft insertion mechanism and number of pick such as insertion of double pick, insertion of single pick, two phase rapier etc.

Single rapier machines:

A single, rigid rapier is used in these machines. The rigid rapier is a metal or composite bar usually with a circular cross section. The rapier enters the shed from one side, picks up the tip of the filling yarn on the other side and passes it across the weaving machine while retracting. Therefore, a single rapier carries the yarn in one way only and half of the rapier movement is wasted. Also there is no yarn transfer since there is only one rapier. The single rapier' s length is equal to the width of the weaving machine; this requires relatively high mass and rigidity of the rapier to ensure straight movement of the rapier head. For these reasons, single rapier machines are not popular. However, since there is no yarn transfer from rapier to rapier, they are suitable for filling yarns that are difficult to control.

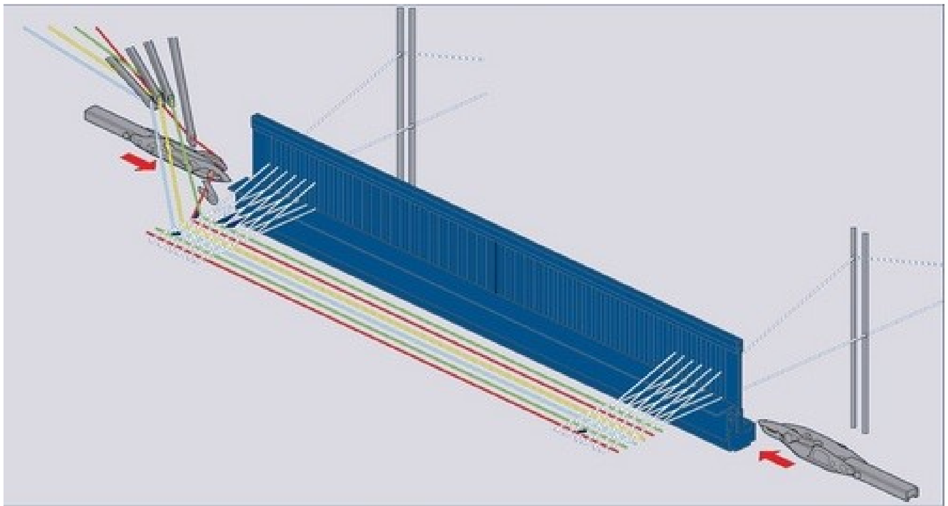
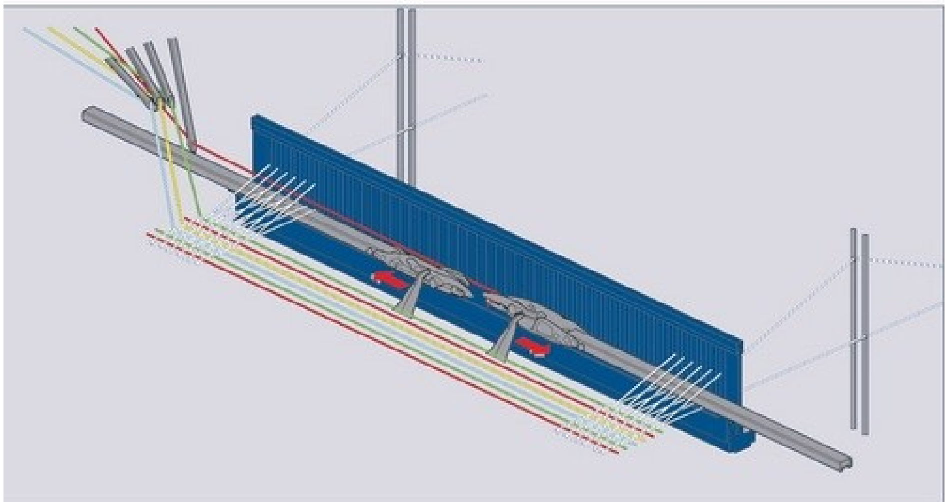
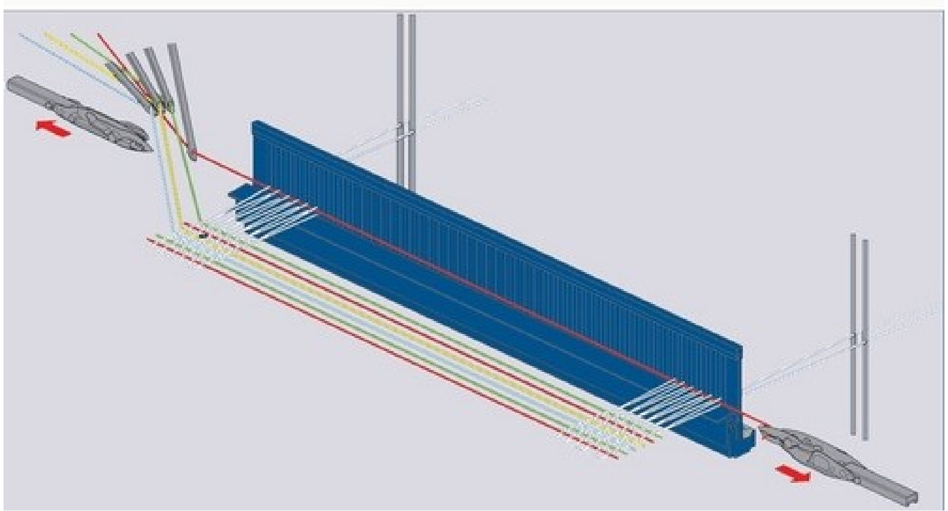
Double rapier machines:
Two rapiers are used in these machines. One rapier, called the giver, takes the filling yarn from the yarn accumulator on one side of the weaving machine, brings it to the center of the machine and transfers it to the second rapier which is called the taker. The taker retracts and brings the filling yarn to the other side. Similar to the single rapier machines, only half of the rapier movements is used for filling insertion.

Double rapier machines can be rigid or flexible. There are two types of double rigid rapiers: Dewas system and Gabler system. In Dewas system, the giver grips the tip of the yarn, brings it to the center and transfers it to the taker which retracts and carries the yarn to the other side of the weaving machine.

In the Gabler system, the yarn is not gripped. The giver extends the yarn in the form of a “U” shape to the center of the weaving machine. The yarn is then transferred to the taker, which extends the yarn to the other side of the weaving machine by straightening it. Since both rapiers extend to the outside of the weaving machine, the space requirement for double rigid rapier machines is high.

In flexible rapier machines, the rapier has a tape like structure that can be wound on a drum. This saves space and allows narrower machine widths compared to double rigid machines. The yarn is gripped both by the giver and taker. Double flexible rapier machines are more common than the rigid rapier machines.

Weft Insertion Mechanism of Rapier Loom:
Rapier looms have an interlocking weft insertion system. The gripper head catches the yarn end from the feed bobbin and transports it through the shed. In the middle of the fabric the yarn is transferred to the opposing second gripper. The **weft insertion** is controlled at every single moment of the process. Therefore, this principle is very flexible and extremely suitable for delicate materials. Rapiers are available in rigid and flexible forms.

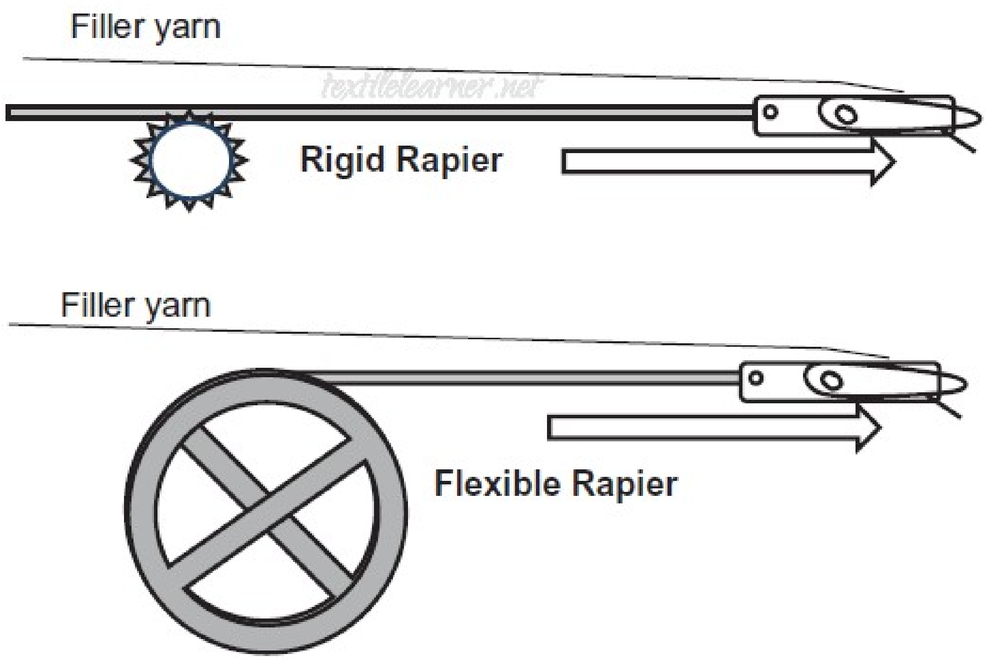


Figure 2: Weft insertion with rapier (Courtesy of Lindauer Dornier GmbH)

Insertion of weft by rapier is a mechanically modern and refined version of the primitive method of fabric production in which the weft was secured in a slot of a stick. At present version of the gripper head which are attached to rapiers which are flexible tapes or rigid rods.

There are various types rapier loom according to the weft insertion mechanism and number of pick such as insertion of double pick, insertion of single pick, two phase rapier etc.

In all rapier looms, to-and-fro-movement of the rapiers is derived initially either from a linkage mechanism or from a cam. The use of linkage mechanism has the advantages of simplicity reliability and is cheap, quiet and consumes less energy than a cam mechanism but it does not provide any dwell to the rapiers.

Single rapier loom can insert weft only on alternate rapier traverse. In many cases this is modified to achieve a higher rapier velocity in the early and late parts of the movement and thus maximum velocity halfway through the movement. A useful feature of rigid rapiers is that they can be simultaneously inserted in two sheds one above the other, for producing double plush and certain carpets.

Due to high rate of insertion, the possibility of yarn breakages rate may increase. Additionally, it is necessary to control the weft by passing it through an effective tension arrangement so that the weaving tension will be more uniform, this can also reduce weft break.

The rigid rapier is driven from the center and has a rapier head at each end. In one cycle of 360° the rapier inserts one pick alternately in the right hand and left hand. The picks are inserted and beaten up in opposite phase.

Electronic Control of Rapier Loom:

Rapier loom is controlled almost exclusively by electromechanical means through punch buttons. If electronic control is used, as applied on one model, it works on the same principle as on shuttle weaving machines, so there is no need to describe it here. Electronics are used on rapier machines primarily for weft monitoring. Exceptions are those weaving machines operating on the Gabler system (loop insertion). On these machines, weft monitoring by piezoelectric weft detectors is not advisable as the thread draw-off speed in the second half of the weft insertion operation in which monitoring is needed is zero.

For rapier weaving machines operating on the Dewas system (tip transfer), the piezoelectric monitoring system is preferred. The weft thread without any additional tensioning is passed at low angle over the sensing unit. The start and duration of monitoring are determined by the control system (trigger). With the Loepfe system, this consists of a stationary coil and a switching quadrant rotating with the weaving machine crankshaft.

A signal is thus produced by induction. Eltex uses a light cell for control, which operates in conjunction with a marker on the crankshaft as an electronic switch. On electronic weft detectors for rapier weaving machines, the required minimum speeds for the positive functioning of the device on the Dewas weft insertion system is dependent upon the following criteria:

1. The warp-round angle of the weft thread
2. The thread material
3. The yarn count
4. The potentiometer setting

It was demonstrated that a certain "pressure" must be exerted on the thread guide eye or the warp-round pin for the weft detector to be able to register any thread movement. The following advantages of electronic compared with mechanical weft yarn detectors may be quoted:

- Monitoring of weft yarns of all types over the full working width
- No movable sensing parts
- Simple mounting, adjustment, and maintenance
- Monitoring of single, double, and multiple weft insertion
- Low thread tension and no weft thread breaks in the center of the cloth

Developments in Rapier Loom:

Rapier loom has been making inroads to heavy fabrics (900 gsm) and also shedding off the known drawback of higher weft waste. The design improvement in rapier gripper permits handling a wide range of yarns without any need for changes.

The machine owes its speed, flexibility and low energy consumption to a combination of high technology and economic design. Style changes can be executed "exceptionally rapidly". Having independent motor drives, this yielded fewer moving parts, fewer gears, fewer oil seals and no timing belts, i.e., there are fewer elements to influence fabric quality, less need for resetting and reduced maintenance. There are no toothed belts, which are prone to wear, and breakage.

Following devices are used in the development of rapier loom:

1. Sumo motor
2. PFL (Programmable Filling Lamellae)
3. ELSY (False Selvedge Device)
4. Electronic take-up and let-off motion
5. FDEI (Filling Detection at the End of Insertion)

Their features and benefits in rapier loom are described below:

Sumo motor:

- Saving on energy consumption of more than 10% in comparison with conventional clutch and brake configuration.
- Machine speed setting is done accurately and completely, electronically via the keyboard of microprocessor. This reduces the setting time to zero.
- Speed setting is easy to copy to other machine either with electronic set card or with production computer with bi-directional communication.
- Automatic pick finding becomes faster, which significantly reduces the downtimes for repairing filling and warp breakages.
- The machine can always work at optimum weaving speed in function of quality of the yarn, the number of frames, and **fabric construction**.

PFL (Programmable Filling Lamellae):
It controls the filling brake ensuring consistent yarn tensions at any time during insertion cycle. The PFL can be installed for each channel between the pre-winder and entry of fixed main nozzle. It has been designed to slow down the filling at the end of insertion. The PFL thus significantly reduces the peak tension of the pick at the end of the insertion and decreases the tendency of pick to bounce back in the shed. As a result of which the filling tip is stretched correctly.

Features:

- Lower peak tension in filling yarn.
- Reduced tendency of filling to bounce back.
- Inserted pick can be stretched more easily.
- Adjustments are done by means of machine keyboard and display.
- The settings can be adopted for each filling yarn.

Benefits:

- Fewer filling breaks.
- Fewer machine stops.
- Better fabric quality.
- Higher productivity of machine and staff.
- Weaker filling yarn can be used.
- Correct setting of filling waste length and consequently less waste.

ELSY (False Selvedge Device):
The unique ELSY full leno false selvedge motion is electronically driven by individual stepper motor. They are mounted in front of harness so all harness remain available for fabric pattern. This only rapier machine that allows selvedge crossing to be programmed on microprocessor independently of shed crossing even while machine is in operation. So result of resetting can be checked immediately. The easiest position of rethreading can be set by a simple push button. When machine starts, the selvedge system automatically comes to original position.

Electronic take-up and let-off motion:
It plays important role. Required pick density can be programmed on microprocessor keyboard. No pick wheel required. The accuracy of settings makes it easy to adjust pick density of fabric with optimum fabric weight and minimum yarn consumptions. By ETU makes it possible to weave fabric having various pick densities. The electronic link between let-off and take-up is an additional tool to manage the fabric marks. Warp beam driven by electric let off motion through separate drive wheel that stays on loom, ensures trouble-free operation of let off system and improves fabric quality.

FDEI (Filling Detection at the End of Insertion):
When weaving “lively” yarns, use FDEI system. It checks the presence of filling at the end of insertion. The system detects short picks, rebounding fillings and prevent **faults in fabric** at right end. At filling breaks, the machine stops and only the harnesses are moved automatically to free the broken pick for removal of weaver. This is outstanding since automatic pick finder is not driven by separate motor but monitored by hydraulic system. In this way a two speed slow motion becomes a standard luxury to the weaver. The transfer position of filling yarn in centre of fabric is always correct even after changing the cloth for new style.