ADVANCE FABRIC MANUFACTURING

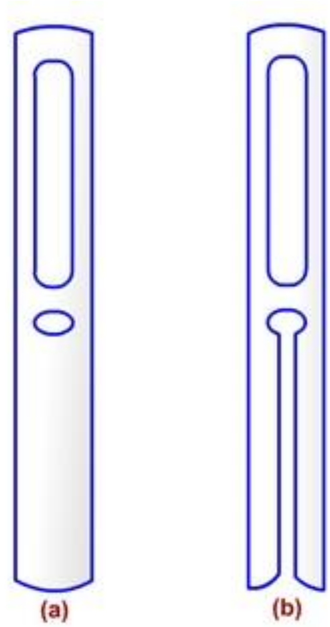
WARP STOP MOTIONS

Objects: Warp stop-motion stops the loom in the event of an end break.

The purpose of warp stop motion is to stop the loom when a warp thread breaks. The loom also stops when a warp thread becomes excessively loose. The warp stop motion is useful not only for the efficient production of high quality fabrics but also to allot more looms to a weaver.
If a broken warp thread is not detected immediately, it will tend to get entangled round adjacent threads thus causing more end breakages or create a fault known as a float in the woven cloth.

Principle of Warp Stop Motion: This mechanism is activated by a light weight metallic drop wire which is also known as Drop Pin. Whenever, any of the end breaks, the drop pin falls down and activates a suitable mechanism (mechanical or electrical) which further stops the loom.

Two types of drop pins are shown in figure:



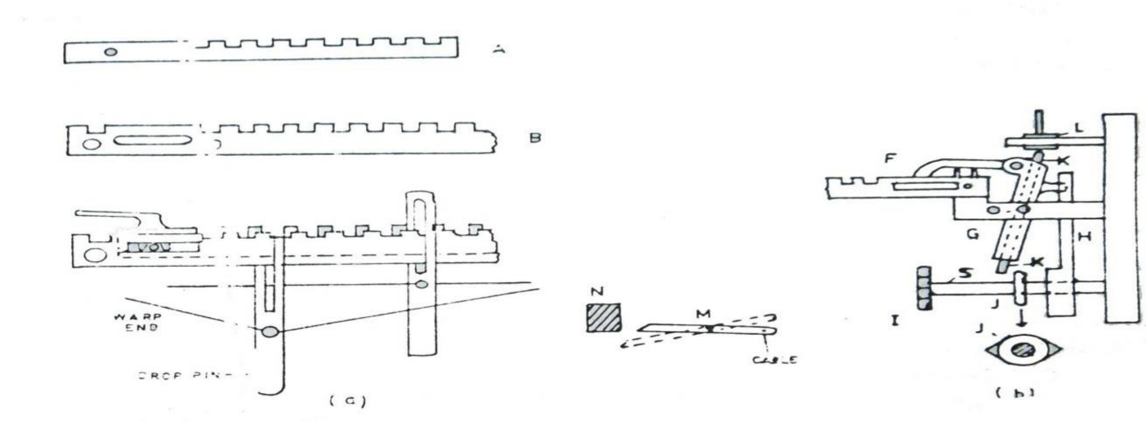
The large slot at the top is for the movement of the reciprocating bars which are used in both mechanical and electrical warp stop-motions.
Closed end drop wires Open end drop wires Open ended drop wires are more popular type used for dropping in the warp threads after the warp has been gaited in the loom Closed type drop wires are positioned in the preparation department, the warp threads being drawn through the drop wires and the heald eyes at the same time.
Design (a) can be used when a single end is passed through the drop wires during the drawing in operation.
Design (b) can be used after the beam gaiting as it has an open-ended hole.

Types of Warp Stop Motions: There are two types of warp stop motions:

1. Mechanical Warp Stop Motion
2. Electrical Warp Stop Motion

Both the cases the basic principle of working is the same, that is, every warp thread is sensed by a thin strip of metal, known as drop pin.
When a warp thread breaks the corresponding drop pin falls by its gravity into a moving part of slide over which it is threaded.
The lateral motion of the slide is thus arrested and a knock-off mechanism will operate and stop the loom.

Mechanical Warp Stop Motion:



A = Slide, B = Slider Bar, C = Hole in the Bars, D = Slot, F = Forked Bracket, G = Tubular Lever, H = Cam Coupling, S = Shaft, I = Chain driven Wheel, J = Double sided Cam, K = Spring Loaded Finger, L = Knock-off Lever, M = Knock-off Finger, N = Striker

Mechanical warp break stop motion:

The warp stop motion is an auxiliary loom motion. The main objective of a warp stop motion is to stop the loom immediately when an end breakage occurs during the loom operation. The warp break stop motion plays a very important role to improve the quality of the fabric and the productivity of the loom. If an end breakage occurs and the loom gets continued to run, the broken end coming from the warp beam gets accumulated behind the eye of the heald wire. This yarn deposition causes multiple end breakages and this multiple ends breakage takes a long time to redraw these broken ends. Thus loom efficiency gets decreased. When the loom gets continues to run in case of end breakage, the fabric getting produced becomes defective. Thus the quality of the fabric gets affected. The warp break stop motion helps to increase productivity and improve the quality of the fabric getting woven on the loom.

Types of warp break stop motions:

The types of warp break stop motions are given below:

1 - Mechanical warp break stop motion

2 - Electrical warp break stop motion

3 - Electronic warp break stop motion

Structure of mechanical warp break stop motion

This mechanism consists of a reciprocating bar, oscillating device knock-off device, and drop wire.

The complete reciprocating bar made of three components. The fixed outer bar consists of two plates.

The reciprocating bar slides between these two plates of fixed outer bar. The top edge of the outer bar and reciprocating bar gets castillated.

In order to ensure that the drop wire will fall into the lowest cut-out point of both bars, it is necessary for the reciprocating bar to be slightly higher than the two fixed outer bars.

The number of castillated bars depends upon the number of ends per inch used in the warp beam. 4 - 8 castillated bars are normally used.

The one end of each castillated bar gets connected with the drive mechanism through a pin.

The castillated bars pass through the slot in the drop wire. The reciprocating bar is connected with the forked bracket.

This forked bracket is attached with a fulcrum lever. This fulcrum lever held in the bottom of the rocking diamond-shaped cut out of the cam lever.

The lower end of the fulcrum lever gets spring-loaded. The one end of the release trip lever rests upon the spring-loaded lever.

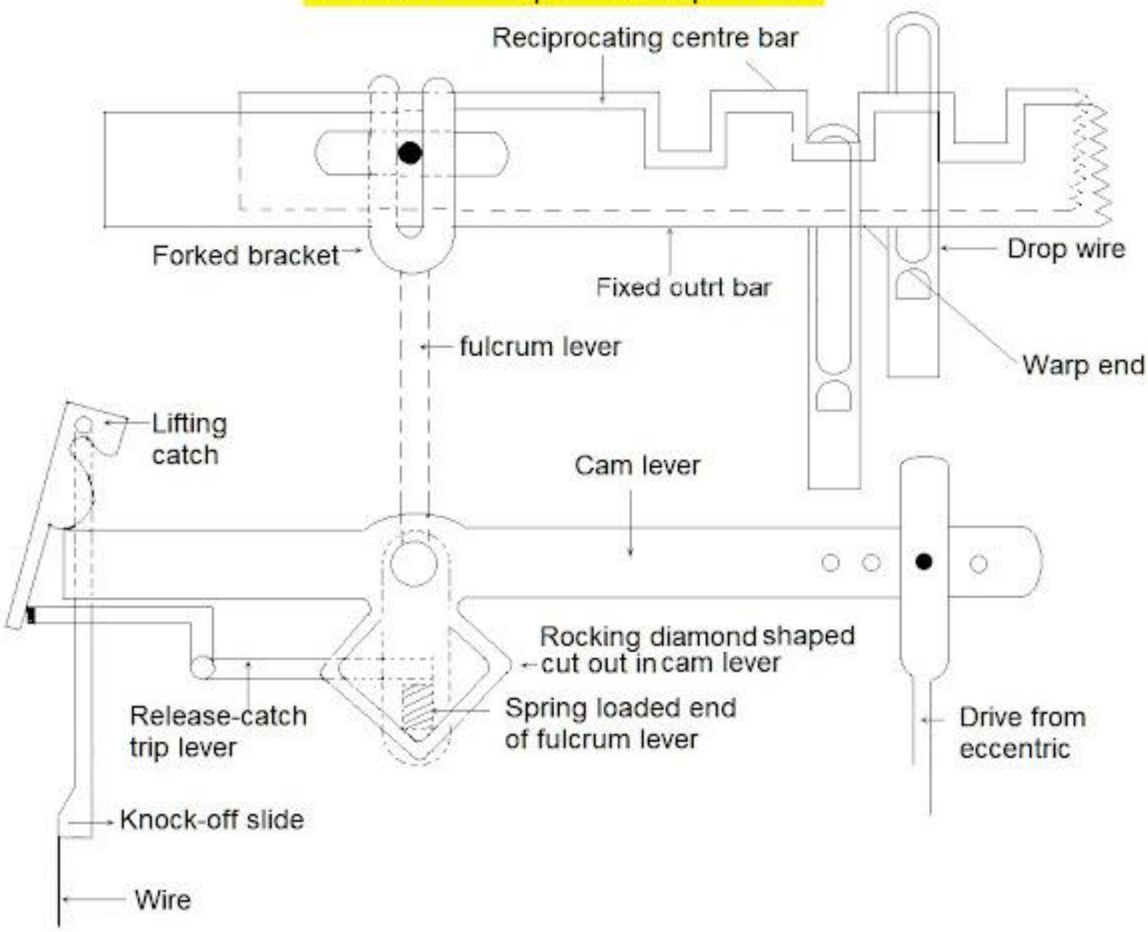
The release catch trip lever gets fulcrummed as shown in the below figure.

The other end of the release catch trip lever rests in front of the lower end of the lifting catch.

The oscillating mechanism is connected to the crankshaft through the sprocket wheel and chain.

The one end of the cam lever is connected to the eccentric.

Mechanical warp break stop motion



Working principle of mechanical warp stop motion:

The cam lever and eccentric are connected through the connecting rod. When the eccentric rotates, it imparts oscillating motion to the cam lever.

The fulcrum lever is connected to the cam lever in the middle. A forked bracket is attached at the top of the fulcrum lever.

When the cam lever oscillates, the forked bracket also oscillates. Since the one end of the reciprocating bar is connected with a forked bracket so that the reciprocating bar also makes back and forth movement**.**

When the loom operates, the drop wire rests upon the warp end due to warp tension.

Enough clearance between the top edge of the reciprocating bar and the slot of drop wire.

This clearance makes a free passage for back and forth movement of the reciprocating bar between two fixed outer bars.

The position of the release catch trip lever doesn't change in this situation and the loom gets continues to run.

When the end breakage occurs, the drop wire falls immediately in the cut-out of the reciprocating bar.

The drop wire creates a hurdle in the back and forth motion of the reciprocating bar.

The spring-loaded end of the fulcrum lever rises in this situation because it cannot be rock side-wise.

The release catch trip lever also rises. Now the outside end of this lever falls and allows the lifting catch to slip over the outside end of the cam lever.

As this end of cam lever rises, it raises the lifting catch, and thus the knock off lever slides and through a wire further catch attached to sley at the front end of the loom is raised into line with a projection of the starting handle unit for the loom to be knocked off.

Comparison: Electrical vs. Mechanical Warp Stop Motion

Feature	Electrical Warp Stop Motion	Mechanical Warp Stop Motion
Response Speed	Fast (instantaneous relay tripping)	Slower (relies on mechanical serrated bar interaction)
Sensitivity	High; suitable for delicate yarns	Moderate; best for heavier, coarser yarns
Wear & Tear	Minimal moving parts; lower mechanical wear	High friction due to continuously reciprocating bars
Fault Indication	Integrated signal light pinpoints the section	Manual visual search required across all drop wires
Maintenance	Requires clean contacts (free from lint/fly)	Requires regular lubrication and mechanical tuning

Advantages

Fast Reaction: Stops the loom before the broken end gets woven into the fell of the cloth.

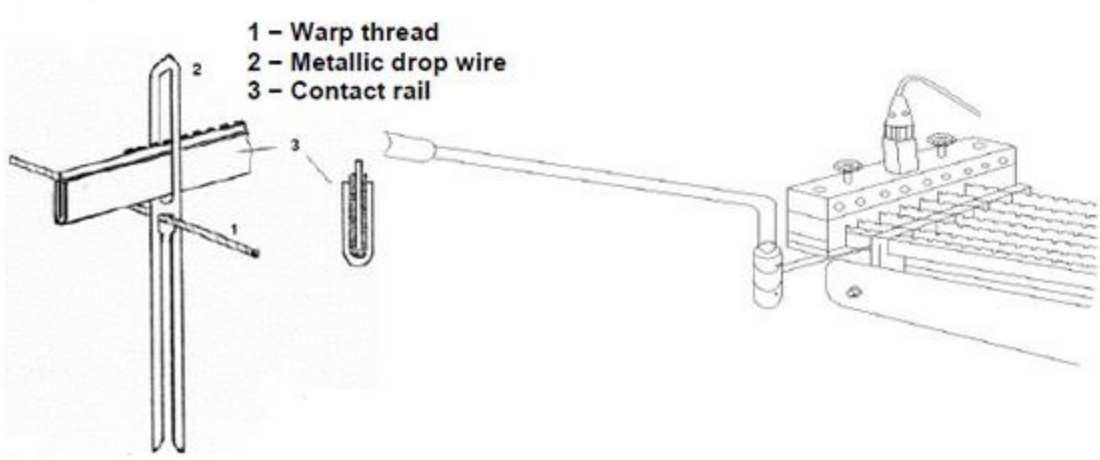
Low Mechanical Friction: Eliminates the continuous reciprocating motion needed by mechanical systems, saving energy and reducing wear.

- **Flexibility:** Works effectively across fine filament yarns, staple yarns, high-speed shuttleless looms (air-jet, rapier, water-jet).

- **Disadvantages**
- **Fluff/Lint Sensitivity:** Accumulation of conductive fiber fly or non-conductive dust can cause false stops or prevent proper contact.
- **Electrical Maintenance:** Requires periodic inspection of wiring, transformers, and contact bar insulation.

Electrical Warp Stop Motion:

The constructional details of Mechanical Warp Stop Motion is shown in the following Figure:



The operating system is the following .:-

- Each warp thread is passed into the bottom slit of a metallic drop wire 2,
- Which this way is supported by the thread under tension. Through the top slit of the drop wire passes the contact rail 3 composed of an u-shaped outside coating in stainless steel, of a strip of insulating material and of a flat conductive inside blade in nickel-plated copper, Provided on the upper part with a toothing. The contact rail 3 is part of a low voltage electric circuit, of which the drop wire 2 acts as circuit Breaker.

Temples

The warp sheet normally contracts from 2% to 15% in width from reed to the cloth. This contraction is due to interlacement of warp and weft.

If, this contraction is not avoided temporarily it may result in the followings:

1. There is a possibility of damage to the warp ends near the selvedge due to abrasion with reed dents.

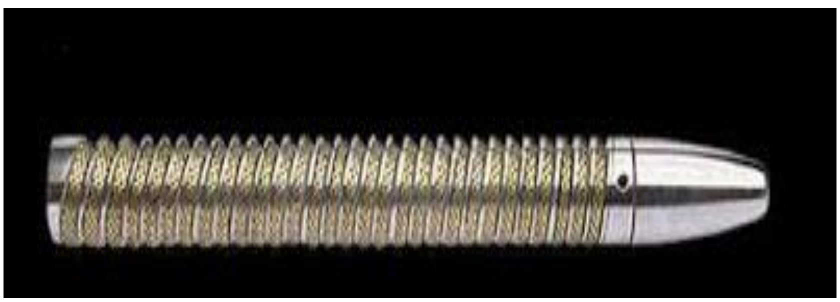
2. There is a possibility of reed dents getting themselves distorted.
3. There will always be a tension in the beat-up zone.

The temples are used to hold the width of the woven cloth stretched as equal to as possible to the width of the warp. Mount the temple as close to the fell of the cloth (the edge where new yarn is beaten in) as possible

Types of Temples: In relation to different types of fabrics, the following are the types temples:

1. Ring Temples:

In ring temples the rings are usually at an angle of 12 degree to 21 degree and the angle reduces in steps of 3 degree towards the centre of the cloth.



For holding the fabric stretched, the rings are pinned and the height of the pins is about 1.5 to 2.0 times of the cloth thickness. The pins exert their pull on the warp.

The length of the temple tube depends upon the cloth width. A rule of thumb is one ring for 10 cm wide fabric. Generally, metallic pinned rings are used. However, for delicate fabrics, pinned rings are used only in the selvedge zone. The inner rings are substituted by rubber, or plastic rings.

2. Roller Temples:

The roller temples usually have two rollers supported at both ends which guide the fabric in the warp directions by means of raised points. Ring and roller temples hold the fabric in the selvedge zones only and stretches the fabric outwards. The rollers are usually of steel and are covered with metallic rings (rubber or plastics for delicate fabrics).

These temples have the following disadvantages:

i) Excess tension is required for the beat-up which may cause in breakages of the warp yarns.
ii) The looping of the fabric around the temple cylinders may cause deformation in the straightness of the weft which creates waviness in the selvedges.

3. Full Width Temples

The full width temples hold the fabric across its full width under uniform tension.

These temples have the following advantages:

i) Weaving can be done at lower warp tension.
ii) There is less stress on the warp ends, resulting in less ends breakage.
iii) There are no temple ring marks.
iv) There is a straight weft insertion over the whole width.
v) Less maintenance is required.

However in full-width temples the warp ends in the selvedges do not pass at straight angle through the weaving reed. This causes extensive friction between yarn and reed and may lead to end breakages.

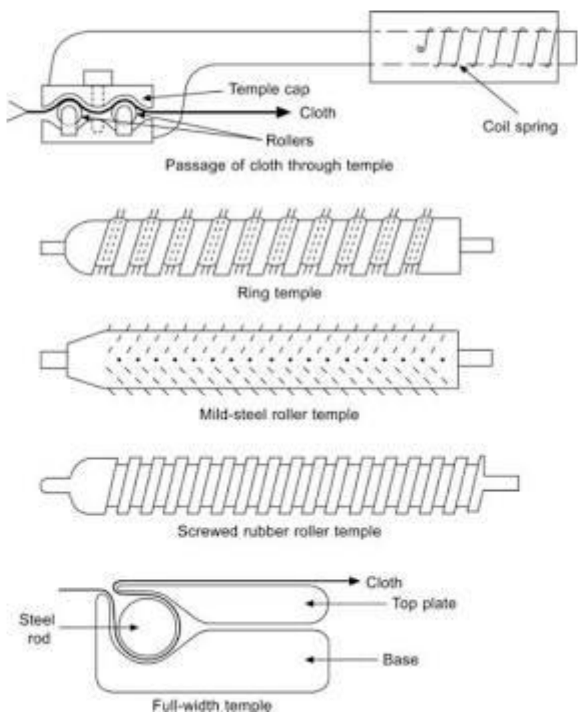
1. **Ring Temples:** Feature a series of angled, spiked rings mounted on a fixed rod at each selvedge. As the cloth advances, the angled pins continually grip and pull the edges outward.

2. **Roller Temples:** Cylindrical rollers with spiraled rubber or steel teeth that grip the fabric edges and roll along with the advance of the cloth.
3. **Full-Width Bar Temples:** Fixed guide bars designed for specific technical textiles where selvedge distortion must be completely eliminated.

3. Comparative Summary

Feature	**Wooden Temple**	**Metal Temple**	**Industrial Ring/Roller Temple**
Operation	Manual (repositioned every few inches)	Manual (repositioned every few inches)	Automatic / Continuous motion
Grip Mechanism	Fine steel pin plates	Fine steel pin plates	Spiked rings, pin rollers, or rubber cylinders
Best For	Wool, cotton, general handweaving	Linen, rug weaving, high-tension cloth	High-speed shuttleless/power looms

Feature	Wooden Temple	Metal Temple	Industrial Ring/Roller Temple
Risk Factor	May leave tiny pin marks in dense weave	May leave tiny pin marks in dense weave	Requires exact angle setting to avoid tearing selvedges



TYPES OF LOOM

Hand Loom: In Hand Loom operations like shedding, picking and beating-up is done by using manual power. This is one of the major sources of employment generation in rural areas.

Power Loom: In Power Loom all the operations of the loom (shedding, picking, beating-up, take-up, let-off etc.) are automatic except the change of the pirn.

Conventional Power Loom: In conventional looms, a shuttle carrying a pirn of weft yarn is propelled to-and-fro across the warp shed by either an over-picking or an under-picking mechanism.

Automatic Loom: In an automatic power loom, the exhausted pirn is replaced by the full one without stopping the loom. Under-picking mechanism is a required in these looms.

Shuttle-less Loom: In shuttle-less looms, shuttle is not used for picking. The insertion of weft is carried out by projectiles, rapiers or fluids (air-jet or water-jet). Based on the picking system, shuttle-less looms can be classified as follows:

- Projectile loom: weft is carried by metallic or composite projectile
- Rapier loom: weft is inserted by flexible or rigid rapiers
- Air-jet loom: weft is inserted by jet of compressed air
- Water-jet loom: weft is inserted by jet of water

  The production rate of shuttle-less looms is much higher, the quality of the fabrics is better and the product range is wider to that of shuttle looms. Most of the modern weaving mills are equipped with different types of shuttle-less looms based on the product range.

Disadvantages of Shuttle Looms: The followings are the disadvantages of a shuttle loom:

1. There is a considerable waste of energy in moving heavy shuttle for transporting a pick of weft.

2. There is no positive control on the shuttle; therefore, it may result in shuttle fly, damage of warp sheet and reed etc.

3. Shuttle picking mechanism consists of assembly of various parts resulting in frequent damage and replacement of parts.

4. The shuttle picking mechanism causes a huge Noise Pollution.

5. A plain loom stops running when a pirn is exhausted resulting in loss of production. Restarting the loom with a new pirn may cause a starting mark in fabric. In automatic loom, an additional worker is also required as battery filler for loading pirns. Also, faulty working of the pirn changing mechanism may result in defect in the fabric.

6. The variation in mass of shuttle from full pirn to the empty pirn has an effect on properties of the fabric.

weft feeler is a tertiary mechanism on automatic shuttle looms designed to detect when the weft package (pirn or bobbin) inside the shuttle is nearly exhausted.

It triggers the **automatic pirn-changing (weft replenishing) mechanism** or loom stop motion just before the yarn runs out completely, preventing fabric defects such as missing picks, thin places, or cracks.

1. Primary Functions & Working Principle

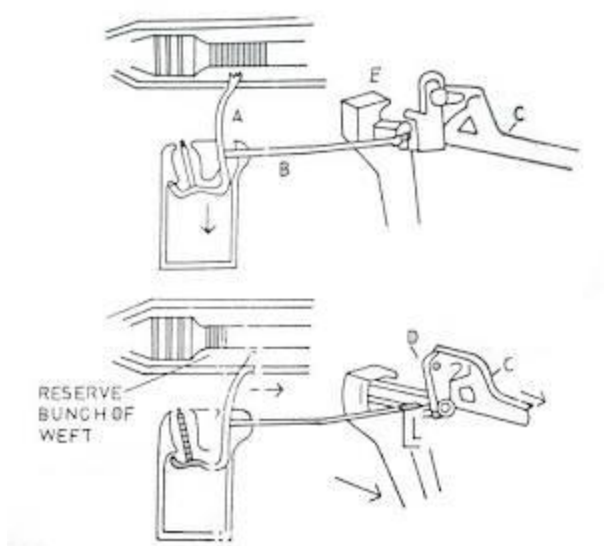
- **Defect Prevention:** Ensures uninterrupted weaving without running out of weft mid-pick.
- **Waste Minimization:** Allows maximum yarn utilization while leaving a tiny safety reserve.

- **The "Reserve Bunch":** A small length of yarn (3–4 pick lengths) wound specifically at the base/butt of the pirn. The feeler detects when the main yarn body is gone and only this reserve bunch remains, giving the loom enough yarn to finish the current shed crossing while the pirn is changed.

2. Types of Weft Feelers

A. Mechanical Weft Feeler

The mechanical feeler works via physical contact between a feeler blade and the pirn barrel.



A = Feeler Blade, B = Trip Lever Connecting Rod, C = Trip Lever,
D = Bell :rank Lever, E = Tripper Heel.

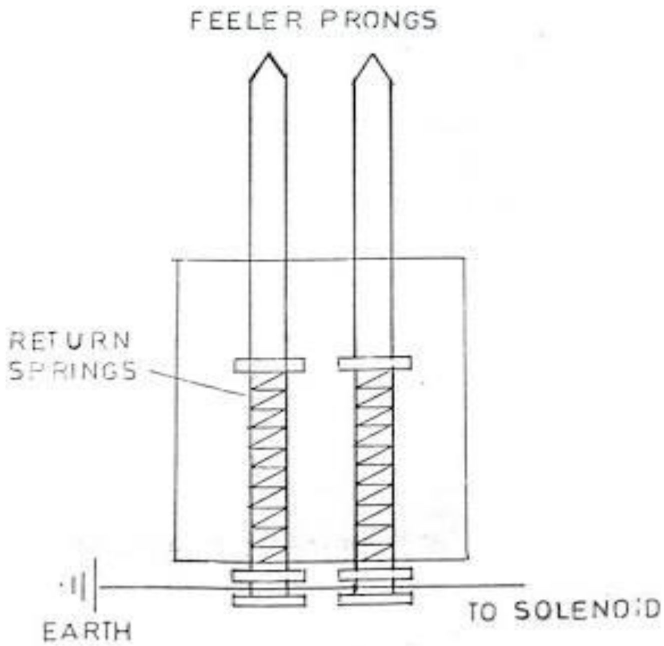
: Mechanical Feeler

- **Key Components:** Feeler blade (A), Connecting rod (B), Trip lever (C), Bell crank lever (D), Tripper heel (E).
- **Working Principle:**
    1. **Yarn Present:** As the shuttle moves forward with the sley, the feeler blade (A) presses against the yarn package. The resistance of the thick yarn package pushes the blade straight backward into its spring-loaded housing. No change signal is given.
    2. **Yarn Exhausted:** When yarn depletes down to the reserve bunch, the tip of the feeler blade touches the bare, smooth wood or plastic surface of the pirn.

3. **Trigger Action:** The smooth bare pirn offers low friction, causing the feeler tip to slide laterally (sideways). This side movement turns the feeler blade, pulling the connecting rod (B) and raising the trip lever (C) into the path of the oscillating tripper heel (E), which actuates the automatic pirn transfer.

B. Electrical (Two-Pronged) Weft Feeler

Designed for delicate or filament yarns (such as fine cotton, silk, or rayon) where the friction of a mechanical blade could damage the yarn.



Electrical Weft Feeler

- **Key Components:** Two spring-loaded conductive prongs, a low-voltage circuit, and a specialized pirn with an electrically conductive metal sleeve/ring at its base.
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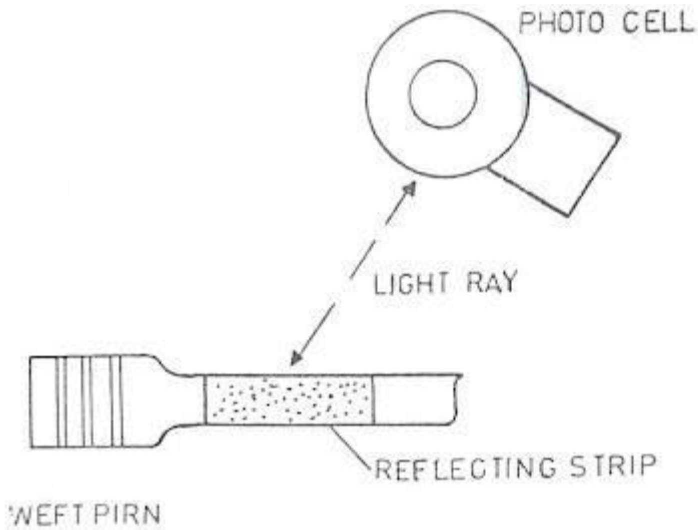
- **Working Principle:**
  1. **Yarn Present:** Yarn covers the metallic ring on the pirn. Because yarn acts as an electrical insulator, no current flows between the two feeler prongs.
  2. **Yarn Exhausted:** As the yarn depletes, the two prongs directly touch the exposed metallic sleeve on the pirn base.

3. **Trigger Action:** The metal sleeve completes the low-voltage electrical circuit between the prongs. The current energizes a solenoid/electromagnet, which engages the pirn-changing mechanism.

C. Photoelectric / Optical Weft Feeler

A contact-free electronic detection method that completely eliminates friction and physical wear on delicate yarns.



Optical Electronic Weft Feeler

- **Key Components:** Light emitter/receiver head (photocell) and a pirn fitted with a retro-reflective strip at its base.
- **Working Principle:**
  1. **Yarn Present:** The yarn covers the retro-reflective tape on the pirn. The emitted light ray is scattered or absorbed by the yarn package.
  2. **Yarn Exhausted:** As the pirn empties, the retro-reflective tape becomes exposed.
  3. **Trigger Action:** The light ray hits the reflective strip and bounces directly back to the photo-detector cell. The photodetector converts this optical pulse into an electrical signal, triggering the solenoid-operated pirn changer.

Comparison Summary

Feature	Mechanical Feeler	Electrical Feeler	Photoelectric Feeler
Sensing Method	Physical blade displacement	Electrical conductivity via prongs	Light reflection via retro-reflective tape
Yarn Contact	High physical contact	Light contact	Contactless
Special Pirn Required?	Standard pirn	Pirn with metal sleeve	Pirn with reflective tape
Ideal Yarn Types	Coarse to medium cotton, jute	Fine cotton, filament silk	Microfibers, ultra-fine filament, delicate silk
Maintenance	Mechanical wear adjustments	Keep prong tips clean	Keep optical lens dust-free

AUTOMATIC LOOMS

Automatic shuttle looms are simple power looms but having an additional mechanism of automatic weft replacement. The operation of automatic weft replenishment can be performed in two ways:

1. The empty shuttle is ejected from the loom at some convenient time in the loom cycle (i.e. when the shed is changing) and a new shuttle is inserted with a full weft package.
2. The empty weft package (pirn) is ejected and immediately replaced with a new full pirn of weft.

Accordingly, there are two different types of automatic shuttle looms: **shuttle changing and pirn changing**.

In shuttle changing, at least two shuttles per loom identical in all respects are required while the pirn changing requires only one shuttle per loom, but this shuttle is of a special shape. The second method is most common.

Advantages of Automatic Loom:

1. The cost of production is reduced due to saving in labour cost.
2. The production of loom is higher. This is due to elimination of major stoppages for shuttle change for renewal of weft package. Therefore, efficiency of automatic loom is higher (85 to 90%) than non-automatic loom (80 to 82%).
3. Automatic looms produce cloth of superior quality. This is due to continuous working of looms, chance of introduction of defect is reduced.
4. Automatic let-off results in uniform pick spacing throughout the length of fabric.
5. The number of operatives required is less. This results in less supervision requirements and less labour problems. The supervision becomes simpler.
6. The operators work on a large number of looms so earns higher wages. So, the morale of workers is high.

Important Parts and Working of Automatic Pirn Changing Mechanism:

In automatic pirn changing mechanism, the following are the important parts or attachments:

1. **Shuttle:**
    - Larger in size,
    - Having a spring jaw to hold and grip the pirn firmly,
    - Having a slot near the spring jaw for sensing of weft by the feelers
    - Equipped with a self-threading device.
2. **Pirn:**
    - Larger size for containing more weft yarn
    - Having a suitable arrangement (metallic rings or grooves) at the base to fit firmly in the spring jaw of shuttle
    - Having a grove (for mechanical feeler) or a metallic sleeve (for electrical feeler) or a reflector (for optical feeler) near the base
3. **Shuttle Boxes:**
    - Changes in the design of the shuttle boxes according to the shuttle
    - Having sufficient opening at the top/ bottom for entry/ exit of full/ empty pirn
    - No spindle in the boxes as it will create obstruction in entry/ exit of pirn
    - Equipped with an under picking mechanism
4. **A Rotary Magazine:**
    - Circular magazine having two discs for holding the full pirns
    - Having spring loaded pirn holder
    - A provision to hold 28 to 30 pirns, but capacity is less by 4 places as this space is used by the mechanism in pushing full pirn into the shuttle box
    - Pirns are held parallel and above the shuttle box
    - Having a thread holder on which free end of weft yarn of each pirn is wound

5. **Weft Feeler:**

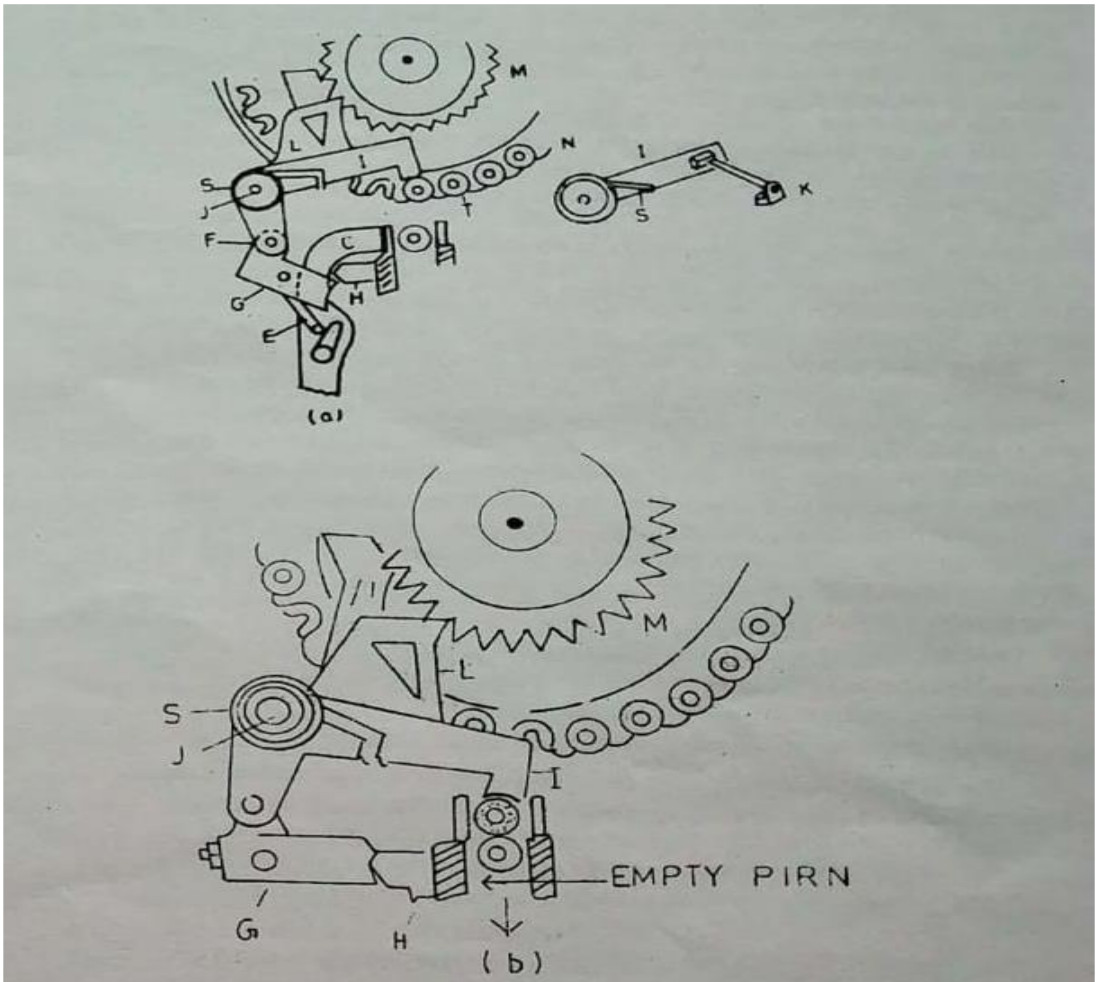
   A weft feeler mechanism to detect the almost exhausted weft on pirn is mounted opposite to the rotary magazine. The weft feeler can be anyone of the three types:

   - Mechanical Feeler
   - Electrical Feeler
   - Optical Feeler (Most commonly used)

6. **Pirn Transferring Mechanism:**

   To push the full pirn from the magazine into the shuttle and ejecting the run out pirn at the same time a pirn changing mechanism is fitted on rotary magazine side. It consists of a spring loaded hammer which is positioned in between the magazine just above the full pirn to be pushed into the shuttle.

   As the feeler indicates for pirn transfer, the change shaft is partially turned. A forked lever at other end of change shaft lifts the latch through latch depressor lever, which is integrated with the shuttle protector. When sley moves forward the bunter, which is fixed below box front on the sley engages with latch and starts pressing it. This causes hammer to come down, suddenly. In doing this it pushes the full pirn in battery on to the old pirn in shuttle, which is exactly under it. Due to this old pirn gets ejected from shuttle jaw and new pirn fits in its place. As the hammer is spring loaded, when the sley returns back the contact of latch and bunter is removed and hammer returns to its top position by spring action.



E = Peg Resting on the Latch Depressor, F = Latch Spring,
G = Transfer Latch , H = Bunter, I = Transfer Hammer,
J =Stud, K = Transfer Depressor, L = Feed Pawl, M = Ratchet Wheel,
N = Battery, T = Fully Wound Pirn, S = Hammer Coil Spring.

The ejected empty pirns having bunch on it is pushed down by hammer through the bottom of shuttle and the bottom plate of the shuttle box. It falls in the empty bobbin collector which is kept on a support fitted to loom frame. The pirns form the boxes are collected at a central place and are cleaned by removing the yarn on it.

Shuttle-less Weaving

Commercially successful shuttle-less weaving can be classified with respect to the nature of the weft carrier. A weft carrier may either be solid or fluid. Also, its flight may be positively controlled, partially guided or absolutely free. Based on the picking system, shuttle-less looms can be classified as follows:

- Projectile loom: weft is carried by metallic or composite projectile
- Rapier loom: weft is inserted by flexible or rigid rapiers
- Air-jet loom: weft is inserted by jet of compressed air
- Water-jet loom: weft is inserted by jet of water

PROJECTILE LOOM

- The Projectile weaving machine introduced into market in 1952 by Sulzer as the first successful shuttle less weaving machine.

- Projectile machine uses a projectile equipped with a gripper to insert the filling yarn across the machine.

- The unique principle of this machine is that we can practically insert the any kind of yarn like cotton ,wool, filament yarn, poly propylene or even jute as well, this is because all the finer or coarser yarns are securely grip by a gripper and inserted by the projectile.

Principle of Operation:

1. The projectile (gripper) draws the filing yarn into the shed.

2. Energy required for picking is given by twisting a torsion rod. On release the rod immediately returns to initial position smoothly accelerating the projectile by means of a picking lever.

3. The projectile slides through the shed in rake shape guide and braked into the receiving unit.

4. Projectile (gripper) is then conveyed into the original position by a transport device (belt) installed under the shed.

Advantages of Projectile Weaving:

- Power consumption is very low.
- Easy to operate and low maintenance
- A low requirement of spare parts
- More than one width of fabric can be woven at a time due to large width of loom.
- Different color combinations and designs can be easily formed.
- Reduced waste of weft yarn due to tuck-in selvedge.

Developments in Projectile Weaving:

1. Up to 6 colors can be used in weft direction.
2. Electronic Weft Braker device is used to keep uniform tension on weft.
3. Pre-acceleration to weft yarn is given by compressed air, which relieves extra tension in weft while inserting.
4. Synthetic projectile is used for weaving of delicate yarns.
5. The number of heald shafts operable is increased to 14.
6. Speed has been increased up to 470 rpm which improves the machine efficiency.
7. LED display for machine speed, projectile arrival time etc. which helps in monitoring of process.

General Operating Specifications

- **Maximum Loom Speed:** 350 to 450 RPM (Picks Per Minute), depending on machine model and width.
- **Weft Insertion Rate (WIR):** 900 m/min to 1,550 m/min.
- **Nominal Working/Reed Width:** Standard models range from **190 cm to 540 cm** (with specialized models reaching up to 650 cm). Multi-width weaving (weaving 2–4 fabrics side-by-side on the same machine) is commonly used.

- **Fabric Weight Range:** Highly versatile, accommodating light-to-medium fabrics as well as heavy industrial fabrics (from fine shirtings to heavy denim, canvas, agro-textiles, and conveyor belts).

2. Projectile Specifications

Unlike traditional shuttle looms, projectile looms use multiple small clamp-style projectiles that operate in a continuous loop.

- **Dimensions:**
  - *Standard Steel Projectile:* ~90 mm length × 14 mm width × 6 mm thickness.
- **Weight:**
  - *Lightweight / Standard:* ~40 grams (compared to a 400g shuttle).
  - *Heavy Duty:* ~60 grams (for coarse yarns or thick fillings).
- **Material:** Fine hardened steel or fiber-reinforced composites.
- **Gripping / Clamping Force:** 600 g to 2,500 g depending on yarn thickness and type.
- **Return Mechanism:** Several projectiles (typically 10 to 17 depending on loom width) are used sequentially and returned from the receiving side to the picking side via an under-loom conveyor belt.

RAPIER LOOM

Principle of Rapier Weaving:

- In this type of weaving, a flexible or rigid solid element, called rapier, is used to insert the weft yarn across the shed.
- The rapier head picks up the weft yarn and carries it through the shed.
- After reaching the destination, the rapier head returns empty to pick up the next weft yarn, which completes a cycle.

- A rapier performs a reciprocating motion.

Classification of Rapiers:

- Types of Rapier : Rigid, Flexible
- Number of Rapier : Single, Double
- Method of Weft Insertion : Gabler, Dewas

Single Rapier Loom:

- A single, rigid rapier is used in these machines.
- The rigid rapier is a metal or composite bar with circular or flat cross-section.
- The rapier enters the shed from one side, picks up the tip of the weft yarn on the other side and passes it across the weaving machine while retracting.
- A single rapier carries the yarn in one way only and half of the rapier movement is wasted.
- The single rapier's length is equal to the width of the loom; this requires relatively high mass and rigidity of the rapier to ensure straight movement of the rapier head.
- Single rapier looms 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.

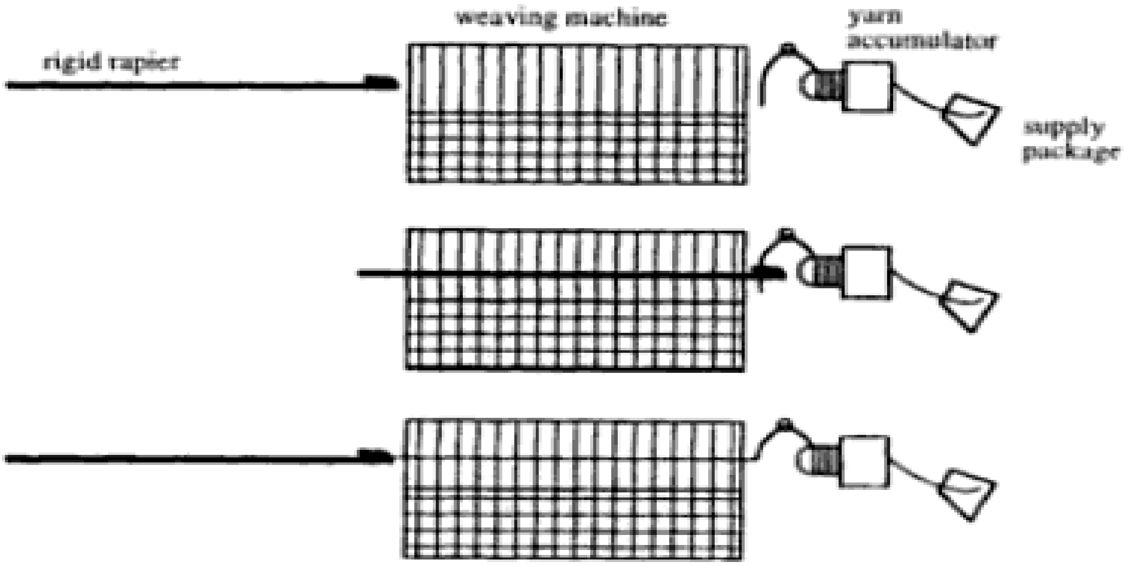
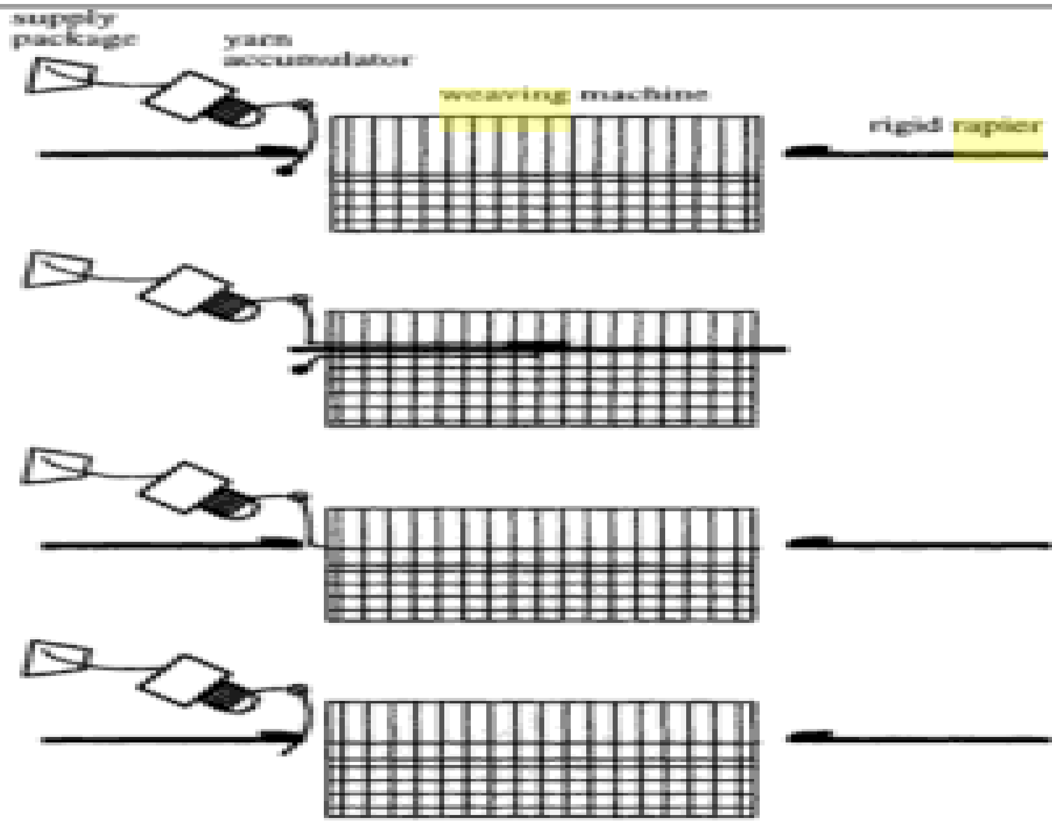


Fig: Single rapier transfer of weft in one way

Double Rapier Loom:

- Two rapiers are used in these machines. One rapier is called the giver, takes the weft yarn from the yarn accumulator on one side of the loom, brings it to the centre of the loom and transfers it to the second rapier which is called the taker.
- The taker withdraws and brings the weft 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.
- Double rigid rapiers are further classified into two types: **Dewas system** and **Gabler system**.
- In **Dewas system** the giver grip the tip of the yarn, brings it to the centre and transfers it to the taker which retracts and carries the yarn to the other side of the loom.

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



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

- Double flexible rapier machines are more common than the rigid rapier machines.

Operational Specifications

Parameter	Standard Technical Specification
Speed / RPM	325 to 600 RPM (up to 800 RPM in modern high-speed variants)
Weft Insertion Rate (WIR)	1000 to 1300 m/min
Nominal Reed Width	150 cm to 380 cm (60 inches to 150 inches)
Weft Selection / Colors	Up to 8 or 16 colors (controlled by Electronic Selector/Dobby)
Yarn Range (Spun)	Ne 8s to Ne 120s
Yarn Range (Filament)	20 Denier to 2000 Denier
Power Drive	3-phase AC Motor (3.5 kW to 5.5 kW) with electromagnetic brake

Core System Specifications

- **Weft Insertion Type:** Double Rapier (Giver & Taker System)
  - **System Variant:** Flexible Tape or Rigid Bar

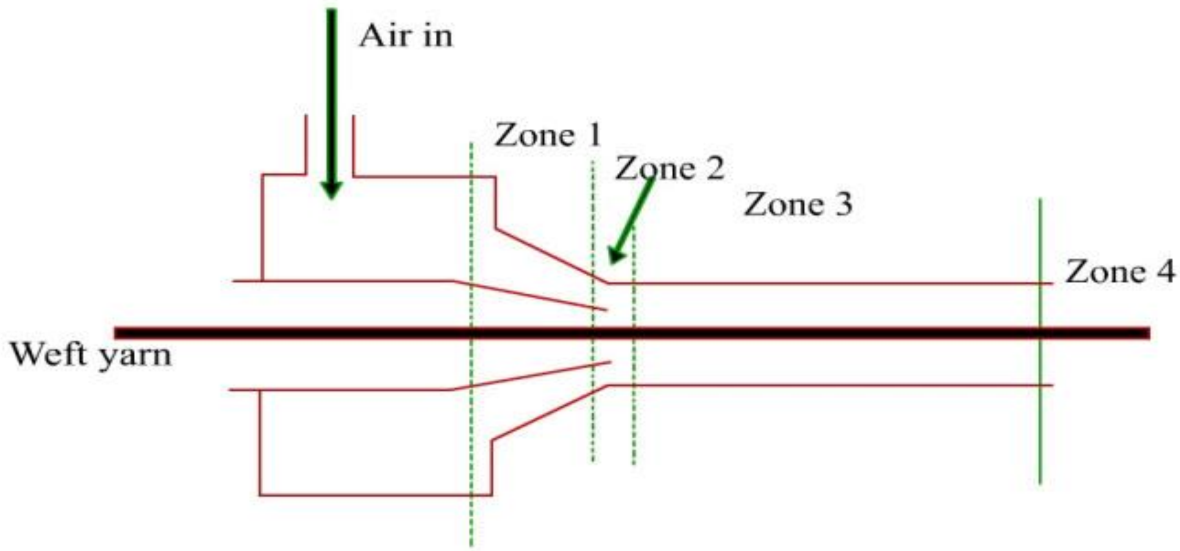
Transfer Principle: Dewas (Tip-to-Tip Transfer) or Gabler (Loop Transfer)

- **Shedding Mechanism:** Electronic Dobby (up to 20 levers), Cam Motion, or Electronic Jacquard
- **Let-Off Motion:** Electronic Continuous Let-Off (ECL) driven by a dedicated servomotor with load cell tension sensing.
- **Take-Up Motion:** Electronic Continuous Take-Up (ECT) linked to pick density adjustment (e.g., 2 to 120 picks/cm).
- **Beating-Up Mechanism:** Conjugate Cams or Short Crank-driven conjugate link motion.
- **Selvedge Formation:** Tuck-in, Leno selvedge, or Melt selvedge (for synthetics).
- **Safety & Monitoring:** Piezoelectric electronic weft sensors, infrared photoelectric warp stop motion, and automatic pick-finding mechanism.

AIR-JET LOOM

Principle of Air-Jet Weaving:

- It is one of two types of fluid-jet looms, the other being a water-jet loom.
- Fluid-jet looms can operate at a faster speed than other shuttle-less looms such as rapier looms, but they are not as common.
- An air-jet loom is a shuttle-less loom that uses a jet of air to propel the weft yarn through the warp shed.
- The important parts used in air-jet weaving consist of a main nozzle, auxiliary nozzles or relay nozzles, and a profile reed.



- In an air-jet loom, yarn is pulled from the supply package, and the measuring disc removes a length of yarn equal to the width of fabric being woven. A clamp holds the yarn and an auxiliary air nozzle forms it into the shape of a hairpin. The main nozzle blows the yarn, the clamp opens, and the yarn is carried through the shed. At the end of the insertion cycle, the clamp closes, the yarn is beaten in and cut, and the shed is closed. The jets are electronically controlled.

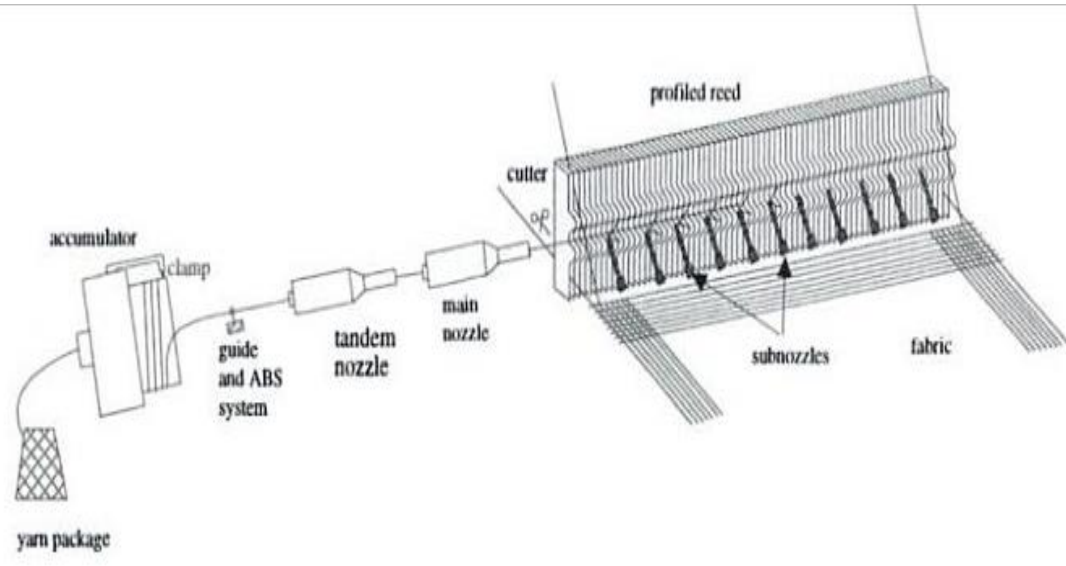


Figure: Principle of Air-jet weft insertion system

Passage of Weft Yarn (Filling Path)

1. **Yarn Package to Pre-Winder:** Weft yarn unspools from a large cone package and wraps onto an electronic pre-winder (accumulator) that measures the exact length for one reed width.
2. **Main Nozzle:** A solenoid valve releases compressed air into the main nozzle, propelling the measured yarn length into the warp shed.
3. **Profile Reed & Relay Nozzles:** The yarn travels along a channeled profile reed guided by booster jets from relay nozzles positioned along the shed length.
4. **Stretching & Cutting:** A stretch nozzle holds the yarn taut at the receiving end until a cutter trims the yarn at the feeding side, completing the pick insertion.

Application and Advantages of Air-Jet Weaving:

- It has an extremely high insertion rate.
- The air-jet weaving machine gives high performance with low manufacturing cost.
- Air-jet weaving machines are used primarily for the economical production of standard fabrics, covering a wide range of applications.
- Air-jet looms are capable of producing standard household and apparel fabrics for items such as shirts, denim, sheets, towels, and sports apparels as well as industrial products such as printed circuit board cloths.
- Heavier yarns are more suitable for air-jet looms than lighter yarns.
- Air-jet looms are capable of weaving plain, dobby and jacquard fabrics.

Developments in Air-Jet Weaving:

- The multi nozzles are divided into two zones and connected directly with separate tanks. Independent pressure tanks make it possible to set weft insertion pressures at optimal levels, and saving in energy.
- Tandem Nozzles: The two main nozzles are arranged in series so called tandem nozzles. It reduces the nozzle pressure which results in saving in energy. Suitable for wide range of weft count.
- Tapered Sub-Nozzles: It consists of a tapered hole to prevent air dispersion. It enables stable weft insertion with lower air volumes.
- Tapered Tunnel Reed: It helps in preventing air dispersion. The weft insertion is more stable and requires less air.

- ATC (automatic timing control) is being used for weft insertion which guarantees optimum weft insertion conditions.
- All settings regarding picking are done by microprocessor keyboard, which reduces machine down time.
- The servomotor controls the warp yarn tension and slack according to the signal collected by the sensor. It ensures that the warp yarn's tension is controlled properly.

WATER-JET LOOM

Principle of Water-Jet Weaving:

- Water jet weaving machines have the same basic mechanisms like air-jet machines except the picking mechanism. The principle of weft insertion is similar to an air jet i.e both use a fluid to carry the yarn.
- Water-jet weaving machine inserts the weft yarn by highly pressurized water.

- The pulling force is provided by the relative velocity between the filling yarn and water jet. This velocity difference between the water and yarn does not allow curling and snarling of the weft yarn.
- The water jet axis forms a parabola, therefore, the axis of the nozzle is kept upward by some angle.
- The diameter of Water-Jet is around 0.1 cm and the amount of water used for one pick is less than 2 cc.
- Double pump system, with two nozzles is suitable for inserting two different weft yarns.
- Water-jet weaving has some special requirements e.g. the yarn must have wetting ability in order to develop the pulling force.
- The width of the water-jet weaving machine depends on the water pressure and diameter of the Jet.

Important Parts of Water-Jet Loom:

- Accumulator
- Pump
- Nozzles
- Leno Devices
- Tension Regulators
- Thermal Knives
- Electric feelers
- Sensors

Working of Water-Jet Loom:

The weft yarn is fed from cone. It is drawn-off by a feeding and measuring device. It then passes through a tension regulator and a weft clamp. When the insertion has to take place, the weft clamp loosens its hold and the thread is inserted inside a nozzle which is struck by a jet of pressurized water which causes the weft yarn to cross through the shed at high speed.

After the insertion has taken place, while the weft is held flat by the threads which are moved by the leno mechanisms, the thermal knives enter into action on the launch side to cut the weft, and on the opposite side to trim the fabric. A yarn clamping device holds the weft waste which is cut off by the right-handed thermal knife while rotating gears arrange for its removal.

Advantages and Application of Water-Jet Loom:

Water-jet loom has following advantages:

- Less noise
- Requires less space
- Less power consumption, so economical
- Production rate is very high.

Suitable for synthetic filaments (Nylon, Polyester), Glass and Carbon Filaments

Advantages of Shuttle-less Looms:

1. The production rate of shuttle-less looms is much higher.
2. The quality of the fabrics is better.
3. The product range is wider to that of shuttle looms.

Therefore, most of the modern weaving mills are equipped with different types of shuttle-less looms based on the product range.

Speed (Production) of Shuttle-less Looms:

The speed of shuttle-less looms can be compared in terms of Rate of Picking i.e. Picks Per Minute (PPM). The comparison of top speed of shuttle-less looms is given below:

- Projectile loom: 420 PPM
- Rapier loom: 475 PPM (Rigid Rapiers), 524 PPM (Flexible Rapiers)
- Air-jet loom: 1200 PPM
- Water-jet loom: 1500 PPM

Selvedge forming mechanism in Shuttle-less Looms

Selvedges of fabrics produced on shuttleless weaving machines are markedly different from those produced on shuttle weaving machines. Insertion of single picks by weft carrier followed by action of weft cutters at both selvedges leaves a small length of free weft hanging free at the fabric selvedges. Unless these threads are secured properly the fabric may start disintegrating along its edges during subsequent wet processing.

Tucked selvedges (gripper and air jet), leno selvedges (air jet and rapier) and fused selvedges (water jet) are commonly encountered on fabrics produced on shuttleless looms.

Tucked selvedge can be created on gripper machine with the help of tucking needles which enter warp shed from under the bottom warp line during retreating motion of sley after beat up and pull in the free segments of pick into subsequent shed **(Figure 1)**.

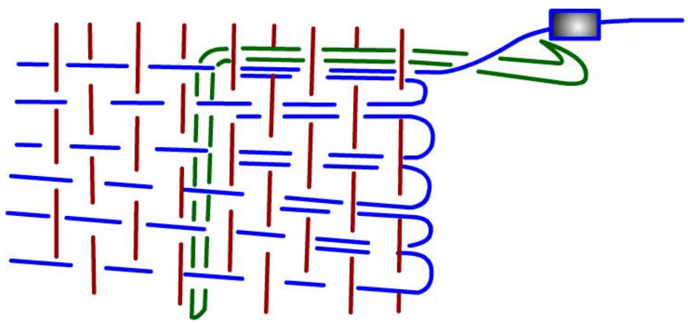


Figure 1

On an air jet loom additional blowers located near fabric selvedges perform this task. Tucked selvedges are fairly firm but contain double picks **(Figure 2)**.

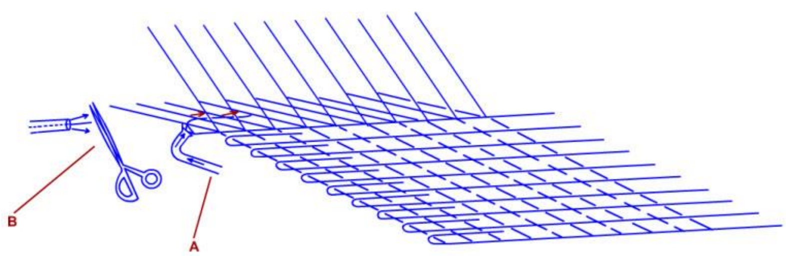


Figure 2

Leno selvedges (**Fig 3**) are generated by extra warp threads supplied from spools. Leno construction involves twisting a pair of warp threads around each other whereby one of the threads (**No. 1 in Fig 3a**) always floats above the interlacing weft thread while the other (**No. 2**) floats under. Such constructions can be practically realized in more than one manner. The practice of employing standard and doup threads (**Fig 3a**), lappet motion involving needles and bars (**Fig 3b**) and rotating discs carrying spools (**Fig 3c**) typically exemplify some commercial processes. With doup and standard threads, chains or specially designed doup healds ensure that doup threads are moved alternately to open and crossed position vis-à-vis standard threads in successive picks while doup threads are always maintained at the bottom warp line during picking. In the method employing needles and bars the respective standard warp threads are drawn through vertically reciprocating needles that are mounted on bars while the doup threads are drawn through eyes mounted on a horizontally reciprocating bar. Rotating discs carry spools and are suitably mounted atop healds in such a way that threads can land directly at the respective selvedges. When the discs are rotated every pick through 360^0 then a double locked leno results which grips relatively smooth weft threads fairly tightly while a disc rotation through 180^0 can be sufficient for usual spun threads.

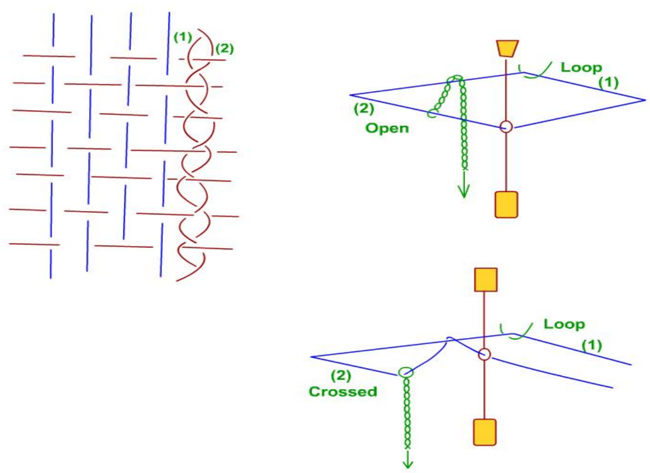


Figure 3A

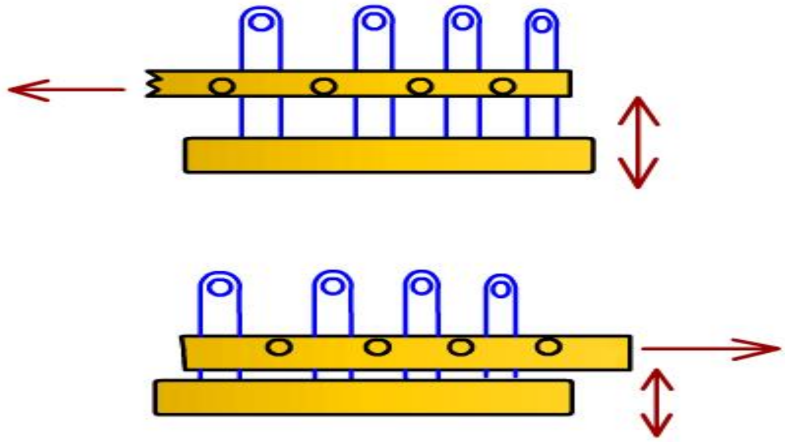


Figure 3B

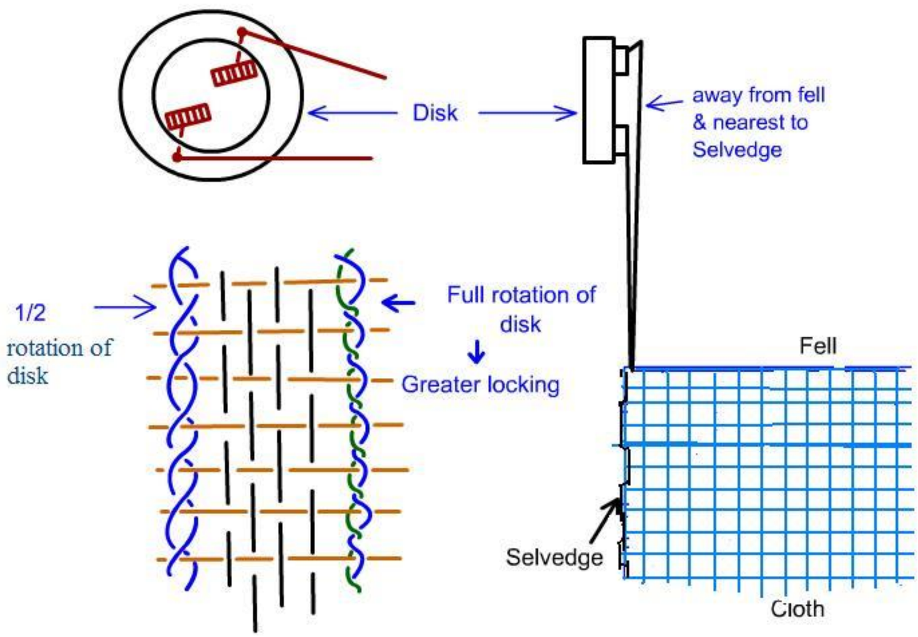


Figure 3C

Fused selvedges are created by employing glowing hot filaments located conveniently near selvedges. Such selvedges are found in fabrics made of thermoplastic yarns.

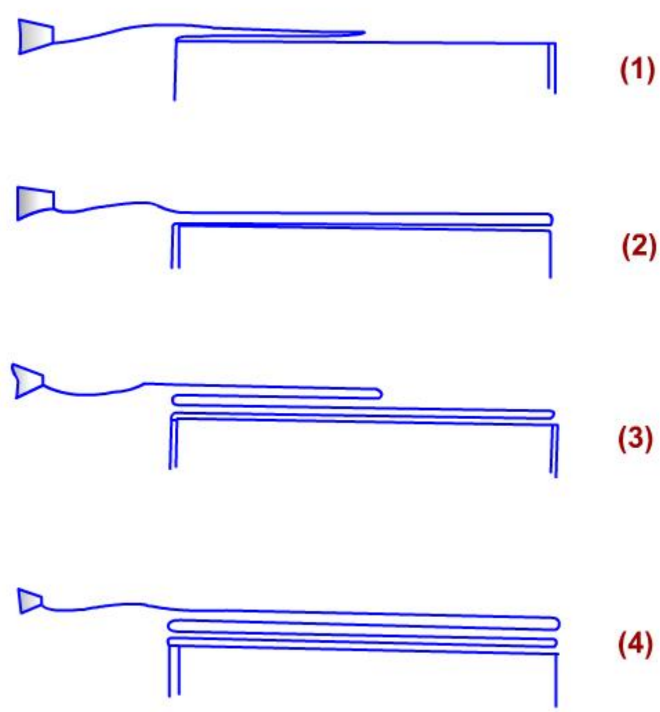
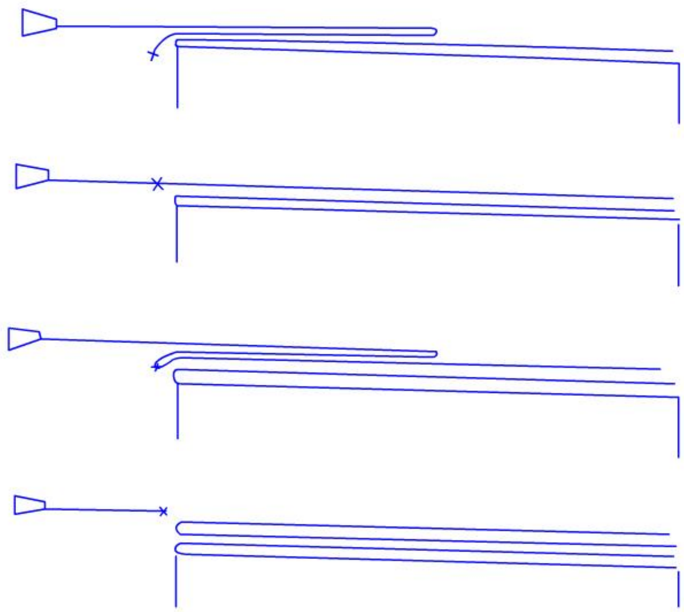


Figure 4A



Classification of Selvedges

Selvedge Type	Loom / Technology Used	Working Principle	Key Characteristics
1. Conventional (Closed) Selvedge	Shuttle Looms	Weft yarn turns continuously around the outer warp ends at both fabric edges.	Smooth, loop-bound, neat, and non-fraying edge; no thickness build-up.
2. Tucked-In Selvedge	Rapier & Projectile Looms	Mechanical tucking needles tuck the cut ends of inserted picks back into the subsequent warp	Strong, clean edge with double thread density at the borders.

Selvedge Type	Loom / Technology Used	Working Principle	Key Characteristics
		shed.	
3. Leno / Gauze Selvedge	Air-Jet, Water-Jet & Rapier Looms	Two outer warp ends (standing & crossing thread) twist around every inserted pick in a figure-8 motion.	Highly secure locking mechanism with minimal thickness; leaves a short fringed edge.
4. Fused / Sealed Selvedge	Thermal/Ultrasonic Cutters on Jet/Rapier Looms	A heated element or high-frequency ultrasonic cutter melts thermoplastic synthetic yarns (polyester, nylon).	Firm, heat-welded edge with no loose fibers; can feel rigid or scratchy.
5. Fringe / Cut-Off Selvedge	Auxiliary Shuttleless Mechanism	Weft picks extend past the outer warp, held temporarily by catch cords before being sheared off.	Loose cut threads along the edge; requires secondary binding (like leno) to prevent fraying.
6. Adhesive / Glued Selvedge	Specialty Shuttleless Looms	A continuous strip of thermoplastic adhesive or chemical binder is applied to lock the cut weft ends.	Smooth and thin edge; suitable for technical textiles where thickness variations cause storage defects.

Structural Variations in Selvedge Design

- **Plain Selvedge:** Uses the same weave structure as the fabric body but uses heavier or double warp ends.
- **Tape Selvedge:** Uses a stronger weave structure (e.g., Matt or Basket weave) at the edges to prevent curling during processing.
- **Split Selvedge:** Used when weaving multiple narrow fabric widths simultaneously on a wide loom, where the fabric is split and edges are bound (typically using leno or fused selvedges).

TERRY WEAVING

Towel: A towel is a piece of absorbent fabric or paper used for drying or wiping. It draws moisture through direct contact, often using a blotting or a rubbing motion. Common household textile towels are made from cotton, rayon, bamboo, nonwoven fibers or a few other materials.

Types of Towel: There are many types of towel. Some are them given below: Baby Towel Bath Towel Beach Towels Golf Towels Hand Towel Hotel Towels

Terry Towel: A terry towel is a textile product which is made with loop pile on one or both sides generally covering the entire surface or forming strips, checks or other patterns. Special type of weaving technique is required for terry towel manufacturing. Terry towels are often very complex with yarns of different types and colors, in combination with various loop pile and flat structures. The name "terry" comes from the word "tirer" which means to pull out, referring to the pulled out by hand to make absorbent traditional. Turkish toweling Latin "vellus" meaning hair has the derivation "velour" which is the toweling with cut loops.

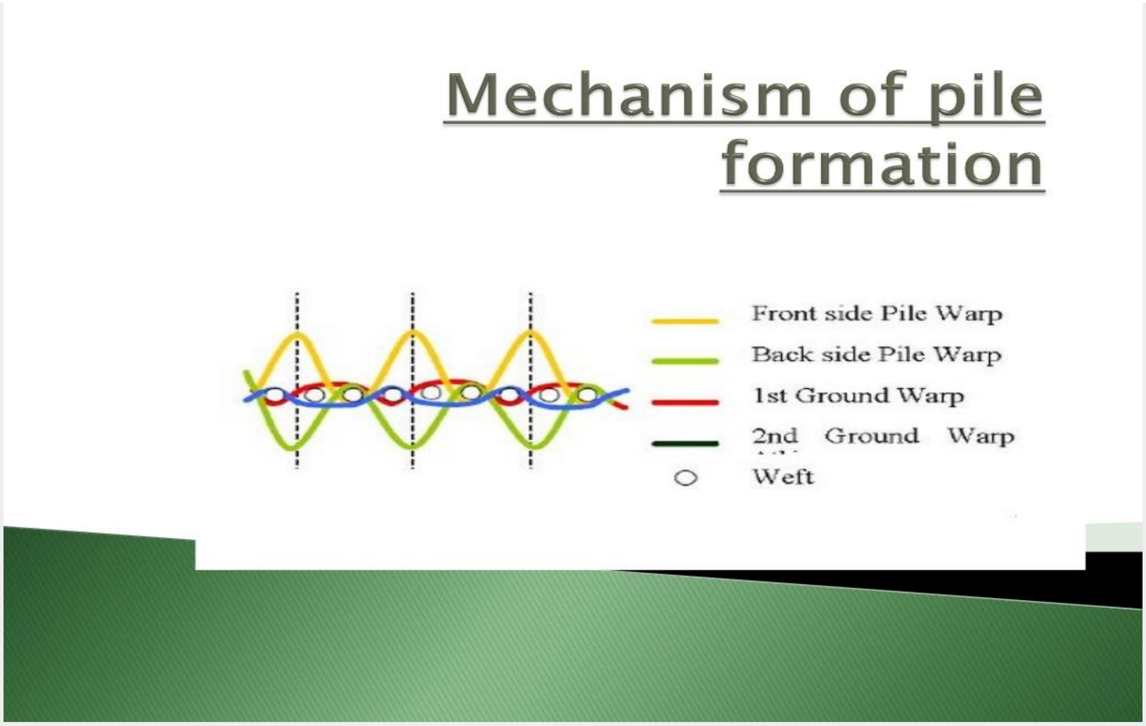
Process Flow Chart of Terry Towel Manufacturing:

Warping (Direct)
↓
Sizing
↓
Terry Weaving
↓

Fabric Inspection
↓
Wet Processing
↓
Inspection
↓
Stitching
↓
Final Inspection
↓
Packing & Cartooning

Mechanism of Terry Towel Manufacturing:

The basic mechanism of terry towel lies in the formation of a loop or uncut pile. The pile is a always a warp yarn and distributed evenly between the ground warp yarns. There can be pile either in one side or in both sides. The following figure above shows the cross section of a terry towel along warp i.e. across the weft yarns.



In the figure green and the yellow yarns represent the top and bottom piles respectively. The red and the blue yarns represent two ground warps of plain weave construction. Off course the ground weave can be twill as well. The small circles represent the weft yarns. The way the pile is produced is that a gap (equal to loop height) is created between fell of the cloth and a group of three picks. This is done in such a way so that after completion of a beat up two successive picks are inserted but are not beaten up.

After insertion of the third pick the group of three picks is beaten up at a time. The three picks we can call a set or group of three picks and these are shown by vertical dotted lines in the following figure:

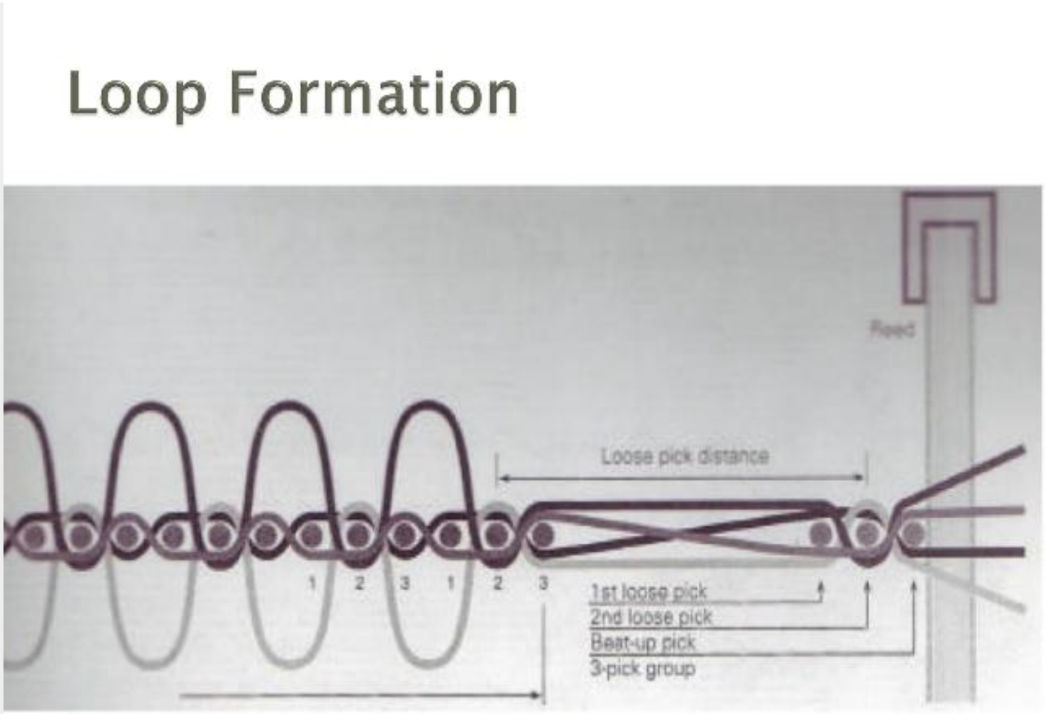


Figure 12 Loop Formation during Terry Weaving (Adanur, 2001)

In between two dotted lines there are three picks. The first two picks are called loose picks and the third or last pick is called fast pick. The weave is chosen in such a way that during beat up of the group of three picks can easily slide through the ground warps but the pile yarn is locked so that after completion of the beat up a loop is produced. A group of three picks weave of ground warp and pile warp is shown in figure. Two loose picks and one fast pick are the simplest form of terry weave and minimum requirements of terry formation.

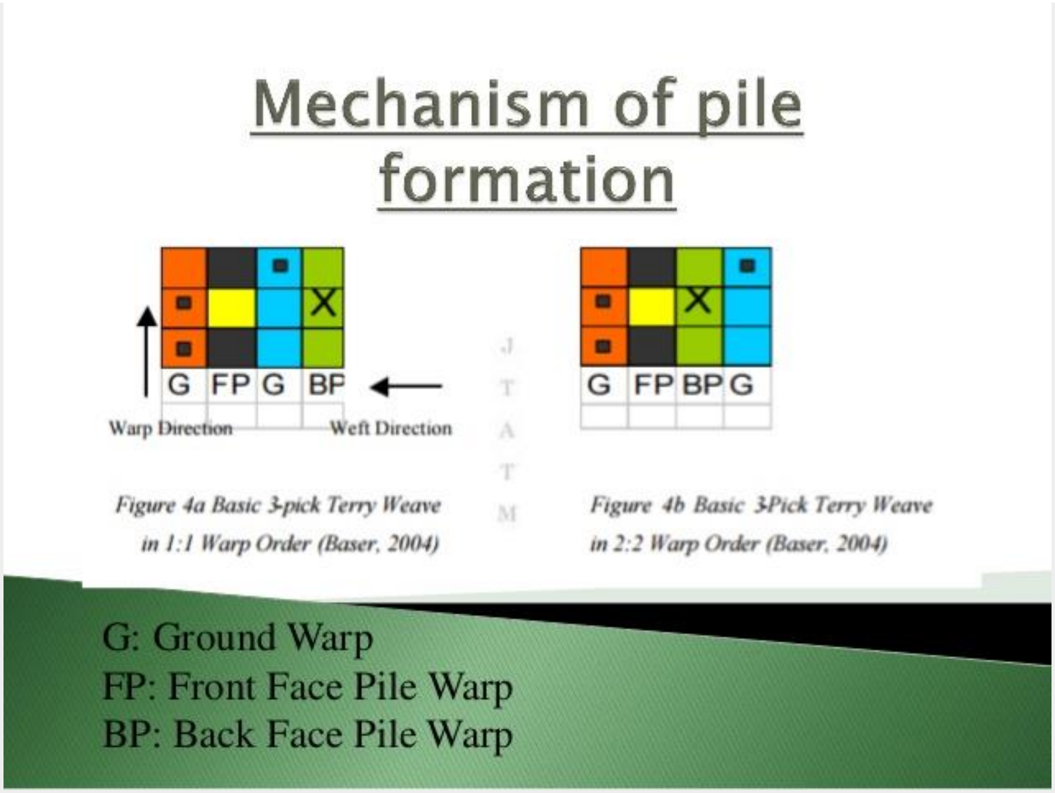


Figure 4A and 4B shows weave structure of 3-picks terry structure. In weave A the ground warp (Red & Blue) and pile warps (Green & Black) are shown alternatively while in weave B the ground warps and the pile warps are shown together. Both the repeats will result same towel. In the two repeats the red and blue are the ground warp while the black and the green are the face and back piles respectively. The number of loose picks always remains same but for producing better quality towels the number fast picks varies.

Let off arrangement of Terry Loom: In any terry loom there are two let off mechanisms one for the ground warp which is just like ordinary weaving, the other let off mechanism is intended for the pile warp. Since the pile warp forms the pile therefore the let off of the pile warp beam is very important to maintain equal pile height as on the whole the quality of the towel. The let off of pile warp is again can be of two types e.g. negative and positive. The negative let off is used in the old version loom where the pile beam is subjected with a very light weight and the warp is let off deliberately due to the tension caused by beat up of the group of three picks. In case of positive beat up, certain length of pile yarn, which is equal to the pile height, is delivered deliberately by the let off system. In case of negative let off there is possibility of variation of pile height.

Normal beat up in Towel Heading: As is shown that in towel there is an area called border or towel heading. In towel heading there is no pile and the pick density is very high so that the beat up is carried out after every pick and therefore the let off of pile warp require some adjustment in the border or towel heading. In case of negative let off additional weights are required to prevent pile/loop formation while for positive let off mechanism, deliberate delivery of the pile is prevented and a normal let off is brought into action. In fact the whole length of a single towel is like a repeat and a pattern chain controls the production.
Special Beat up mechanism/Crammed mechanism: The special beat-up system has prevented its loose pick and fast picks action and instead it has to work like ordinary beat up action. Apart from the pick density of the towel heading also increases in the towel heading. This special arrangement in the beat up is called crammed mechanism.

Pick skip mechanism: Sometimes it is seen that certain length of fringe are kept at the end of each towel. This is produced by allowing the take up motion to wind certain length of the fabric without inserting any weft in it.

In order to choose fibre for manufacture a towel the following criterion are considered important:
(i) high absorbency (ii) high wet strength, (ii) ability to dye well , (iii) good color fastness, (iv) wash ability, (v) softness , (vi) cost and (vii) availability. Considering these facts it seems that in manufacturing terry towel cotton fibre is the most widely used fibre in the world. Apart from this fibres like Modal. Lyocel, Bamboo, Flax, Microfibre and silk are widely used. In some special cases fibres like soybean and corn are also used widely.

There are three types of yarns used in terry towel namely the ground warp yarn, the weft yarn and the pile yarn. Though the yarn parameters vary depending on the type towel but in most cases the Warp yarns are of carded 20/2 to 24/2 Ne count with 550 turns/metre. The Pile warp yarns are either carded or combed and count range is of 16/1 to 20/1 Ne, 240-255 tpi. The Wet yarn carded 16/1 or 20/1 Ne counts with 240-255 turns/metre twist and 15-25 picks/cm.Both ring and rotor yarns are used.

Designing and Decoration of Terry Towel Textiles are always associated with fashion. Towels are not different from that. Towels can be decorated by dyeing, printing as well as weaving. One of the most common form of designing is alternate block of pile plain surface. This is done by the changing the weave structure. Production of pile in only one side is also part of this. Apart from this there are dobby and jacquard designs used in terry structure. A more complicated type of design is produced by jacquard weaving where pile height varies to different extent.

Weight & Pile Orientation: Totally depends on process line. Softness/ Hand feel: It depends on properties of the yarn used in pile, finishing chemicals and too some extent on pile orientation.

GSM: Weight and GSM should be same as required by customer.

Absorbency: Depends on type of fiber, yarn properties, fabric characteristics and finishing Softness: Depends on type of fiber, yarn properties, fabric characteristics and finishing.

Dimensional Stability: How a towel is behaving after washing is fall under dimensional stability properties. Dimensional stability is measured by the residual shrinkage % in a finished towel.} Absorbency: Terry towel should be highly water absorbent.

Lint: Lint are basically protruding fibers present in a finished towel. It is measured by weight of accumulated fiber collected from washing machine and tumble drying machine during testing.

FABRIC DEFECTS

Various types of faults found in woven fabrics are mentioned below:

1. **Bad or defective selvedge:** Bad selvedge in **woven** fabrics due to the faulty weaving. Here, warp ends being set too far apart for the thickness of the yarn or in finished fabric.
2. **Broken ends or warp:** A defect in the woven fabrics caused by a warp yarn that was broken during weaving or **finishing**.
3. **Broken picks or weft:** A filling yarn that is broken in the weaving of fabric.
4. **Loose warp:** This type of fault is produced in woven **fabrics** when the tension of warp yarn is slow.
5. **Loose weft or snarl:** It is produced in woven fabrics due to the looseness of filling yarn.
6. **Double ends:** This kind of fault is produced in woven fabrics when the two ends of warp sticks get together after sizing.
7. **Tight ends:** If the tension of warp yarn is more than the other ends present in the loom then this type of fault is produced in woven fabrics.
8. **Float of warp:** If someone pulls the **fabric** together the cloth roller intentionally or unintentionally then this kind of defect is produced in woven fabrics.
9. **Wrong end color:** It is produced in woven fabric due to the wrong drawing of colored yarn.
10. **Miss pick:** This kind of **defect** is produced in woven fabric when operator starts a stopped **machine** without picking the broken weft from the shade.
11. **Double pick:** It is produced in woven **fabric** when the cutter don’t work properly.
12. **Weft bar:** When count of yarn varies from one cone to another cone then a bar of weft will be appeared in fabric after weaving.
13. **Ball:** If the warp is too much hairy then the reed will create ball in warp yarn in between reed and heald shaft. If the ball is small enough to pass through the dent of reed then those will form the ball in fabric.

14. **Hole:** A fabric imperfection in which one or several yarns are sufficiently damaged to create an opening.
15. **Oil spot or stain:** Discoloration on a local area of a substrate that may be resistant to remove by laundering or dry **cleaning**. It occurs during spinning, weaving or **finishing**. It is also often seen in the woven fabric. It is also produced in woven fabric if too much oiling has done on the **loom** parts.
16. **Tails out:** This kind of fault is produced in woven **fabric** if the cutter doesn't work properly.
17. **Temple mark:** If the placement of ring in the temple bar is wrong or the pressure of temple to the fabrics is too high then this type of fault is produced.
18. **Reed mark:** In woven fabric, a crack between the groups of warp ends either continuous or at intervals. It's may be caused by the wrong drawing-in of the warp or damage to the reed wires.
19. **Slub:** If the yarn contains unexpected slub in it then those slub will be appeared in the fabric as a fault.
20. **Thick and thin place:** Fabric defect in which fabric count varies more than a specified percentage from the intended count. If the thick or thin place is more than one inch (2.54cm) wide then it is considered as a major defect in **fabric** grading.

    A segment of yarn at least ¼ inch (0.6cm) long that is noticeably thicker than adjacent portions of yarn is called thick place. A segment of yarn at least 25% smaller in diameter than adjacent portions of yarn is called thin place.

Factors influencing Productivity in Weaving

The internal as well as external factors affecting the productivity of power loom industry given below:

There were total 51 factors under consideration which were divided into eight groups namely

(1) Product factor (PF) discussing about the variety, cost and quality of the product.

(2) Material factor (MF) discussing about the count variations, strength variations and inventory level of the firm.

(3) Preparatory function factor (PFF) discussing about the functions such as dying, drying, loading time of the beam etc.

(4) Plant and equipment factor (PEF) discussing about the machine utilization, layout, maintenance, ergonomic conditions and housekeeping.

(5) Market factor (MF) discussing about the purchase, sales, export etc.

(6) Technological factor (TF) discussing about the use of IT software, R&D efforts and use of automated material handling.

(7) Government and infrastructure factor (GIF) discussing about the cost of electricity and water, regulation of market, cost of yarn, subsidy and various schemes.

(8) Human factor (HF) discussing about the skill, training, professional culture, dedication, attitude of the workers.

At the same time motivation schemes, satisfaction of employees. Also the communication strategy and management style of the entrepreneur and supervisor.

References: **1. National Programme on Technology Enhanced Learning (NPTEL)**

2. Guest Lecture by GOPALAKRISHNAN DURAISAMY

3. MHRD Project "National Mission on Education through ICT"

Video Links:

1. **Weft Insertion Methods:** https://www.youtube.com/watch?v=s0W0iDj7_hc

2. **Fabric Defects:** https://www.youtube.com/watch?v=9VFLaSVkmYE