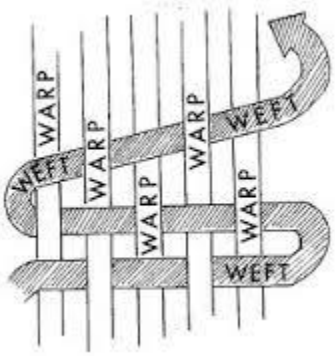
Energy efficient Loom

This document is a report describes the efficiency improvement works of NRG solutions, an enterprise based in Delhi working towards improving efficiency of machineries used in garment related industries.

How a loom functions?

A basic understanding of loom functionality would be beneficial before we discuss the efficiency of looms. Fabric is created when horizontally and vertically threads are interwoven with each other. The easiest way to do this is keep a set of vertical threads fixed and move horizontal threads up and down alternately between them.



These vertical threads are called WARPS and horizontal threads WEFTS

Now instead of moving weft up and down between the warps, it is even easier if alternate warp threads are lifted up and the weft thread is simply moved across horizontally. This simple principle is used in all looms. A picture is given aside for better understanding.

The warp is usually first fixed and set in the loom through a reed which helps keep each warp in its place. Then the above mentioned interweaving is achieved through 3 different operations in a handloom:

1. **Shedding**: Alternate warp threads are lifted up in this operation. Achieved by a pedaling operation in regular handloom.
2. **Picking**: This is when a weft is moved horizontally between the lifted and non-lifted warps. This is achieved through a shuttle in regular handloom, operated by hand motion.
3. **Beating**: After a weft is interwoven between the warps; the weft need to be rammed towards one end to tightly fix it in the fabric. If this ramming is not tight enough, the fabric would turn out to be like a fishnet or a mosquito net at the end!!! This is also a manual hand operated action in a handloom.

Other settings and controls: To co-ordinate the above said motions, certain settings and controls are also necessary.

1. **Warp tension**: Warp when fixed through reed, the tension on the threads need to be controlled. If this tension is above a certain limit, the warp would break, and if too less it would not hold the wefts tightly in place. Due to the tension, thread used for warping usually will be thicker and stronger than those used for wefting. Also while shedding and while rolling finished part of cloth, the tension is to be controlled
   This is automatically controlled even in handlooms.
2. **Pick per inch setting**: Pick is another word for weft. The number of weft threads needed in an inch of fabric length is set through a setting. This setting determines how close two weft threads

are. The finished fabric after each ramming of a shuttled weft need to be moved back by a length based on this setting, for new weft to be rammed in.
A weaver can select P.P.I by a variable setting provided in the loom (18 P.P.I, 30 P.P.I etc.)

3. **End per inch setting**: This is the number of warp threads in an inch of the fabric width. This is usually set initially before operating loom by properly selecting the reed accordingly.

Energy Requirement:

In the processes mentioned above, the energy demanding processes are shedding, picking, beating, rolling back of beaten wefts and tension control of warps.

Productivity:

In a handloom, the speed at which a weaver co-ordinates pedaling and hand movements determines the productivity whereas in a powerloom, the speed at which a drive can safely carry out the motions without breaking the threads determines productivity.

Productivity can be increased by following methods:

1. Increasing efficiency: This can be achieved by reducing friction wherever movement is needed in the loom. Thus in a handloom it becomes easy for the operator to move the machine parts and hence the actions would be faster
2. Better automated controls for the co-ordination between different actions required: The less the required manual co-ordinated action, the move productive would the weaver be. Also less the failure in automated co-ordination, less the manual intervention needed
3. Lower the time required for movements: This is achieved by techniques like rapier where instead of one shuttle moving across horizontally, weft is carried by a shuttle only half way and then another shuttle carries it across the other half way reducing time for wefting by half.
   This can also be achieved through better and faster shuttling technologies like carrying weft with the help of superfast air jet or water jet etc. Each method has its own advantage and disadvantages

NRG Solution

NRG Solutions looks at techniques 1 and 2 to improve the regular handloom into more productive handloom. This is achieved by automating all the co-ordinated movements through a single movement and by reducing friction together by which even a lower skilled weaver can weave quite fast with just one hand (as against pedaling and two hand motions in regular looms). NRG also provides option to automate this one motion required into a motorized action thereby converting the entire handloom into a powerloom.

The advantage is that those who want to retain handloom status for reasons related to govt. schemes, a motor need not be used. Else a motor can be easily fitted.

Higher end Power Looms

Higher end power looms use all the 3 techniques given above to increase productivity. Hence they are both efficient and productive than smaller looms. Disadvantage is that the fast production forces weavers to use stronger and thicker threads which generally consumers do not appreciate. Hence the general perception that power loom products are of lower quality. Also in air and water jet looms, the thread quality is sometimes reduced due to their engaging with the jet of air or water.

Loom design

The basic factors needed to design a loom, and hence to compare them, are given below. While comparing productivity, these factors need to be same for the two looms compared.

Fabric width: Generally mentioned in inches. 36 inch, 45 inch, 60inch etc are common width of fabrics. The loom width would be slightly higher than fabric width. For example 60inch fabric would need a 72 inch loom.

Reed Ends per inch (eg. 64 ends per inch): The more end per inch, there are more widthwise threads (warp) per inch and hence better quality. When this number reduces, fabric becomes more translucent. The red is selected based on the desired ends per inch and fixed on to the loom. Reed is hence replacable

Picks per inch (PPI): This determines the amount of weft per inch. 18 PPI, 30 PPI are common.

PPI alongwith picks per minute speed of shuttle determines amount of fabric woven per hour.

Fabric woven per minute calculation and comaprisons

Conventional handloom:
For example suppose a handloom weaver is just enough skilled for ***30 picks per minute*** speed in his loom. Then there are different picks per inch setting like 18, 30, 60 etc. If for example, the requirement is setting pick at ***30 picks per inch*** (settings provided in the loom to vary this), the fabric woven per minute would be ***30/30 = 1 inch per minute***. If this is changed to ***18 picks per inch, 1.6 inch*** (30/18) will be woven per minute but the fabric will now have less lengthwise threads (weft) per inch (18 against 30) and hence considered lower quality.

Efficient handloom
If the efficiency of loom is increased like how NRG solution did, with automation of various actions to single action, the same weaver with same skill can weave now at say **50 picks per minute** speed. So at **30 PPI** setting he can now weave **50/30 = 1.6 inch per minute.** At ***18PPI*** the production will be ***50/18 = 2.7 inch per minute***

Efficient handloom with motor:
Now if a motor is connected to the efficient handloom developed by NRG Solutions, the speed can be set to around ***100 pick per minute*** with a ***100Watts motor consuming around 150Watts of electrical power.*** Hence for 30PPI setting, the fabric woven will be ***100/30 = 3.3 inch per minute*.** At 18PPI the production will be ***100/18 = 5.5 inch per minute***

Conventional Power Loom:
Conventional power loom can be set usually at a speed of ***120 pick per minute*** with a ***0.5HP motor consuming around 750Watts of electric power*.** Hence for 30PPI setting, the fabric woven will be ***120/30 = 4 inch per minute*.** At 18PPI the production will be ***120/18 = 6.6 inch per minute***

Rapier Loom:
Let's assume the Rapier loom is set at a speed of **300 pick per minute**. A ***1.5HP motor with final electric consumption of around 1500Watts*** can be used to achieve this. Hence for 30PPI setting, the

fabric woven will be ***300/30 = 10 inch per minute*.** At 18PPI the production will be ***300/18 = 16.6 inch per minute***

Important point: This comparison of Rapier and other lower end looms is not complete. Rapier loom has other advantages like much higher fabric width looms are available at same power, much higher PPI that cannot be achieved in regular looms etc. Also the controls used with Rapier looms are usually electronic controlled with very less chance of any failure. Hence it's not just efficiency but features what also need to be taken into account for comparison.

In short it's based on quantity of fabric to be woven and features required that the selection of loom need to be done.

Design in fabric:
Designs in fabric are achieved through various methods:

1. Manual Jacquard/Dobby: Where a technician skilled in setting the designs does the setting whenever a new design is arrived to be woven. It takes 2-3hours to do this setting and technicians typically are paid around Rs.500/- for the setting
2. Electronic design setting: Just a design download from memory card would do. With high end looms like Rapier, Projectile, jet etc, electronic jacquard or dobby is commonly used.

Comparison chart:

Parameters	Conventional Handloom	Efficient handloom (NRG)	Conventional power loom	Efficient power loom (NRG)	Rapier Loom
Usual speed (picks per minute)	20	50	120	100	450
Usual fabric width	Upto 72 inch	Upto 72 inch	Upto 72 inch	Upto 72 inch	Upto 120 inch
Per day production in metres @ 10hr* shift and 50 pick per inch	~ 6 metres	~15 metres	~35 metres	~30 metres	~135 metres
Design settings for multi color	Manual Set Jacquard/Dobby	Manual Set Jacquard/Dobby	Manual Set Jacquard/Dobby	Manual Set Jacquard/Dobby	Electronic Jacquard/Dobby
Power consumption	NA	NA	~750 Watt	~150 Watt	~ 2000 Watts
Efficiency factor in inch/Watts**	NA	NA	~1.8	~7.87	~2.66
Cost of loom	100000	100000	200000	1,20,000	600000
Cost of solar hybrid for 6hr backup	NA	NA	200000	75000	550000
Total cost	1,00,000	1,00,000	4,00,000	1,95,000	11,50,000
Suitable	Single weaver	Single weaver	Single weaver	Single weaver	Cluster of

application	upto 6m/day	upto 15m/day	upto 35m/day	upto 30m/day	weavers upto 135m/day

*Assuming 4 hours grid availability and 6 hour backup.

** Inch/Watts is not a standard efficiency factor. Just used it for easy comparison

Handloom:

NRG's efficient Loom:

Rapier Loom: