DEVELOPMENT OF A RAPIER KIT TO SUIT THE POWER LOOM INDUSTRY

A PROJECT REPORT

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in partial fulfillment for the award of the degree

of

BACHELOR OF TECHNOLOGY

IN

TEXTILE TECHNOLOGY

KUMARAGURU COLLEGE OF TECHNOLOGY, COIMBATORE

ANNA UNIVERSITY : CHENNAI 600 025

APRIL 2009

ANNA UNIVERSITY : CHENNAI 600 025

BONAFIDE CERTIFICATE

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INTERNAL EXAMINER **EXTERNAL EXAMINER**

ACKNOWLEDGEMENT

We wish to thank Prof.R.Annamalai, Principal incharge, Kumaraguru College of Technology, for the encouragement and support given to us in doing this project work.

We are immensely thankful and highly indebted to Dr.Louis D'Souza, Head of the Textile Technology Department, Kumaraguru College of Technology, for his timely and valuable guidance that helped us in executing this project work successfully.

We are also highly obliged to our class advisor, Asst.Prof.S.Kathirvelu for providing the exposure to learning during the entire execution of this project work.

We whole heartily thank all the staff members of the Textile Department for lending a helping hand in completing the project work and all the other non-teaching staffs for their excellent co-operation and help.

We are grateful to Mr.Krishnamoorthy, Mechanical Department, KCT, whose valuable assistance helped us in competing the project.

We like to thank Mr.Senthil, Power loom service centre, Somanur for providing his valuable time in fabricating our 'Rapier Loom' model and completing our project.

ABSTRACT

The cost of presently available high speed automatic loom and shuttleless weaving machines are high and beyond the reach of powerloom industry. The existing powerloom manufacturers find it difficult to invest a huge sum in R & D to develop suitable low cost shuttleless loom. Also, the quality of fabric produced by the powerloom industry is inferior compared to International standards and the power required to operate the shuttle during picking is about half of the power required to drive the whole loom. Also because of this heavy impact and shock, smooth sequence of weaving is disturbed which affects the maximum running speed. To overcome the above limitations of shuttle loom, the need for production of a loom with low cost and low power consumption is of high importance.

This can be achieved by modifying the power loom into a rapier loom which can run at 180 ppm. This consumes less power and the production cost is considerably low compared to a power loom.

The conversion of power loom into rapier loom involves the removal of shuttle moving parts, alteration of wooden sley and assembly of components such as gripper, rapier tape, rapier head and drive wheels. A Rapier loom kit is created and the production sequence is verified. This mechanism expresses an idea of improving or to develop the Indian Power loom industry significantly.

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LIST OF SYMBOLS AND ABBREVIATIONS

R & D – Research and Development

RPM– Revolutions Per Minute

PPM – Picks Per Minute

MPM – Metres Per Minute

HP – Horse Power

η – Efficiency

CHAPTER 1

INTRODUCTION

1.1 An Overview of Weaving Loom Industry

1.1.1 Evolution of Weaving Looms

History of weaving looms can be traced back to 17th century. The first power loom was invented by Edmund Cartwright in 1785. Originally Power looms were with shuttle, and they were very slow. But as the industrial demands for faster production accelerate, faster looms without shuttle came in use in early part of 20th century. As developments and innovations take place, various types of looms were developed for faster production. Today, Air-jet, Water-jet, Rapier and other computer operated looms are used to maximize production of special materials.

1.1.2 Indian Scenario of Weaving Looms

Though weaving is one of the important sector for Indian textile industry, it has not been given due attention like spinning sector. Moreover structure of the industry plays a major role in making it competitive. Nature of this sector is mainly unorganized. The sector consists of fragmented, small and often, un-registered units that invest low amount in technology and practices especially in the power loom.

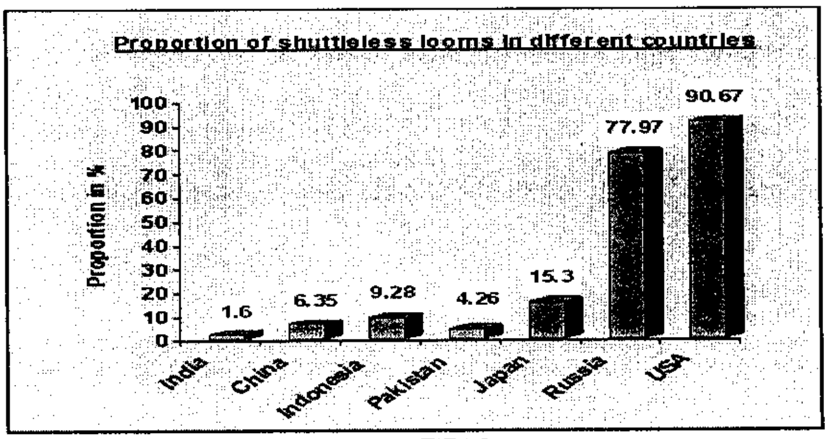
In India, there are approximately 5mn looms in the country. India has 1.8 mn Shuttle looms and 3.90 mn handlooms. The Indian loom industry is small scale unlike industry of China and Taiwan and therefore incurs high co-ordination cost. Advance technology installation demands skilled labor to understand and install such facilities, but shortage of skilled labour is also a roadblock in adaptation of new technology.

1.1.3 Power loom

The power loom sector produces more than 60% of cloth in India and textile ministry's estimation says that more than 60% of the country's cloth exports originated from that sector and comprises approximately 60% of total textile industry employment.

But modernization in looms is less and Indian industry still lags significantly behind US, China, Europe, Taiwan etc. (Texmin, 2005). Most of the looms we have currently in country are shuttle-less. There are less than 15,000 modern looms, whereas traditional looms are in large numbers. Value addition and the manufacturing of fabrics according to customer's compliances, is not possible due to obsolete technology of looms.

1.1.4 Shuttleless looms



Source: TIFAC

Figure 1

Proportion of Shuttleless Looms in Diffferent Countries

Shuttleless weaving looms are up to three times more efficient than shuttle looms, but the penetration of modern shuttleless loom is very less. In 2001, there were some 27,000 shuttleless cotton looms in Indonesia, 21,000 in Thailand and 10,000 in India. In world share of shuttleless looms India ranked 9th. The chart shows the comparison of shuttleless loom proportion of India with other countries.

As described in the chart India has lowest number of shutteless looms among all competing countries. While competitors like China and Indonesia are far ahead in this modernization. USA and Russia has highest proportion of modern shuttleless looms.

1.2 Classification of Weaving Machines

Looms are classified mainly into handlooms and power looms. The power looms are classified further into the following categories.

1.2.1 Non- power looms

These looms have only the basic mechanisms, viz. primary, secondary and some auxilliary mechanisms. The following are examples of non-automatic power looms.

1. Tappet looms
2. Dobby looms
3. Jacquard looms
4. Drop box looms
5. Terry looms

1.2.2 Automatic looms or conventional automatic looms

To get high productivity and good quality of fabric, additional mechanisms are added to ordinary non-automatic power looms. These looms are becoming popular because of their advantages of versatility and relative cheapness.

Examples :

- Pirn changing automatic loom
- Shuttle changing automatic loom.

1.2.3 Shuttleless looms or unconventional looms

In the non-automatic and automatic looms, shuttles are used for inserting the weft yarns. In these shuttle-looms, preparation of weft yarn and the weft insertion mechanism itself limit the loom production and fabric quality; they are also prone to mechanical problems in propelling the shuttle. Hence loom manufacturers have developed looms with various innovative and alternative means of weft insertion.

These modern looms are known as "shuttleless looms" and some examples of the looms are :

- Air-jet loom
- Water-jet loom
- Projectile loom
- Rapier loom
- Needle loom
- Various other methods include rectilinear multiphase looms.

1.2.4 Circular looms

In these looms, the shuttles move simultaneously in a circular path and tubular fabrics are produced.

1.3 Significance of Modernization

The powerloom sector produces only low and medium value products in grey fabrics, yarn dyed dress materials and bed/kitchen linen items. The loom technology level is awfully low as more than 90% of the looms are plain looms without auto stop motions for warp and weft as well as absence of positive let off motions. In order to move up in the value chain, the loom technology level has to be improved substantially along with forward and backward process improvements.

The quality of fabric produced by the powerlooms is by and large inferior compared to the international standards. Although the quality of yarn supplied by spinning mills to weaving industries are quite acceptable, the poor quality of fabrics produced by the sector are mainly due to the following reasons.

- Powerloom units are small in size, majority of them having 8 to 12 looms. The powerlooms used are of low cost and obsolete in technology.
- The existing powerloom manufacturers find it difficult to invest a huge sum in R & D to develop suitable low cost shuttleless loom.
- The cost of presently available high speed automatic loom and shuttleless weaving machines are high and beyond the reach of powerloom industry.

Considering the above aspects, it is proposed to design and develop a low cost rapier weaving machine as a means to modernize Indian powerloom sector.

CHAPTER 2

LITERATURE REVIEW

2.1 Need for Shutteless Weaving

In the conventional shuttle looms, it is necessary to pass a shuttle weighing around half a kilogram through the warp shed to insert weft yarn. The shuttle has to be accelerated rapidly at the starting of the picking cycle and also to be decelerated, stopped abruptly at the opposite end. This process creates heavy noise and shock, and consumes considerable energy. The power required to operate the shuttle during picking is about half of the power required to drive the whole loom. Also because of this heavy impact and shock, smooth sequence of weaving is disturbed which affects the maximum running speed.

The small weft package requires frequent replenishment, which increases the workload of a plain loom weaver. In case of automatic looms where the replenishment is done automatically, for each change there is a possibility of weft failure. The probability of fabric defects in weft way is higher due to frequent replenishments. It may be noted that about 70% of the fabric defects are in weft way in case of shuttle looms. In case of multi color weft insertion, there is necessity for multiple box motion which limits the speed of the machine.

To overcome the above limitations of shuttle loom, the need for a better weft insertion system without shuttle has been realized and many attempts have been made. In the early fifties projectile weft insertion has been accepted as commercially viable unconventional weaving machine i.e. Shuttleless loom. Later in late sixties the rapier weft insertion and in early seventies air-jet,water-jet weft insertion systems were broadly accepted by the industry. These unconventional weaving machines proved technically and commercially feasible alternatives to shuttle looms. The different types of weft insertion systems were used for different fields of application. For example air-jet weft insertion system can be used for medium range mass production requirement, rapier weft insertion system for fancy and fashion materials, projectile weft insertion system for industrial fabrics etc.

The replacement of shuttle by other methods of weft insertion does not bring any fundamental change in the sequence of basic weaving operations i.e. shedding, picking and beat-up. However, lot of improvements in terms of precision has been taken place in order to withstand the comparatively higher speeds. Similarly primary and auxiliary motions like take up, let-off, warp stop, pick finding etc. do not differ in priniciple. The most common features of all unconventional weaving machines are:

- Large weft supply package, mostly in the form of a cheese or cone.
- Unconventional selvedge formation i.e. Leno, tucked in etc.
- Weft accumulator
- Weft cutter on either one or both sides.

2.2 Salient Features of Rapier Machine

2.2.1 General Factors

- The low cost rapier loom can be manufactured by small powerloom manufacturers, which will be affordable to powerloom units.
- Weft way defects like starting mark, weft crack, etc. can be minimised.
- Stable weft insertion.
- Intermediate process of pirn winding can be eliminated.
- More allocation of looms per weaver.
- Gain of 2.5 times more output per shift.
- Low power consumption due to direct drive.

2.2.2 Weaving Weft Insertion by the Rapiers

The main distinctions as regards weft-insertion methods are illustrated in Fig.2. In the simplest cases, in each loom cycle' the tip of a single rapier is inserted across the whole width of the shed and then withdrawn, weft being inserted during rapier motion in one direction only. Because the progress of shedding and beat-up is inhibited over the

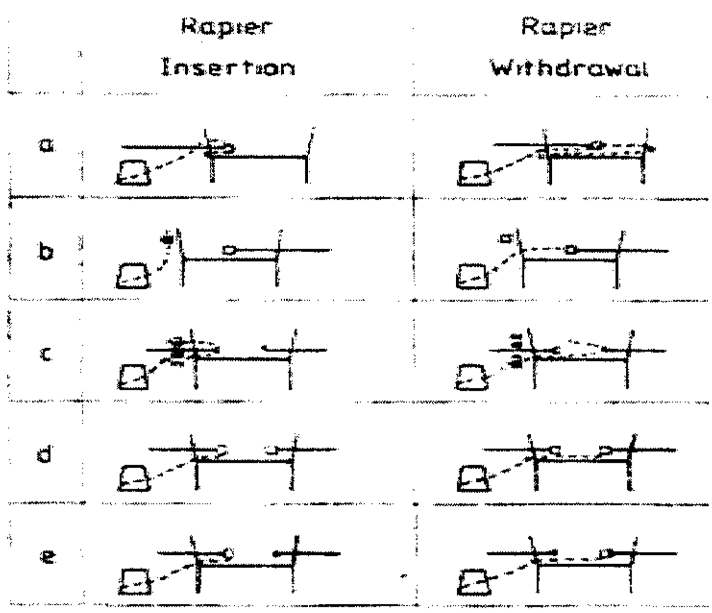


Figure 2

Weft Insertion Method

whole period for which the rapier is in the shed, the loom cycle is not utilized well, and only a few looms use this method: is has the merit that problems of weft transfer do not arise. Furthermore, if double picks are inserted there is no need to cut the weft, no weft waste, and one selvedge is automatically secured. The loops of weft at the other selvedge can be secured either b knitting them together or with a catch thread. The rapier can simply have the weft permanently threaded through a hole near its tip, and it must then enter the shed from the weft supply side(Fig. 2a). This technique is widely used on narrow fabric looms and on carpet looms, but otherwise on a few special-purpose machines. If single picks are inserted then, of course, the normal range of weaves can be produced, but looms using this technique are slow running and it too is not often used (Fig. 2 b).

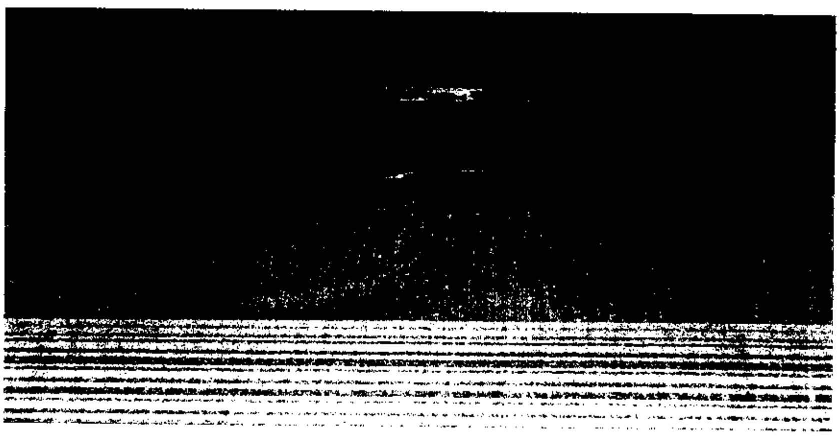
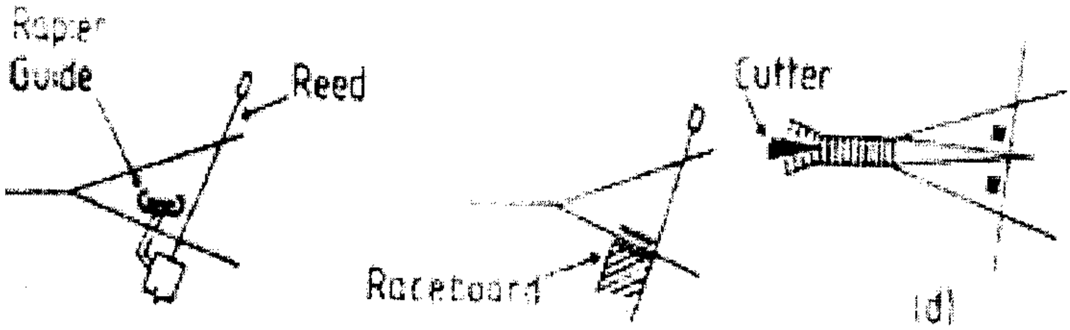


Figure 3

Weft Transfer

Normally, two rapiers enter the shed from opposite ends and the weft is transferred from one to the other when they meet, and they are-then withdrawn. In this way, the intervals for rapier insertion and for rapier withdrawal are both used for weft insertion. Invariably, on full width looms, only a single pick of yarn from a given supply package is inserted, but it may be inserted as a loop up to the time of transfer,



and the transferred loop straightened out during rapier withdrawal from the shed (the loop-transfer or Gabbler system). Yarn withdrawal from the weft package is thus completed at the time of transfer. This has the disadvantage that prior to the transfer the rate of weft withdrawal from the up ply package is' high (it equals twice the rapier velocity), and subsequently it is zero; also after transfer the free end of the pick could untwist (Fig. 2 c). Loop transfer was at one time widely used as it can facilitate the formation of semi-conventional selvedges, but it is now available as one of the options on only a few looms. With loop transfer the use of some form of weft accumulator is often standard.

Thus, almost invariably it is the cut end of the weft which is transferred (end or tip transfer, also known as the Dewas system, Fig. 2 d). This entails incorporating yarn clamps in the head of both the giver and taker rapiers, instead of just yarn guides. There is a continuing development of new techniques to improve weft control or conditions during the weft-transfer operation, and four quite different strategies may be noted. First, the yarn clamps in the rapier heads can be positively actuated at the transfer (in addition to any positive actuation at weft pick-up and release) as on the Dornier and Iwer K2-330 100ms.Second, control of rapier location (perpendicular to the. weft direction) during the transfer can be improved. Note the guidance of the rapier head by the reed and race board on some rigid rapier loom such as the MAV, and the use of electromagnets in the central zone of the race board on the Meteor loom, for instance.

Third, the rapier displacement-timing characteristic may be elaborated with the aim of giving more favourable conditions in the transfer region. As an example, we may note the varying pitch along the screw-cam on the Vamatex Propeller loom. Fourth, there is the use of indirect transfer. That is, problems of yarn handing during transfer are avoided, by transferring the yarn clamp from one rapier to the other than the weft yarn itself, which remains gripped by the same clamp throughout (Fig.2 e.)

If indirect transfer is used to insert weft from only one side of the loom, a given yarn clamp will have to be returned empty o the supply side ,after use, and different methods of doing so are encountered on the two currently available looms. On the Acutis loom there are several yarn clamps, and these are returned empty to the supply side by a conveyor running under the weaving zone, in a manner reminiscent of the Sulzer machine. On the Mintiss each rapier enters the shed carrying a clamp, and these are exchanged at transfer, one bringing yarn from the supply side, the other returning empty.

The ability to insert single pick is usually required, to give the normal range of weaves, but some weaves can be produced most efficiently if in addition, when required, picks of more than one yarn can be inserted together in a single-loom cycle. It is only possible for given yarns to be inserted dither together in this way or separately, as required, on shuttle-less looms, and this facility has been provided on some rapier looms eg. Dornier Iwer. (The possibility of simultaneously inserted picks twisting needs to be considered though.)

Finally, it may be remarked that now a days rapier looms almost always insert weft from one side of the loom only. Apart from avoiding the need to duplicate the weft supply and selection systems, each rapier has then to perform only one role, that of giver or taker, and can be designed specifically for that role. Insertion from both sides was common, since it can readily be used together with loop transfer to produce semi-conventional selvedges.

2.3 Types of Rapiers

The rapiers used for weft insertion usually take the form either of rigid rods or of flexible metal or plastic tapes or bands. Both rigid and flexible rapiers have long been used on comparable numbers of makes of loom. Rigid 'rods can, of through the shed from outside the working width. In some cases, though, guidance within the working width is provided at the shed boundary by a board, possibly aided by the upper warp sheet or reed, or both, presumably to facilitate control over rapier location at weft transfer. In contrast, rapiers consisting of flexible tapes must always be guided within the working width. In some cases the rapiers are guided at the shed boundary as described, but more often guide plates mounted on the sley at short intervals across the width are used. The motion given to the plates is such that they enter the shed through the bottom warp sheet as the sley moves back, and leaves by the same route prior to beat-up.

Rigid-rapier method lends itself to simultaneously inserting weft in two sheds one above the other, using a separate pair of rapiers for each shed, Rapier looms of this kind have been found to have advantages for the face to face weaving of warp-pile fabrics, and such looms are also available for weaving two separate fabrics without pile, one above the other.

A third type of rapier has recently come into use. Like the rigid rapier this has lateral rigidity, but consists of two or three 'telescopic' components. One component is connected directly to the rapier drive, and its weft-way position determines that of the second component, by means of a mechanism such as, the rapier thus becomes fully extended when' inserted in to the shed, and the components telescope together when it is withdrawn.

2.4 Benefits of Rapier Loom over Conventional Power Loom

Table 1

Conventional Power Loom Vs Rapier Loom

Conventional Power-Loom	**Somet Silver Hi-drive**
55-65% Efficiency	85-90% Efficiency
Max. 120 RPM (eff. 70 RPM due to lower efficiency)	Max. 350-400 RPM
Lower Output per shift	Upto 3 times more output per shift
High Labour requirement	Low labour requirement
'Kandi / Shuttle / Pirn-Winder' machine & operator required	Shuttleless (No Kandi, No Pirn, No Pirn Machine Operator)
High Maintenance because of extremely high vibration	Extremely low vibration, hence lower maintenance
Light-Weight leading to shorter life and higher vibrations	Heavy-Duty Structure to reduce vibration thus leading to longer life
Lower Output per unit area of floor space	3 times more output per unit area of floor space
High Production Cost: Due to lower labour productivity and lower efficiencies and higher costs per meter of fabric.	Lower Production Cost : Due to lower labour and lower area and lower power requirement per meter of fabric.

CHAPTER 3

OBJECTIVES AND METHODOLOGY

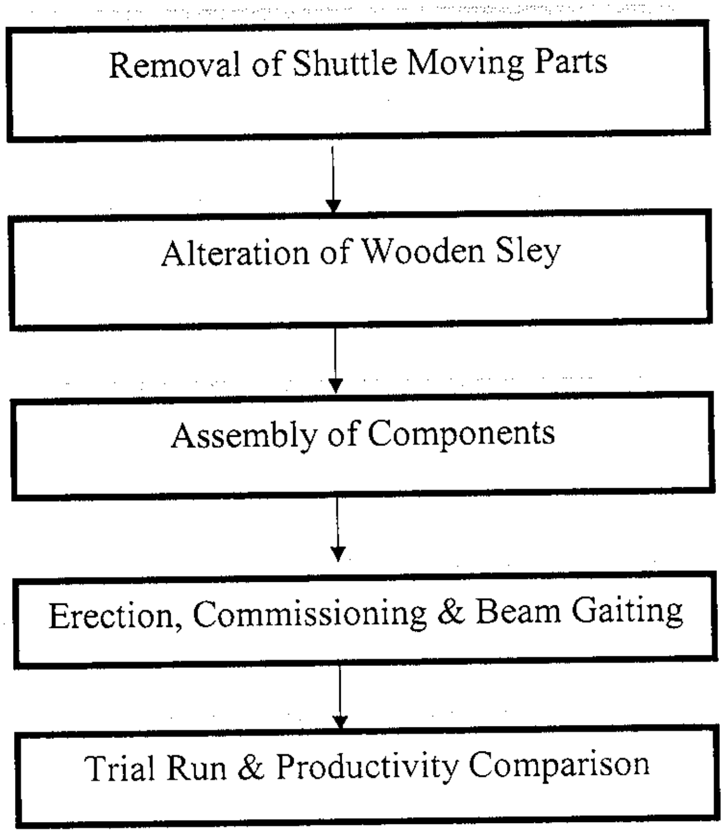
3.1 Aim of Developing a Rapier Kit

The major scope of developing a Rapier kit is as follows:

- To reduce the cost of manufacture and power consumption.
- To produce a fault free fabric.
- To make it simple, durable and ease of maintenance.
- To make it affordable for the power loom manufacturers that gives a higher scope for improving their production with increase in speed of the loom.

3.2 Work Plan

3.2.1 Methodology



3.2.2 Assembly of Components

The power loom meant for conversion is set place for shuttle removal. The parts like shuttle, picking stick, picking lever, picking strap, and cam are removed. The Sley wood is arranged with a set of guide hooks and the box sides are fixed with rapier tape side plates and covers.

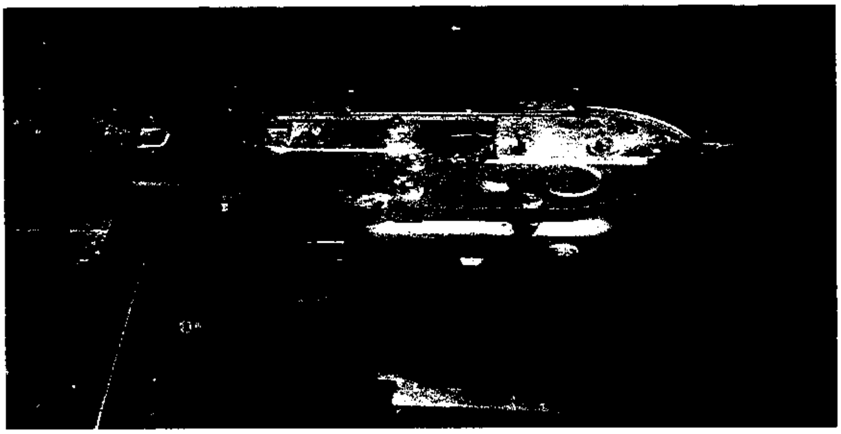


Figure 4

Rapier Tape - Assembled

Rapier drive wheels are fixed below the shuttle boxes. Bevel gear is attached on the reed frame along with the arm and lever. Cam and lever are fixed onto the crank shaft.

Figure 5

Assembled Bevel Gear, Arm, Lever and Cam

3.2.3 Working Principle of Newly Developed Rapier Kit

The drive from the motor is given to the crank shaft which gives rotation to the cam and the lever inturn makes the arm attached on the machine frame, to oscillate. The oscillation of the arm gives rotation to the bevel gear and by its touch, the pinion also rotates which drives the wheel that gives to and fro movement to the rapier.

3.2.4 Beam Gaiting and Trial Run

The machine is designed and fabricated. The beam is gaited and the machine is made to run for trial. The observations are made and the comparison of the results are noted.

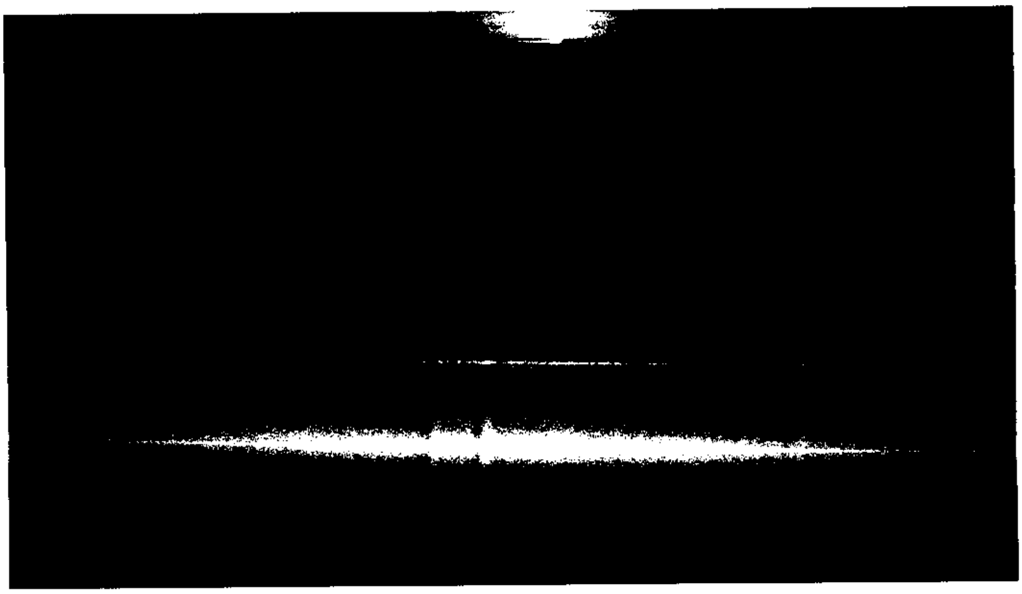


Figure 6

Beam Gaiting

3.3 Technical Specifications of the Newly Developed Rapier Loom

Table 2

Technical Specifications of Newly Developed Flexible Rapier

Machine Type	Flexible Rapier
Reed Space Width	56'' (or) 142 cm
Speed	220 ppm
Shedding	Negative cam type
Let-off & Take-up	Positive & 7-wheel
Weft Selection	6 or 8 colours
Motor	0.75 Hp
Weft feeding	Accumulator
Warper's beam dia	700 mm
Cloth beam dia	400mm

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Cost of Conversion

The total cost of converting an ordinary Power loom into a Rapier loom depends on various factors as follows.

Table 3

Cost of Conversion

S.No	Particulars	Cost(Rs.)
1	**Conversion of Spare Parts**	14,OOO
2	**Machining charges**	10,000
3	**Erection, trial & Commissioning charges**	8,OOO
4	**Travel & Miscellaneous charges**	6,OOO
	Total	**38,000**

4.2 Images of the Loom

Figure 7

Front view of the Loom

Figure 8

Rapier Gripper

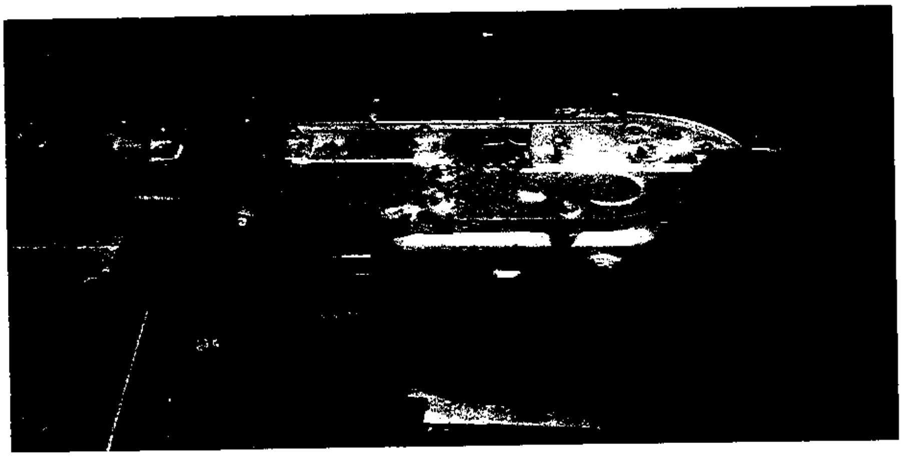


Figure 9

Bevel Gear

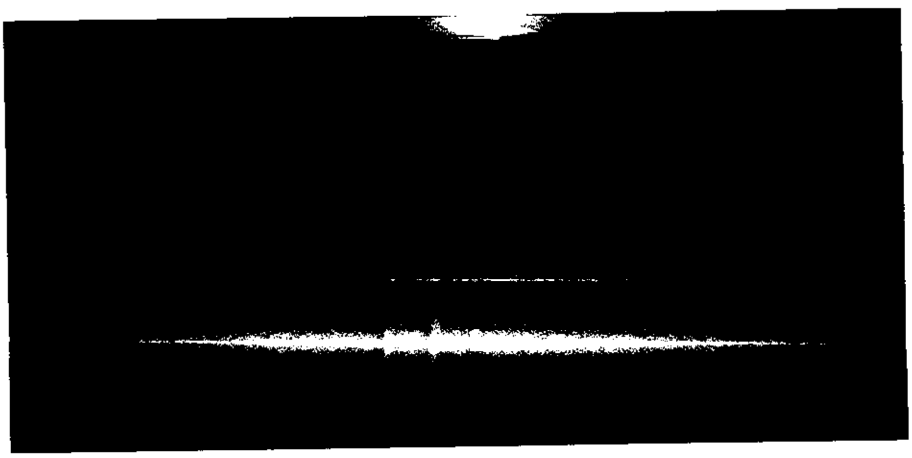


Figure 10

Back view of the Loom

4.3 Comparison of Newly Developed Rapier Kit With Other Looms

4.3.1Comparative Loom Speed and Looms/Weaver for Different Type of Looms

Table 4

Comparison of Loom Speed, Looms/Weaver and Efficiency

Type of Loom	Looms/ Weaver	Loom Speed(rpm)	Expected Efficiency(%)
Power loom	4	140	75
Projectile	8	400	95
Rapier	8	350	85
Air-jet	10	1100	95
Developed Rapier	6	220	80

From these observations, it is clear that the newly developed rapier loom provides a little higher number of looms per weaver with increase in speed when compared to ordinary power loom. The efficiency is also 5% higher than a power loom.

4.3.2 Comparative Power Consumption per Loom Shift (8 hrs)

Table 5

Comparitive Power Consumption per Loom Shift of 8 Hours

Type of loom	Power Consumption/loom shift of 8 hours (in units)
Power loom	8.8
Projectile	14.7
Rapier	17.6
Air-jet	20.6 + 30.0 (for air compressor)
Developed Rapier	12.6

The use of flywheel in the power loom consumes more power whereas in developed rapier loom, the power consumption is less due to absence of fly wheel and presence of individual drive for motor. From the table, it can be seen that developed rapier consumes less power than projectile, rapier and air-jet looms.

4.3.3 Comparison of Newly Developed Rapier Loom & Imported Shuttleless Loom

Table 6

Comparison of Newly Developed Rapier Loom & Imported Shuttleless Loom

S.No	Details	Semi-Auto drop box loom	Used imported Rapier loom	New imported Rapier loom	Developed Rapier loom
1	**Cost of loom (Rs. in lakhs)**	1.00	6.00	17.00	1.25
2	**Speed (ppm)**	90	350	500	220
3	**Production in meters per loom per day at 80% efficiency**	25	127	159	57
4	**Conversion cost per pick (Paise)**	15	25	25	25
5	**Consumable spares cost per loom shift (Rs.)**	5	65	40	15
6	**Value loss (%)**	5	2	1	2
7	**Power Consumption in H.P**	1	6.5	11.25	3
8	**Payback period for 12 looms in years**	8	5	6	5

The above comparisons are made assuming the same sort of fabric in all the looms at standard efficiency of 80%. From the above table, it can be seen that the cost of the newly developed rapier loom is not very high than the semi-auto drop box loom, and also significantly less than used and new imported rapier loom.

The power consumption is lower for newly developed rapier loom compared to imported rapier looms. The power consumption is almost triple that of the indigenous shuttle loom, about half of the used imported loom and about one fourth of the new imported loom.

The cost of consumable spares per loom shift for new developed rapier loom is expected around Rs. 15/-, whereas the same for used imported rapier loom is at Rs. 65/- and for new imported rapier loom is at Rs. 40/-. However the consumable spares cost per loom shift is three times higher than that of indigenous shuttle loom.

The value loss due to rejections is expected around 2% for developed rapier loom which is better than the indigenous shuttle loom and is comparable with the imported rapier loom. Due to lower cost, higher production and better labor productivity, an attractive pay back period of 5 years for a 12 looms unit is possible. This is better than the pay back period for indigenous shuttle loom and new imported rapier loom and is equal to the pay back period for used imported rapier loom.

CHAPTER 5

CONCLUSION

The following conclusions are drawn within the limitations of this experimental study.

5.1 General Conclusion

The powerloom sector occupies a pivotal position in the Indian textile industry. Though current growth of this sector has been restricted by technological obsolescence, fragmented structure, low productivity and low-end quality products, in future, technology would play a lead role in this sector. Innovations would also be happening in this sector, as many developed countries would be innovating new generation machineries that are likely to have low manual interface and power cost.

To reap benefits of these developments, Indian powerloom industry has to prepare itself for drastic technological changes and will have to focus on area such as technology upgradation: modernization of Power loom Service Centres and testing facilities; Welfare schemes for ensuring a healthy and safe working environment for the workers in future.

5.2 Specific Conclusion

Through this work, an attempt was made to help the existing power loom manufacturers to develop shuttleless looms in short investment which caters to the societal needs with the following benefits.

- Better environment due to low noise level.
- Low consumption of spares and less floor space.

- More economical and is made cheaper.
- Low power consumption and less pollution.
- Easy maintenance and less work load for jobbers.
- Lesser accidents.

A low cost rapier loom has been designed and fabricated. The working performance of the loom is found to be good and the outcome of the work is as follows.

- The technology transfer of designing a rapier loom with low cost and low power consumption as retrofit for powerlooms.
- Gain of 2.5 times more output per shift.
- The speed of the loom can be increased upto 50% when compared to ordinary power loom.
- More allocation of looms. In other words, less numbers of weavers required in loomshed.
- The quality of the product is significantly high compared to the fabric woven from a power loom. Weft way defects like starting mark, weft crack, etc. are considerably reduced.
- The loom is ideally suitable for decentralised powerloom sector. Since weft insertion is continuous from cone feed and intermediate process of pirn winding is eliminated.

5.3 Future Scope

It can be assured that a promising future awaits the power loom sector based on the notes of available literature on the development of the same. Research in this field should be focused on the development of novel manufacturing techniques and quest for technology upgradation.

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