Developments in weaving machines

P K Ilari & B K Behera
Department of Textile Technology
Indian Institute of Technology, New Delhi 110 016, India

The major developments in weaving machinery are highlighted. The maximum weft insertion rates achieved by the various shuttleless weaving systems along with their application potential are described. Microprocessors have been recognized as an inseparable part of all modern weaving machines. The increased importance of versatility over productivity is highlighted keeping in view the present trend of fast changing fashion and style in textile trade.

Keywords: Microelectronics, Quick-style-change system, Weaving, Weft insertion rate

1 Introduction

Excellent fabric quality and maximum profitability are the two major requirements in today's competitive fabric forming system. If one examines the developments in weaving machinery and woven fabrics during the period since the second world war, it would be observed that weaving has undergone a sea change. Mechanisation, through automation of shuttle loom machinery followed by shuttleless looms, has entered in a new era of electronics, microprocessors, information technology and their application to the production of woven fabrics. Microprocessors, particularly in the last 10-15 years, have revolutionized the whole weaving process including all the available systems of weft insertion. Briefly, all major developments in weaving machinery have been geared primarily towards the four objectives:

- increasing productivity,
- improving fabric quality,
- reducing the number of operations and hence operating through automation, and
- use of electronics and microprocessors for better monitoring of various mechanism to achieve the above objectives and reduce the cost of production.

In recent years, besides above, flexibility and improvement in machine utilization are receiving more attention by the machine manufacturers. A decade ago, the need was for faster and more productive machinery, but today the weaving machines operate just about as fast as most yarn systems can handle. In fact, the textile manufacturers worldover now demand for more automation, more versatile and better quality product in view of fast changing trend in fashion and design. This paper reviews some of the most important developments in the weaving machinery during the last few years.

2 Developments in Weft Insertion Systems

There has not been any basic change in the weft insertion systems, that is the shuttle, projectile, rapier and jet. However, developments were aimed at fine tuning these systems to maximize performance efficiently.

2.1 Shuttle Looms

The conventional shuttle looms account for about 85% of the total world loom capacity. However, in terms of productive performance (m²/h), the average output of the shuttleless weaving machine is twice or even more than that of the conventional shuttle loom. During 1951-1971, international textile exhibitions were dominated by the shuttleless looms. After 1971, when the shuttleless looms started making a big breakthrough, shuttle looms slowly started disappearing. At ITMA 1987 and 1991, there was no exhibitor of shuttle looms, indicating that the shuttle loom had reached its maximum saturation performance. The weft insertion rate during the above transition phase has increased from 380 m/min to a maximum of 650 m/min. The increase in weft insertion rate was achieved due to the following:

- increasing the machine width to 380 cm,
- electronic shuttle flight control, and
- increase in machine speed by mechanical improvements which reduced vibrations.
The loom speed was increased up to 30% without any significant increase in shuttle speed. This gain is achieved by extending the shuttle transit time by retarding the shuttle end position. The shuttle is electronically monitored over practically the whole of its travel; in case the shuttle speed is slow, the machine is stopped immediately at a predetermined safe position by means of an electrically transmitted impulse. In addition, the electronic turning and control equipment helps in optimal adjustment of the pick, shuttle flight and shuttle end position.

2.2 Projectile Looms

The first Sulzer machine with a reed width of 216 cm, exhibited at ITMA 1955 at Brussels, had a maximum speed of 280 picks/min, giving a WIR of about 600 m/min. Further developments continued and a major breakthrough came in 1969 when the first 540 cm wide six-colour prototype machine with a WIR of 840 m/min was displayed at ITMA 1971 in Paris. The projectile loom has a width range of 185-540 cm and maximum speed of 470 rpm. It is suitable for tappet, dobby, jacquard and terry weaving. It is suitable for spun and filament yarns for a range of count (200-6.4 tex, 10.8-5000 denier). Now, the projectile machines are running with a WIR of 1540 m/min without any further change in the working width. The high weft insertion rate has been achieved by:

- using new guide teeth which reduces friction drag,
- redesigned acceleration system,
- new shed geometry which reduces warp strain even at high speed, and
- using carbon fibre reinforced synthetic material for the projectile.

However, the impulsive movement of the projectile can surely strain the weft yarn.

2.3 Rapier Looms

Rapier looms form the largest group of shuttleless looms have about 10% share in the world's looms. They have been substantial developments in both rigid and flexible rapiers over the last few years. The most important out of them are production speed and maximum working width. Some models are now operating at 600 picks/min (1380 m/min WIR). The maximum working width has gone up to 181 in and 165 in for flexible and rigid rapiers respectively. Although rapier weaving is not as fast as jet weaving, these looms are most versatile, adaptable and widely applicable. The tremendous flexibility of fabric design and the range of styles that can be woven on rapier looms due to the availability of up to 16 colours weft patterning, these looms are most suitable for fancy fabrics, apparel and furnishing fabrics. Most of the developments in flexible rapier loom have taken place in the design of rapier heads and tapes to improve smooth handling of the weft yarns at high speeds.

2.4 Airjet Looms

Airjet weaving achieved its commercial penetration more or less at the same time as projectile weaving in 1953. However, the real breakthrough came around 1968 when airjet looms running with relay nozzle, spaced at intervals of 40-80 cm, across the entire sley were available. Further developments continued to achieve increased speeds and width, greater patterning possibility, more electronic control and broader application versatility. As a result, the machine width and weft insertion rate increased dramatically up to 213 in and 2500 m/min respectively. The machine speed range from 500-1200 revolutions per minute. The number of colours in weft direction has gone up to 8 with the pick and pick system. Airjet weaving, in fact, in the past few years has become most popular. A large number of machinery manufacturers are producing this loom due to the increasing popularity of this technology. Airjet system is considered to be the best system for mass production of a wide range of fabrics. Its popularity has further increased due to successful weaving of denims, glass fibre, terry cloth and double plusses. The fabrics woven by the airjet method account for some 7% of the total of woven fabrics, making it one of the most competitive methods. During the last ITMA, it was observed that with the fast growing area of shuttleless weaving, which for many years was dominated by the Sulzer gripper shuttle looms, the airjet looms have now taken lead. However, the requirement of very high quality yarn and modern preparation method are must to extract optimum performance from airjet looms. Further comparatively very high energy consumption due to more air consumption while using relay jets has also raised the eyebrows of researchers.

2.5 Waterjet Looms

The waterjet loom is probably the most efficient machine for weaving 100% hydrophobic filament yarns among all available systems. Next to the multiphase loom, this technology offers the highest weft insertion rate and minimum noise. Some manufacturers have developed machines which are operating at about 2600 m/min. Besides twin picking mechanism, the loom width has also gone up to 280 cm. The waterjet system could further penetrate into the world market if it can process the normal single spun sized yarn in warp direction. Sizing agents manufacturers are still search-
ing for a suitable size material to make possible processing of single spun sized yarn in warp direction.

2.6 Multiphase Loom

The first commercial multiphase loom was demonstrated in 1971. Although the multiphase loom offers highest weft insertion rate among all shuttleless looms, it has not yet made an impact in the world textile trade due to many design limitations. All the models of multiphase looms are producing plain weave only. Although a major share of the worlds' fabric production is of plain weave, it is surprising that the multiphase loom has not become popular, probably due to the lack of versatility, design limitation and problems in correcting a loose pick at the time of a weft break.

2.7 Comparison between Shuttleless Weaving Machines

Only the airjet, rapier and projectile are accepted as the most popular systems. Airjet weaving is well accepted for mass production as due to high weft insertion rate the cost of production is lowest. However, the warp and the warp preparation needs to be better due to highest loom speed. The rapier weaving machine is excellent for pattern weaving and in gentle dealing of delicate weft yarns. The projectile loom gives weft insertion rate comparable to the rapier looms. It has limitations with respect to the rapier loom in terms of weft colour potential and the tension on the weft yarn.

Now, all the shuttleless looms are equipped with electronic let-off and electronic take-up to have a control on the warp tension and cloth feel position to prevent starting marks.

3 Other Developments

Apart from the various weft insertion systems, the other striking features among the developments in weaving have been the higher production speed, microprocessor application, information technology, quick-style-change system, energy conservation, safety measures, etc. Some of these developments and their applications are given below.

3.1 Speed Potential and its Utilization

The speed potential of various weaving machines mainly depends on the weft insertion method, i.e. projectile, rapier, waterjet, airjet or multiphase system. During the last 20 years, machinery manufacturers have achieved the mechanical speed limit of various looms through continuous research and development of machine design and, more importantly, through the use of microprocessor technology. From weft insertion point of view, both water- and air-jet weaving systems have made dramatic enhancement to the tune of about 250% compared to flexible rapier (150%) and projectile (33%). However, the Sulzer projectile has now come out with a model operating at 1540 m/min. Despite the fact that the weft insertion rate of multiphase loom is the highest among all the shuttleless looms, its chances of capturing the market appears to have diminished for the reason that these looms are less versatile and, more importantly, the weft insertion rates of jet weaving machines are fast catching up to multiphase weaving.

The increase in loom performance in terms of productivity has been the prime objective of any loom manufacturer. It is evident from the achievements made so far that the increase has been quite remarkable during the last decade. The weaving experts also expect further increase in weft insertion rate but at a lower pace. Further, it may be mentioned that the speed potential of most machines is usually not fully utilized in view of the limitations imposed by the physical properties of spun yarns and also due to the recent change in consumers preference for lighter fabrics which need finer yarn and are more critical from quality and mechanical properties point of view. It is also apparent that the productivity has been improved at the cost of versatility. Looking at the present trend of fast changing fashion market, textile specialists have given more emphasis on versatility and quality rather than on productivity.

3.2 Microprocessor Technology

Electronics have always been a key factor in the development of science and technology. In the last decade, textile industry has entered a new era of electronics, microprocessors, information technology and their application to the production of woven fabrics. The contribution of microelectronics has become more remarkable in case of airjet weaving and jacquard designing. The manufacturers of various types of shuttleless looms have made the best use of the great potential offered by the use of electronics and microprocessors for the automation of following functions on the loom:

- machine speed efficiency,
- weft entry angle,
- cause of stoppage,
- machine running and down time,
- total number of stoppages and their nature, display of trouble shooting messages on the screen and suggestion for action,
- machine variables adjustment,
- starting, stopping and reverse position,
- electronic weft insertion control, - automatic pick finder,
- automatic weft breakage repair,
- automatic faulty pick removal,
- in case of airjet loom: (i) auto setting and opening of valves, and (ii) measurement of weft insertion velocity and control of main nozzle,
- Transfer of messages and storage and production of vital data,
- machine settings for weave, colour and colour pattern,
- automatic package switch over,
- electronic let-off and take-up,
- automatic speed control inverters,
- automatic stop mark preventer,
- automatic cloth doffing, and
- automatic package supply system.

All the machine functions mentioned above are monitored and controlled and some of them can be optimized by the multifunction microprocessor and also by using suitable software with PC-link. The microprocessor also allows bidirectional communication, enabling the dialogue between the weaving machine and production management system. The adaptation of electronics to various functions has simplified numerous manual intervention, leading to improvement in the general management of the weaving process.

3.3 Quick-Style-Change System (QSCS)

In today's weaving system, the weaver is expected to be more flexible in terms of style change, order size and at the same time he has to produce better fabric quality. To fulfill the purchaser's demand in a fast changing fashion oriented market, the weaver has to get away from a single purpose machine. In the above circumstances, it is important how quickly one can adjust to the new situation which primarily depends on the flexibility and versatility of the machine.

The QSCS is a response to changing market conditions is arousing lively interest, particularly in the high fashion sector with short warps and thus frequent warp changes. The reduction in order size calls for short changeover time on the weaving machine. Therefore, quick and efficient style changing on all modern weaving machines has become a star attraction.

The concept of quick style changing offers a number of fundamental advantages. In this system the entire process of style preparation and loading of the weaving machine can be carried out by a single person within a time period of 30 min, even under the spatial conditions as they prevail in a weave room. The process is to be performed outside the weaving machine in a separate preparatory room which otherwise requires the weaving machine to be at standstill. With a special insertion truck, the empty warp beam, complete with warp stop motion, harness and reed are taken out of the machines within a few minutes by only one person. The same truck is used for inserting the new warp beam with the complete weaving harness into the machine. Time gained in changeover procedure and the saving in labour cost may be partially counterbalanced by higher capital spending and additional space required for the extra module. The QSC system has now been developed by many reputed machine manufacturers and successfully used.

3.4 Environmental Problems

Loom speed and weft insertion rates are not the only criteria to assess loom performance. There are other factors like environment which are equally important and should be considered while designing a loom. In weaving, environmental problems include noise emission by weaving machines, the vibration they generate and its impact on surroundings, disposal problems, protection of personnel, and energy consumption.

The major noise sources of the conventional looms are the picking and checking mechanisms and the elimination of shuttle has significantly reduced the noise generation. It may be seen from Table 1 that the noise generated by different shuttleless looms, barring airjet loom, is much less compared to that generated by shuttle loom.

<table>
<thead>
<tr>
<th>Loom</th>
<th>Noise level, dB</th>
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<tbody>
<tr>
<td>Shuttle</td>
<td>92-107</td>
</tr>
<tr>
<td>Rapier</td>
<td>87-100</td>
</tr>
<tr>
<td>Projectile</td>
<td>90-100</td>
</tr>
<tr>
<td>Airjet</td>
<td>97-99</td>
</tr>
<tr>
<td>Waterjet</td>
<td>82-92</td>
</tr>
</tbody>
</table>

The lowest noise level is given by the multiphase loom but unfortunately due to many technical limitations, it has not yet been established as a promising technology. Among other weft insertion systems, waterjet appears to have less noise level in the vicinity of 80 dB.

The simplest method of reducing noise is to reduce the operating speed which is certainly not the solution. Although remarkable success has been achieved in improving the performance of loom in terms of productivity and quality, an insignificant reduction in noise has been achieved by use of electronics. There-
fore, this particular field needs further attention by researchers.

3.5 Energy Consumption

Energy consumption is one of the crucial parameters which has to be taken into account by the weaving machine makers when developing new weaving technologies.

Fig. 1 shows the correlation between the mass of the weft insertion element and the energy input for various weft insertion systems, related to the weft insertion rate. It is apparent that the projectile machine is best among the shuttleless weaving machines as regards energy consumption.

With weft insertion rates of up to 1500 m/min the power input is only 5 kW. Despite relatively high overall energy consumption, airjet weaving machines have the advantage that most of the energy is converted into heat in the compressor plants outside the weave room. The compressor can be equipped with heat exchanger so that the waste heat can be used for other purposes. The rapier looms are the most critical as regards the energy consumption due to their relatively large moving masses. Moreover, all the lost heat occurs in the weave room and has to be removed by air conditioning. It is believed that a lot of work is yet to be done in this area to reduce energy consumption.

4 Summary

Weaving has undergone a sea change during the last 20 years. A decade ago, the need was for faster and more productive machines. Today, the weaving machines operate just about as fast as most yarn systems can handle. In recent years, the demand has been for more automation, more versatility and for better quality fabrics. Apart from automation, the application of microprocessor has completely revolutionized the weaving process including all the available weft insertion systems. However, the contribution of microprocessors has been more in airjet weaving than in other weaving systems. It is true that the increase in loom performance of any type of shuttleless loom beyond the levels prevailing a few years ago has been made possible only through the use of electronics.

Fig. 1 – Trend of the mass of the weft insertion element and of energy demand from the insertion [(o)-mass; and (.o-) energy]

Leading manufacturers of projectile, rapier, airjet and waterjet looms have incorporated this advance technology in their weaving machines which virtually can give any information connected with production, loom faults, design change, etc., As regards the noise reduction and energy conservation, there exists a vast scope unlike in loom speed. Further innovations in weaving will largely depend on developments of new fibres and yarns in the 21st century.

Literature Cited

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