Journal of Zhejiang University SCIENCE A
ISSN 1009-3095
http://www.zju.edu.cn/jzus
E-mail: jzus@zju.edu.cn

Advanced tufted carpet patterning technology

ZHAO Yue (赵 越)†, DAI Hui-liang (戴惠良)

(*Department of Mechanical Engineering, Donghua University, Shanghai 200051, China*)

†E-mail: yale1980@peoplemail.com.cn

Received Aug. 12, 2005; revision accepted Nov. 10, 2005

Abstract: After a review of the tufting industry's development, and a brief introduction to available systems for producing patterned tufted carpets, the principle of ICN (Individually Controlled Needle) and the related advanced tufting technology Colortec are presented. Finally, Colortec machine, Axminster weaving machine, and Wilton loom are compared. It is believed that the Cobble Colortec machine is a significant jump forward in the tufted carpets industry as it now allows access to all major carpet markets in a competitive fashion.

Key words: Tufting, Patterning, Sliding needlebar, Colortec, Creel, Scroll
doi:10.1631/jzus.2006.A0374 **Document code:** A **CLC number:** TS103.33+6.3

INTRODUCTION

China's tufting machine industry has recently been developing rapidly against fierce competition from UK and USA manufactures, and its formerly narrow width tufting machines are now available in five meter width. The width increase was accompanied by the speed increase of up to 2000 r/min and integration with sliding needlebars and yarn feed roller control with scrolls and finally with computerized servo motors (Cooper, 2003).

Until recently, facilities for producing patterned carpets by tufting have been more limited than facilities for producing carpets by weaving. Despite the availability of many variants on the basic patterning mechanisms, more ingenuity has been demanded of designers to make tufted carpets aesthetically attractive. The patterning in tufted carpets can be created in many ways, including the control of the backing cloth, yarn feed and sliding needle bars. These different mechanisms can be controlled by electronic and (or) mechanical means.

The two major categories of techniques available in the industry are sliding needlebar techniques and yarn tensioning techniques. The sliding needlebar technique changes the sequence of pre-colored yarns laterally to give "crossover" style of carpet, all the colors being visible in all weft rows of the carpet. Yarn tensioning technique is commonly used to produce carpet with high and low loop, or carpets with areas of cut pile and loop pile. These two basic techniques have been elaborated by means of more sophisticated mechanisms: by combining the techniques or by designer's techniques such as "planting" additional colors in the creel when using a yarn tensioning technique; or using space-dyed yarns to provide additional color in what is essentially a two-color design. Patterns may be controlled by mechanical, photoelectric or microprocessor systems.

In the last decades of years the patterning technique has evidently progressed. Varies of new techniques are created, such as computer controlled scroll patterning mechanism, buried end technology, MRA (multi roll attachment), enhanced sliding needlebar mechanism, full repeat scroll system, and so on. In the mid-1990s two quite new patterning mechanisms Colortec and Tapistron with the core principle of ICN became commercially available. They can generate six-color patterns similar to those produced on gripper Axminster looms. The status of these machines in the world carpet industry will undoubtedly develop in relation to industrial attitudes and consumer prefer-

ences for pattern in different countries.

INDIVIDUALLY CONTROLLED NEEDLE (ICN)

ICN method was invented by Cobble, one of the most important tufter manufacturers in the world. The ICN concept allows an individual needle to be selected to tuft or not to tuft. If the yarn is not required in any part of the design, it does not appear in the carpet at all, so there is no unnecessary buried yarn as in two-color scroll patterning or multi-frame Wilton weaving.

Fig.1 shows the design of the individually controlled needle. The needlebar carriers (at a standard gauge of 3/16″) are supported independently of the needle drive mechanism and a needle does not penetrate the backing fabric unless selected by the pattern control system. The solid state patterning system can instruct the pneumatic latching cylinder to engage or disengage the lath pin from the needle holder. When the latch pin is engaged, the needle interacts with a cut-pile looper in the conventional way. When the latch pin is disengaged, the needle holder is returned to its rest position by a lift spring. Yarn feed is started by the tufting action only, so yarn feed rollers are not installed. Until required, a spring tensioner located in the needle unit in the yarn feed mechanism holds each cut end of yarn securely (Xue, 2003).

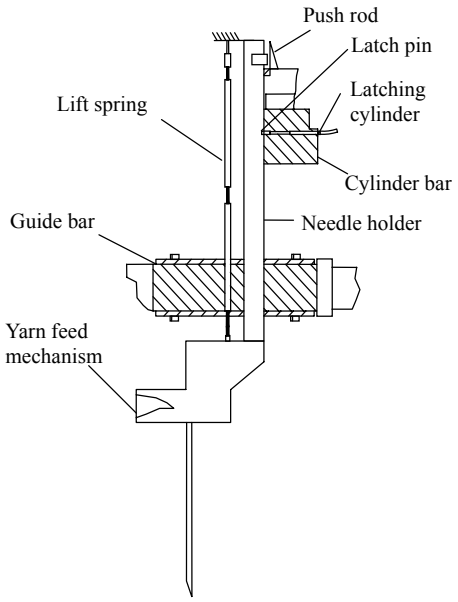

Fig.1 Mechanism of the individually controlled needle

Patterns are prepared by a separate CAD unit to allow the designer to prepare designs stitch by stitch for the exact placement of tufts into the base cloth. Patterns can be up to full-width repeat.

The Colortec machine is a further development that uses the ICN mechanism in combination with a sliding needlebar. The Colortec machine has broadened the market to allow tufting machines to enter the previously exclusive Wire Wilton and Axminster loom market. This is because intermittent cloth feed in conjunction with sliding needlebar and ICN needle selection, allows sideways filling of each row. Three sliding movements are used with three colors threading and six sideways movements with six threading colors. In this manner each tuft can be sewn selectively with any of the colors in use, producing individual tuft definition in complex patterns directly comparable with Axminster or Wilton pattern carpet.

COLORTEC

Cobble first created the Colortec machine that uses ICN tufting needles mounted on a single sliding needlebar. It can tuft full-width repeats of cut-pile carpet in up to six colors. Ohno, which used to be the cooperator of Cobble when it innovated the Colortec, used the machine for producing rugs, but initial interest in Europe and the USA was in the broadloom style.

The size of the creel for the Colortec machine is the same as that of a normal tufting machine. At most six colors are threaded in the same repeating sequence, e.g. 1~6, across the machine. The same color of yarn may be tufted by a particular needle up to six times within a cycle of the machine. Only one sixth of the creel positions are, therefore, occupied by a particular color.

In a six-color design, the sliding needlebar moves six times, one gauge point at a time. Therefore, each needle in a group of six has the opportunity to interact with any of the six loopers in the sequence. Selection of the interacting needle (color) is determined by the patterning system, which actuates the ICN mechanism. At the extreme, the same color may be selected for six strokes of the needlebar in all groups of six needles, giving a row of tufts in a single color. The needle movement within a cycle of six

strokes fills the row with a variety of colors. When a design needs only five kinds of colors, the machine will be creeled with only five colors threaded in the needles in a repeating sequence 1 to 5. A cycle of only five strokes is needed to finish a row of the design.

Tests showed that the machine applicable to yarns with six different colors, has 70% efficiency, and output of around 9 linear meters per hour (approx. 2.5~4 times the output of an Axminster loom).

Available gauges are 5/32″, 1/6″ and 1/7″, with a future possibility of 1/8″ gauges. The running speed is 300~500 r/min.

COLORTEC COMPARISON WITH WIRE WILTON AND AXMINSTER

Colortec output is 3~13 times that of WW or Axe looms, creel size is 1/6 of creel ends in 6 color WW or Axe looms. Five colors of Colortec occupy 1/5 of the creel ends. Colortec can evidently save a lot of preparation time. Axminster is limited in gauge, down to 1/8″ gauge only. Because of the difficulties encountered there are very few 1/8″ gauge looms. Axminster's most common gauges are 1/6″ and 1/7″ gauge. Wire Wilton's having fine gauged is limited in the market because of the penalty of buried or incorporated yarns giving no value to the pile but giving more disadvantages due to the higher number of colors woven. The Colortec machine can be manufactured in 5/32″, 1/7″ and 1/10″ gauge with no consequential disadvantages as in the case of the other two looms. Colortec is most suitable for tufting high twist yarns to produce carpets that would mix yarn textures as well or instead of colors. Axminster is unsuitable because of the gripper pick up with twist yarns. Wire Wilton will process high twist yarns. There is a Wilton loom called face to face Wilton which produces rugs. The two rugs produced are mirror images of each other but edge matching is poor. Comparison with the 1/10″ Colortec shows that, wasted yarn is a factor of 2.47 US$/m² for wool yarn as shown in Table 1.

Table 1 Yarn cost comparison—Wilton to Colortec (Unit: US$/m^2)

Yarn	Wilton	Colortec	Difference
Wool	15.85	13.38	2.47
Nylon	12.59	10.62	1.97
PP	5.59	4.72	0.87

Wilton is face to face CRM 82 VAN de Wiele machine with 80% efficiency, Colortec is Cobble 1/10″ 6 color Colortec machine with 70% efficiency

Another advantage of Colortec yarn usage is that although a 5 m wide Colortec utilizes 1407 needles, not every needle requires yarn on the creel. For example it is feasible that some 6 color 5 m wide designs will require only 1100 packages of yarn to produce the finished carpet in the required design entailing very little yarn wastage. A 5 m wide gripper Axminster machine would require a staggering 8842 packages to manufacture a 6 color design, i.e. 6 times 1407 packages of each color. The process of winding these yarn packages to the required length and placing them correctly in the position on the creel would be a long and labor intensive operation and the residues of yarn length left after production would be very high (Carnaby *et al*., 1979).

Tufting speeds are compared in Table 2 showing that Colortec machines are superior to other looms (Cooper, 2003).

CONCLUSION

As we can see that with a matched versatility in patterning ability to both the Wilton and Axminster, the Colortec is superior in both cost reduction of the

Table 2 Tufting speeds—Colortec compared with Wilton and Axminster

Equipment		Tuft speed (r/min)				
		6 color	5 color	4 color	3 color	2 color
Colortec	5/32″ & 1/7″ 450 r/min	75	90	112.5	150	225
	1/10″ 500 r/min	83.334	100	125	166.67	200
	1/10″ 600 r/min	100	120	150	200	300
Wire Wilton 70 picks/min				23.334		
Axminster 3 shots				23.334		

Note: Efficiency 100%

manufactured carpet and the speed that it can be made at.

In summary the Colortec benefits can be said to be:

(1) Excellent yarn savings;

(2) Sewing widths can be rapidly changed to suit any requirements;

(3) Carpet surface needs only minimal shearing;

(4) The fewer colors used in a design will increase output speeds;

(5) Up to 6 color carpets and rugs can be produced in virtually any pattern imaginable.

It is believed that the Cobble Colortec machine is a significant jump forward in the tufted carpets industry as it now allows access to all major carpet markets in a competitive fashion.

References

Carnaby, G.A., Garden, G.M., Hammersley, M.J., Watts, D.M., 1979. Tufting efficiency Part 1: Some causes of stoppages during tufting. *Textile Institute and Industry*, **17**(8):282-285.

Cooper, I., 2003. Tufted Carpet Patterning System. Textile Institute Conference, New Zealand, p.1-5.

Xue, S.X., 2003. Machine-Made Carpet. Chemical Industry Press, Beijing, China, p.340-347 (in Chinese).