Advances in Wool Carpet Technology

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INGHAM Peter[a], MEADE Warren[a] , McNEIL Steven[a]
(a) AgResearch, Private Bag 4749, Christchurch, New Zealand

Corresponding author: INGHAM Peter, peter.ingham@agresearch.co.nz

Abstract: Wool carpet technology, particularly for tufting, has advance significantly in recent years with large increases in production efficiency and quality. In addition, many of wool's traditional weakness as a carpet fibre have been overcome through new technology and new carpet styles have arisen. The developments of Twistset and melt-bonding technology are now widely used globally to meet the demands of premium and high-performance low-cost yarns respectively. The problems of photobleaching, fibre shedding, shading and insect resistance have been largely overcome through new technology whilst new tufting technologies (including needles specifically designed for tufting wool) have increased efficiency and enabled new styles of tufted carpets.

Keywords: wool; carpet; wronz; tufting

1 Introduction

The manufacture of pile rugs from animal fibres dates back at least 6000 years with the area encompassing Iran believed to be the origin. Trading of these rugs was believed to be carried out by Nomadic herdsmen and by the 3rd century BC carpets were traded along the Silk Road and the technology was also passed on.

The oldest existing carpet was excavated from a tomb at Pazyryk near the Outer Mongolian border in 1953 and is estimated to be 2400 years old [1].

Handknotting spread westwards with the spread of Islam and spread to Spain, Italy and France and England. The first powered loom for carpet weaving was used in 1839.

Since then, we have seen the development of weaving machines as well as the rise of mechanised tufting of carpets starting with Albert & Joe Cobble. Cotton, then rayon were the pile fibres first used for carpet tufting followed by nylon.

The advent of wool into tufting was initiated by wool interests (such as the International Wool Secretariat) as the traditional wool-using weaving industry declined as production of tufted carpets accelerated to dominate production (over 80% of the market in Europe/USA).

The Wool Research Organisation of New Zealand was the most prominent R&D centre which developed a number of new technologies to assist the use of wool and to overcome the problems and deficiencies of wool as a tufted carpet fibre.

This paper will outline some of the significant developments in this area. Presently, some 30% of the world's wool production is used in carpets and rugs.

2 Coarse-wool scouring

Pioneering work in the early 1970s resulted much improved scouring efficiency, reduced environmental impact (energy use and effluent) and a smaller footprint.

The combination of the WRONZ Scoured Wool Cleaner to remove dirt and dust and to open the wool together with the WRONZ/ANDAR Comprehensive Scouring System and the later use of minibowls was commercially highly successful. The WRONZ designed minibowls (2.7 m in length) were as effective in cleaning as the conventional 6-7 m conventional bowls thus saving space, reducing energy losses, cost and maintenance.

This was probably the first systems approach to woolscouring which integrated the contaminant removal systems into the operation of the scour so that all heavy effluent from the hot scouring bowls was treated before discharge in a fully continuous process.

3 High density spools (HDS)

The HDS concept originated at WRONZ as a means to improve the package density of card slubbings and thus reduce the doffing frequency at the card and spinning frame.

Large-scale mill validation showed the following benefits [2]:

- fewer ends down at the condenser
- an increase of at least 50% of material on a condenser spool

- 60% reduction in ends down in spinning
- 15% increase in strength and extension
- carding and spinning efficiency improved by 14%
- 7% reduction in yarn manufacturing cost

4 Chemset/twistset technology

The manufacture of plain pastel coloured wool carpets without disfiguring stripes is a difficult task requiring evenly-scoured yarn with almost zero colour variation throughout the batch. Traditional tape scours gave a significant colour shift throughout a batch; initial production with fresh liquor was significantly cleaner than the end of the batch. Additionally, appearance retention of cut-pile carpet is heavily dependent on good retention of folding and ply twist.

These problems were eliminated with the Chemset (later Twistset) system, a major engineering and process development developed by WRONZ and ANDAR Engineering. This is a package-to-package yarn wet-processing (scouring and setting) system which eliminates the need to make hanks and to backwind them.

A schematic layout of typical Twistset equipment is shown in Figure 1. Yarn packages are loaded onto a creel and 2 groups of 12 or 18 ends of yarn are fed to a coiler which lays down two coiled blankets of yarn into a conveyor. These blankets are fed through the scouring/setting bowls/rinsing bowls, dried, uncoiled and fed to an accumulator which provides buffer storage, then the yarns are separated from the blanket into an autodoffing winder.

Bowl 1 typically contains non-ionic detergent levels of 0.5 – 1.0 g/l. Chemical setting is carried out in bowl 2 using sodium metabisulphite concentrations of 5-10 g/l. The chemical setting process occurs by the sulphitolysis redox reaction which increases the number of mercaptide anions from wool's cysteine. The liquor is set to pH 7 with sodium carbonate typically at 75-85ºC.

Additionally, insect-resist agents can be added to bowl 2, or preferably from an effluent point of view, in a separate minibowl application after bowl 4.

Bowl 4 is a rinse bowl which reverses the sulphitolysis reactions and reforms the disulphide bonds. Investigations into oxidative treatments to improve this process showed no practical advantages over simple rinsing [3].

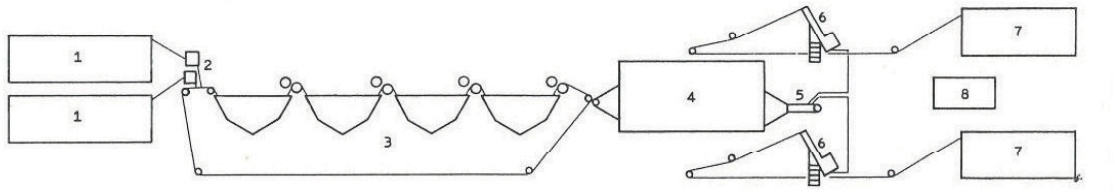

Figure 1 Schematic layout of twin-channel ANDAR-WRONZ CHEMSET machine 1, creel; 2, two 12-end coilers; 3, four wet-process bowls with main conveyor; 4, Unidryer; 5, uncoiler conveyor; 6, Superba MAT accumulators; 7, Gilbos autodoffing winders; 8, control panel

5 Tufting needles

The development of the WRONZ Eye needles enable smoother passage of yarn through the needle eye to assist with tufting of wool yarns and yarn joints which have lower tensile strength (Figure 2). Carpet tufting started with nylon yarns and early attempts to tuft wool yarns were largely unsuccessful. Both improvements in yarn specification and the introduction of the WRONZ Eye needles overcame these problems.

More recently, the Fernmaster needle was introduced by Eisbar following further WRONZ research [4]. This incorporates a second eye near the top of the blade of the needle. This upper eye acts as the last guide and is engineered to reduce friction and avoid sharp discontinuities in the yarn path. Trials have shown reductions in the needle insertion force of up to 70% and tufter power usage reductions of up to 38% and a significantly improved appearance of loop-pile carpets. Less damage to the primary backing is another benefit which leads to less bow and skew distortions.

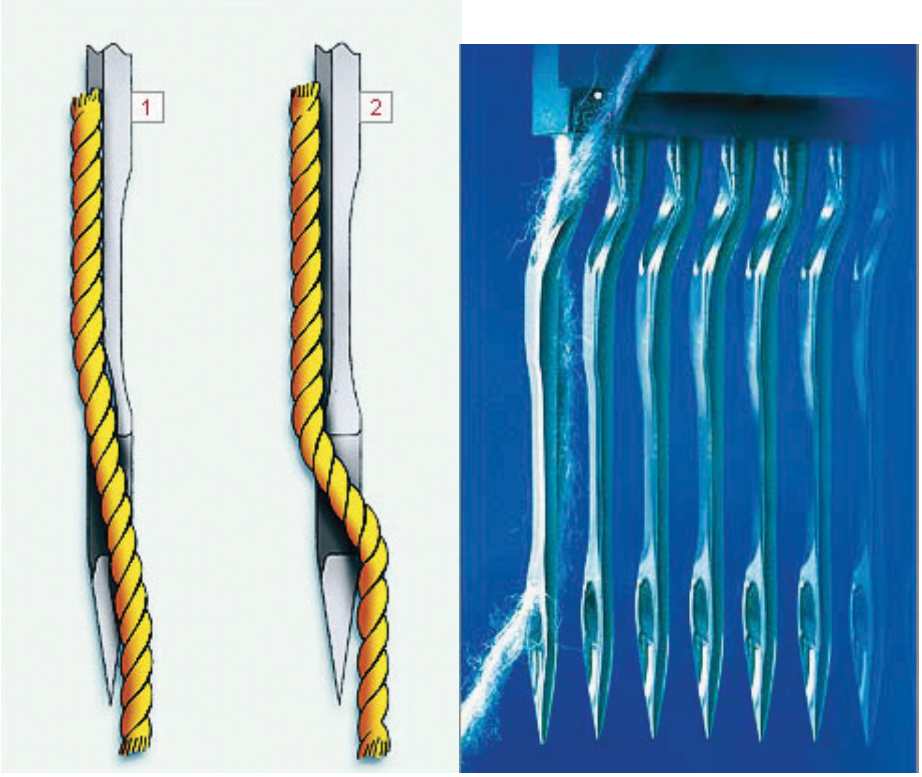

Figure 2 WRONZ Eye (1), Conventional (2) and Fernmaster tufting needles. Images curtsey of Groz-Beckert, Germany

6 Anti-photobleaching technology

The problem of photobleaching or first/red fade has long been a problem for wool carpets and furnishings. Some of the natural creamy yellow chromophores in wool are rapidly bleached by sunlight behind glass giving rise to a significant colour change most noticeable in pastel or undyed shades [5].

To overcome the problem, WRONZ developed a compound that photoyellows at the same rate as wool photobleaches. This is applied during dyeing and when the correct amount is added, the effect of photobleaching is cancelled out. The compound was commercialised by Clariant as Lanalbin APB and is in widespread use globally.

7 Anti-shedding technology

Cut-pile carpets made from staple fibre will always shed some loose fibre from cut short fibres in the tufts but in wool carpets the problem is more severe due to the initial wider fibre length distribution.

A Canesis innovation based on a nano-particulate product which exhausts on in the dyebath, Lanasan NCF (Clariant), significantly reduces the amount of shedding by increasing the inter-fibre friction [6]. Additional benefits in the finished carpet are increased yarn strength, lower soiling and increased abrasion resistance.

8 Shading/pile reversal

The permanent change in cut-pile carpet appearance known as shading or watermarking is an optical effect resulting from the carpet pile leaning in different directions. All types of cut-pile carpets are susceptible and shading can occur with any fibre type.

Many conflicting ideas for the cause of shading have been proposed including dimensional changes in the backing, uneven moisture levels, air currents, floor levelness variations, underfloor heating and even ‘earth rays’ or magnetic currents.

Following research into establishing the causes of shading [7], WRONZ developed the Trutrac™ machine which enhances the natural pile lay, temporarily setting it in one direction, so that the residual recovery forces are neutralised and the frictional locking mechanism will cause the pile to always want to lie in that direction. To date two commercial machines have been sold which were installed in the normal carpet finishing line.

9 Insect-resist treatment

The larvae of a very few of the many millions of insect species have developed the ability to digest wool and a variety of agents have been used to protect wool from attack.

The main agent in use from the 1970s is permethrin, a synthetic pyrethroid insecticide which has very low mammalian toxicity. However, in recent years, some problems have arisen; in Australasia some species have developed resistance to it and in Europe (UK particularly) there are effluent problems due to the geographic clustering of the wool industry and permethrin's broad spectrum effect, particularly on aquatic invertibrates.

In response to these problems, Canesis/AgResearch have researched and developed a number of alternatives with much reduced environmental impacts. Bifenthrin- and chlorfenapyr- based agenets are now in use commercially (MAL, Shamrock and Catomance) and recently a new non-pesticide dye-bath auxiliary with an anti-feedant effect has been introducted by Chemcolour.

10 Melt bonding

Melt-bonding was developed by WRONZ and Allied Signal for wool- and nylon-pile carpets respectively. In the case of wool, 5-10% of a bicomponent polyester bonding fibre is added to the wool component to give improved tuft definition and reduced fibre shedding. These polyester fibres do not bond with wool, but, once the sheath of the low-melt polyester is melted, the polyester fibres stick to each other to form a bonded scaffold which constrains and contains the wool. This breakthrough not only lifted performance in Saxony and frisé styles, but it also enables cost-effective singles yarns to be used successfully in tufted carpets.

11 Tufting developments

Following the introduction of machine tufting, a rapid increase in the rate of development occurred in the latter half of the twentieth century. Notable developments have been:

- The first broadloom tufter, the Cobble BMN in 1940.
- The Computer Yarn Placement Machine (Tapistron) was the first successful development for highly patterned tufted carpets although speed limitations have reduced the commercial success.
- The Cobble Colortec machine is based on Individually Controlled Needle (ICN) technology can produce highly patterned tufted carpets at speeds comparable to weaving.
- Tuftco Servo Scroll and Single End Servo Scroll.

Scroll technology has been around since the late 1960s using clutches or hammers pressing on the yarns to vary the feed rate but Tuftco introduced servo motors to control the scroll, initially one servomotor for a number of yarn ends and more recently one servomotor for each needle providing single-end pattern control, ie, around 2000 yarn feed servomotors for a 4m wide tufter!

12 Conclusions

The wool carpet industry is, despite some contraction, a major textile industry. Research and development has almost revolutionised the production of machine made carpets with significant innovations and cost reductions in all areas of the production chain from the sheep to the finished carpet.

The problem for the woolgrower is the low price received for crossbred wool which has caused a cessation of grower R&D funds which are essential to maintain wools position as a prestige carpet fibre against new challenges from its synthetic counterparts.

The consumer guarantees for solution-dyed nylons offering 10 year warranties against staining, fading and wear are a great consumer draw card even if the warranties turn out to be very largely valueless.

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