Development of specification and processing prediction techniques for the Chinese and Indian wool industries (AS1/1997/070)

Bill Humphries and Shouren Yang

<table>
<thead>
<tr>
<th>Project number</th>
<th>AS1/1997/070</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project name</td>
<td>Development of specification and processing prediction techniques for the Chinese and Indian wool industries</td>
</tr>
</tbody>
</table>
| Collaborating institutions | Australia: Woolmark Company, Cooperative Research Centre (CRC) for Premium Quality Wool, CSIRO Textile and Fibre Technology  
|                       | China: Dong Hua University (DHU), Xi’an Polytechnic University (XPU)  
|                       | India: Indian Woollen Mills Federation |
| Project leaders      | Dr Bill Humphries (CSIRO Textile and Fibre Technology), Professor Ding Xin (China Textile University), Professor Baoyu Zhu (XPU), and Dr A.C. Chaudhuri (Indian Woollen Mills Federation) |
| Duration of project  | 1 July 1999 – 30 June 2002; extension 1 July 2002 – 30 June 2003 |
| Funding              | $956,630 |
| Countries involved   | Australia, China and India |
| Commodities involved | Wool |
| Related projects     | AS1/1997/69 |
Motivation for the project and what it aimed to achieve

The major aim of this project was to carry out research to develop, in a form suitable for Chinese and Indian spinning mills, techniques that can be used to predict yarn quality and spinning performance from knowledge of fibre properties.

What the research project produced

The most pleasing aspect of the project was the level of cooperation received from the mill and university partners. This cooperation was central to the success of the project. Mills carried out very large processing trials and supplied large amounts of processing data. All the mills carried out the project work at their own expense, demonstrating their commitment to the project.

Based on comprehensive data compiled during the project and from additional mathematical modelling, the spinning prediction model, Yarnspec, has been improved to suit the needs of Chinese mills. In addition, mill-specific Yarnspec prediction models have been developed for individual mills. The new Yarnspec model can predict not only the world’s best practice but also the mill’s specific performance. This makes Yarnspec more useful as a quality-control tool for spinning mills since it will allow a mill to easily optimise the input parameters of fibre properties and machine settings for its specific circumstances.

Visit to Ruyi Group for ACIAR adoption study, May 2007. L–R: Ms Ding Cai Ling, General Manager of Ruyi Worsted Spinning Company; Dr Shouren Yang, CSIRO Australia; Mr Qiu Dong, Managing Director of Ruyi Group.
A neural-network prediction model was also developed during the course of the project. This will be useful in the future for developing mill-specific versions of Yarnspec and for easily keeping the mill-specific model up to date as the performance of the mill improves.

Through the direct participation of the six leading Chinese worsted-spinning mills and the two major Chinese textile universities, Yarnspec spinning-prediction technology has been introduced into the Chinese wool industry. Yarnspec is now a well-known name in the Chinese wool industry and at the two Chinese textile universities.

The benchmarking of Chinese mills provided vital information on the mills’ performance relative to the world’s best practice, which in turn provided an important stimulus for improvements in performance. Through years of effort, the partner mills have made excellent progress in catching up with, or even eclipsing, the existing world’s best practice. Some partner mills are now leading the Chinese wool industry in product quality and fashion trend. Wool fabrics produced by the partner mills have become the choice of some of the world’s leading garment manufacturers for production of top-brand garments.

Objective measurement of fibre diameter was implemented for Chinese domestic wool in a central laboratory in the Lanzhou Sanmao mill and appropriate sampling methods instituted so that the mill was able to use the objective measurement of fibre diameter during wool sorting and consignment building. The implementation of fibre-diameter measurement for domestic wool in the mill is a major achievement of the project.

The project has enhanced the linkage between university teaching and research activities and industry practice. Processing prediction technology and quality control have been introduced into universities as important areas for teaching, research and consultation. As a direct result of the project, partner universities and mills have received significant additional funding from the Chinese Government for implementation of the technologies introduced by the project.

The domestic wool subproject has clearly demonstrated the need for good clip preparation and the benefits of using objective measurement in consignment-building decisions. Importantly, this has been commercially demonstrated at the mill level (112 tonnes of wool were processed in the trial described above) and, because
of the commercial advantage gained, the mill has sent strong signals to the production industry aimed at improving clip preparation and the general quality of the wool delivered to the mill. The project has therefore started what is hoped will be a commercially driven, sustainable process that will result in an improvement in the quality of wool delivered to the mill, a reduction in mill costs and improved returns to wool producers. The outputs clearly demonstrate that the research undertaken within this project has the potential to significantly contribute to the reform of the domestic wool-marketing system.

Nanjing Wool Market (NWM) has put considerable effort into improving on-farm practices, shearing, clip preparation and packaging. From 1998 it has been developing the domestic wool-marketing system in collaboration with local wool farmers’ associations in Xinjiang and Inner Mongolia. Excellent progress was made from 1998 to 2004 in reforming the domestic wool-marketing system. However, there has been a slowdown in the reform in recent years due mainly to the lack of support from the state and local governments.

In India the benefits of the project were summarised by the project review committee as follows:

We were impressed with the experimental design of the project, and although not all phases of work have been completed at the time of our review, there are positive results available. Most of the participating mills are already finding benefits from the introduction of Yarnspec into their mill quality control. It has benchmarked their current yarn quality and spinning performance to world best practice, and enabled them to begin analysing how to improve quality and profitability.

In the major wool-input optimisation trial carried out in India, two batches of 4 tonnes of greasy wool were assembled from 5–6 sale lots purchased at auction in Fremantle. The first batch conformed to the typical specifications of leading Indian mills. The second batch greatly increased the allowed range of staple length and strength. The batches were spun into yarn at five Indian mills. The mean yarn properties and spinning performances were found to be essentially identical, within errors, except for the strength properties of the yarns, where the conventional batch was marginally superior. Analysis of auction data showed the batch made up with the wider range of staple properties would be cheaper, and more wool would be available for the mills’ buyers to bid on at auction.

Visit to Xi’an Polytechnic University for ACIAR adoption study May 2007. Left (L–R): Dr Ren Xueqin, Mr Zhang Dekun, Mr Zhao Wei, Prof. Zhu Baoyu, ex. Vice-President of XPU, Prof. Huang Xiang, Vice-President of XPU, Dr Shouren Yang, CSIRO Australia, Prof. Yao Mu, Honorary President of XPU, and Prof. Sun, Director of S&R Department. Right: Prof. Zhu Baoyu and Dr Yang.
Adoption— how the project outputs are being used

At the start of the project the quality-control system at the Chinese partner mills was poor from the international standards point of view. Their main focus was to keep the raw-material costs as low as possible at the expense of product quality and ignoring the overall economic efficiency. This improper mill-management policy, had, to some extent, contributed to the breakdown of many state-run mills in China in the 1990s.

Through adoption of the processing-prediction and objective fibre-measurement techniques the partner mills have gained a better understanding about the importance of choosing the most suitable wool tops to ensure product quality and overall economic efficiency. The partner mills are moving away from trying to reduce material costs at the expense of quality and overall economic efficiency. This has led to significant savings through optimum wool-fibre selection and improved product quality and processing efficiency.

Before the project, the quality control system at the partner mills was based mainly on experience. They used their experience to purchase wool top and there were no adequate specifications for the wool tops they wanted. As a result, the mills suffered significant economic losses from using poor wool tops, which resulted in poor yarn quality and spinning performance. This led in turn to low overall economic efficiency.

Now the mills have adopted the international standard specifications for wool tops and they consider the overall quality of wool tops more wisely by taking into account the influences of various fibre properties, including fibre diameter and length, and their variations. The mills now have a good understanding of the importance of fibre length and the trade-off between fibre diameter and length. By applying this trade-off, mills are able to optimise wool-top selection by choosing the most suitable wool tops to meet customers’ requirements for the end products while keeping the material costs low. The fibre lengths of wool top used by the partner mills have increased significantly, by about 10–15 mm, which has been important in contributing to the improved yarn quality and spinning performance.

Fibre damage in top dyeing is a key factor affecting yarn quality and spinning performance. Before the project, top dyeing quality at the partner mills was poor, which resulted in significant damage to the fibre strength, which led in turn to poor yarn quality and high spinning ends-down. By adopting spinning-prediction and low-temperature dyeing techniques partner mills have optimised top-dyeing procedures. As a result, fibre damage in top dyeing has been greatly reduced, leading to significant improvements in yarn quality and processing efficiency. Data collected from Ruyi show that from 2002 to 2006 fibre damage in top dyeing at the mill has been reduced by 58%, 54% and 66% for fine, superfine and ultrafine wools, respectively. This indicates the same percentage increase in the resulting yarn strength. As a result, spinning ends-down has been reduced by 35% and weaving efficiency improved by 13%. This has led to a reduction in labour for weaving operations by 100%. Similar progress has been made at other partner mills.

The quality-control system at these mills has changed from ‘fire fighting’ to ‘fire prevention’. This helps mills minimise economic losses caused by producing bad lots due to poor material selection or wrong specification of spinning parameters.
Adoption of ACIAR project outputs: studies of projects completed in 2003–2004

The benchmarking study in 2001 indicated that all the mills’ performances were below the world’s best practice. For some mills the spinning ends-down rate was as high as 5–10 fold that of the world’s best practice. Over the years, all the partner mills’ performances have significantly improved and are catching up with, or even outperforming, the world’s best practice. Pleasingly, the best of the partner mills have now become the leaders of the Chinese wool industry for fabric quality and fashion trends and the dominant suppliers of high-quality wool fabrics to the key overseas markets for the Chinese wool-textile industry.

As claimed by the mill and university partners, the most important change is the change in people’s thinking and the concept of quality control. Under the influence of the project, many Chinese wool-spinning mills have adopted the new concept of scientific management for the traditional wool industry.

Due to the higher level of competence in the Indian mills, the improvement in the performance of the partner mills is less profound. However, the Indian mills have taken advantage of the economics of better fibre specification for spinning. The project also highlighted the damage due to dyeing occurring in the mills and, although no specific follow-up has taken place, it is likely that the mills would have improved their performance in this area.

---

**Impact—the difference the project has made or is expected to make**

**Characterisation of the impacts**

At the 2001 Shanghai Conference of the International Wool Textile Organization (IWTO), Shandong Ruyi claimed, on behalf of the Chinese wool industry, that by adopting the new technology, the quality-control system at Chinese mills has changed from ‘Experience Based System’ to ‘Scientific Pre-Known and Pre-Control System’ (sic), which has resulted in a significant improvement in yarn quality.

A partner mill has claimed recently that:

> Yarnspec has played a critical role in improving top dyeing and spinning quality. Yarnspec has produced a profound impact on the Chinese wool industry and the impact is beyond the technology itself. The wool industry is a traditional experience-based industry. Yarnspec has introduced a new concept of prediction and pre-control into the industry. This will produce great impact on the Chinese wool industry through revolutionising people’s thinking.

The partner mills have upgraded their testing laboratories by purchasing advanced test equipment and establishing conditioned testing rooms. This will be vital to their efforts to improve their yarn quality in the future. Some partner mills have established technology or R&D centres that have played an important role in facilitating applications of new technology and new product development.

The impact of the project has extended beyond the six partner mills. This is evidenced by a statement by Lanzhou Sanmao at the 2004 IWTO Shanghai Conference:

> Lanzhou Sanmao and most Chinese worsted spinning mills have established internal quality control and quality assurance systems. Some enterprises have gained the ISO9000 authentication. These companies have abandoned the old experience-based quality control concept and adopted
a new system, which is based on scientific objective measurement and processing prediction. The companies are now paying high attention to raising the corresponding quality target for intermediate products according to the quality requirement for the final products. We are confident to say that the Chinese wool industry is definitely moving from the traditional experience-based management towards the scientific know-how new system.

The success of the ACIAR project has created strong demand from the Chinese wool industry for a wide adoption of the spinning-prediction technology and quality-control procedures to improve yarn quality and spinning efficiency in China. This is evidenced by overwhelmingly strong support from the Chinese wool industry for a proposed project ‘Enhancing China’s capacity for processing superfine Australian wool’ for the Australia–China Agricultural Technical Cooperation Programme. The Chinese Wool Textile Association, NWM, 11 major wool-top making and spinning companies and three leading textile universities have expressed strong interest in and support for the proposed project.

In 2001 the Chinese Government listed the development of a spinning-prediction system as one of the six key wool-related projects in a major program supported by the state government, and granted significant funding for the implementation of the program.

In June 2006 the Chinese Government announced ‘The Eleventh Five Year Plan’ for the textile industry. Optimising processing and improving product quality, which has been the key objective of the ACIAR project, has been adopted as a guiding policy for the Chinese wool industry. Professor Zhu of XPU stated that this is the best evidence of the impact that the project has made on the Chinese wool industry.

At the start of the project, Australian wool exported to China was about 25% of the total exported wool. In 2002 it increased to 40% and in 2006 reached 64%. The successful transfer of spinning-prediction technology into the Chinese wool industry has no doubt played a part in promoting the value of high-quality Australian wool in China.

The domestic wool subproject conducted successful pioneering work into the introduction of objective measurement into the Chinese domestically grown wool supply chain in collaboration with Lanzhou Sanmao and NWM. With strong influence from the project, excellent progress was made in advancing the reform of the domestic wool-marketing system during the project period. However, the full impact of the project was not fully realised for reasons that were beyond the control of the Australian and Chinese researchers.

The major impact in India has been the adoption of the purchase of longer wools, which has brought technical and economic benefits. The benchmarking of Indian mills’ performance against global best practice gave an important impetus to mill improvement in reducing damage during dyeing and more cost-effective wool specification.

**Capacity building and scientific impacts**

Under the direct influence of the project, partner universities have developed strong collaborations with the Chinese wool industry and applied for a number of state and provincial projects. In 2001, XPU and Lanzhou Sanmao were awarded one of the six major national wool-research projects for the application of spinning-prediction technology for domestic wool, with grants of RMB2 million in cash and RMB14 million in interest-free loans. This project, entitled ‘Prediction and control of product quality in topmaking and spinning’, in 2004 won the highest award of the Chinese Textile Industry Science & Technology Advances program.
The two partner universities play an important part in textile education in China. Under the direct influence of the project they have established collaborative relationships with major Chinese mills, which have enhanced their capability to carry out industry-related research.

The project has trained university staff who were directly or indirectly involved in the project and, through them, younger-generation students. University staff at XPU claimed that they have learned scientific attitudes and methods of project planning through participation in the project.

The project has greatly strengthened the linkage between university teaching and research activities and industry practice. Processing prediction and quality control have been introduced into university as important areas for teaching, research and consultation. Many postgraduate students have received training in this area and made good progress in their studies and career development.

As stated by a project-sponsored PhD student at DHU, ‘the project has built a bridge between the university and the industry, which has facilitated the cooperation between the two parties and helped to transfer research fruit to daily production quickly’.

As a direct result of the project, quality control and spinning prediction have become hot topics for postgraduate studies at the partner universities. Encouraging progress has been made in advancing the technology. The knowledge and skills gained through their direct or indirect involvement in the project will help their future career development.

In summary, the most important impact comes from the introduction of objective measurement, quality-control techniques and processing prediction into the Chinese and Indian wool industries. Secondly, benchmarking mills against world’s best practice has produced a powerful stimulus for mills to improve their quality-management system in the course of catching up with the world’s best practice. We believe the above two outputs have led and will continue to lead to improvements in quality and efficiency, that will allow the mills to more readily compete in global markets. It is also crucial for the continued expansion of employment opportunities and conditions in the partner countries’ textile industries.