International Specialised Skills Institute

Seamless Knitwear Technology: Informing the Australian Industry

Patricia Chircop

The George Alexander Foundation/ISS Institute Fellowship

Fellowship funded by The George Alexander Foundation

THE GEORGE ALEXANDER FOUNDATION

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International Specialised Skills Institute

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Executive Summary

Most fashion designers are not trained in knitwear due to the extremely limited availability of institutions equipped with machinery and technical capability offering suitable courses in Australia. Knitwear design requires the structure of the fabric and pattern to be developed. A disconnect currently exists between textile design and fashion design courses. Textile design courses focus on developing the fabric and not the garment itself. Fashion design courses do not teach knit structure and shaping, thus leaving designers at a huge disadvantage in this particular area. The availability of education relevant to knitwear design, technology and manufacturing is very limited. As a consequence, the Australian knitwear industry is not being promoted.

Australia once had a thriving knitwear industry; however, a handful of Australian fashion knitwear manufacturers now remain and their prices are much higher in comparison to their offshore competitors. Only high-end labels are manufacturing knitwear in Australia at this time as increased costs are able to be passed on to the consumer.

As the machinery becomes more compact, the new knitwear technologies are more suitable for Small to Medium Enterprises (SMEs). However, considerable barriers exist that hinder the adoption of these technologies, i.e. cost of labour, a lack of design technologists and advanced machine operators. By developing these skills within the Australian industry and improving the Australian fashion industry's understanding of knitwear techniques and capabilities, the volume of knitwear produced may increase as designers can then understand the possibilities and costs involved and have access to the resources to enable them to develop product.

Aims of the Fellowship

The main focus of the Fellowship involved understanding the latest technological developments regarding seamless manufacturing of knitwear garments. A greater understanding of seamless manufacturing when related to knitted garments could give Australia the opportunity to enhance our knitwear industry, increase education relevant to knitwear design, technology and manufacturing, and enable the Australian knitwear industry to compete in the global marketplace.

With this focus, the Fellow undertook training with knitwear manufacturing companies overseas including Shima Seiki in Japan and Stoll in Germany. The Fellow highlighted skills deficiencies present in the Australian knitwear industry that need to be addressed. These skills deficiencies underpin the strong focus of this Fellowship.

The skills deficiencies highlighted by the Fellow are as follows:

1. **Advance previous training with Shima Seiki by undertaking the seamless programming course offered in Japan.**

   Aim: To gain a greater understanding of seamless technology: the latest technology that results in a seamless garment. To be able to create WHOLEGARMENT® garments using the automatic software and gain a greater understanding of Shima Seiki knitting machines and design systems.

2. **Build on the limited understanding and technical knowledge of industrial knitting machines and fashion knitwear designs in the industry.**

   Aim: To gain a greater understanding of seamless garment knitting techniques in order to have a greater ability to advise designers on the way they design to achieve the desired result with maximum efficiency through the most cost effective techniques.

3. **Design more proficiently by understanding the limitations and abilities of knitting by reducing manufacturing cost and enhancing design understanding of knitwear.**

Executive Summary

Aim: To improve on knitwear design skill base by further understanding of structures and process of industrial knitting machines. Such knowledge would allow the Fellow to be at the forefront of understanding the latest technology available worldwide and the Australian knitwear industry, enabling this knowledge to be passed on to others in the industry to strengthen the Australian knitwear industry as a whole.

Outcomes of the Fellowship

The Fellow travelled to Shima Seiki in Japan, The International Exhibition of Textile Machinery (ITMA) held in Barcelona, and H. Stoll GmbH & Co. in Germany as a part of the Fellowship. Whilst overseas the Fellow gained an understanding of:

- The basic programming used to create the WHOLEGARMENT® garments of Shima Seiki.
- Seamless knitwear technology, such as circular and flat bed knitting.
- The technical knowledge related to industrial knitting machines.
- The limitations and abilities of available technology and how to design more proficiently.
- How to reduce manufacturing cost and enhance design through a greater understanding of knitwear technology.

Benefits to Australian Industry and Occupation

- The time, cost and the processes used to make a garment are reduced, as it is a seamless garment.
- Innovative design possibilities through understanding of state-of-the-art technology.
- Australian designers are exposed to the same technology as overseas designers.
- Knitting industry may have a chance to re-establish by the promotion and use of technology and by raising the level of awareness of the barriers to entry.
- Promoting the use of more Australian wool and yarns.
- Keeping up to date with the knitwear technology available worldwide with ability to benchmark.
- Facilitates communication between manufactures and designers.
- Possibility to utilise seamless technology to design and manufacture garments for specific purposes e.g. compression garments for those with disabilities or physical ailments.
- Possibility to cut down on labour time.

Sharing the Knowledge

To address the skills deficiencies, greater education and resources that need to be available within Australia in all areas of knitwear production including manufacturing, programming and design. Education has a direct link with the strength of industry as can be seen in New Zealand and Italy. The skills the Fellow gained will be passed on to the Australian industry in a number of ways, including workshops, training courses, consultation and design services, and through the Fellow's knitwear business. These avenues of dissemination are expanded upon in the 'Knowledge Transfer: Applying the Outcomes' Chapter of this report.

As a result of the knowledge gained, the Fellow has provided recommendations for implementation by government, industry and education institutions in order to strengthen the Australian knitwear industry. These recommendations are outlined in the 'Recommendations' Chapter of this report.

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Abbreviations/Acronyms

AWI	Australian Wool Innovation Limited
DIA	Design Institute of Australia
DIISR	Department of Innovation, Industry, Science and Research
DSCS	Digital Stitch Control System®
i-DSCS	Digital Stitch Control System with Intelligence®
ITMA	International Exhibition of Textile Machinery
RMIT	Royal Melbourne Institute of Technology
SME	Small to Medium Enterprise
TAE	Certificate – in Training and Assessment
TCF	Textiles, clothing and footwear
TFIA	Council of Textile and Fashion Industries of Australia Limited

Definitions

Bind off

To bind off, or cast off, is to loop one stitch over another to make a finished edge on knitted fabric.

Cam

Cams pass across the needles causing the needle movements required to produce each stitch.

C knitting

The first knitted course is on the back of the garment then the front is knitted on one side, then the back again, then the front of the other side. This is only used for v-necks and when there is an opening.

Design

Design is problem setting and problem solving. Design is a fundamental economic and business tool. It is embedded in every aspect of commerce and industry and adds high value to any service or product—in business, government, education and training, and the community in general.[1]

Gauge-less knitting

The machine is able to knit a wide variety of gauges on the one garment.

Innovation

Creating and meeting new needs with new technical and design styles. (New realities of lifestyle).[2]

Intarsia

A ‘jacquard’ knit using a variety of structures, comprising of different yarns in the same course. The yarn is only knitted where used in the design, the back and the face of the design look the same.

Knitting priority

An option on Shima Seiki machines that gives the automatic processes within the design system priority to knitting time and efficiency.

Knit & Wear ®

Stoll’s trademarked brand of seamless technology.

Neck drop

The distance from the shoulder point to the bottom of the neck opening.

Needle bed

The area where all needles are fixed to the machine.

Rack

The movement of the needle bed to the right or left.

Rib tension

The tension (tightness or looseness) of the rib structure.

Shoulder drop

Distance from the top of the shoulder down to the top of the arm opening.

Definitions

Silhouette priority

An option on Shima Seiki machines that gives the automatic processes within the design system priority to look and finishing of the garment to ensure the silhouette of the garment is the best it can be.

Skill deficiency

A skill deficiency is where a demand for labour has not been recognised and training is unavailable in Australian education institutions. This arises where skills are acquired on-the-job, gleaned from published material or from working and/or studying overseas.[3]

There may be individuals or individual firms that have these capabilities. However, individuals in the main do not share their capabilities, but rather keep the intellectual property to themselves. Over time these individuals retire and pass away. Firms likewise come and go.

Sustainability

The ISS Institute follows the United Nations for Non-Governmental Organisations' definition on sustainability: *"Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".*[4]

Take down

Amount of tension by which the fabric is pulled down.

Transfers

The transferring of a stitch (loop) from one needle to another.

2nd Stitch

The loop previous to the loop about to be transferred is given extra length to ensure a easy transfer with minimal tension.

Wales

One column of stitches.

WHOLEGARMENT®

Shima Seiki's trademarked brand of seamless garment technology.

Yarn Carriers

The yarn carrier guides the yarn to the machine's needles as knitting loops are formed. The yarn passes through the carrier and is fed to the needles at a specific angle and at a constant, slight tension.

Acknowledgements

Patricia Chircop would like to thank the following individuals and organisations who gave generously of their time and their expertise to assist, advise and guide her throughout the Fellowship program.

Awarding Body – International Specialised Skills Institute (ISS Institute)

The International Specialised Skills Institute Inc is an independent, national organisation that for over two decades has worked with Australian governments, industry and education institutions to enable individuals to gain enhanced skills and experience in traditional trades, professions and leading-edge technologies.

At the heart of the ISS Institute are our Fellows. Under the **Overseas Applied Research Fellowship Program** the Fellows travel overseas. Upon their return, they are required to pass on what they have learnt by:

1. Preparing a detailed report for distribution to government departments, industry and educational institutions.
2. Recommending improvements to accredited educational courses.
3. Delivering training activities including workshops, conferences and forums.

Over 200 Australians have received Fellowships, across many industry sectors. In addition, recognised experts from overseas conduct training activities and events. To date, 25 leaders in their field have shared their expertise in Australia.

According to Skills Australia's 'Australian Workforce Futures: A National Workforce Development Strategy 2010':

> Australia requires a highly skilled population to maintain and improve our economic position in the face of increasing global competition, and to have the skills to adapt to the introduction of new technology and rapid change.
>
> International and Australian research indicates we need a deeper level of skills than currently exists in the Australian labour market to lift productivity. We need a workforce in which more people have skills, but also multiple and higher level skills and qualifications. Deepening skills across all occupations is crucial to achieving long-term productivity growth. It also reflects the recent trend for jobs to become more complex and the consequent increased demand for higher level skills. This trend is projected to continue regardless of whether we experience strong or weak economic growth in the future. Future environmental challenges will also create demand for more sustainability related skills across a range of industries and occupations.[5]

In this context, the ISS Institute works with Fellows, industry and government to identify specific skills in Australia that require enhancing, where accredited courses are not available through Australian higher education institutions or other Registered Training Organisations. The Fellows' overseas experience sees them broadening and deepening their own professional practice, which they then share with their peers, industry and government upon their return. This is the focus of the ISS Institute's work.

For further information on our Fellows and our work see http://www.issinstitute.org.au.

Acknowledgements

Fellowship Sponsor: The George Alexander Foundation

The George Alexander Foundation supports activities in the following two areas:

Education

- to help talented young people achieve their full potential in any endeavour
- to support programs designed to improve educational, employment and leadership opportunities for disadvantaged young people

Environment and Conservation

- to develop partnerships with communities, government and the private sector to prevent irreversible damage to the environment and to encourage the maintenance of biodiversity

The Fellow would like to thank the George Alexander Foundation for providing funding support for this Fellowship.

Supporters

- Adrian Brener, Director, AB Knitwear
- Peter Jackson, Managing Director, WMC Jackson
- Jo-Ann Kellock, CEO, Textile & Fashion Industries of Australia
- Steve Long, Sales Representative, Ramsay & McDonald

Organisations Impacted by the Fellowship

Government

- Australian Government, Department of Innovation, Industry, Science and Research (DIISR), Textiles, Clothing and Footwear (TCF) Division

Industry

- Australian Wool Innovation Limited (AWI)
- Council of Textile and Fashion Industry of Australia (TFIA)
- Design Institute of Australia (DIA)

Fashion Industry

- Fashion Designers
- Knitwear Designers
- Product Developers

Professional Association

- Jo-Ann Kellock, Executive Director, TFIA

Education and Training

- Australian and Victorian TAFE, TCF Sector
- Higher Education organisations – Universities and Private Collages

Community

- Designers
- Fashion based companies

About the Fellow

Name: Patricia Chircop

Employment

- Director/Consultant, KNIT Melbourne; Director, Sprocket Rocket & Co.

Qualifications:

- Certificate of Completion, M1 Plus® – Fully Fashion & Special, Stoll (Reutlingen, Germany), 2011.
- Certificate of Completion, M1 Plus® – Handling and Pattern Designing, Stoll (Reutlingen, Germany), 2011.
- Certificate of Completion, Use of CMS, Stoll (Reutlingen, Germany), 2011.
- Certificate of Completion (WHOLEGARMENT®), Authorized course for Shimatronic Computerized Jacquard Flat Knitting Machine, Shima Seiki (Wakayama, Japan), 2011.
- Certificate of Completion, Authorized course for the Shimatronic Computerized, jacquard Flat Knitting Machine, Shima Seiki, Wakayama, Japan, 2007.
- Bachelor of Science (Biological Science), Major: Zoology & Statistics, La Trobe University, Bundoora, Australia, 2002.

Breif Biography

The Fellow has displayed an interest in textiles for a large portion of her life as a result of her cultural heritage. She comes from a line of woman who have been involved with textiles. However, despite her passion for the textile industry, her initial educational direction took a scientific path, with the completion of a Bachelor of Science with a major in Zoology and Statistics.

Upon the completion of this qualification, the Fellow travelled the globe investigating the variety of local textiles. She focused on the various techniques that enabled unique textile production in different regions, such as vegetable dying techniques in Turkey, chain stitch embroidery in Kashmir, contemporary design techniques in Helsinki and the amazing, quirky printed fabrics of Africa.

After travelling, the Fellow undertook a Bachelor of Arts (Textile Design) at Royal Melbourne Institute of Technology (RMIT) and volunteered at the National Gallery of Victoria in the Australian Fashion and Textiles Department. During her time at the National Gallery of Victoria, the Fellow had the opportunity to work with a broad range of garments and textiles that hold social, historical and design significance. During this time she also undertook work experience with Blossom Road, one of Australia's leading fashion knitwear manufacturers, and, with that, cemented her passion for the knitwear industry.

The Fellow completed two years of the three years required to complete the Bachelor's degree and concluded that the necessary skills to allow her enter the industry as a knitwear fashion designer could not be obtained through achieving this qualification. The Fellow felt that the Bachelor of Arts (Textile Design) solely focused on the design of the textile swatch, as opposed to all the other factors required to produce a couture or prêt-a-port knitwear fashion garment; studying fashion design only skims the surface of knitwear. Before terminating her studies, the Fellow was offered the full-time position of Product Developer at Blossom Road.

The position of Product Developer enabled the Fellow to work with a variety of mid- and high-end Australian brands and designers to gain exposure to utilising the machines involved in the assembly of knitwear garments. The types of machines included linkers, buttonholers and cup-seaming machines amongst others. The Fellow felt that the more that was known of each process during the construction of a garment, the better equipped she would be as a designer and product developer. Whilst in the role of Product Developer she also handled the importation and development of garments made in China, gaining invaluable experience to the processes and communication skills that have now been applied in her own business.

About the Fellow

After some time as Product Developer, the Fellow was presented with the opportunity to travel to Japan to learn Shima Seiki's industrial knitting machine technology. After a three-week course about the Shima Design System and associated technology, the Fellow returned to Melbourne to begin understanding the very complex nature of programming industrial knitting machines.

Armed with experience gained in Japan and creative confidence, the Fellow decided to undertake a new challenge – her own business. The Fellow then decided to start a children's wear label, and was unfortunately forced to look offshore for production to achieve a reasonable price point. After a successful sourcing trip to India the Fellow was able to produce her first season. The Fellow continued to establish a lucrative manufacturing contact base in India and later in China, and along the way learnt enormous amounts about manufacturing, logistics and communication.

The Fellow is also a maker of knitted and fabric costumes and soft props and has worked with The Australian Ballet, Nickelodeon and Back to Back Theatre. She also acts as a consultant and collaborates with other designers and artists involving knitting in different capacities.

As a result of recognising a skills gap in the industry, the Fellow is now a knitwear consultant to the fashion industry. With the accumulation of skills she had already gained through her work and her contacts within the industry, the Fellow felt a consultation service could greatly aid the knitwear sector of the Fashion industry. The industry need for a consultation service combined with the Fellow's desire to learn more and enhance her industry, is what led her to apply for The George Alexander Foundation/ ISS Institute Fellowship.

Aims of the Fellowship Program

The Fellowship provided the opportunity to learn the most advanced technology to create seamless knitwear. The aims of the Fellowship were to:

- Undertake the seamless program course at Shima Seiki to advance previous training.
- Gain a greater understanding of the new technology:
  - Gain exposure and understanding of seamless knitwear technology, such as circular and flat bed knitting.
  - Build on technical knowledge of industrial knitting machines in order to be able to consult with fashion-based companies on design, manufacture and cost.
  - To design more proficiently by understanding the limitations and abilities of available technology.
  - Reduce manufacturing cost and enhance design through a greater understanding of knitwear technology and process.

The Australian Context

Most fashion designers are not trained in knitwear due to the limited availability of institutions equipped with leading edge knitwear machinery offering suitable courses in Australia. Knitwear design requires the structure of the fabric and pattern to be developed. A disconnect currently exists between textile design and fashion design courses. Textile design courses focus on developing the fabric and not the garment itself. Fashion design courses do not teach knit structure and shaping, thus leaving designers at a huge disadvantage in this particular area. The availability of education relevant to knitwear design, technology and manufacturing is very limited. As a consequence, the Australian knitwear industry is not being promoted.

Australia once had a thriving knitwear industry; however, a handful of Australian fashion knitwear manufacturers now remain and their prices are much higher in comparison to their offshore competitors. Only high-end labels are manufacturing knitwear in Australia at this time as increased costs are able to be passed on to the consumer.

By developing the Australian fashion industry's understanding of knitwear techniques and capabilities, the amount of knitwear produced will increase, as designers can then understand the possibilities and costs involved.

SWOT Analysis

Strengths

- The time, cost and the processes used to make a garment are reduced, as it is a seamless garment.
- Innovative design possibilities through understanding of state-of-the-art technology.
- Australian designers are exposed to the same technology as overseas designers.
- Knitting industry may have a chance to re-establish by the promotion and use of technology.
- Promoting the use of more Australian wool and yarns.
- Keeping up to date with the knitwear technology available worldwide.
- Facilitates communication between manufactures and designers.
- Possibility to utilise seamless technology to design and manufacture garments for specific purposes e.g. for those with disabilities or physical ailments.
- Possibility to cut down on labour time.

Weaknesses

- Availability of seamless garment machinery and programmers are limited in Australia.
- Possibility to cut down on labour time. This could result in manufacturers reducing an already small workforce.
- Lack of training support in TAFEs and universities.
- Designers are unaware of the capabilities of the technology.

Opportunities

- Skills and knowledge base of this cutting-edge technology can be passed on to industry.
- Australian knitwear and wool can be promoted through application of skills gained and greater application of these skills in the fashion industry.
- Greater enthusiasm through knowledge on how to design using these techniques.

Threats

- Continued knowledge gaps between knitwear technicians and designers.

Identifying the Skills Deficiencies

1. **Advance previous training with Shima Seiki by undertaking the seamless programming course offered.**

   Knitted garments for bulk production have three main manufacturing approaches:

   I. Cut and sew garments: the fabric is knitted in panels then cut and sewn to form the garment.

   II. Fully-fashioned garments: the pattern is translated into the computer design system. The program is then uploaded on to the industrial knitting machines; the machine then knits the garment in the exact shape required for each panel, producing a higher-quality garment with less waste.

   III. Seamless: the latest technology, known as seamless technology, results in a seamless garment. This technology has the capacity to knit a complete garment without any further processes needed except for the cutting of four strings. This results in no waste and unique design features. This technology is not as yet widely used, as knowledge and exposure to the technology is limited.

   Aim: To gain a greater understanding of seamless technology: the latest technology that results in a seamless garment. To be able to create wholegarments using the automatic software and gain a greater understanding of Shima Seiki knitting machines and design systems overall.

2. **Build on the limited understanding and technical knowledge of industrial knitting machines and fashion knitwear designs in the industry:**

- Understand the technical aspects of producing seamless knitwear on industrial knitting machines.
- Understand the computer programming required to achieve desired outcomes and the basic mechanics of how the machine works in order to produce the desired outcome.
- Improve on the knitwear design skill base through a more thorough understanding of structures and process of knitting using the industrial machines.

  Aim: To gain a greater understanding of seamless garment knitting techniques in order to have a greater ability to advise designers on the way they design to achieve the desired result with maximum efficiency through the most cost effective techniques.

3. **Design more proficiently by understanding the limitations and abilities of knitting by reducing manufacturing cost and enhancing design understanding of knitwear:**

- Understanding of abilities and limitations of the technology in order to be able to design garments that challenge theses limits and concepts.
- Undertake training with knitwear manufacturing companies overseas: Shima Seiki in Japan and Stoll in Germany.

  Aim: To improve on knitwear design skill base by further understanding of the structures and processes of industrial knitting machines. Such knowledge would allow the Fellow to be at the forefront of understanding the latest technology available worldwide and the Australian knitwear industry, enabling this knowledge to be passed on to others in the industry to strengthen the Australian knitwear industry as a whole.

The International Experience

Destination: Shima Seiki Mfg., Ltd.

Location

- 85 Sakata, Wakayama, 641-8511 Japan

Contacts

- Masayuki Takenaka, Chief, Overseas Sales Division, Shima Seiki
- Yasuhiro Taniyama, Sales, Total Design Center, Shima Seiki.
- Masatoshi Wakano, Programmer, Total Design Center, Shima Seiki.

Objectives

The objectives of this Fellowship were to advance previous training with Shima Seiki by undertaking seamless programming course offered, and to build on the limited understanding and technical knowledge of industrial knitting machines and fashion knitwear designs in the industry:

- Understand the technical aspects of producing seamless knitwear on industrial knitting machines.
- Understand the computer programming required to achieve desired outcomes and the basic mechanics of how the machine works in order to produce the desired outcome.
- Improve on the knitwear design skill base through a more thorough understanding of structures and process of knitting using the industrial machines.

Outcomes

Advance Previous Training with Shima Seiki by Undertaking WHOLEGARMENT Programming

There are a small proportion of knitwear companies utilising, creating and advancing seamless technology in the world; however, this is slowly growing. This technology is not as yet widely used as knowledge and exposure to the technology itself is limited. The Fellow undertook the Certificate of Completion (WHOLEGARMENT®), Authorized course for Shimatronic Computerized Jacquard Flat Knitting Machine offered by Shima Seiki, and was the only one taking part from across the globe at that time.

The course provided the Fellow with the unique opportunity to gain knowledge of Shima Seiki's unique seamless knitwear technology, known as WHOLEGARMENT®. Shima Seiki's WHOLEGARMENT® knitwear technology is at the forefront of seamless knitwear manufacturing, producing a garment in an entire piece with no further construction processes required, unless desired. WHOLEGARMENT® knitwear is manufactured with no waste and less labour. The production of a seamless garment requires less manufacturing processes, time and cost. This is very beneficial when labour costs are high. This knowledge will greatly benefit the Australian knitwear industry.

Understand the Technical Aspects of Producing Seamless Knitwear on Industrial Knitting Machines

There are a variety of machines available for the production WHOLEGARMENT® knitwear. The latest is the Mach X machines. These machines have four needle beds used for finer gauge fabrics: two needle beds are used for knitting and two needle beds for transferring. Four needle beds allow all needles on the needle bed to be used – the extra two needle beds on the top making it possible to transfer stitches.

The Mach S machines have two needle beds – one for the front and one for the back. The Mach S knits at half gauge, meaning every second needle on the needle bed is used, producing a heavier weight fabric. Half of the needles are available for transferring and the other half are occupied with stitches.

To produce a fine gauge knitted fabric on the Mach S all needles are occupied on the needle bed, there are no empty needles for transferring, therefore, limiting the garment to a simple structure.

The word 'Mach' in the machine's name indicates that these machines are faster and more productive than other types of machines. Both types of machines have the same capabilities except for the needle gauge range, the range of fabric weights knitted on one machine can vary, for example a 10-gauge machine can also produce 7- and 8-gauge fabrics. The Mach S has a latch needle and the X Machine has a slide needle. The slide needle creates the possibility for gauge-less knitting. It also allows for a wider variety of yarns to be used, and is better for a finer gauge garment. The loops produced are much neater and symmetrical when the fabric is fine the loops are more noticeable. Slide needles can cost at least five times as much as a latch needle depending on the machine. Yarn type and tension can also make a huge difference to the handle of the fabric.

The SWG-First series is a versatile machine capable of fully-fashioned garment production, rib shaping and seamless knitwear production. This machine also utilises the slide needle, which increases the versatility, production and quality.

The SES-C-WG is also a very versatile machine that is capable of shaping, integral knitting and producing coarse-gauge seamless knitwear.

Within the variety of WHOLEGARMENT® machines the following gauges are available in 3, 5, 7, 8, 12, 15, 16, and 18. The gauge can vary not only depending on the type of machine but also the width of the needle bed.

When developing a seamless pattern the design of the front and back of the garment are done concurrently, as the garment program is being read as a three dimensional structure. Seamless knitwear garments can only be manufactured on the shaping machine if the garment program is to be knitted in half gauge, to allow for the transfers. The machines used to produce fully-fashioned garments have a much narrower space between the needle beds making it difficult when knitting heavier fabrics, such as two layers simultaneously. The rib tension and take down can also be difficult to control on a fully-fashioned machine. Creating a seamless garment pattern on a shaping machine requires a very complicated program as all information for the front and the back of the garment must be entered for one program.

The Digital Stitch Control System® (DSCS) is a standard component on WHOLEGARMENT® machines. DSCS easily and accurately controls the quality of each stitch in a garment, and can be programmed with a set loop length calculating how much yarn is being used for each stitch – the system then controls the loop length of the stitch as well as the tension by limiting the yarn feed. By controlling the loop length for each stitch, a consistent quality of fabric can be assured and the amount of yarn can be calculated. Not only does this mean that each garment will be exactly the same throughout each production run but it also makes it very easy to know how much yarn will be required, meaning the right amount of yarn can also be ordered.

The DSCS has been developed further leading to the Digital Stitch Control System with Intelligence® (i-DSCS). The i-DSCS has the same benefits as the DSCS, with even better performance. The i-DSCS actively controls both the yarn feed and retrieval as required. This ensures greater quality and productivity over a broader range of yarns, including very fine and delicate yarns.

Accurately controlling the stitch length and tension is extremely important in seamless, shaping, and fully-fashioned garment manufacturing in order to ensure a consistent product. Both the DSCS and i-DSCS can be installed on the one machine, the DSCS is located on the left of the machine and the i-DSCS is on the right.

Seamless garments can be designed to be entirely finished on the machine and ready for immediate shipment. The digital program, DSCS, is used to control the feeding of the yarn guarantying the quality by controlling the feeding of the yarn. This allows repeat orders to be done on demand exactly as they were the first time. As the garments can be designed to require no linking, quality control is very easy to maintain, as there is no room for human error.

Understand the Computer Programming Required to Achieve Desired Outcomes and the Basic Mechanics of how the Machine Works to Produce the Desired Outcome

The Fellow undertook training on the powerful SDS-ONE APEX complete design system's KNIT PAINT component; however, the system can be used to program designs as well as plan and design an entire range. The SDS-ONE APEX also has a virtual sampling component that can be extremely useful for WHOLEGARMENT® knitwear, allowing a three dimensional simulation of the garment to be generated on screen before knitting begins – easily simulating different colour-ways and yarns on the simulated garment. The focus of the training undertaken was to understand and learn the programming used in the creation of Shima Seiki's WHOLEGARMENT® knitwear using the SDS-ONE APEX system.

There are two methods of programming – the manual method and the automatic method. The manual method allows the programmer to enter all the specifications for a particular garment into the machine's software program and create a unique garment. The automatic method allows a wide variety of garments to be easily generated by the machine, utilising pre-programmed shapes.

The software used for the automatic method can be used to focus on either knitting priority or silhouette priority. Silhouette priority enables the program to give priority to the shape of the design; however, this design or shape could be much more difficult to knit on the machine and a take longer time to produce. Knitting priority gives priority to knitting time and efficiency, thus being more cost effective.

If a basic garment is required then the automatic method is the most appropriate method of programming and an automatic program is chosen. There are a variety of different automatic programs available within the KNIT PAINT component of the SDS-ONE APEX system. The Fellow is of the view that using automatic programs for simple garments is better, faster and easier to use than using manual programming. Once the selection of the basic garment shape is decided, a large number of options are available within each automatic program, such as the choice of connection used to join the sleeve and the body of the garment, size specifications, choice of neck type, choice of sleeve, knitting or silhouette priority, method used for binding off the neck, a choice of hem types.

Both automatic software and manual programming can be used in conjunction to create one garment. As manual programming is used to create a program for a garment with a unique design, and an automatic program can be used to create a garment with a basic design, you can combine both methods to achieve the desired result for a single garment. For example, for a garment with a hood design, a basic cardigan shape can be produced using the automatic software and then a hood can be designed by creating a manual program and then added onto the basic cardigan shape.

The KNIT PAINT program makes use of layers to allow changes, similar to the way layers are used in Photoshop®. The garment program is developed on a base pattern, once developed and expanded the base pattern becomes a compressed pattern showing the front and back of the garment on the one pattern. If structure is added to the front body of the garment design then it needs to be done on the base pattern and not on the compressed pattern. If changes are made on the compressed pattern they also need to be manually made on the front and back. The compressed pattern is on a different layer to the base pattern, allowing it to be modified without affecting the base pattern. KNIT PAINT allows the programmer's changes on the base pattern to be made automatically on the compressed pattern. The compressed pattern automatically adjusts the transfer stitch directions to enable the front of the sleeves to be copied and pasted onto the back of the sleeves without manually changing the directions.

Stitch structures within the garment should only be drawn on the front and back of the body on the compressed pattern and not on the base pattern. The front and back should have exactly the same shaping as the base pattern.

Seamless knitwear technology is based on three tubes being knitted alongside each other simultaneously – sleeve, body, and sleeve. There are many different options for connecting the body to the sleeve and bind offs depending on the requirements of the garment. The bind off is used to finish an edge i.e. binding off the neck trim diminishes the need for waste yarn and the need for further finishing after the garment is knitted; therefore, the garment is completed on the machine. There are six methods for connecting the body and sleeve.

There are different types of connections to suit the different types of structures used on the garment – depending the type of structure used the method of connection will be determined. For example, the 1 x 1 Rib connection technique results in a strong and flexible join. In general, Shima Seiki recommends the C + D connection for the body and sleeve, this connection optimises the stitch, strength and knitting difficulty for the best quality and knitting time.

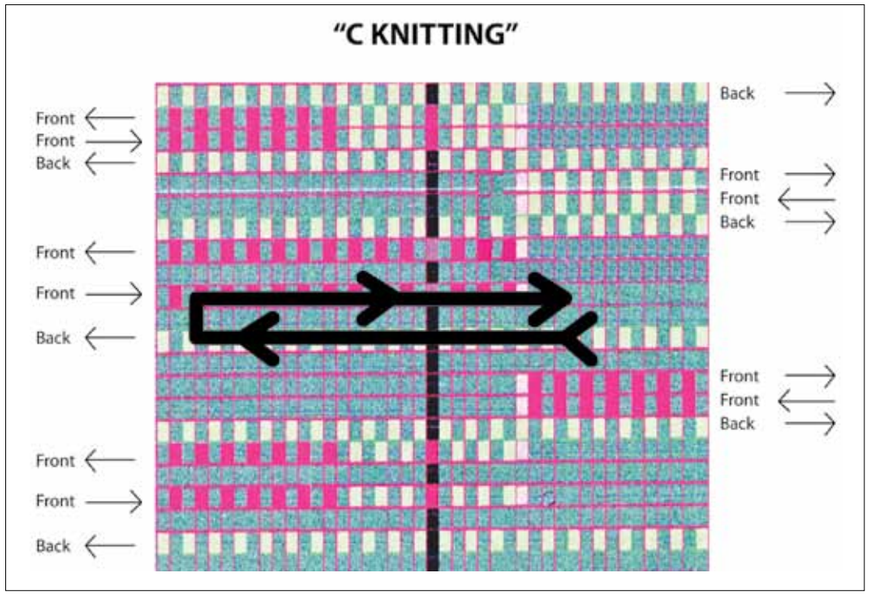
A jacquard pattern allows knitted fabrics to incorporate a coloured or structural pattern. There are two options to generate the jacquard program either using the Free Colour Package or the Paint Colour Mode. The Free Colour Package creates a basic package for each colour used within the garment program, two-colour jacquards require two types of base patterns to be created for one package base pattern. Paint Colour Mode develops basic packages for each colour combination in one line of the base pattern. If there are many colour combinations in the garment one package needs to be created for each variation, which can be time consuming and require a lot of effort.

Jacquard designs can be easily knitted with two different coloured yarns. However, if fine yarn is used it is possible to have a three-colour all over jacquard. The use of automatic software limits the jacquard to be on the body only and not the sleeves; however, by creating the pattern manually, the jacquard can be placed anywhere on the garment, including the sleeves.

When stripes are knitted into a seamless item, loose ends of yarn remain where the yarn has travelled in and out of the knitting area. Each time the colour is changed, the remaining loose yarn end needs to be sewn in after the knitting of the garment is completed on the machine. To avoid loose yarn ends on each stripe the yarn in position and the yarn out position can be made at different sides with a tuck stitch before carrying the yarn out.

Buttonholes can be knitted into seamless garments; however, the fabric cannot be overlapped unless the garment is knitted horizontally. Intarsia is possible although the cost can be very high because the knitting time is due to the number of needle actions the program requires. The program then needs to be adjusted for each size – simple intarsia does not require extensive programming time; however, complicated designs do, thus increasing the overall costs.

The machines used to produce seamless garments knit the back course first and then the front course in a clockwise direction. The front of the garment is knitted in the left direction and the back in the right. C knitting is used to knit cardigans, hoods, v-necks or any occasion when the neck drop is lower than the shoulder. When the machine is knitting in a ‘C’ shape, this is called C knitting. Please see image on following page. If the back and the front are knitted using ‘C’ knitting the definition of the shoulder drop is lost; therefore, it is beneficial to bind off the shoulder, which results in a nice neat finish. If every row is ‘C’ knitted every stitch is closed and as a consequence the shoulder has an extremely steep drop. Alternatively, if the shoulder is narrowed then the bind off performed, the operator has more control over the gradient of the shoulder drop. In order for the take down to be maintained and the fabric supported during bind off, a pick up stitch on the edge of the shoulder is sometimes required.



This diagram shows movement of the carriage to knit the opening of a wholegarment. This carriage movement is known as C Knitting. Image courtesy of Patrcia Chircop

The maximum a WHOLEGARMENT® machine can rack is 1.5” in the left and right directions, making a total of 3”. The machines rack much wider than a shaping machine and allow for a more dramatic shape to be created – such as the shoulder shape. 2nd Stitch allows the loop size of the one stitch in the same row, before the transfer, to be larger so it can easily be transferred on WHOLEGARMENTS®. If the stitch cam is down then the loop size is bigger, if it is up then this creates a tighter loop. The shaping machines have a fixed stitch cam.

Improve on Knitwear Design Skill Base Through a More Thorough Understanding of Structures and Process of Knitting Using the Industrial Machines

The three-week Certificate of Completion (WHOLEGARMENT®), Authorized course for Shimatronic Computerized Jacquard Flat Knitting Machine, that the Fellow undertook at Shima Seiki focused on the new SES-S WG machine. During the course the Fellow became familiar with operating and maintaining the machine, as well as the basic principals of programming the SDS-ONE APEX system that is used by this machine. There is an amazing amount of knowledge to be learnt about the system, as there are so many different garment design options possible.

One of the main designers at Shima Seiki began her career on the factory floor assembling machines, without having had any previous experience in knitwear design. After working in the factory for three years, she transferred over to the design centre and undertook the basic SDS software course, she learnt the basic structures, stitch moves and knitting actions. She then used the SDS system as a learning tool to compare fabrics and the knitwear program to understand how the fabric was constructed. The design software simulates the knitted fabric after being programmed so the design can be seen straight away.

The approach taken by a designer and a programmer when constructing a knitted garment can be very different. The designer needs to have the basic knowledge of knitting to communicate with the programmer in the right language; communication between the programmer and the designer is essential at every stage. Designers familiar with aspects of programming and the basics of knitwear can ensure the dialogue with the programmer is quick and more efficient. It enables the designer to direct the programmer to use other approaches and methods, pushing the boundaries and not staying within the rules that the programmer may be accustomed to. Highly experienced programmers are important in order to resolve any design challenges that a designer may pose, even if it is out of the ordinary. Therefore, a designer with some knowledge of knitwear techniques and a highly experienced programmer are often the best combination for quick, efficient and innovative product development.

During the visit to Shima Seiki the Fellow interviewed the head designer and head programmer to understand how the company approaches the design process and production of a range. First the designer plans the fabric and discusses the initial ideas with the programmer to understand the machine possibilities. The designer simulates a design, in this case using the SDS software to make the proposed outcomes clearer to the programmer. The programmer will then establish if the garment is possible on a particular machine for the desired gauge and detailing. This process is significantly faster because of the designer's knowledge of knitwear.

The Fellow attended a tour of the Shima Seiki's Knit Museum and Factory Boutique Shima, Shima Seiki's retail shop, allowing a great insight into the complete process of the company's WHOLEGARMENT® manufacturing in the retail environment. Factory Boutique Shima offers a mass customisation service to customers in Wakayama and department stores in Tokyo, Osaka and soon Kyoto.

Mass customisation of apparel from the customers' perspective is described as *"a technology-assisted process that allows the purchaser to modify a company's product line in order to meet personal design taste or fit requirements",* according to Seung-Eun Lee, Professor in Apparel Merchandising & Design at Central Michigan University.[6]

A basic diagram of the mass customisation process

"The enormous potential behind WHOLEGARMENT® knitting technology and its on demand production capabilities allows mass-customisation scenarios in which knitwear can be produced according to individual size, shape and design." — Shima Seiki's creative head, Masaki Karasuno.[7]

The WHOLEGARMENT® technology allows the customer to modify existing products on demand to meet their own individual needs, whether their needs are design- or comfort-based. The well-trained staff available in the store have an understanding of the technology and the customer's requirements enabling them to understand the customer's desired outcome. Using the latest three dimensional modelling software the customer is able to view a simulation of the final garment prior to manufacturing.

Mass customised garments are achievable at competitive price points if the designs are well thought out and adhere to certain design and manufacturing processes. However, value is added to the garment by allowing the customer to be involved in the process, within the set constraints offered by the boutique, thus allowing the customer to be a designer for a day. Research shows that too many options can inhibit the customer's experience, unless they are offered the many options in a very well organised and systematic way. Confusion can lead to a loss in sales. Having knowledgeable staff to ensure that the customer feels secure about their design decisions can minimise the chance of confusion. The wait time for a customer designed WHOLEGARMENT® at Factory Boutique Shima is approximately one week.

This customised service is popular amongst both ladies and men. The service is very convenient for those who have changing body shapes or who find it difficult to find garments that fit well. Mass customisation can also benefit people with an irregular body shape as the customer is measured to ensure that the garment fits well, making the garment a more comfortable fit.

The Factory Boutique Shima is located in central Wakayama and provides three options to purchase WHOLEGARMENT® apparel:

I. Ready Made
II. Semi-Order
III. Full-Order.

Each one of these three options is expanded on further below:

<u>Ready Made</u>

Options: Garments are purchased off the shelf.

Lead Time: On the spot.

Price range: Price Range: ¥9900 – ¥30,000.

<u>Semi Order</u>

Options:

- Choose style from designated choices
- Size S, M, L
- Choice of colour
- Choice of sleeve and hem length.

Lead Time:

- One week for basic garments
- Two weeks for jackets.

Price Range: ¥15,000 – ¥35,000.

Example: Full outfit including dress (¥12,900), bolero (¥11,025) and leggings (¥6090).

Left: This is the example of the semi order full outfit available at Factory Boutique Shima. This garment has a total of ¥ 30,0015 ($350 AUD).

Full Order

Options:

- Choose style.
  - Pullover, cardigan, dress (sleeveless is also available)
  - Collar e.g. round, v-neck, high-neck and turtleneck
  - Hem length e.g. short for a jumper or long for a dress
  - Sleeve length
  - Some structure detail e.g. pointelle border on hem.

- Choose yarn
  - 100% Silk
  - 100% Egyptian cotton
  - 100% Wool
  - 100% Cashmere.
- Measurements are taken from customer for exact fit
  - The customer can request variations of length for body and sleeve, and can select the loose or tight fit.
- Finishing – linked collar if requested, washing and drying.

Lead Time:

- 1 week for basic garments or accessories
- 2 weeks for cardigans.

Price Range: ¥15,750 – ¥30,450.

Example: Full outfit including silk dress (¥31,500) and cardigan (¥34,650).

Left: This is the example of the full order full outfit available at Factory Boutique Shima. This garment has a total of ¥ 66,150 ($750 AUD).

The WHOLEGARMENT® technology at Shima Seiki offers a range of benefits to the consumer, designer and manufacturer, these are outlined below:

Visible Benefits

- No seams on shoulder or side – ideal for a good fit and silhouette
- Beautiful draping
- Lace can be made without interference of seams
- Light finish for bulky garments by elimination of bulky seams
- Different layers of fabric with no seams making a smoother transition between the layers of fabric.

Stretch Benefits

- Continuity of knit fabric is maintained, as there are no seams
- Retains elasticity
- Increased mobility.

Pattern-Based Silhouette

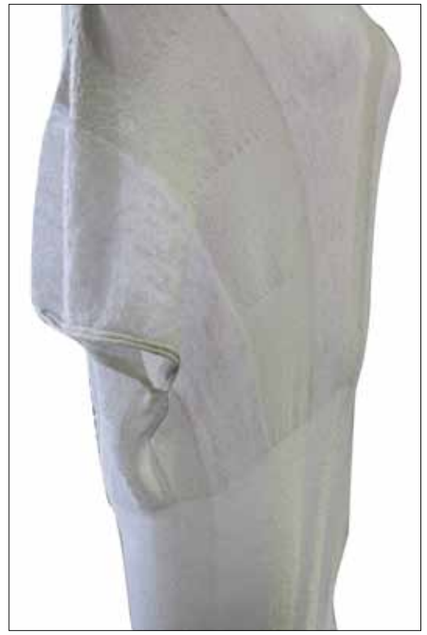
- Have comfort of three dimensional knitting
- Small gusset knitted in under arm – no tugging under sleeve
- Second skin approach.

Material Savings and Ecological Benefits

- No waste.

When producing garments in large or small gauges by shaping, the seams can interfere with both the design and comfort. After construction, garments knitted with a large gauge machine, for example chunky knits and bulky jackets, then also have bulky seams to match. By constructing the garment using WHOLEGARMENT® technology, the bulky seams are eliminated resulting in a lighter weight garment, a better fit and increased comfort. No seam lines allow for a stronger fabric and a more beautiful finish. WHOLEGARMENT® technology allows a second skin garment to be created that is much more comfortable and provides a better fit.

In contrast, fine knit garments can be more difficult to sew. Therefore, eliminating the seam assembly of the garment is a great benefit as the production time and cost is reduced and quality control is guaranteed.



WHOLEGARMENT® technology can also be used to give fine knit garments an element of transparency because this technology eliminates the visual interference caused by seams, diminishing the need to consider the seams creating unwanted lines in the design of the garment.

Finer yarns and gauges allow more detail to be added to a garment and produce a better draper, nicer silhouettes and shaping.

WHOLEGARMENT® machines make it possible to knit different yarns on the inside and outside of a garment.

WHOLEGARMENT® machines make it possible to knit different yarns on the inside and outside of a garment. For example, cotton can be knitted on the inside of coarse yarn, making it more comfortable to wear. Alternatively, silk can be knitted on the inside and a textured yarn on the outside of a garment. A loose knit could be knitted on the outer layer and a fine knit on the inside layer, creating more interest. Holes can be also created to highlight the beautiful yarn used on the inside.

During the design process, the elimination of additional trims needs to be considered – stitch detail can be carried through into the neckline and arms to give an elegant finish. For extra continuity on an all over rib garment, the rib can finish at the top of the neck trim. Using WHOLEGARMENT® machines enables the trims, plackets and stitch details to be knitted in continuum resulting in a nicer finish when designed correctly.

During the design process, the elimination of additional trims needs to be considered – stitch detail can be carried through into the neckline and arms to give an elegant finish.

WHOLEGARMENT® technology allows more panels (gores) to be knitted into a garment making it much easier and cheaper to assemble as it is completed on the machine, minimising labour costs and ensuring quality control.

Garments produced using WHOLEGARMENT® technology do have design limitations. The garment needs to be carefully designed, as there are technical limitations, such as the amount of puffiness that can be created on a sleeve.

The chart below shows the comparison of waste by each method of manufacturing when making a medium sized ladies jumper.

METHOD	Cut and Sew	Shaping	Seamless using WHOLEGARMENT® technology
WASTE	30% loss of fabric due to cutting out of pattern on square of fabric = 130 grams wasted per garment.	14% material loss from 1 cm seams being knitted =700cm2 per garment. 6% of total fabric area for yarn required to link garment = 42 grams.	No waste – no linking required
FINAL WEIGHT	Final garment weight = 300g	Final garment weight = 136 grams	Final garment weight = 128 grams

Destination: International Exhibition of Textile Machinery (ITMA)

Location

- Fira de Barcelona, Recinto Gran Via, Avenida, Juan Carlos I, 58-64, 08908 L' Hospitalet de Llobregat, Barcelona, Spain

Contacts

- Victor M. Almeida, Textile Engineer, Sales, Customer Support, Buhler Quality Yarns Corp.
- Mario Cacciolatto, Area Manager, Filature Miroglio
- Philip Delamore, Senior Research Fellow, London College of Fashion
- Angelo Facchinetti, Technology-Engineer and Service, Conit Complett
- Laura Hepworth, Sales Manager, World Textile Information Network
- Professor. Dr Ir. Leiva Van Langenhove, Full Professor, Universiteit Gent
- Miquel Puigedellivol, Export Manager, S. Vilarrasa
- Marcello Vanali, Assistant Professor, Politecnico Di Milano

Objectives

- Understand the technical aspects of producing seamless knitwear on industrial knitting machines.

Outcomes

Understand Technical Aspects of Producing Seamless Knitwear on Industrial Knitting Machines

ITMA is held every four year and is the world's largest international textile and garment machinery exhibition. At ITMA the latest cutting-edge solutions for the entire textile-making chain are exhibited.

Seamless knitted garments can be produced via a few different technologies: Circular, Warp, weft and flat bed knitting.

Circular knitting produces garments made by single jersey electronic circular knitting machines. Circular knitted seamless garments include underwear, outwear, swimwear, sportswear, sanitary garment. The term 'circular' covers all weft knitting machines that have needle beds arranged in circular cylinders, the machines have a cylinder and dial arrangement.

Santoni's machines are body size circular knitting bed machines capable of producing shaped panels; the machines are usually between 10–24 inches in diameter. This is a fixed diameter; however, the size can be adjusted through the use of different knit structures, such as a knit, purl or tuck. A wide variety of fabric structures, garments, hosiery and other products can be produced in a variety of diameters on circular knitting machines.

Left: The term 'circular' covers all weft knitting machines that have needle beds arranged in circular cylinders.

Knits, tucks, floats, and false ribs are used to modify the shape of a tube, the lengths of stitches or unbalancing the structures can also have an effect. Sanotni garments are knitted as tubes, producing seamless sleeveless garments; therefore, these machines are frequently used to create intimate garments. In cases where sleeves are necessary, the sleeves are knitted separately then sewn on after the knitting process. The process of producing a sleeveless garment requires additional processes however knitting part of the process is significantly quick. Some Santoni machines can also create intarsia garments using a similar technique to that used on flat bed knitting machines, the technique of one- to four-needle overlap or tuck joins.

Santoni's Mecmor compact is an open panel circular knitting machine that is recognised as the most complete circular knitwear machine. Santoni considers that circular knitwear production is vital in creating a complete, well equipped knitting mill – as the circular machines have an enormously quick production time and very high productivity of fine gauge garments.

Left: Two seamless garments side by side, each set knitting one after the other in a chain formation, which would later be cut to separate each garment.

The world premier of the electronic double knit circular machine SM6 RIB 2 machine with six feeders was at ITMA 2012. The machine produces fine quality causal or sportswear at high production. A variety of fashion styles are available and the SM6 RIB 2 was specifically designed to manufacture garments with true rib borders. This technology is focused towards causal and leisurewear.

Santoni had five new machines on display at ITMA, amongst them were two prototype SDW8 double needle-bar Raschel knitting machines. This machine has a working width of 1118 cm (44 inches) and a gauge of 24 needles per inch. To demonstrate the machines capabilities two seamless garments were being knitted side by side, each set knitting one after the other in a chain formation, which would later be cut to separate each garment. The sleeves are knitted integrally, reducing both knitting time and yarn wastage.

Circular knitting can also produce fashion garments; however, there are limitations due to the different techniques used to achieve the seamless garment. Generally, circular knitting machines have a fixed diameter; therefore, a factory would require more machines to make a wide range of sizes. Circular knitting seems to be most popular when producing sportswear, activewear, beachwear and undergarments.

Another method of producing seamless knitted garments is warp knitting. Seamless warp knitting uses two opposing needle bars equipped with compound needles, yarns are fed by moving guide bars. Karl Mayer pioneered this technology; however, Santoni have recently developed a similar type of technology, the SWD6/2 J and SWD4/2 J compact seamless warp models. These machines are only designed to produced garments, as opposed to wide width fabrics as with Karl Mayer machines, allowing the machines to be much more compact. Therefore, Santoni machines are able to knit a true seamless garment, knitting the sleeves integrally and saving the sewing and cutting process. The garments produced are very fine knits and are designed for sportswear or undergarments.

A number of different Chinese flat bed technology brands with very similar technology to Shima Seiki were on display. It is known by Shima Seiki that there are knitting machines on the market with almost exactly the same technology as used in their machines; however, the cost is much cheaper. As a consequence, often the quality of the machine is sacrificed. The Chinese brands do not usually have a spare parts section to support the machines, so the spare parts are often required to be ordered from Shima Seiki.

Eleven new machines were on display at the Shima Seiki stand, the highlight of which being the first 21-gauge flat bed knitting machine ever produced. A V-bed prototype machine equipped with two additional loop presser beds was also on display for the first time. A strong interest was seen in both the shaping and WHOLEGARMENT® machines, as well as the new SDS-ONE APEX3 design system. The SDS-ONE APEX3 system allows the customer to plan the products being developed and design for consumer markets by producing virtual samples – leading to less samples being required to be made.

Destination: H. Stoll GmbH & Co.

Location

- KG I, Stollweg 1, D-72760, Reutlingen, Germany

Contacts

- Francesco Collura, Fashion & Technology Product Development, Stoll.
- Joerg Hartmann, Head of Fashion & technology, Stoll.
- Sandra Peixoto, Stoll service centre programmer, Stoll.
- Andreas Wilde, Sales Director, Stoll.

Objectives

- Understand the technical aspects of producing seamless knitwear on industrial knitting machines.

- Understand the computer programming required to achieve desired outcomes and the basic mechanics of how the machine works in order to produce the desired outcome.
- Improve on the knitwear design skill base through a more thorough understanding of structures and process of knitting using the industrial machines.

Outcomes

Understand Technical Aspects of Producing Seamless Knitwear on Industrial Knitting Machines

The Stoll seamless knitwear machine range are known as Knit and Wear® machines. The largest market share of Knit and Wear® machines is held by Italy, followed by Spain and France. Stoll made the business decision to direct the research and development focus on the traditional flat bed machines whilst maintaining a small proportion for Knit and Wear®. On display at ITMA 2012 there were numerous knitwear machine manufacturers competing with each other. As mentioned previously, the technology is extremely similar to that used by Shima Seiki and Stoll. These machines do not offer the same quality or efficiency and do not have the same life expectancy as the Shima Seiki or Stoll machines, however they do sell at a remarkably lower price.

Stoll decided to invest their research and development budget into producing more versatile and cost effective machines to retain a good market share in flat bed knitting machine segment of the market. Shima Seiki's WHOLEGARMENT® machines are expensive; therefore, China, the largest consumers of knitting machines, weren't taking up the WHOLEGARMENT® technology. Labour is cheap in China and the elimination of labour costs made by adopting these machines and processes was not seen as major benefit. It is economically more beneficial for Chinese manufacturers to pay the costs involved with additional garment assembly rather than the large outlay of a WHOLEGARMENT® machine. With so many new flat bed machine companies coming on the market producing cheap machines, Stoll decided to direct the majority of their research and development resources to develop low-price high-quality machines. Stoll continue to develop Knit and Wear® machines; however, the priority is to maintain the market share they already have with flat bed machines and expand on it.

Stoll's presence in the New Zealand and Australian market isn't as large as that of Shima Seiki. This is due to the small market existing in this region and factors surrounding geography, making the venture of marketing in this region less beneficial considering the resources required. Stoll believe that seamless technology could become the way of the future; however, this would not be for some time yet. The fact that Stoll don't offer a large range of Knit and Wear® machines is purely an economic business decision, as opposed to being behind in the technology.

Stoll also believe that the lack of highly experienced programmers in the industry is limiting the uptake of the technology. For example there is a worldwide shortage of programmers, and China in particular does not have many highly skilled programmers to make full use of the seamless technology. Italian educational institutions support the fashion industry by offering many specialised knitwear-training qualifications. Leading to the best programmers being found in Italy and making Italy the largest consumer of seamless technology, and a lucrative knitwear industry.

However, when the Fellow was attempting to organise courses at Stoll to learn the Knit and Wear® program, they were unavailable until a class of six students had been filled. A course did become available whilst the Fellow was studying at Stoll; however, with such late notice she was unable to amend her travel plans. In contrast, Shima Seiki will run the courses at any time, as long as somebody is willing to learn – the Fellow was the only person undertaking the WHOLEGARMENT® course at that time.

Currently the geographical distance between designers and factories is inhibiting the growth of seamless technology, as everything is done offshore and certain countries are not taking up the technology. If designers are dealing with new technology, they may require numerous samples to get the garment right.

The large distance between the two can prolong the sampling time. The ideal situation would be to have the machine, programmers and designer in the one place; however, the price of the machine often inhibits this. Italy has the entire necessary infrastructure required to produce knitwear locally, as it is one of the few developed countries that has retained on shore manufacturing. Unlike most other countries, such as Australia, the factories and skills necessary to complete any garment within the local vicinity are difficult to find at a reasonable price.

Stoll believe that if an automatic linking machine (an automatic linking machine has now been developed but there are no machines in use in Australia at this time) were developed it would have a big impact on the necessity of the Knit and Wear® market. Consumers generally don't know the difference between a seamless garment and a regular garment. There are many non-fashion-based industries utilising Knit and Wear® technology internationally. For example, in the medical industry doctors have a direct link to knitwear factories that specialise in medical garments. The majority of medical garments are made using Knit and Wear® technology.

Stoll have a range of support options available for customers including a helpline that can assist with resolving technical issues. They have also developed a pattern database where designs can be downloaded for free, providing you own a machine.

Understand the Computer Programming Required to Achieve Desired Outcomes and the Basic Mechanics of how the Machine Works to Produce the Desired Outcome

M1 Plus® is the pattern software for Stoll Machines. The program has many automatic functions as well as the option to manually program. When using the automatic software contained within M1 Plus®, the desired garment is selected from the variety of basic pre-programmed garment shapes. Garments that require the shape to be programmed manually can be produced using Shape Editor or manually generated then loaded into the Shape Wizard.

The Shape Wizard can be used for Knit and Wear® garments – creating single shapes, which are then combined into a complete shape by adhering to the Shape Wizard rules. The Shape Wizard automatically places the yarn carriers, knitting sequences and directions in the most efficient and reliable settings for each situation. The same knitting sequence used by the shape wizard is necessary even when manually generating a program, Stoll has preset Knit and Wear® arrangements. If the garment programming requires a different arrangement then the existing Stoll module can be modified.

The Shape Sizer component of the software is used as a garment-grading tool. The Shape Sizer was briefly explained in training but is often not used in production. Most customers create shapes manually whereby no specifications are added automatically and all adjustments are manually programmed.

Stoll uses modules to create knitting actions in the design software. A module is a preset knitting action with all machine adjustments pre-programmed, these could be anything from a stitch move to a structure such as a cable. There are set Stoll modules for a range of Knit and Wear® techniques in the database that are standard with all Stoll design software packages. There are modules specially designed for Knit and Wear® garments and these modules consider the fact that both front and back are being knitted at the one time. The Knit and Wear® modules automatically perform the transfers associated with the desired structure to avoid confusion when programming. The modules are protected to prevent the user from placing the modules in the wrong place i.e. a module designed for the front of the garment cannot be placed on the back and vice versa. However, if the sequence is not in the correct order for the design or needs to be changed the modules can be modified.

Using the automatic software to develop basic garments is very time efficient and cost effective; however, there are many limitations to Knit and Wear®, as there are with any seamless knitting machines. The limitations include the time taken to produce intarsia designs on the machine. The intarsia designs produced on a Knit and Wear® machine diminish any costs saved by eliminating labour processes due to the cost of the machine time.

Jacquards are of a limited variety and welts are not possible because the yarn carriers cannot pass through when the needles are in the holding position. This could be achieved when using the 1 x 1 technique but not for an all-needle design.

Stoll's M1 Plus® is a shape-focused design program, the shape of the garment being the dominant factor of the garment program design, whereas Shima Seiki's SDS is a structure-focused design program, making the structure used within the garment the key factor of the garment program design. Hence, many different types of connections are required for structurally-based Shima Seiki designs depending on the structure used. Stoll has one universal connection under the arm to connect the sleeve and body independent of the structure used. Stoll Knit and Wear® is engineered to make the sleeve move next to the body, whereas the Shima Seiki WHOLEGARMENT® programs the sleeve to overlap the body; therefore, the connection and structure need to be compatible.

After knitting in 1 x 1 for Knit and Wear®, various finishing treatments can be performed on the garment such as washing. Washing eliminates the obvious 1 x 1 structure to shrink the stitches. There are also specialised yarns available for seamless garments that achieve a similar look by closing the gaps between the knitted wales. A lot of fabric testing and garment sampling can be necessary to see how the yarn reacts after washing and steaming to ensure the end product is desirable. The twist of the yarn, being an 'S' or 'Z' twist of the yarn, can also have an effect on the final shape.

Improve on Knitwear Design Skill Base Through a More Thorough Understanding of Structures and Process of Knitting Using the Industrial Machines

To answer this component of the intended outcomes the Fellow interviewed Francesco Collura of the Fashion & Technology Product Development Department at Stoll. Collura is a leading programmer at Stoll and specialises in Knit and Wear®.

The design benefits of Knit and Wear® are based around what can be created without seams and thinking in a three dimensional form as opposed to the traditional flat pattern approach. For example, detail can be added where there are usually seams and the sleeve line can be enhanced with detail.

Structural detail can be continued over the shoulder, neckline and sleeve edges

Structural detail can be continued over the shoulder, neckline and sleeve edges, especially effective with sculpted edges and three dimensional structures. Not only are such details usually difficult to knit as a consequence of seam interference but they are also very costly and time consuming to link. Knit and Wear® makes it possible to add detail to the actual fashioning marks, which is impossible with fully-fashioned knitwear.

Sculpted edges and three dimensional structures

Sculpted edges and three dimensional structures

Coarser gauge machines have limits when shaping on the shoulder – as the bind off is required for the shoulder stepping. Other details, such as turned up cuffs and hem, can become a feature as the messy look of seams being exposed is eliminated.

Turned up cuffs and hem can become a feature as the messy look of seams being exposed is eliminated

The Knit and Wear® machines become limited to jacquards with a minimal amount of colours. There is always a difference of one course between the front and back to consider in jacquard designs, this is because the machine starts knits at the back adding a new course on top of the last each time. Therefore, it is not possible to have a perfectly straight line running through the side of the garment, as there will be a difference of one course of knitting in height.

Knit and Wear® requires a high level of technical knowledge because of the complicated technical requirements of programming. Good communication between programmers and designers is essential because they may be able to achieve a certain look by implementing different techniques, and at a quicker rate because fewer samples will need to be developed.

Designers need technical knowledge because it is hard to find a programmer with a creative mind, in the sense of design, as they are most often engineers. Designers and programmers need to work together so that they can push each other in terms of what can be done. You can become concerned with the technique as opposed to designing freely; therefore, it could stifle your design.

With Knit and Wear®, you are also working in a three-dimensional aspect as opposed to a two-dimensional aspect. Changing the way one needs to think about design. Technical staff can be hard to find, the machines are expensive and there are limits to the technology. Having programmers and designers working together is often the best combination. Chanel uses the approach of having a design with a limited amount of information detailing the specifics, they then give the design to four different factories to see what each comes up with, then they choose the best one. This is done so that Chanel believes they have explored the technical possibilities associated with the design, and they have a wealth of resources.

It is good if designers have a medium level of knowledge and a very skilled programmer. This gives the designer enough information to be able to efficiently communicate and even present other technical possibilities without stifling the design process by being caught up with technical constraints. This allows the designer to push the programmer by asking the right questions.

Concluding Remarks

Overall, the overseas component of the Fellowship was imperative to be able to meet the aims and objectives of the Fellowship as a whole. No institution in Australia offers any education that allows the opportunity to gain such knowledge. As a consequence, the Australian knitwear industry is at a major disadvantage when compared to the international knitwear community. Sharing of the knowledge gained with designers and the knitwear industry in Australia is essential to ensure the industry is on a par with the international community and at the forefront of innovation and design.

Knowledge Transfer: Applying the Outcomes

Sharing the knowledge gained with designers and the knitwear industry in Australia is essential to ensure the industry is on a par with the international community and at the forefront of innovation and design. The Fellow will share the knowledge gained and to improve the skills base in the Australian industry. The knowledge will be shared in a number of ways, including workshops, training courses and consultation and design services.

Workshops

The Fellow aims to conduct workshops at the TFIA Hub, Richmond, at the KNIT.melbourne studio and in-house at interested companies. These workshops are as follows:

1. Basic Workshop

This workshop will encompass:

- Basic principles of knitting – yarn, knit structures, tension, shaping, and costing
- Introduction to industrial knitting machines – types of machines, basic shaping (seamless, integral and fully-fashioned), and costing.

2. Tailored Workshop

- Customised content to meet the companies needs
- Focus on structures or techniques tailored to the desired outcomes
- Individual workshops based on the knowledge required.

3. Knitwear Discussion

- Basic information about knitwear techniques and technology
- Construction of basic knitwear garments is explained
- Achieving a variety price points and designs by using different techniques.

Training Courses

The proposed training will be a much more involved and in-depth continuation of the workshops, including:

- Basic knitwear principles – yarn, knit structures, tension, shaping, design, and costing
- Introduction to Knitwear Manufacturing – types of machines, basic shaping (seamless, integral and fully-fashioned), design, and costing.

Consultation and Design Services

Through the Fellow's consulting practice, KNITmelbourne, she will be offering consultation, training and workshops on seamless knitwear manufacturing and design, as well as her existing knowledge of fully-fashioned knitwear. Consultation will be available on:

- Garment production and design
- Manufacturing options
- Product Development of knitwear ranges covering design, production options and costing
- Programming service & Sampling:
  – Shima Seiki – WHOLEGARMENT®, intergral and fully-fashioned knitwear
  – Stoll – fully-fashioned knitwear.

Knowledge Transfer: Applying the Outcomes

The Fellow will also use her children's knitwear label, Sprocket Rocket & Co, to share the knowledge gained and to improve the skills base in the Australian industry. This will allow the Fellow to program her own samples as well as do her own production.

This is a great advantage and almost the only way it is possible to demonstrate how achieve small production runs at a reasonable price for children's clothing in Australia.

Recommendations

Government

- Provide input into the development of Australia regaining the skills to re-establish the knitwear industry.
- Provide input into the redevelopment of the knitwear industry in Australia by implementing the latest technology available.
- Provide training to give industry more understanding of knitwear design and manufacturing processes.
- Encourage TCF industry capital investment in leading edge knitwear technologies by creating incentives through programs grants.

Industry

- Develop training programs with RTO in order to offer accredited courses.
- Identify leading experts (local and international) and encourage professional development.
- Understand available technology to be able to achieve cost effective and quicker production and sampling.
- Development of Knitwear Mass customisation possibilities.

Education and Training

- Develop and implement appropriate training that is specific to knitwear design and manufacturing in TAFE and Tertiary institutions. The Fellow is available to work with TAFE and higher education institutes to develop and implement curriculum and teaching resource materials.
- Invest in seamless and whole garment knitwear equipment.

References

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