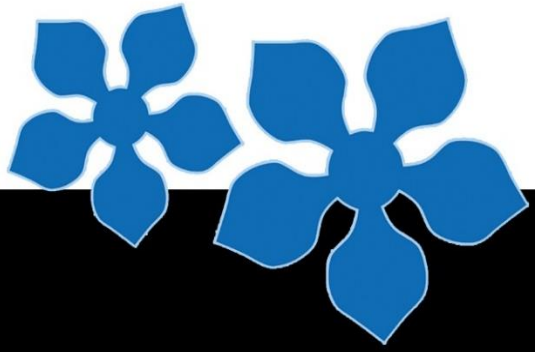
colegsirgâr

"Bod yn rhagorol - y coleg dewisol
To be excellent - the college of choice"

Technical and Commercial Feasibility Study Jacquard Loom Weaving Technology



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Suzi Parks	Make it in Wales
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1. EXECUTIVE SUMMARY

A compression garment is an item of clothing designed to apply pressure to particular areas of the body. Predominantly they are constructed from stretchable knitted fabrics in the form of stockings, tights and arm sleeves. Used extensively in the medical field, graduated compression garments are prescribed for the treatment of a number of illnesses. Currently 1.5 million pounds worth of products are being distributed monthly on the NHS drug tariff highlighting a large medical demand for compression therapy products. Recently compression fabric technology has been introduced into the sportswear market with brands highlighting the fabrics ability to reduce lactic acid build up and improve after workout limb recovery. This expanded use of the technology in both the medical and sportswear fields has pushed the demand for technically efficient products beyond the expectations and needs of the international standards for graduated compression garments. Research into graduated compression garments has highlighted a number of product issues. These include: problems with product usability, issues with garment sizing, inconsistence pressure levels in garments, and lack of cosmetic appeal in products.

This feasibility study outlines an investigation into whether jacquard woven technology can be utilised in the manufacture of compression fabric and garments, as well as identifying whether there is a demand and need for advancement in the technical design of compression garments.

A computerised jacquard loom is a textile manufacturing machine that is capable of utilising computer aided design to create complex woven fabrics. Unlike knit construction where the fabric is created by interlinking loops in a continuous length of thread, woven fabric is created by interweaving vertical (warp) threads with horizontal (weft) threads. The structural differences between knitted and woven fabrics means the processes offer varying fabric characteristics and solutions to different fabric technical demands.

It is clear that the challenges to overcome are diverse and varied within the field of compression garments. These challenges fall under three main categories: -

Manufacturers and test standards

Current compression garments are manufactured to a number of international standards. Having been published in 1985, the British Standard for Graduated Compression Stockings has not been updated to cover the extended use of medical compression garments that are currently being prescribed. This is evident by the lack of any standard guidelines for the treatment of upper body illnesses with compression garments and the lack of informed compression levels for the treatment of lymphoedema.

With high demand for compression products, manufacturers have been catering for the product demands rather than the varying needs of the consumer. This has meant that

product development has remained static. Manufacturers however, welcome further academic research to support their manufacturing output.

Product design

Research into lymphoedema has highlighted a market need for aesthetically improved compression garments, which require location focused pressure and utilise specific garment shaping. How a patient uses a compression garment ultimately affects the fabrics technical demands. The market clearly requires multiple styles of compression product to cater for a variety of patient needs. These include both wrap-style and hosiery-style products. Although stretch knit fabrics form the basis for most compression products on the market and is clearly the suitable manufacturing choice for hosiery-style products, current compression therapy research highlights a need for further investigation into inelastic wrap-style fabrics. Fabrics with elements of stiffness could remove tourniquet problems, an issue caused by the movement and gathering of knitting fabric into the folds of the skin. Jacquard technology's ability to weave complex fabrics where the variations of weave structure can be utilised to create all over patterns may be beneficial for the development of fabrics that explore focused areas of pressure, greater stiffness and improved aesthetics. It is worth noting that the woven fabric manufacturing process itself has limited shaping ability and therefore relies on the cut and sew method of production. Both knit and weave manufacturing processes offer the opportunity for aesthetic improvement as both fabrics can be digitally printed.

Knit technology has developed considerably over the last twenty years through the development of seamless knitting technology. However, with limited financial capability, industry has not been able to utilise these technical developments within compression garment manufacture. Further application of innovative knit technology to the manufacturing process of compression garments could extend the products capabilities.

Financial

Economic investment in Wales can be drawn from innovation funding. Currently manufacturing has limited awareness of this opportunity or the benefit of working with R&D and collaborating with academic institutions to profit from their significant resources and expertise.

In conclusion, the study has identified that there is a need for collaboration between academia and industry to prove 'proof of concept' through experimental development, applying expertise and innovative mechanisms, technology and design strategies. For example, it was identified that technological applications in other industries have the potential if explored within this context to revolutionise manufacturing. This in turn, would reform current and future manufacturing within industry through pioneering sector leading advancement that confronts the needs across all platforms.

2. BACKGROUND

Compression garments have a long-standing history for the treatment of a number of illnesses. These include venous thromboembolism, burns, venous leg ulceration and lymphoedema. Compression therapy has a positive effect on the circulatory system. By applying pressure to a limb, compression therapy can reduce vein diameter and therefore assist damaged valves and accelerate the blood flow. In recent years, this has seen the use of compression garments extended beyond medical products to be used within both the sportswear and the fashion shapewear markets, whether used as fabric or as a complete graduated compression product. This diversification in use has seen the compression garment industry expand.

Controlling body shape with the use of external garments has been around for centuries with items such as the corset being very popular. With the current trend for figure hugging garments, body-contouring garments have seen an increase in demand. Body contouring garments are now being advertised as not only occasion wear garments but also as daily wear garments that promote the natural shaping and smoothing of the body long term. Due to material innovation, fabrics used in these garments have become thinner and therefore sit naturally under everyday garments. These fashionable contouring garments now utilise area focused compression panels that look to flatten, smooth and lift areas of the body. Some manufacturers are even promoting multi-layer garments that have a textured layer next to the skin to promote cellulite breakdown and garment breathability.

Compression garment use has expanded dramatically within the sportswear market. Promoted for its ability to improve circulation, it is claimed to help eliminate lactic acid build up. Due to the supportive nature of compression garments around limbs, sportswear brands have found that garments support the muscles during active use and therefore limit injuries. Although clinical evidence related to the promoted benefits are limited, the Union Cycliste Internationale banned compression garment products in 2012 for professional cyclists seeing them as performance enhancing tools. [1] The use of compression garments in the sportswear field has now gone from professional athletes to the active public with many sportswear brands offering graduated compression products in their standard ranges.

Through a connection with Lymphoedema Network Wales, the Fashion & Textile Lab at Coleg Sir Gar University was asked to research the possibility of further compression product development for the treatment of lymphoedema exploring alternative construction and manufacturing processes, namely jacquard weaving. With the support of the Welsh Government, the European Agricultural Fund for Rural Development and Carmarthenshire County Council, the Fashion & Textile Lab undertook a feasibility research project to explore stretch and compression fabric manufacturing technology and its current use within the UK textile industry.

The focus of this feasibility study was to gain a better understanding of the different textile manufacturing processes and fabric technologies related to compression products,

exploring how they are currently being utilised and where there may be further opportunities for development within the Welsh textile industry. Through engagement with industry experts and multiple trips to manufacturing facilities, the study looked to explore factors affecting the development of compression products within the UK textile industry.

The feasibility study used lymphoedema compression treatment as a case study to explore the technical requirements of product development whilst taking an in-depth look at both the illness and the external factors effecting products on the UK market. This case study allowed us to gauge a targeted impact analysis of new products and develop an understanding of a new product range's route to market.

To be able to understand the compression market, textile manufacturing and issues related to lymphoedema, the research established links with a number of stakeholders. The research engagement with stakeholders is showcased in a table at the back of this document.

3. NEEDS ANALYSIS

'The productivity of the fashion and textile sector in Wales has been impacted greatly by the recession […] This is mainly due to the closure of a number of high profile, large employing apparel manufacturing plants and the off-shoring of these operations during this period.' [2]

The weaving industry has had a long-standing history within Wales' manufacturing sector but over the years has seen the slow decline of industry due to globalisation. Due to a demand for heritage textiles, a small number of mills continue to survive and thrive due to their traditional methods of production and products. These mills utilise dobby-weaving equipment.

Although jacquard weaving technology exists within Wales' label weaving industry, the fact that it utilises narrow width looms (up to 4cm wide) means there is limited scope for adapting the technology for other industries. However, within other areas of the UK, jacquard weaving technology is being utilised in the technical textile field with the manufacture of items such as airbags. Many of the textile manufacturing businesses within Wales are small and therefore they hold limited financial and resource capability to diversity from their existing production methods. 'Technical textiles are a growing area for traditional textile companies to branch into after traditional textile base has been eroded and new market opportunities afforded by branching into technical textile production become apparent. A recent DTI report put the contribution of technical textiles to the UK economy at £1.5 billion [3]

According to figures provided by the ONS for 2014, manufacturing in Wales remains critical to the economy of the country and accounts for £7.8Bn of manufacturing output and employs over 138,000 people. [4]

By developing new technology in a product line currently not manufactured in Wales, we will provide an opportunity and new market for manufacturers of textiles, medical care and compressed garments. It is apparent that with the increasing demand on our own Health Boards in meeting demand for this product, remedial and proactive action needs to take place.

Compression garments expenditure in Wales is currently in the region of £1.5 million per annum. Overall expenditure in the UK is approximately £1.5 million per month on garments through the NHS UK drug tariff. Back copies of the drug tariff are available online. For the feasibility study November, October, and December 2016 were analysed.

Manufacturers in both the medical and sportswear markets claim that compression products apply particular gradient pressure levels to encourage positive lymphatic and blood flow within the wearer. However, manufacturers do not need to back these claims up with evidence to be able to supply these products. Each patient's limb is unique and

yet patients are provided with standard sized compression products that claim set compression levels. Custom-made products are actively available but the process of fitting relies on varied measuring processes that do not provide clear dimensions of the limbs. Manufacturer provided tape measure systems offer measuring processes that allow for variable size readings. Swansea University College of Engineering are currently researching 3D scanning of lymphoedema patients as a way of improving their understanding of lymphoedema. Translating their research into textile developments will form part of the strategic aim of the academic research taking place within Wales.

Testing

Issues relating to product testing highlight the need for further investigation. Currently there is no unified European standard for compression garments. Manufacturers supplying the UK market are working to different country standards with the British Standard being the oldest, published in 1985. The extent that compression garments are being used has developed since 1985 with the introduction of sports compression garments and medical garments for areas of the body other than legs. Therefore, many experts and manufacturers question whether the British Standard test method adequately tests gradient compression levels as it only tests three locations along the stocking.

In order to address this, the market will need to distinguish the best textile fabrics suitable for both garment and technology. This will be established during proof of concept stage.

4. APPRAISAL OF EXISTING PROCESSES

In 2006, compression garments for lymphoedema became available on prescription as part of the UK drug tariff FP10. Unlike pharmaceuticals, compression garments are classified as class 1 medical devices which means that they can be self-certified and require no third party approval before being advertised and sold onto the market. 'Published evidence on the clinical effectiveness of individual products is often lacking. Compliance with standards does not guarantee clinical effectiveness.' [5] With currently 114 products listed on the UK drug tariff spanning from 18 different international manufacturers there are a vast variety of products, fabric qualities, product accessories, compression levels, product standards and sizes available. This wide selection of products makes it difficult for clinicians to know which products are the most suitable for their patients. It also makes it difficult for the NHS to monitor product standards.

As a way of improving the service to lymphoedema patients concerning the supply and recommendation of compression garments in Wales, an All-Wales Lymphoedema Compression Garment Contract began in 2014. A collaboration between the Lymphoedema Service, Procurement Wales and Abertawe Bro Morgannwg University's Surgical Materials Test Lab (SMTL) saw nine manufacturers respond to a tender for the independent comparison and testing of products. The results highlighted inconsistencies in products graduated compression levels with some products falling far below the advertised compression levels. The testing found that there was a 78% pass rate for lower limb compression products and only a 50% pass rate for upper limb products. This meant that some contracts could not be offered and the programme needed to re-tender. The All-Wales Lymphoedema Compression Garment Contract was achieved in Wales due to the small scale of the region.

The compression garments available on the UK drug tariff are manufactured to a number of international standards. These include British Standard BS 6612:1985 - Graduated Compression Garments, the German standard RAL-GZ 387/1 and the French standard AFNOR G 30.102. The multiple standards used are the result of the international manufacturers catering for the many international markets that they service.

Figure 1 Hatra Mark II - Graduated compression garment test equipment utilised as part of the British Standard.

Published in 2008, the German standard provides a detailed technical framework for the production of compression garments whereas the British standard mainly outlines the product test method. Both standards, however, focus on standardised compression garments for lower limb usage with little or no reference to custom fit products. Upper body compression garments claiming alignment with the BS and RAL standards are available on the market, yet the RAL standard only covers compression arm sleeves. Manufacturers are applying the general understanding of lower limb compression onto the upper body even though anatomically they are different. [6] This lack of detail in the standards towards upper body compression is mainly due to the lack of research into compression treatment for upper body illnesses. This leaves manufacturers without clear guidance.

One compression garment manufacturer stated that the UK manufacturing industry has all of the technical and manufacturing capabilities to cater for the treatment of lymphoedema but as the British standard for graduated compression hosiery does not cater directly for lymphoedema, there are no guidelines for manufacturers to work towards in terms of providing specialist products. He questioned the correct compression levels for lymphoedema treatment and welcomed further research.

After visiting a UK supplier, it is very evident that compression garment manufacturers are able to offer patients a quick and relatively effective product delivery service. Most suppliers offer patients a 48-hour delivery service for standard product sizes and a one-week delivery service for custom-made garments. Efficiency in garment delivery times is important for the treatment of lymphoedema. A compression garment is donned after the patient has received their manual lymphatic drainage treatment, a time when the limb is at its reduced size state. A delay in the use of compression garments could mean that the size of the limb may have changed by the time the compression garment is worn which could result in discomfort and the possible removal of the garment by the patient.

Current manufacturing processes

There are two different knit manufacturing technologies used to create the standard compression hosiery garments available on the market. These are flatbed knitting technology and circular knitting technology.

Circular Knitting technology

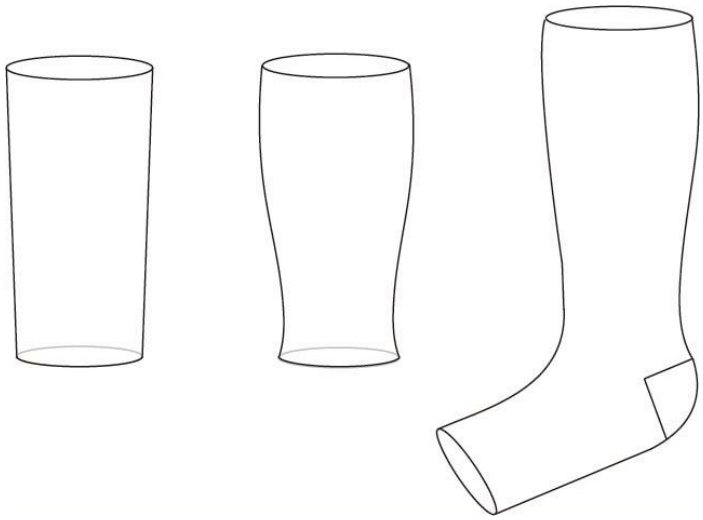

Figure 2 Illustrative examples of basic tubular garment designs

Circular knitting machines produce seamless tubular fabrics. Created on varying diameter circular knitting beds, machines can produce different quality fabrics depending on the size of the machines needles. Unlike flatbed knitting technology, circular machines have a set number of needles and therefore create garments with a set number of stitches. To make shape changes to the tubular fabric, tension changes to the elastic inlay yarns are applied to draw the fabric inward. [7] The stitch length can also be utilised to make shape changes. The larger the diameter of the circular knit bed the more scope there is for shape changes within the compression garment. Utilising large circular beds for this method creates garments where the compression is produced by the power of the two-core spun yarn. Two-core spun yarn is further explained in section 5 – Product engineering and design under heading Yarn technology.

Figure 3 Examples of circular knitted compression stockings. Brand - Medi UK

Used extensively in the sock and hosiery industry, circular knit technology has advanced to create finished knitted products with shaped toes and heels. Mainly used to produce the lower level compression products, circular knitting compression products have the advantage of appearing like traditional hosiery. This makes them cosmetically more appealing to patients than the visually heavier flatbed garments. Clinicians generally recommend a circular knitted compression garment for the treatment of lymphoedema where the limb/limbs are experiencing limited shape distortion. This is mainly due to the way the finer fabric stretches and moves. [8]

Figure 4 Circular knitting machine utilised at Sallis Healthcare

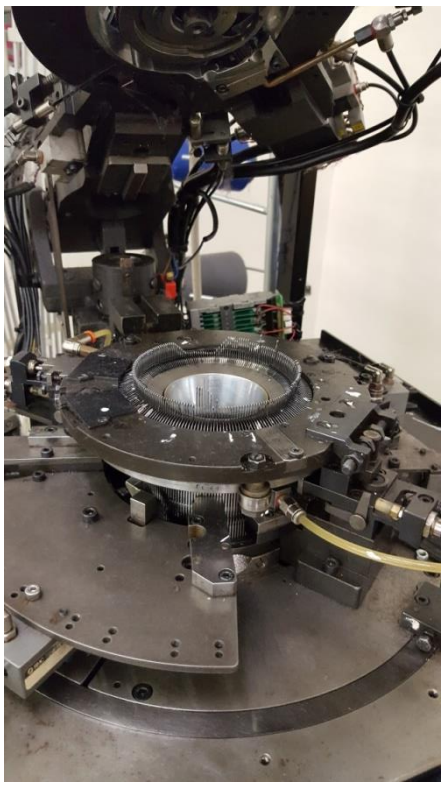

Figure 5 Close up of circular knit needle bed

Flatbed knitting technology

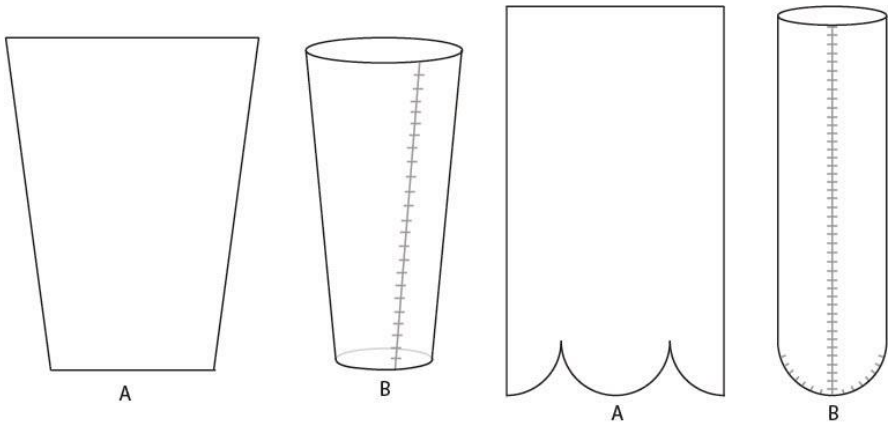

Figure 6 Illustrative examples of simple flatbed designs where drawings marked (A) represent the knitted pattern pieces and drawings marked (B) represent the stitched garments

Flatbed knitting technology produces fully-fashioned pattern pieces. Machines are set up with two straight beds of parallel needles where fabrics can be produced using either one or both beds simultaneously. By adding and removing needles on the knit bed, three dimensional garment shaping can be achieved. This manufacturing process is suitable for manufacturing lymphoedema compression garments as the technology's shaping abilities are able to accommodate varied limb shape distortions. Knitted as flat pattern pieces, the garments require stitch finishing. As the knitting process creates a clean fabric edge, flatlock seams can be used to finish the garments. Popular in sportswear, the flatlock stitch method butts and stitches two finished seams together. As no hemming or overlapping is required, the finish is flat and comfortable.

Figure 7 Close up of double bed knitting machine

Figure 8 Stoll multi gauge knitting machine, Camira Technical Knit

Flat bed knitting technology offers the opportunity for pockets to be knitted into the fabric. This means that padding for comfort and the integration of sensors can be designed into the garments.

Figure 9 Flat knit stockings

Both, circular and flatbed knitting technology allow different tensions to be applied to each of the input yarns added to the fabric.

Both manufacturing processes are actively used within the UK textile industry with a wide range of textile products being produced.

It is worth noting that knit machinery manufacturers have made considerable advances in knit technology over the last 20 years with manufacturers like Stoll and Shima Seiki leading the way. However, many of these advances are not being fully utilised in industry due to the expense of the technology and the investment time needed to integrate new processes and develop new products.

To gain a better understanding of the UK knit industry and technology, the research project engaged with a number of manufacturers:

Sallis Healthcare, Nottingham

Sallis Healthcare is a UK medical textile manufacturer of compression hosiery, tubular bandages, support products, and compression garments. Based in Nottingham, the company has been producing knitted products for over 150 years. Utilising a wide range of manufacturing equipment, the company is able to offer a varied selection of products including a wide selection of bespoke custom made items. As a relatively small manufacturer, the owner believes that the company is able to adapt and cater for niche markets as they offer small production runs and bespoke items.

The company utilises both flatbed and circular knitting technology to produce their compression garments. Production machinery used ranges from computerised circular knitting machines to traditional manual flatbed machines. Although not as quick and technical as the computerised machines, the company has found that the traditional equipment can still be utilised due to the custom nature of the bespoke compression garments.

Figure 10 Manual double bed knitting machine utilised at Sallis Healthcare

As well as the production of in-house knitted garments, Sallis Healthcare also manufactures a range of post-operative compression garments. Utilising the cut and sew method of manufacturing, the company use off the roll compression fabrics to construct bespoke medical garments.

Camira Technical Knitting, Nottingham

Camira Technical Knitting manufactures innovative seat backs and covers for the designer furniture market. Utilising flatbed and seamless technologies, the company works to create one-piece products that require no cutting and sewing and produce no waste materials. With the latest technology, the company is able to produce 3D pattern pieces on their flatbed machines. As part of the feasibility study, the company's manufacturing plant was visited to gain an insight into the equipment and CAD technology behind their product developments.

Figure 11 Stoll multi gauge knitting machine utilised at Camira Technical Knit

Camira manufacture their knitted products on a selection of Stoll multi gauge knitting machines. Multi gauge knitting machines allow manufacturers to produce a range of fabric qualities without requiring them to change needles and therefore without purchasing further equipment. The machines can be set up to run independently with limited staff needed.

CAD software to run the Stoll machines showcased software similar to the jacquard weave technology seen on both Scotweave and AVA programmes. Patterns with blocks of colour can have individual structures applied. This means that every stitch within the fabric can be different and therefore complex patterns can be achieved.

The Stoll software is production focussed with calculated production times and yarn usage with each pattern piece. Comparisons can be made to calculate the most cost effective design to manufacturer.

Figure 12 An example of a Camira flatbed knitted seat cover

Figure 13 Camira knitted pattern piece before being fitted onto chair frame.

The technology allows Camira to add tension into the fabrics to produce 3D structures that appear under tension to be padded. The technicians stated that using the technology enabled them to produce fabrics that have the same quality handle as both knitted and woven fabrics.

5. PRODUCT ENGINEERING AND DESIGN

Yarn Technology

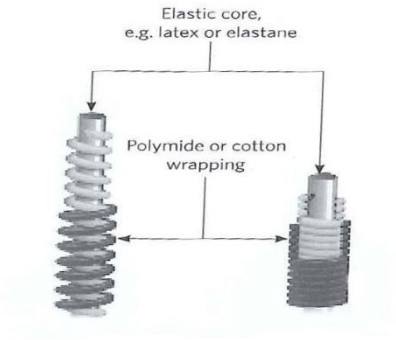

Figure 14 Illustration of two-core spun yarn [1]

Fundamental to the creation of a compression garment's ability to compress and control the stretch in a knitted fabric is the selection and use of technical two core spun elastic yarns.

Two core spun yarns are manufactured by covering an under tension elastic core with two layers of yarns wrapped around the core yarn in alternating directions. The outer materials tend to be either cotton or polyamide (nylon). Both of which add comfort qualities to the overall fabric and take to dyeing. When manufacturing two core spun yarns, manufacturers can alter the yarn set up allowing the machinery to create a wide range of qualities. By adjusting the tension applied to both the core elastic and wrapping yarns, yarns with varying stretch and power can be created. [9] A compression garment's ability to stretch is outlined as a technical requirement for the garment being manufactured in line with the German RAL standard.

A factory visit to a UK yarn manufacturer allowed the project to gain an insight into stretch yarn manufacturing.

Stretchline UK

Stretchline UK is a yarn manufacturer for the fashion and medical textile market. With a plant in Leicester, the company manufacture both two core spun and air spun yarns. They are yarn suppliers for a number of the compression garment manufacturers and are currently the only UK manufacturer producing this quality yarn. They offer of a range of 100 different yarn qualities and work with manufacturers to develop new technical yarns with either latex or elastane cores.

Product engineering

Fabric structure

Figure 15 Illustration of woven fabric

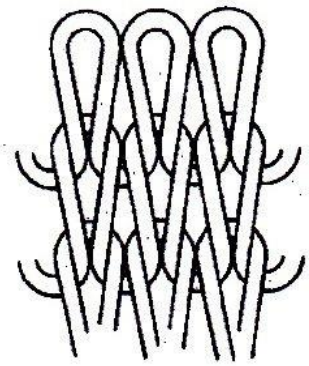

Figure 16 Illustration of knit fabric

The term knitting describes the technique of constructing textile structures by forming a continuous length of yarn into columns of vertically intermeshed loops. [10] The interlocking loops within knitted fabric allow the fabric to stretch in multiple directions as the loops distort under force. It is this stretch and regain ability of the structure that results in knitted fabrics being suitable for a range of fashion and medical fabrics.

Weft knitting utilises three different stitches: knit, tuck and float (miss) stitches. These stitches create visual pattern effects as well as change the physical quality of knitted fabric. By alternating the combinations of stitches as well as alternating either single or double bed structures, fabrics can be created with varied tensions as the stitches effect the length of the continuous yarn in each knitted row.

Stitch combinations can hold yarns in place. In compression fabric, the alternating knitted rows of stitches hold the elastic inlay yarn in place. This stops the surrounding loops from sliding along the inlay yarn as well as applying a tension within the fabric. It is only under force that the elastic inlay yarn is able to stretch and allow the surrounding loops to stretch and distort as well. The inlay yarn therefore adds the compression within the garments whereas the surrounding knitted structures allow the fabric to stretch for ease of use.

Compression garment manufacturers utilise stitch combinations to create areas within the garments that have varying qualities. This can be seen in the tops and heels of compression stocking where rib-like structures have been used to add stretch for comfort reasons. Additional rows of stitches are added to create shaping. This is to form dart like areas within the knitted fabric. An example of this is the shaping around the elbow.

The construction of woven fabric varies greatly from knit structure. In woven fabrics construction horizontal and vertical threads are interwoven at right angles from each other. A woven fabric's ability to stretch relies on the stretch of individual threads rather than the distortion of the structure.

Different quality weave structures are achieved by varying the sequence of the interlacing threads as well as varying the fabric set - a term known for the number of threads in either an inch or cm. A fabric with a high density of threads has a stiff compact quality whereas a fabric with a sparser fabric set has more opportunity for fabric movement and breathability.

Infinite combinations of interweaving threads can create varied woven structures which offer practical uses. For instance, honeycomb structures where the interwoven threads form cell-like structures are used in fabrics that need to draw moisture away from the surface. Woven structures can be formed to create multi-layered fabrics that offer the opportunity for pockets, padding and the embedding of sensor technology.

A jacquard loom is a weaving machine that simplifies the creation of fabrics with complex designs. Unlike standard looms where threads are lifted in set sequences to form woven structures, jacquard looms are set up to lift individual threads. This removes many fabric construction limitations and offers infinite fabric designs across the whole fabric. Computer aided design has further simplified this process and offers quick fabric design and development of complex fabric construction.

The jacquard loom's ability to create multi-layered fabrics and complex all over designs can be seen in the manufacturing of car airbags. The one-piece-woven (OPW) airbags are shaped according to the contour of the car interior to which they will be fitted. The airbags are manufactured with built in woven seams, which means that no additional stitch finishing is require in the production process.

Figure 17 Close up detail of woven airbag [2]

Fibre content

Recently the compression garment industry has seen the use of new fibres utilised within the garment's yarn construction. Fibres such as silver have been used and advertised for their anti-bacterial qualities. Whereas Seacell, a cellulose based fibre combined with seaweed has been utilised for its advertised revitalising properties for the skin. To what extent these new fibres are improving the quality of compression garments is to be questioned.

Silicon banding is added to the tops of arm sleeves and leg stocking to assist and hold the garments in place.

Design Techniques

From assessing a number of guides and articles on compression therapy, it is clear that garments need to be designed to comply with a number of design considerations. These include:

- Be comfortable
- Adjustable to accommodate varied sizes or changes in size
- Be unaffected by the washing process
- Easy to don and wear
- Inconspicuous
- Apply consistent compression level regardless of garment size
- When worn does not produce a tourniquet effect on the folds of the skin [11] [12]

A report by Cancer Research UK found that some patients believed that the wearing of a compression garment visually highlighted their illness and put them in a position where they may be asked about their illness/previous illness. [13] Currently, many compression garments are only available to the patients in a basic nude colour. Many patients consider that the nude products appear medical. A few manufacturers are trying to make their product ranges appear more fashionable by offering bright colourways and additional surface knit structures. However, Gavin Hughes from SMTL questions whether the varied dyeing of compression garments affected the compression performance.

One US manufacturer is now offering patients digitally printed compression arm sleeves that follow current fashion trends. These products aim to give patients a positive feeling towards the garments by making them a fashionable eye catching item.

Figure 18 Compression arm sleeve by Lymphedivas [3]

A number of manufacturers have added traditional details to make their compression garments inconspicuous. This has seen Medi UK offer men's stockings that appear like sports socks or professional suit socks.

Whilst visiting Sallis Healthcare, a range of sports knee supports were being manufactured on their circular knitting machines. These support garments featured several knitted design details including garment shaping, brand logo and decorative detailing. It is worth noting that although these techniques were being utilised within the sportswear products they are not being utilised in the medical compression products available.

Figure 19 Circular knitted sports knee support manufactured at Sallis Healthcare

Medi UK are offering an adjustable compression product called the JuxtaCure. Created for the treatment of leg ulcers, this product can be cut to size and has Velcro straps that allow the wrap to be adjusted throughout the day. The product aims to promote self-care and assist patients that struggle with the donning and removal of compression products. It is worth noting that the fabric quality has limited stretch and utilises the belief that inelastic fabrics are better for compression products. The stretch within most products is to allow the wearer to don the garment and for the garment to accommodate subtle limb sizes changes. As the garment does not need to stretch over the foot and ankle for the wearer to position the garment, the JuxtaCure garment can be made out of breathable inelastic fabric.

Figure 20 Medi UK JuxtaCure compression leg wrap

6. CASE STUDY – LYMPHOEDEMA

Case study: Lymphoedema

Lymphoedema is a consequence of impaired lymphatic drainage. The failure of the lymphatic system's ability to drain waste fluids properly causes lymphatic fluid to accumulate in the affected limb's tissue which results in changes to both its shape and size [14]. As well as limb changes, patients experience a 'heaviness' and aching in the affected limbs. If left untreated, the illness can progressively become worse. Resulting consequences can include long-term disability, reduced quality of life, emotional problems and problems at work.

Causes

The international consensus best practice statement for lymphoedema states that from birth, approximately 1 in 6000 people will development lymphoedema [15]. Lymphoedema can also be caused by damage or trauma to the lymphatic system. Patients that have received cancer treatment can development lymphoedema.

Once diagnosed with lymphoedema, a patient will go through a clearly mapped out treatment programme depending on how advanced their condition may be. There are two phrases: the treatment phrase and the maintenance phrase.

The first phase includes skin conditioning to reduce the risk of infections, exercises to encourage muscle movement in the affected limbs, specialised massage treatment known as manual lymphatic drainage (MLD), and the donning of compression bandages (post massage). MLD forms an important part of the treatment phase as it works to stimulate the flow of fluid in the lymphatic system and reduce the swelling.

The second maintenance phase promotes self-care and treatment management as the patients return to their normal lives. The aim of this phase is to maintain the reduced limb size through self-massage, exercise and wearing compression garments. The use of compression garments forms an important part of the patients' treatment. [16]

Unlike blood circulation, the lymphatic system has no central pump that works to move blood around the body. Instead, it uses the massaging effect of surrounding muscles to move fluid to the lymph glands. The use of compression garments and exercise encourages the correct movement of fluid in the lymphatic system by compressing the limb and encouraging the muscles massaging action. [17] 'The aim of wearing compression garments is to limit the formation of oedema within the tissue space providing graduated compression, encouraging it to the root of the limb. This is achieved through the garment altering interstitial pressure, improving lymphatic drainage by the stimulation of lymphatic contraction and can result in a breakdown of fibro sclerotic tissue.' [18]

7. SWOT ANALYSIS

Strengths

A few international companies dominate the compression garment market. They tend to function in a vertical manufacturing set up, whereby they control all or many of the elements needed to manufacturer their products. For instance, many of them have in house yarn manufacturing, knit garment manufacturing, product finishing, and materials/ garment testing. This vertical set up enables them to adapt to changing product developments, improves their product manufacturing times and of course saves them money.

With the limiting of resources within the NHS, larger manufacturers are able to engage with medical professionals by funding research and training programmes. This allows manufacturers to gain first-hand experiences of how their garments are being used by patients and clinicians as well as embed their products into current research and medical departments.

Weaknesses

Although manufacturers appear to be capable of controlling all aspects of the manufacture of compression garments from the yarn creation to the delivery of the final product, products appearing on the market are still not meeting their advertised compression levels when independently tested.

Upper body compression garments are available on the market and are advertised as being manufactured to the BS/RAL standard. However, both standards do not cover upper body products and therefore manufacturers are applying the general understanding of lower limb compression onto the upper body even though anatomically they are different. This lack of detail in the standards towards upper body compression garment is mainly down to the lack of research into compression treatment for upper body illness.

Opportunities

Currently university research investigating compression garments is taking place within multiple facilities. This includes research into compression for sportswear at Nottingham University and Scan2knit research at Manchester University. There are currently no universities researching compression garment technology and its development for lymphoedema.

The current standards for graduated compression hosiery do not cover garments for the targeted treatment of lymphoedema. With further research, there could be a better understanding of the fabric qualities and the compression levels that are more suitable for the treatment of the condition.

From researching patient feedback on life with lymphoedema, the study has found that patients also struggle to find suitable footwear. Therefore, further research into footwear development for patients with distorted feet could be considered.

Threats

Product matching is considered by some manufacturers to be a threat to product sales and the overall credibility of the products. Some manufacturers believe that similar products are being brought into the market place that appear on paper to be similar but are actually lower in quality. Due to budget limitations, clinicians are likely to purchase the lower priced product regardless of quality and therefore may purchase products not fit for purpose.

With plans to leave the European Union, which would result in possible changes to the free movement of trade, material costs may be affected as most of the raw materials for the yarn industry are imported. The plans to leave the European Union may also affect many suppliers ability to offer 48 hour delivery on their compression products.

8. NEW PRODUCT DESIGN AND TECHNIQUE DEVELOPMENT

CHALLENGES

Garment sizing and fit

For compression garments to exert the correct amount of pressure on to an affected limb, correct measurement of the area as well as correct selection of garment size for the product to work effectively is critical. Too large and the compression level is too low and therefore ineffective. Too tight and the garment could cause discomfort and further medical problems for the patient. There are many challenges surrounding the measurement and fitting of compression garments.

Firstly, many of the manufacturers have different measuring tools and rules for measuring and selecting the correct fitting products. Some are more complex than others, which makes it difficult for clinicians with so many varied products on the market. Many researchers and manufacturers have questioned the best method to measure a patient's affected limb. Currently the basic practise is to use a tape measure at set points on the limb. There is scope for further understanding and this has seen the use of measuring tools such as 3D scanning and water volume method being explored. 3D scanning is of particular interest for the treatment of lymphoedema with its irregular limb swelling as the condition does not always fit within the manufacturers measuring rules. One manufacturer stated that they had been researching into 3D scanning to improve garment fit and highlighted that the research found that the measurement tool could not completely replace the insight and experience that the clinician has when fitting a garment. Their insight into how the condition affects individual patients greatly affected the selection of improved fitted garments.

It must be noted, however, that lymphoedema is a difficult condition to measure due to its particular limb swelling. Measurement for a compression garment generally happens after a patient has received Manual Drainage Therapy. The limb is in a reduced state at this point and the compression garment is fitted to try and maintain the limb shape achieved. From the time the limb is measured and the garment is ordered there is a possibility that the limb may start to swell again. A standard garment size will take 48 hours to be delivered but a custom-made garment can take up to 7 days. Clinicians will aim to measure the patient with the wait in mind but cannot always predict an individual's limb changes.

Garment donning

Due to the high compression and stiffness levels in garments, patients experience issues with putting garments on. Many patients experience other medical conditions as well as lymphoedema. These can include mobility issues, age related issues and weight issues. These of course affect the patients' ability to put on garments. Needing assistance to put on garments affects individuals' lives and their ability to live independently. There are

many products on the market to assist donning of garments but currently there are no aids to assist taking garments off.

Fabric breathability

Due to the yarns and quality of many of the flat knit compression garments currently on the market, patient experience issues relating to the garments being too hot to wear. This is a particular problem in summer and warmer climates. As well as the physical warmth of the garments, there is the issue that in warmer weather the garments are more visually noticeable as people start to wear summer clothes and expose their skin more.

Styling of garments - Compliance Issues

How well a garment fits and feels, whether it feels too warm to wear, how easy it is to put on and take off, and how the garment makes you feel effects whether a patient will wear a garment as recommended by their clinician. A clinician's understanding of how effective a compression garment is for a patient is informed by whether a patient is wearing the garment as regularly recommended and how honest they are with their clinician about their experience with the garment. Compliance is an issue that is currently being researched by other universities relating to compression therapy. This issue will ultimately affect any research moving forward with product development, as all products will need to be trialled on individuals.

DESIGN AND MANUFACTURING CHALLENGES

Seams

The ability of the flat bed knitting process to create 'fashioned' garment pieces with edges that do not require overlocking means that the use of flatlock stitch seams which are considered comfortable for close fitting garments can be used. In addition, the naturally finished edges add to the structural integrity of the overall garment.

To create a woven compression garment, the process would require a cut and sew method of garment creation. This process is considered more time consuming as it requires more finishing. To create a stable and secure seam the garment edge would require hemming before being flat lock stitched. This would result in a bulkier and less comfortable seam.

Yarn tension in manufacturing

The ability to control yarn power, yarn extensibility and overall fabric extension is fundamental to the successful creation of elastic compression garments.

One of the ways developers control yarns within the fabric is through the manufacturing process. How much tension is applied to the yarn through the knit process affects the overall fabric quality. There are multiple points within the knitting process and varied knitting machinery that control the tension of the yarn being input into the fabric. These include tension cams on the knit carriages and tensioning points on the yarn feeds. It is also worth noting that knit machinery manufacturers have developed further ways to control yarn tension within the manufacturing process. Scholl knit machines have the ability to maintain constant yarn tension even when the yarn carriages change direction.

Tension within the manufacture of woven fabric is fundamentally different to knit manufacturing. The basic principle of woven fabric creation sees the insertion of tensioned weft yarns within the open sheds of tensioned warp threads. The tensions are generally set and balanced between the requirements of the fabric and the needs of the loom to run successfully.

Narrow width weaving technology

To gain an insight into varied weaving technologies, the narrow width weaving company, M.Wright & Sons was visited. Varied warp tensions are utilised in the creation of woven bandages and support straps in the narrow width weaving industry. Straps are woven on looms up to 35 cm wide. Using varying stretch elastane yarns in the warp, threads are separated on to different beams and therefore each beam can be individually tensioned using weights. This allows the use of multiple qualities of yarn and creates fabrics that can have varying stretch qualities across the width.

When considering utilising woven structures for varying stretch fabric qualities it is worth noting that 'an open weave fabric offers higher stretch than a close weave. The thread count distribution significantly varies fabric stretch. The finished fabric stretch reduces with an increasing ends and / or picks per inch.' ([20]

Many of their narrow width looms utilised weft insertion technology to create fabrics that had finished edges where some woven fabrics were even technical finished with knitted stitches along one side. This means that the finished fabrics were stable and do not require additional hemming. Most of the looms used within the narrow width industry are set up to weave bandages and ribbons. Structural patterns are created using both dobby and jacquard lifting technology. Narrow width weaving with its multiple warp beam set up could be a possibility for creating woven compression garments but it must be noted, there is currently no demand for larger narrow width jacquard looms and therefore manufacturers are currently only supplying 15mm ribbon weaving widths.

What changes need to be made to accommodate the jacquard technology

To aid the delivery of weft yarns across the loom, the installation of weft accumulators is recommended. As most of the yarns used within the new fabric developments will have high levels of stretch is it vital that the loom is able to control yarn movement. Weft accumulators control the yarns as they move off the cones and gradually release yarn as its feeds into the loom.

Currently the jacquard loom at Coleg Sir Gar has a fixed warp and fabric take up electronic system. This means that vertical threads within the loom have fixed tension and will automatically adjust to set parameters created by the manufacturer. From witnessing the creation of stretch fabrics within the narrow width weaving industry, it is clear that controls and being able to adjust the warp tension is important for the successful development of compression fabrics. With this in mind, it is recommended that the jacquard loom be adjusted to accommodate an adjustable tension warp back beam with a new tension gauge to clearly assess tension input levels.

What manufacturers would need to do:

Legislation changes

Changes to the standards have been in talks for many years with discussions regarding the merging of German and British standards to form a unified European standard being considered. A development from the 1985 British standard has been slow to be realised with one manufacturer claiming that currently the standard is in place to protect manufacturers as much as it is to protect patients and therefore there has been resistance to allow change.

Experimental development

- Should utilise technical developments in yarn production
- Design techniques applied to the fashion and sportswear market should be utilised and developed for medical products.
- Fabric structural development should be explored in both knit and weave constructions. Techniques used within the knit industry for furniture development should be applied and developed for medical products. CAD development in both areas offers up further exploration for product design.

Opportunity for Proof of Concept

Coleg Sir Gar's involvement with the research for this feasibility study has formed part of a larger network of university research established by the Lymphedema Network Wales.

Swansea University College of Engineering is researching to determine the most effective dosage time for compression garments in managing lower limb lymphoedema. Their research currently looks to measure and analyse lymphedema parameters, investigate scan-data processing methods, and undertake software engineering to achieve the desired software prototype functionality.

Swansea University Centre for Health Economics is working to undertake a Health Technology Assessment relating to the value of, and quality-of-life outcomes from conventional measurement and prescription, and from new digital measurement and custom garment design.

Photometrix Ltd is researching the development of a prototype 3D scanner, which will produce data suitable for use by the prototype software.

PDR is a world leading design consultancy and applied research centre. It has a unique approach, blending leading high quality research activity with award winning and highly experienced consultancy practice. Located within Cardiff Metropolitan University it is organised across eight groups, each a leading exponent in its field with an extensive history and back catalogue of projects, innovations and ground breaking knowledge. The Surgical and Prosthetic Design team were awarded a Queen's anniversary prize in 2015 for their work on applying product design techniques to the production of customised surgical devices. In this project, they will synthesise the disparate technical and clinical specialities – both acting as, and creating interfaces between engineering, fundamental science, clinical knowledge, and the development of viable product and service prototypes. They will also design and fabricate the limb phantom.

The Welsh universities are all working closely with the Lymphoedema Network Wales to improve the quality of care and service provided to patients within Wales. As all research is related to lymphoedema, the universities are in a positive position as the research gathered in one area could be shared and aid the development of another. Developments in compression fabrics can be applied to multiple areas of the fashion and sportswear market but working with the parameters of lymphoedema adds a focus to the research.

Trial and Testing

Further research into fabric developments for compression will look to trial unique fabrics designed with a patient-specific focus, accommodating shape distortions and areas of pressure. Utilising ideas from fashion shapewear and the technology available in seamless knitting and jacquard weaving, the fabrics developed will look to contour the affected limb, not only applying compression but also assisting in shaping the limb to its normal shape. Utilising the latest yarn developments available, fabrics trialled will explore how

different structures can control the stretch of inlays yarns whether through knitted yarn tensions or density of woven structures. The research will aim to take forward some of the research gathered from the partner research groups. A catalogue of varying structures with set stretch and compression levels could be developed and then applied to each patient's custom map/pattern.

Fabrics and garments created will be assessed and trialled to an industry standard through the projects stakeholder Surgical Materials Testing Laboratory (SMTL). The test laboratory will supply further research with academic R&D testing at £100 per hour.

Issues related to patient compliance and the demand for more fashion-focused products will be explored through the trialling period with structural details being developed and incorporated. With in-house print facilities and CAD design software available within Coleg Sir Gar's Fashion & Textile Lab further development can be trialled with how the new fabrics take to print techniques.

An understanding of how the compression garments and fabrics will work will be explored through the use of sensors that will read the pressure levels. Both knit and weave technology offer the opportunity for fabrics to incorporate pockets and therefore the development of fabrics with sensors will be explored to coincide with the research taking place within the other universities.

Working to support and address the challenges faced within the Welsh textile industry through textile innovation

Conclusion

'The UK's technical textiles sector was worth over £2 billion in 2016, and the UK remains a major centre for R&D and textiles innovation… Textile innovation in the UK is ranked at No.3 in the world and No.1 in Europe in terms of patents generated between 2000 - 2015.'
***Report* - Alliance report May 2017 p18**

However, the vast majority of textile technology innovation has been located in the English historical textile centres of Lancashire, Yorkshire, Greater Manchester, Leicestershire and Nottinghamshire. The products, advancements, processes and investment have yet to impact on the Welsh economy. For sustainability and to preserve the industrial and heritage nature within Wales there is a need for future proofing the textile industry.

Wales with its traditional methods of clothing manufacture and heritage textile industry has seen 'textiles, leather and clothing production continually and steadily decline at a much faster rate than the rest of the UK.' **Report - *Sector Skills assessment for the fashion and textiles sectors in Wales pub 2011 p18***

In 2012, The Alliance Project (TAP) was established to investigate the UK textile industry and assess whether the industry could compete internationally for trade and be financially profitable. The project discovered early on that although the textile industry could not compete on price with other cheaper international exporters, due to the large demand for textiles products there was still a demand for higher price point products and therefore UK

mills could still operate profitably. This discovery resulted in 5 years of research and engagement with every element of the textile industry between 2012 -2017 and concluded with the report: Realising the growth potential of UK Fashion and Textile Manufacturing published May 2017.

For example, through research and engagement with the industry, TAP highlighted barriers for growth within the sector and looked to establish a model of working to overcome these challenges. Their areas of focus included skills, investment, innovation, and reconnecting supply and demand chains. The in-depth understanding of the industry and its needs established a clear pathway forward, which resulted in £27m of government money and £123m of private sector money invested in the Textile industry in Greater Manchester area alone.

It is clear throughout this feasibility study and research, that the same barriers and challenges face the textile industry in Wales. We have compiled a table of comparison to advise the recommendations to invest in sectorial economic development and investment in order to not only grow the textile industry but to allow for continuation of growth and competitiveness amongst the leading global market.

<table>
<tr><th colspan="2">Table of comparison</th></tr>
<tr><th>UK industry barrier to growth findings outlined by The Alliance Project (TAP)</th><th>Welsh textile industry barrier to growth findings outlined from our feasibility research</th></tr>
<tr><td>• The predominately micro-size nature of the supply chain hampers information exchanges, supply chain integration, and is a challenge to initiating major investment in capital, training and R&D.</td><td rowspan="2">• Unlike the English textile industry, the decline in the Welsh textile industry has resulted in an industry centred on the heritage textile market. The micro-sized mills that make up the Welsh industry have limited capability to modernise.
• The decline of the Welsh textile industry has also resulted in a fragmented supply chain. For instance, there is no longer a textile finishing company within Wales. An awareness of what is currently available to the textile industry within Wales is limited. This ultimately results in business looking outside of Wales for services.</td></tr>
<tr><td>• A lack of ‘prime’ manufacturers to invest in research, innovation and up-skilling; the decline of UK textile manufacturing in the early twentieth century was hastened more by underinvestment in implementing technology rather than developing it.</td></tr>
<tr><td>• A growing skills gap and ageing workforce created by a lack of investment in training and negative image of the industry as a career path.</td><td>• The Welsh textiles industry has an ageing workforce. Currently many mills are experiencing a lack of recruitment for skilled labour. Due to the micro-size nature of the businesses, the skills required are diverse and generally unique to each manufacturer. The factors affecting recruitment include negative industry image, a lack of</td></tr>
</table>

	modernisation of working environments, remote locations, and limited financial resources to train new staff. • The results of off-shoring at the start of the century has resulted in a loss of high level skills. This can be seen in the garment manufacturing industry in Wales. Micro businesses are struggling to get products to market due to the limited availability of trained staff to sample and manufacture.

Recommendations

Using The Alliance Project as an example of a successful model, it is very clear that innovation alone is not going to improve the Welsh textile industry. It is evident from the feasibility study research that there is currently limited substructure to underpin the transformational changes needed to drive forward improvements and investment to support the Welsh textile industry. Exploring further opportunities to advance technology through further engagement with Academia, to create new products and processes that will offer the industry competitiveness at a global market platform.

Currently the Welsh textile industry is receiving limited financial investment. This has not been the case of the English textile industry where through the support of TAP the textile industry received £150 million worth of investment. This investment successfully supported the creation of 4,450 high skill jobs and 380 apprenticeships over the 5-year period of the project.

A financial investment in the Welsh textile industry is critical to advance the sector in both growth and inward investment.

One key barrier to highlight is that due to the decline of the industry, Wales now has fragmented into an industry of micro businesses that are relatively isolated with limited resources and knowledge of supply chain to engage beyond the demands of their production. This isolation has created a lack of awareness to the resources that are available in Wales. Restoring the textile network through Design Wales or such an industry forum can support opportunities for collaboration and shared knowledge. Marketing the current and future industries advance manufacturing and product development.

An example of such is the Make Works online platform, which bridges the gap between isolated manufacturers and business. Currently displaying mainly Scottish textile manufacturers, the website highlights the capabilities of presenting the industry sector as a collective, whilst enabling each mill to promote services and equipment and products available.

The textile industry is an important part of the supply chain for multiple industries within the UK. These include but are not limited to the pioneering involvement of textiles within aerospace, automotive, medical and construction industries. Innovation and investment

within the textile industry automatically affects economic growth in other sectors within not only Wales but the UK.

Having considered the UK context and recent developments, we propose the following plan of recommendations to inform and facilitate the growth and sustainability of the Welsh textiles sector with a particular focus on innovation and entrepreneurship.

Recommendation for the Welsh textile industry				
		Phases		
Growth barriers within the Welsh textile industry	**Recommended actions to overcome barriers**	**Year 1**	**Year 2**	**Year 3**
The decline of the Welsh textile industry has also resulted in a fragmented supply chain.	Re-establish a textile industry advisory group within Wales to support industry with innovative product, advanced technology, growth and development			
	Expand network of industry and academic contacts both in Wales and Europe.			
	Catalogue and map Welsh textile industry – skills, equipment and products manufactured.			
The Welsh textile industry is made up of micro-sized businesses with limited ability to modernise, grow and engage with innovation research.	Invite UK technical textile leaders to Wales to promote the textile industries current developments			
	Increase opportunities to engage with innovation and business specialists to establish support and routes to market for Welsh businesses			
	Establish links with Welsh businesses that have capacity to take forward new research and product development			
	Present new findings and technology developments to network			
	Raise the profile of textile innovation to the Welsh textile industry			
The Welsh textiles industry has an ageing	Engage with further and higher education providers to establish training support for businesses			
	Engage with businesses to assess current and future skill gaps			

workforce and a growing skills gap.	Engage with local councils to understand where there maybe support and need business and marketing support			

Next steps

From the work undertaken in this feasibility, there are clearly three key observations:-

Welsh Government

- The need from a Government perspective to enhance the level of support and investment, to create greater opportunities to advance the industry, futureproofing and protecting a declining skilled profession within Wales. It will be with sadness that these micro industries will not be protected and what was once thriving, influential and affluent industry will not figure within the global competitive market. This will also mean a considerable cost to the economy with oversees sales to other textile manufacturers.
- The need to develop network and marketing of current textile industries their products and services to maximise potential opportunities and exploit new developments at a greater influential height
- Create closer collaboration partnerships between academia, industry and Textile forums. This will align and influence the education offering and further support research and innovation new product development.

Coleg Sir Gar

It was identified through the research undertaken by the established expertise within the Textiles Research centre at Jobs Well campus that the opportunity Coleg Sir Gar has to support new product development could stimulate and influence the sector; working alongside other research academies and HE.

In the first instance and as already industry led the college will establish links with NHS to embark on the potential of Jacquard weaving within medical compresses. We will work with other Higher Education institutions to explore the incorporation of other pioneering product development such as fibre optics, which sense change in fluid to notify patients that there is a need to reduce the pressure of the compression Garment. This fibre optics could potentially be woven into the design.

In order to do this we will utilise SMART funding or possible Health funding direct from Welsh Govermnent.

Industrial Research

- Present feasibility study findings to academic and industry partners
- Establish a patient and clinician advisory group to gather further research and feedback on project development
- Catalogue used processes and technologies

- Research and record material and fibre findings and developments related to varied compression fabrics
- Catalogue and map Welsh textile industry – skills, equipment and products manufactured. This will aim to highlight an opportunities with the project moving forward as well as highlight any gaps with potential product manufacturing
- Research into the sensor technology and how it can inform and assist our product development
- Work with Surgical Materials Testing Laboratory to establish a standard for working and recording fabric and prototype developments

Stakeholder engagement

Date	With whom	How many took part	Method used	Main findings
18/01/2017	Andy Holman, Managing Director of Medi UK	2	Informal conversation	
19/01/2017	George Wright, Director at M.Wright & Sons	2	Informal conversation	- Minimum manufacturing quantities for stretch yarns means supply is difficult for R&D projects and small batch production and bespoke yarn costs are high - Company creates their own stretch warps in house
24/01/2017	Gavin Hughes	2	Visit to SMTL with formal meeting and test equipment demonstration	- Pressure levels in 1985 BS standard are considered quite low. - Standard issues with manufacturers changing product qualities after tender contract has been awarded - BS standard for graduated compression is more of a method for testing than a standard. - Testing has found that products are not meeting their directed compression levels - 400 patients complain about their compression garments per year but Gavin questions how many more do not complain - There are limitations with the test equipment as it has been built for smaller leg sizes - The BS standard does not test the stocking bands

01/02/2017	Andy Holman	2	Visit to MEDI UK with formal meeting	- British Standard does not test the stiffness of the fabric. MEDI UK want the static stiffness index included in the standard. - Compression garments are classed as Class 1 medical devices and therefore do not require testing before being sold. Products can be self-certified. - Medi's sport compression garments are believed to improve performance by 5% - Many companies are selling flight socks based on shoe sizes; however, the fit is actually based on ankle size. Therefore people are being misguided and are likely to be purchasing the wrong fit. - When products are selected for the UK drug tariff, they are assessed on criteria such as price, service and delivery. Products are not tested for safety and quality. - Medi products do not use rubber due to latex allergies - Previous Medi research created 3D images of limbs to inform manufacturing but study found it lacked clinician insight into skin and limb quality to improve outcomes - Medi products do not contain cotton due to their belief that is has quality issues
02/02/2017	Neil Wale and Rob Weedon from Stretchline Ltd	3	Factory tour and meeting	- Stretchline manufacture and supply 100 different varieties of stretch yarn. Uniquely created for each company - Rubber is cheaper - Elastane recovers more, has a longer shelf life and is a cleaner product to create in the manufacturing process.
02/02/2017	George Wright and Ruth From M.Wright & Sons LTD	3	Factory tour and formal meeting	- Medical textile products tend to have a short use period and therefore price is considered more important than quality - Most stretch medical products are now being knitted - Business has moved towards engineered short run specialist fabric production - 350mm is the widest elastic fabric that they produce as on shuttle looms it is not economical to weave wide stretch fabrics.

15/02/2017	Darren Hill and Giles at Camira Technical Knitting	3	Factory visit, software demonstration and formal meeting	- 3D knit technology reduces manufacturing costs as it removes the Cut and Sew method - It takes 18 months of R & D to develop new products - From their in house testing they believe that knitted fabric creates an even pressure when sat on and therefore is better at shaping and comfort than woven fabrics. - Zero waste in their knit production. Woven fabric production still works to cut and sew method and therefore creates more waste. - Input tension is key to successful knit production - Knit software allows stitch by stitch all over pattern designs - Technician believes that they are able to achieve woven quality fabrics within their knit process
15/02/2017	Miles Cain Stretchline	2	Informal meeting	Outline current research into their stretch seams and production methods
16/02/2017	Peter Sallis from Sallis Healthcare	2	Factory visit and meeting	- The British Standard for graduated compression is currently up for review - Believes there should be a standard and set test method for lymphoedema products. Manufacturers would like to see more guidance on correct compression levels for illness. He believes this would also inform the NHS when purchasing the products. - Sallis Healthcare can manufacture 1 pair of stockings every 10 minutes on each circular knitting machine - Currently using inlay copper yarns for sports garments - It is not cost effective for his company to manufacture large quantities and therefore short run production such as lymphoedema compression garments are suitable for UK manufacturers.

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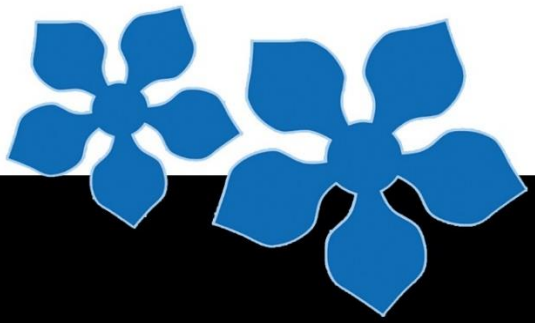

Rhan o / Part of:

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