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CRAFT

SYTHESIS REPORT

Project number: CR-1069- 91
Contract number: BRE2.CT93.0631
Code name: KNIT-CO-OP
Starting date: 1-12-93 **Duration: 24 months**

Title: Development of printing and Continuous finishing operations for knitted fabrics, based on a new machine concept.

Scientific officer: Mr. F. Sgarbi

Project technical Adviser: Prof. Deliège, E.M.E.

Industrial proposers:	**Belgaknit, prime proposer, Belgium**
	Adalberto pinto Da Silva, Portugal
	Carl Meiser, Germany
	Van Damme, Belgium
	Maryann's Style, France
	Interposer, Portugal
sponsors	**Febeltex, Belgium**
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SYNTHESIS REPORT

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2. INTRODUCTION

At present the majority of the finishing and dyeing operations of knitted materials are performed in batch processes. The main reason is that for continuous processes (e.g. foulard impregnation) high tensions are put on the material and knitted goods are very sensitive to it. This can result in a permanent disorientation of the knitted structure and in a poor shrink resistance during home laundering.

The general objective of the project is the development of continuous, finishing and printing processes for knitted materials, preventing tension to the knitted fabric.
The proposed process is based on the magno-roll concept, developed by Zimrner and originally applied in paper manufacturing. Since only limited tension is applied to the materials, delicate goods such as knitted fabrics can be treated. Based on this technology two different installations were investigated: a GMA magno-roll system, for the application of finishing liquids to the fabric and a magno-roll multi colour (screen) printing line.

During the project the integration of the technology into continuous lines was studied and optimised and implemental ion into a variety of applications was developed. The major advantages envisaged are situated in the field of productivity, flexibility, quality, economics in energy and chemicals and especially the environment. In a batch finishing process up to 50 % of the chemicals applied are discharged with the waste water, while a continuous process can be operated with zero pollution. Also some of the batch dyeing processes - highly polluting the environment - might be replaced by a cheap pigment printing process having zero pollution,

3. OVERVIEW OF GENERAL OBJECTIVES OF THE PROJECT

For the realisation of the research programme, a CRAFT project was introduced and accepted by the European commission.

The project was performed by an international consortium composed of industrial partners active in several fields of the knitwear processing.
The active partners are:

Belgaknit (B) prime proposer, Carl Meiser {G) and Adalberto Pinto da Silva (P) active in printing and chemical finishing of knitwear,
Interhoser (P), C. Van Damrne (B), Maryann's Style (F); confection of knitwear,
Centexbel (B) (co-ordinator) and Citeve (P) as research institutes,

The project was also sponsored by Febeltex (B) and Zimmer (A).
The project was followed by Mr. Sgarbi (F), as scientific officer of the CEC and by Prof. Deliège (B), the project technical advisor assigned by the CEC, who also contributed to the success of the project.

The research project was defined in the following tasks :

3.1 INTEGRATION OF THE NEW-MACHINE CONCEPT IN THE THERMOFIXATION LINE

The Zimmer equipment had to be integrated in the continuous printing and finishing lines.
During the project it was shown that the combination of a GMA application system, integrated on a printing line could offer large advantages, this is the reason why this combination (which was never realised on an industrial scale before) was examined also.

3.2 OPTIMISATION AND CONTROL OF THE ADD-ON AND PENETRATION.

To obtain a reproducible and optimal finishing effect, it is essential to measure the add-on and penetration of the finishing liquid. A mathematical model describing the add-on as function of machine and processing parameters was developed. This should lead to a better understanding of the process and specific adaptations according to the effects envisaged,
Towards printing the objective was to obtain a sufficiently high add-on and penetration in order to obtain a "uni-colour dyeing effect" both in width, length and on both sides of the fabric using *e screen printing technology.

3.3 DEVELOPMENT OF SPECIFIC RECIPES AND SEMI-INDUSTRIAL TRIALS

Both for **the** "printing" and for the "finishing" application the project aimed at optimising recipes both from a technological, economical and ecological point of view. to enlarge the number of applications (e.g. special finishes) and to increase the overall quality of the final product.

3.4 EVALUATION OF GARMENT MANUFACTURING AND WASH-AND-WEAR PROPERTIES

Evaluation methods regarding the processability of the fabric were developed in order to allow confection firms to make better control of the incoming materials. The experimental materials produced on the Magno-roil systems, are evaluated during confection trials and for *their* wash- and wear-properties.

3.5 FINAL *ECONOMICAL AND* ECOLOGICAL EVALUATION.

The potential economical benefits of the use of the magno-roll system both for printing and finishing and of the developed know-how was evaluated in order to examine the exploitation possibilities. Also the ecological aspects, savings of water and chemicals, were included.

More details concerning the planned time schedule and man-power allocation are given in the final technical report.

4. TECHNICAL OVERVIEW - RESULTS

The project could be earned out according to the originally planned programme and time schedule. Only minor adaptations were needed due to technical problems that couldn't be overcome. The main results are summarised in the following pages. Further details are given in the final technical report.

4.1 INTEGRATION OF THE NEW-MACHINE CONCEPT IN THE THERMOFIXATION LINE

For a better understanding a scheme of the GMA Magno-Roll finishing applicator and the printing line based on the magno-roll concept are presented in figure 1 and 2.

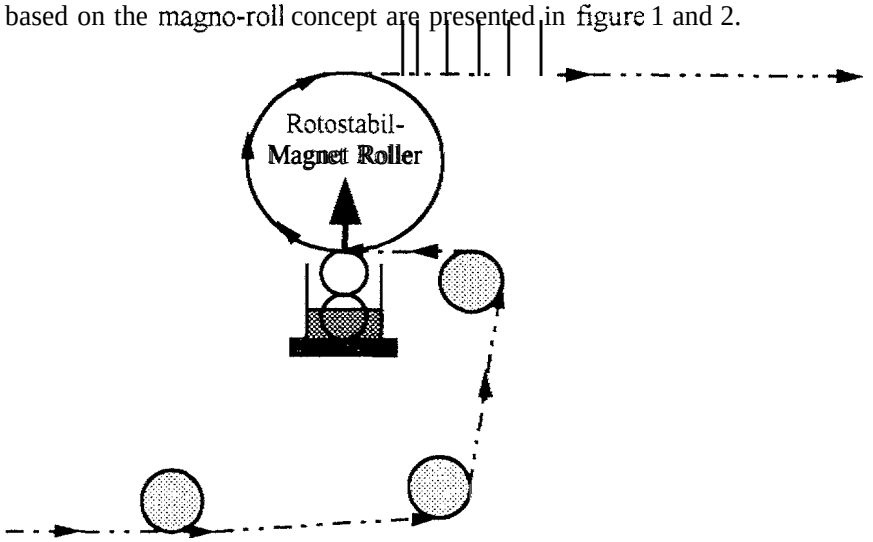

Figure 1.: Scheme of a GMA magno-roll system

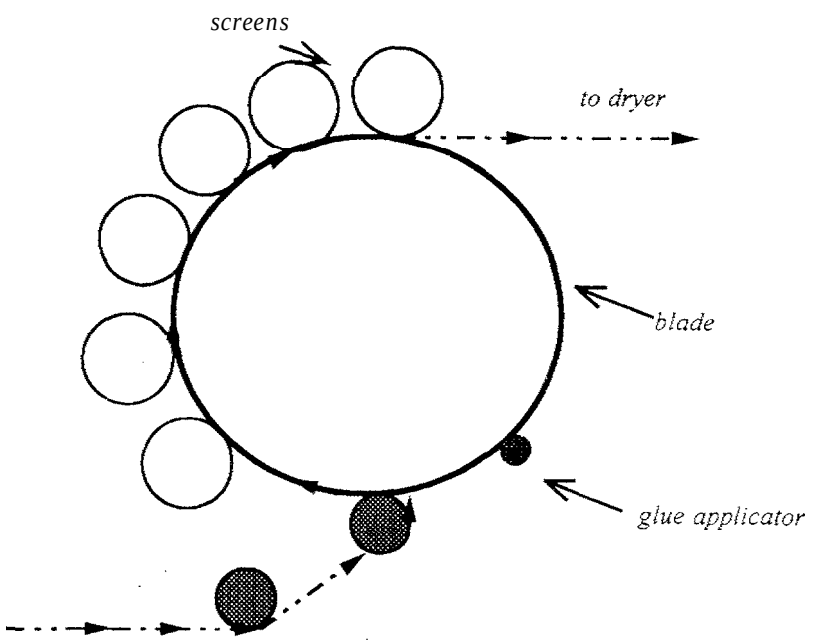

Figure 2.: Scheme of a six-dour magno-roll printing line.

The GMA system was integrated into a stenter frame. The integration could be successfully accomplished.
Special attention had to be given to synchronisation of the equipment with the other line elements. since an overfeed of the knitwear has to be made to allow some shrinkage during the thermofixation action,
Before the knitwear is presented to the printing or finishing machine. a perfect opening, centralizing and decurling has to be obtained. This was realised by a combination of commercially available technical devices such as spiral rolls, lattice rollers, pneumatic or mechanical decurlers. Only the decurling action was insufficient since the commercial available decurlers couldn't be placed just near the magno-roll and the material started to curl again before it reached the magno-roll. To solve this problem a very small home-made pneumatic decurler was installed.
The problem of dust and lint could be largely reduced by installation of "glue rollers", a shield between the opening of the knitwear and the finishing part and by installation of a filtration system on the GMA applicator,

4.2 OPTIMISATION AND CONTROL OF THE ADD-ON AND PENETRATION

To optimise printing and finishing applications and develop new ones, it is essential to have full control on the add-on and the penetration. The add-on is defined as the amount (g/m^2) of finishing liquid (water and chemicals) that is transferred to the fabric, The add-on and the penetration should be altered in function of machine and processing parameters and material characteristics,

In order to measure the add-on during finishing, humidity sensors were installed on the industrial line: a contact humidity sensor in front of the line (low humidity content) and an µ-wave humidity sensor after the GMA application unit (higher humidity content),
The measurement with the p-wave system gives a value not on an absolute scale. A calibration was therefore developed to determine the water content. expressed as g/m^2. Although the accuracy of the p-wave sensor is influenced somewhat by the distribution of the added water, the accuracy is still sufficient to calculate the add-on of water and of the chemicals. Using this measuring technique, it was shown clearly that the add-on depends strongly on fabric quality (% printed area) and only marginally on application conditions, This means that steering possibilities (varying the add-on according to the fabric needs) are limited. For this reason it is also impossible to develop a model for the add-on.
The penetration of finishing liquids is normally limited on printed fabrics but good on hydrophilic materials (bleached fabric). This offers opportunities for pigment dyeing.

Regarding the objective to obtain a homogeneous colour on both sides of the fabric, by using the screen printing equipment it was shown that this is not possible using either a magno-roll or a traditional printing machine. The amount of print paste transferred to the fabric remains too low and too mutt colour differences are observed.
However an alternative is offered by using the magno-roll GMA system originally developed for the finish application. By replacement of the finish liquid by a pigment dye formulation, and selection of the appropriate processing conditions one can transfer a sufficiently large amount of dye solution to the fabric. If the fabric is prepared well (bleached) the penetration of the dye solution is perfect and no colour differences will be observed between the two sides of the fabric. So using the GMA system a homogeneous pigment dyeing effect can be obtained.
By combining the GMA pigment dyeing with the magno-roll pigment printing in one single operation, a new and interesting process is created for wet on wet printing. This offers an enormous amount of possibilities for new creative designs at very low process costs.

4.3 DEVELOPMENT OF SPECIFIC RECIPES AND SEMI-INDUSTRIAL TRIALS

A large number of finishing recipes were tested at the laboratory of Centexbel on several knitted fabrics from Belgaknit (different qualities and printed or not printed materials),
Some experiments were performed on the industrial line during the second year of the research. The recipes combine several additives together to obtain an improvement cm softness, water-, oil- and soilrepellent, flame retardancy, sewability and/or curling behaviour.
The general conclusion of all these trials was that chemicals, normally used for foulard application on woven materials, can be used on the magno-roll finishing equipment.

A recipe with softeners, based on the discontinuous softening procedure, was first optimised. A distinct improvement in softness could be seen when compared with the not finished reference sample. In between the laboratory finished sample and an industrial finished knitted fabric on the Magno-roll equipment, the difference is however small.

Several recipes have been tested to make the knitted fabric water-, oil- and soil-repellent. The different products were examined in function of their concentration and in combination with other finishes. All products seemed to be sufficient for the oil- and soilrepellent effect, Water repellency is however difficult to obtain in comparison with woven fabrics. This is due to structural differences. Since knitwear has a more open structure and can be deformed more easily. water repellence will remain always inferior, unless a very compact knitted structure (microfibres) is used.

Another finishing application was to make the material flame retardant. A first series of trials were performed on knitted fabric suited for children clothing. AH the treated samples were - just after application - sufficient flame retardant. Sometimes there is a "light" colour change and a change in grip (= stiffer) when applying a very high concentration. This sensation is gone after washing,
A second series of trials were started *on* knitted fabric used in the automotive industry. The result was - even in combination with other products used (products for the stabilisation of lycra containing knitted fabric) - very good. The finish is however not wash-resistant.

For the printing application, "eco-recipes" are defined, taking into account the formaldehyde content and selection of eco-acceptable d-yes (absence of arylamines and heavy metals).
Also recipes are developed for pigment dyeing using the GMA system and wet on wet printing. Special attention is given to obtain an homogeneous dye effect, a high coverage. sharp definition. high fastness (wash and crock-fastness) and a limited stiffness. The recipes offering the best compromise are tested on larger semi-industrial scale,

For details on specific recipes evaluated and the obtained results, we refer to the specific technical report.

4.4 EVALUATION OF GARMENT MANUFACTURING AND WASH-AND-WEAR PROPERTIES

On demand of the confection partners some evaluation methods regarding processability of the fabric were evaluated: the determination of the curl tendency of knitwear and the ability to facilitate sewing during confection.
The routine processing of knitwear in production is difficult by the edge curl tendency of these fabrics. Independently of the stitch forming process, the beginning and end of the fabric piece and the selvedges these fabrics cud inwards. Several methods to determine the curl tendency were evaluated on industrial samples with different weight/m² and composition. A good correlation was found between the subjective quotation of the confection possibility and the result of the objective methods to determine the curl tendency. These relatively simple measuring techniques can be easily integrated in a systematic analysis of the incoming materials.

In order to evaluate the final quality and confection properties of the printed and finished articles a final set of finishing trials were prepared under industrial circumstances.
Two different qualities (composition: 100% cotton and 95% cotton/lycra) were considered and treated in the following circumstances : finished continuous (with the Zimmer apparatus) , finished discontinuous and printed or not printed.
Several evaluations were made on these samples : the determination of the colour fastness to rubbing and washing, the determination of the curl tendency of the knitwear and the ability to facilitate sewing during confection. The examples showed very clearly that continuous finishing with the Zimmer installation on pigment printed articles offers a nearly perfect stabilisation (decurling effect is perfect) of the treated fabrics. One could also observe that the printed articles finished with the continuous GMA application system offer the best processability. Even with the larger needles the damage to the fabric is minimal. Especially the materials containing lycra that normally have a high curling tendency are nearly perfectly flat and have the best processability. There is no difference in result between the discontinue finished knitted cotton article and the continue finished cotton tit-ted fabrics.

The finished knitted samples were also evaluated for their garment manufacturing properties since these properties have a great influence upon the costs of the confection process. Therefore full scale confection and embroidery tests were performed to illustrate the benefits of the applied technology.
Especially the benefits in the case of automated confection are important. Knitted fabric that still curls during automated confection can easily cause a drop in the production efficiency to 30% of the normal production value. Continuous finishing using the GMA magno-roll finishing system (Zimmer) can offer a perfectly finished and stable fabric that can be processed with full-automatic sewing machines.

Also for the growing field of technical lad-wear textiles the GMA magno-roll finishing process offers special advantages since a larger range of chemicals can be applied and higher requirements of the finishing are requested since the further processing is often automated or performed with larger needles and thicker yams.

4.5 FINAL ECONOMICAL AND ECOLOGICAL EVALUATION

Based on the results mentioned above the major advantages of the magno-roll finishing and printing equipment can be summarised as follows:

FOR THE FINISHING APPLICATION

- tensionless continuous finishing of knitwear,
- reduction of process time (a discontinuous process. taking 30 to 60 minutes of time, is replaced by an integrated continuous treatment),
- reduction in water (up to 90%) and chemical consumption (up to ***500/0),***
- ecological advantages since no **water** nor chemicals are discarded,
- improved quality towards (automated) confection and end-uses; raised production efficiency with. I O up to 70°A,
- large range of functional finishes: also chemicals that are less stable in a process bath can be used,
- special possibilities for technical textiles (automotive, medical, mattress) due to high processing demands.

FOR IWE PRINTING APPLICATION

- lower investment costs (20% lower than traditional machine),
- compact machine (less room needed),
- only one operator needed at limited speed,
- low water and glue consumption,
- possibilities to combine "GMA" system on the printing line,
- creates dyeing possibilities (same colour on both fabric sides).
- the integrated pigment dyeing can for some applications replace the expensive and polluting, discontinuous dyeing process with reactive dyes,
- pigment dyeing and wet on wet printing possibilities in one operation offers large possibilities for new creative designs at a very competitive price.

Only one remaining weak point should be mentioned: during finishing there are only limited possibilities to adapt the add-onto the specific fabric needs during processing.

5. CONCLUSIONS

In general we can conclude that the printers and finishers in the project have succeeded in optimising the implementation of the magno-roll systems in their production. A better knowledge and control of the systems is obtained and the number of potential applications could be increased considerably.

Firms which will invest in the technology and in the developed know-how can come much faster to an optimal use of the systems and will benefit from the economical and ecological advantages.

The combined pigment dyeing and wet on wet printing offer enormous advantages compared to the traditional discontinuous (reactive) dyeing and printing in separated steps. Confection, especially the automated sewing, can benefit from the improved processability and quality of the final products due to the improved finishing operation. Also the growing field of technical knitted textiles can benefit from the increased possibilities and quality of the finishing operation.