PROJECT FINAL REPORT

Grant Agreement number:*CP-FP 214181-2*

Project acronym: *MODSIMTex*

Project title: Development of a rapid configuration system for textile production machinery based on the physical behaviour simulation of precision textile structures.

Funding Scheme: Collaborative Project

Period covered: **from** 1st November, 2008 **to**30th April, 2012

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4.1.1. Summary

Introduction and General Technical Goals

The textile industry faces important challenges regarding the production of new advanced textile products. It is not possible to define the characteristics and parameters of a given textile structure due to the difficulty of measuring them. This situation makes very difficult to configure the machines involved in the production of such textiles; the typical practices consists in manufacturing samples and through trial and error adjust the processing operations until the desired characteristics are achieved in the final product. With this procedure it's very expensive to match the designer's idea with the final product. The production setup takes a long amount of time and efforts and increases the cost of the final product. This is especially critical when a company is trying to develop new technical textiles. The vast majority of the existing systems capable to simulate textile products are limited to the visual representation, without any kind of mechanical or physical evaluation of the properties of the textile structures. Of course, these tools don't take into account the configuration of the production machinery, so they aren't capable of help in the setup of production machinery. Unlike these conventional design systems, the core of this project has been the development of a virtual simulation system of the physical-mechanical properties of the textile structures oriented to the fast setup of the machines involved in the whole textile chain manufacturing process (yarns, woven fabrics, knit fabrics, needle-punch non-woven, hydro-tangled non-woven, and composite structures). This virtual construction system allows the prediction of the multifunctional textile performance before the actual textile is manufactured allowing the settings of the production machines to be either an input or an output of the computation thus reducing dramatically the effort and cost to produce small batches or develop a new advanced technological textile.

MODSIMTex Project Partners

The research of this project has being developed by 5 textile institutes/universities (INTEXTER-UPC, KEMLG-UPC, TU-LODZ, TU-LIBEREC, STFI and DITF-MR), members of Autex and Textranet. Combining the knowledge of these organizations, the full spectrum of textile knowledge, and more specifically, the knowledge on the simulation of textile structures physical properties has been covered by this project and has allowed the successful achievement of the objectives.

Each member in the consortium has contributed in the project with an indispensable expertise area: INTEXTER-UPC has given its proven experience in managing European projects and also its knowledge of textile image processing and spinning techniques, TU-LODZ and TU-LIBEREC gave a high skill in mathematical models, simulation and A.I applied to textiles, and STFI is in the lead of the non-woven research area in Europe. The software development was mainly executed by INFOTEX, which sells its textile design software to all Europe. The required online analysis and metrology has been completely assured by the participation of BMS bvba, the world leader in on-line textile monitoring and process control. DITF-MR collaborated in this project with its high expertise in innovation management and information technologies in order to continuously assess innovation level and therefore the success of the system to be developed.

The critical mass at the industrial participation level is excellent since this project has gathered 2 of the most important European textile machinery constructors (TFA alfas.r.o and SANTONI SPA) and 3 of the major textile manufacturers in Europe (Heimbach GmbH & Co. KG, Gebr. Röders AG and SINTEX, s.r.o.); the expertise of these 5 companies in the textile processes knowledge (manufacturing parameters, knowledge

on the products, machinery) has been invaluable to develop the integration of the simulation software MODSIMTEX in the textile machinery.

4.1.2. Summary description of project context and objectives

The textile industry faces important challenges regarding the design of multifunctional textile products, because of the enormous difficulty to relate the design/processing parameters of the component materials with the quality parameters of the resulting textile structure. It is often impossible to define the characteristics and attributes of a given textile structure due to the difficulty (and sometimes impossibility) of measuring these parameters (parameters like flexibility and compressibility of some kind of fabrics). New multifunctional textiles have to meet a long list of quality and usage requirements with their attributes. Furthermore, product performance failures are unacceptable because there is clear risk of functionality loss and in consequence, sometimes danger for human life.

Up to now, the typical development practice for multifunctional textiles is to adjust the processing parameters and modifying preliminary products by trial and error, producing samples until the desired quality parameters, design and functionality can be safely achieved during production.

This procedure accumulates problems along the manufacturing value chain (for instance, a deviation in the specifications of a yarn can produce a fabric that doesn't match the required performance or functionality), moreover, it proves very difficult to match the designer's idea with the final product. Furthermore, this procedure costs a lot of time and effort and therefore makes prototype development a very expensive process with high energy and material waste. This is especially critical when a company develops new multifunctional technical textiles. In order to overcome this obsolete paradigm, there is a need for the development of new tools for rapid prototyping and production setup of these multifunctional textiles taking into account the simulation of their physical behaviour. The concept is shown in the following figure:

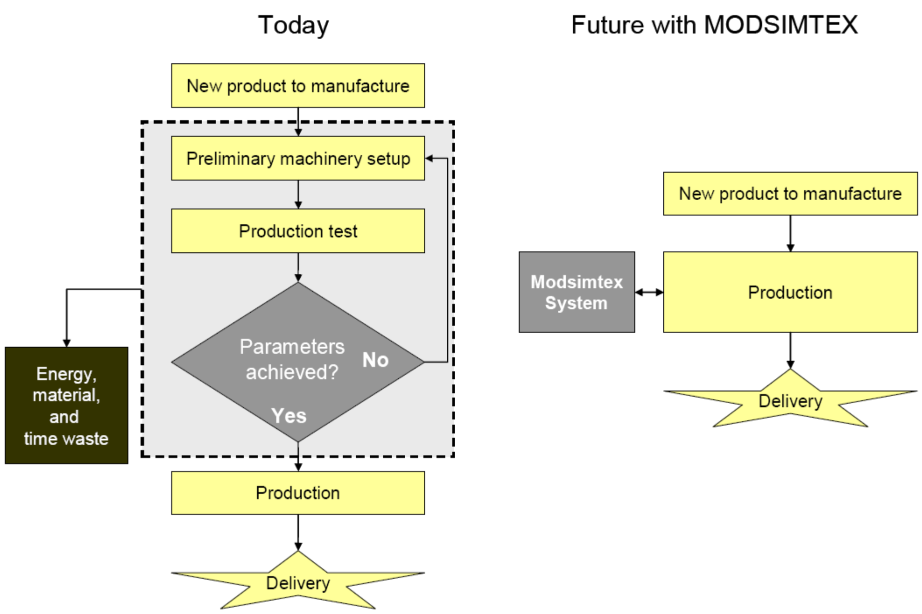

Fig.Modsimtex concept

The vast majority of the currently available textile design software applications, which are capable to graphically represent textile structures, are limited to the visual representation, without any kind of mechanical or physical evaluation of the properties of the textile structures. Since their only mission is to represent the visual image of the yarns/fabrics, these software tools do not take raw materials, types of structures or their influence over the physical properties of the final textile into account. None of these currently available applications is capable to simulate the physical-mechanical properties and behaviour of the textiles. Hence these systems lack the ability to assist in the rapid manufacturing process configuration.

To overcome the described functionality limits of the currently available textile design systems, the objective of this project has been the development of a simulation system for the physical-mechanical properties of the textile structures that enables the rapid manufacturing process configuration. The system supports the product development and production for all products in textile value-added chain (yarns, woven fabrics, knitware, and needle-punch non-wovens). This virtual construction system allows the performance prediction of multifunctional textiles before the starting to manufacture. Production machine settings can be both computation input an output. This will thus reduce dramatically the effort to produce small production lots and the process setting-up times (small or large lots).

The project has had therefore the following main objectives:

- Development of the simulation model of the physical properties of the basic structural units that compose the multifunctional textile structures. Mathematical models have been developed to simulate the behaviour of the 4 textile structures studied in this project (yarns, woven fabrics, knit fabrics and non-woven fabrics). Starting from their manufacturing parameters and machinery setup.
- Development of a finite elements simulation system to simulate the physical properties of the textile structures, based on the mathematical models developed for these textile structures.
- Development of an artificial-intelligence based simulation system for the physical properties of textile structures. This A.I. based simulation system complements the results of the finite elements simulation system to fill in the gaps where the finite elements system cannot simulate. The composition of both systems generates a very strong and robust composed system that generates precise results
- Implementation of the 2 simulation models (finite elements and A.I.) in one single composed simulation system that is the core of the MODSIMtex software package which has been the final milestone of the project.
- Integration of the simulation system results into the manufacturing process through the adequate interfaces, to produce real multifunctional textiles using the parameters established during the design process with the simulation software MODSIMtex. This way the design phase and the manufacturing phase are seamlessly integrated for the first time in the textile industry. This integrated software package MODSIMtexhas been focused to the final user, and it has been the final deliverable of the project. The software has been divided into many modules oriented to each kind of machine inside the process, in order to be adapted specifically to it.

4.1.3. Description of the main S&T results/foregrounds

4.1.3.1. Spinning group

Workgroup Objectives

- To exactly define which were the parameters that the system needed as inputs, as well as the resulting properties.
- This parameters and properties had to accomplish the objective of not adding complexity to the simulation system, and at the same time, be capable of exactly defining the yarn structure from the point of view of the system user (mainly Sintex). The functional range of the simulation system was established.
- Establish the AI simulation system requirements in the Spinning field, as needed for the correct integration of both systems. The exact functional parameters of the machinery to be used were also specified, in order to adapt the simulation and the A.I. system to the production spinning machines, which was the final objective of the project
- To obtain an analytical and mathematical model that describes the physical behaviour of the yarn produced with the most important spinning processes: ring and OE-Rotor. These parameters were obtained in the WP 1 and were the basis for the final model.
- To develop yarn analytical and mathematical models to simulate the physical behaviour of the yarn structural units.
- Developing of yarn samples and analyse them,obtaining reliable methods in order to determine the physical properties to test the validity of the models developed.
- Experimental measurements were also carried out using standards and these new analysis methods.
- The A.I. development partners were provided with the information needed for them to represent correctly the problem, helping them to select the righ method and tool to the project.
- A table of relationships between the variables of the process were defined, focused in the integration of the CBR system,along with the rest of algorithms to estimate parameters of the spinning process.

Scientific Objectives

The main scientific objective were the development of a software tool (integrated in the software platform of Modsimtex) that provides a complete technical solution for the product development and production problems of the staple fibres spinning mills, estimating with reliability the complete list of process settings as well as the total relevant product properties, as requested for the user, for a wide range of yarns in terms of fineness and raw material, using the combination of existing techniques, models and algorithms as well as new ones developed explicitly inside the Project.

To achieve this global scientific objective, many partial and progressive objectives were defined; the most relevant were:

- Study of the different spinning processes used by Sintex and spinning mills in general, identifying the key variables, (inputs and outputs) as well as the most appropriate method for calculating them, applying different techniques progressively, in order to reduce degrees of freedom, starting from the most reliable methods.
- Study of the state of the art in order to identify existing mathematical models able to be applied in any step of the process and adapt them to the problem, defining their validity range.

- Development of new mathematical models, when suitable for the estimation of variables not covered by existing models (for both estimation of product properties as well as the settings of the product process).
- Configuration of A.I. techniques (CBR and ANN) in order to provide a robust answer to the variables that cannot be estimated in any other way or to increase the confidence degree of the estimations provided by some models.

Integration within the MODSIMTex Framework

The final objective for integration in the spinning group was to provide to the Modsimtex system the functionality described as the first scientific objective. The industrial partner now has an application that allows him to store all his products and processes information and lets him try to find new improved product properties or optimize specific processes in a web interface, by only providing the desired product properties.

The final product obtained is the DITF Retrieval System with the added functionality of MODSIMTex. Sintex also produces fabrics, so he needs the woven fabrics functionality,too;althougin this case the graphical representation is more relevant for them (just for fabrics, not for yarn).

Two main integration concepts were implemented in the final software for Sintex:

- A general system (suitable for most spinning mills): DITF retrieval system with the functionality of Modsimtex added
- A Sintexspecific system: anapplication covering the key aspects from the yarn to the fabric. For this, the DITF equation solver was the choice, as it can be easily manteined and upgraded by the end-user

Spinning workgroup activities

Analysis of the Industry Partner's Business Processes

Sintexwas the spinning industrial partner of the project. It is a small spinning and weaving mill, and sells both yarn and fabric, using also its own yarns for the weaving processes.

Their spinning plant is focused in the production of short-fiber yarns from flock of natural fibers, man-made fibers or blends.

The machinery available in the spinning line of the company allows them to cover a wide range of raw materials and yarn counts, but always working with short-fiber:

The company is only using one spinning technology: compact spinning (from Rieter in their case). This technology, (based upon a modification in the spinning triangle of the conventional ring spinning machine) allows them to produce high quality yarns (as this technology reduces significantly hairiness and improves evenness and strength under certain production settings (1) (2)), covering final uses especially for sport and work protection textiles between others. The machine is able to work as a standard ring spinning machine (removing suction from the lower aprons and replacing them for thicker yarn counts).

Their product development is simple in concept and based on the experience of their spinning experts.

Sintex has his own analysis laboratory, and is able to perform the most common analysis necessaries in the above steps regarding dynamometry and evenness; this point were taked into consideration when establishing data inputs and outputs as well as the possibilities of implementation of the Modsimtex system for Sintex.

Sintex provided Intexter a list of the process settings and product parameters that they use during the product development stage; after that, there was a discussion about which of them should be considered as inputs, outputs or both. After this stage, Intexter extended these tables with many parameters that usually are not considered by the Sintex. These additional parameters were considered necessary for the implementation of different calculation methods or valuable information for Sintex in the future.

The process wasdivided into two phases: preparation (covering from bale to sliver) and spinning. Although Sintex only uses compact spinning, it was also included OE-Rotor parameters for generalization issues.

Processes inputs and outputs: Preparation phase

The following tables include the parameters that were taken into account in the process, as inputs, outputs or for intermediate calculation. The tables were divided into:

- Raw material (bulk fiber) parameters
- Process machinery settings used from bale to sliver or roving
- Yarn parameters (common for compact and OE-Rotor)
- Spinning machine (compact or OE-Rotor)

Some intermediate materials properties (sliver and roving) are considered inside the processing machine.

The number of passes through the draw frame were taken as a parameter belonging to the process itself (so not included in the following tables), that should be considered as both input and output, depending on the data required by Sintex in a determinate test.

State of the Art

Here, we summarize our conclusions to the state of the art that was done at the very first beginning of the project, in addition to the conclusions of the initial document developed by DITF-MR “Artificial intelligence in spinning”.

- There was no software providing an integrated solution like Modsimtex in the staple fibre spinning area (although there is for wool).
- There were lots of mathematical models for cotton or blend with PES that estimates dynamometric and geometric properties of the yarn, and most of them were quite old though still valid in its operational range (raw material, yarn count, spinning process). Intexter had also some publications in this field.
- The operative range for parameter estimation (especially outside A.I.) of the existing models is usually narrow in terms of raw material properties, spinning technology and yarn count.
- There were almost no specific publications for polypropylene yarn parameter estimation, because the trend was to solve this problem by using ANN and other A.I. techniques, that were easily adapted from cotton (where the publications intended was) to other staple fibres.
- CBR uses in this field were found in only few publications. In the A.I. field ANN seemed to be the preferred A.I. technique.

- Since 2004 the SVM (Support Vector Machines) techniques gained terrain in the field of spinning parameter estimation.

There was found only one Similar,although very limited, solution: a tool for worsted spinning mills: SirolanYarnspec; this tool was created in 1996 and developed inside an ACIAR founded Project (3) involving Asian, Chinese and Australian partners. This software uses mainly ANN together with mathematical models in order to predict many yarn properties using wool fiber characteristics and processing parameters as inputs. The software predicts what may be achieved under the "best practice" by the spinning mill. The system claims to "allow a mill to easily optimise the input parameters of fibre properties and machine settings for its specific circumstances" (3 pág. 32) The approach of this system is very close to the original concept of Modsimtex but is narrower in comparison and only cover some specific factor of the wool industries, that uses very different production processes. In addition, it seems to be a closed system with difficulties to be applied in other platforms or applications.

Applying a simpler, similar system in the wool industry supposed reductions of 10% ends-down, 5%-8% speed improvement and increase of a 10% in weaving efficiency ratio (4)

The package is commercialized by the company CSIRO textile and fibre technology, including some physical analysis equipment required by the system.

There were found also some references to laboratory software that estimates specific parameters or performs simulations of especifics aspects of the yarn, like (5), that simulates the appearance of yarns in 3D, but with a very low functional range.

Material Research

The sources used for the material research had been: Compendex, Web of Science, World Textiles, Google Scholar.

Although lots of articles were evaluated, here are summarized the most relevant under our point of view and for our application case:

The work of Majumdar and Majumdar (6) compared the results of breaking elongation (for cotton too) estimated by three methods: mathematical model, statistics model and ANN, concluding that the best accuracy was obtained by ANN, followed by statistics methods, and that mathematical models are the less accurate system. This was useful when integrating composed results offered by our system, because it seemed to be also applicable to OE and other raw materials.

Regarding mathematical modelling of staple fibre yarn, the existing models were basically developed for cotton, polyester or blends, and focused in the estimation of physical properties, especially yarn strength and elongation; and many of this models were quite old (before 1990 most of them) but some of them (7) (8)were considered adequate to be used as estimation models for cotton in the generic spinning calculations and also to be used as an starting point to be transformed to other fibres treated in the Project (PP and Lyocell).

Looking for advances in ways of calculating critic physical properties of the spun yarns, the following ones were also been found of interest for us:

Aggarwal (9) (10) provides two models of special utility covering high twisting yarns of CO and blends, they were used as a project starting point with raw materials; on the other hand, low twist yarns were modelled in the work of Shao (11), who studied the yarn behaviour starting from fibre slippage effects (the technique with which we had more experience), although the work even considered effects of cyclic loading. Ghosh (12) provided also a very general model that uses as inputs the characteristics of the bulk fibre, and suitable for all the spinning technologies in focus, with an acceptable accuracy degree inside its operating range, so it was also considered for the application case development. The first part of this article (13) justified the effect of the yarn geometry in its strength properties.

The model of Koo (14)was especially useful for the project because was able to also estimate the variance of the yarn strength, with the input of CV values of raw material. Moreover the method is applicable to other raw materials than cotton.

A key point when processing the sliver was the drafting system. There were many variables involved and was mandatory to find which were the influencing ones; some literature was found, and Pillay (15) in a very old article from 1964 gave important data about this point, studying also tension in the twisting zone and cursors, but always analyzed the resulting yarn hairiness (which was also interesting for us). However no literature was found on pressure clips.

The internal models (developed in Intexter) that were considered dealed with strength and elongation estimation and the modelling of the cross-section geometry of ring spun and OE-rotor yarns, developed (before the Project started) by Kassem (16) (17) and Tornero; these models were found convenient after comparison with other existings with the same aim, although some modifications were needed for adaption to new raw materials and/or spinning technologies, and they were of interest for further applications in the weaving area, so they were considered too.

Artificial Intelligence for the Application Case

CBR is used in very few cases,and the most significant publication was evaluated (already found in the preliminary study of the art carried out by DITF during the Project)

Looking for works dealing with polypropylene yarns, we didn't found any publication (only for continuous filament, also called yarn so it was a bit confusing when performing the searches); but taking into account the nature of teh ANN calculations, it was considered that cotton or PES publications were also successful for our case.

For predicting yarn properties from fibre properties, ANN were used in many publications; Chattopadhyay (18)was interesting because analyzed the performance of the network used (for cotton, but was found suitable for other materials). Igadwa (19) used an ANN to predict yarn properties in a case that was found problematic for us; he reduced the input variables to 14 (we had 30 at the moment), so this article was taked into account to understand the selection criteria.

ANN seemed to be very suitable for our application case; however, considering our specific problem of low amount of samples available, the ANN was not a good tool as it reduces its performance dramatically (and CBR as well), so other techniques were also searched: Fuzzy expert systems and Support Vector Machines (SVM): both gained terrain in the last years and seemed that both could deal with less previous samples than ANN

Fuzzy exepert systems were evaluated through Majumdar's work (20), which was very clear in its document (already present in the preliminary literature research).

SVM: The most relevant works foundedwere done by Yang (although he has a lot of works very similar between them), who developed many works regarding the application of SVM in fields of our interest: in (21) and (22) he introduces the method for yarn properties prediction and compares its performance with ANN dealing with low amounts of samples;

Elaboration of yarn samples

Samples needed to validate theoretical results were produced by SINTEX and Intexter. SINTEX produced the ring spinning and compact yarn samples while Intexter produced the OE-rotor and ring spinning yarns (see Table 1).

Sintex produced 68 different yarns. Studying the composition influence (LYocell, Polypropylene and Polyester), spinning process used (Kompact orconventional), spindle speed, yarn count and twist coefficient.

Intexter produced 155 different yarn (126 were OE-rotor and 29 ringspun conventional).

As it is posible to see at the Table 1, for conventional yarn, sintex produced the different yarns modifying the yarn configuration structure (yarn count and twist) and Intexter focused in the process settings (previous draft, OLC type and roller pressure).

<table>
<tr><th>Producer</th><th>Raw material</th><th>Spinning system</th><th>Variables studied</th><th>Main variables obtained</th></tr>
<tr><td rowspan="4">Sintex</td><td rowspan="2">Lycocell</td><td>Kompact spinning</td><td rowspan="4">• Spindle speed
• Yarn count
• Twist coeficient</td><td rowspan="4">• Yarn count
• Twist
• Strenght
• Elongation
• Tenacity
• Yarn eveness
• Thin places
• Thick places
• Neps</td></tr>
<tr><td>Ring spinning</td></tr>
<tr><td rowspan="4">Polypropylene</td><td>Kompact spinning</td></tr>
<tr><td>Ring spinning</td></tr>
<tr><td rowspan="3">Intexter</td><td>Ring Spinning</td><td>• Twist coefficient
• Previous draft
• OLC Type
• Roller pressure
• Spindle speed</td><td rowspan="3">• Yarn count
• Strenght
• Elongation
• Tenacity
• Yarn eveness
• Thin places
• Thick places
• Neps
• Hairiness</td></tr>
<tr><td rowspan="2">OE-rotor</td><td rowspan="2">• Yarn count
• Twist Coef
• Rotor Speed
• Disgregator Speed
• Rotor Type
• Disgregator Type
• Nozzle Type
• Torque-Stop Type</td></tr>
<tr><td>Lyocell</td></tr>
</table>

Table 1–Yarn samples developed

The laboratory analysis of all the samples were carried out by both Intexter and Sintex, obtaining dynamometric and evenness results.

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4.1.3.2. Knitting group

Knitware samples analysis

The aim of the knitting group was to develop a simulation system for the physical-mechanical properties of the knitted textile structures that enables the rapid manufacturing process configuration. This virtual construction system allows the performance prediction of knitted fabrics before the starting to manufacture. The project has had therefore the following main objectives:

- Development of the simulation model of the physical properties of the knitted textile structures. Mathematical models will be developed to simulate the behaviour of the knitted fabrics.
- Development of a finite elements simulation system to simulate the physical properties of the knitted textile structures, based on the mathematical models developed for these structures. Analytical and next discrete model of the product allowing for the use of FEM in order to analyse the product behaviour under service load and its response, i.e. displacement, strain and stress distribution.

Taking these objectives, due to the fact that the knitwear production design based large lyon trial and error. These greatly extend time and increases costs of implementation the intended assortment knitwear to production .In agreement with the main coordinator together with a foreign partner Italian firm Santoni ,the following types of knitted fabric shave been adopted to research:

- single jersey knitted fabrics,
- rib knitted fabrics
- interlock knitted fabrics

These knitted fabrics are the basic structure of manufactured products on circular weft knitting machine MEC-MOR: Above types of fabrics were made of the following raw materials:

- Cotton yarn with linear mass: 15 tex, 20 tex, 25 tex.
- PES yarn with linear mass: 300/f72 dtex, 220/f72 dtex, 167/f48 dtex
- PA yarn with linear mass: 312/f272 dtex, 234/f204 dtex, 156/f146 dtex
- Pa textured with linear mass:
- PP yarn with linear mass: 300/f252 dtex, 200/f168 dtex, 140/f144 dtex

For each type of stich and yarn linear density, firm Santoni made fabrics variants for three values of CF factors: maximum, minimum and average (60variants).

With this raw materials were also made single jersey knitted fabrics with elastomeric yarns. A total 95variants of knitted fabrics were made

Metrological evaluation of following structural and physical parameters for the above-mentioned variants was made: course density *Pr,* wale density *Pk*, surface mass M_p, g/m^2, porosity *Pd*, cover factor $CF=l/\sqrt{tex}$, air permeability *W , mm/s*, breaking force along wales *Fmax c, N/cm*, breaking force along courses *Fmax r, N/cm*, resistance against ball bursting $F_{max}b$, *N.*

The measurements of these parameters were based on existing standards and test procedures.

The experimental results were used to develop a mathematical analytical model and were the base data to the model of artificial intelligence AI. To develop a mathematical model predicting the structural and physical parameters, it is necessary to know the relationships between the parameters of the structure and physical properties of knitted fabrics. In the case of knitted fabrics, the most important parameter that affects all structural and physical parameters of knitted fabrics and machine setting is the length of yarn in the loop. Based on qualitative analysis a general form of the function to list the parameters of knitted fabrics was proposed.

The results of measurements of number of courses and number of wales were presented based on the model Doyle -Munden. According to this model, number of loops on surface unit is inversely proportional to loop length square.

The results of strength along courses and wales measurements were presented as a function, where calculated value of these parameters is directly proportional to the product of adequate density and the tensile strength of the yarn

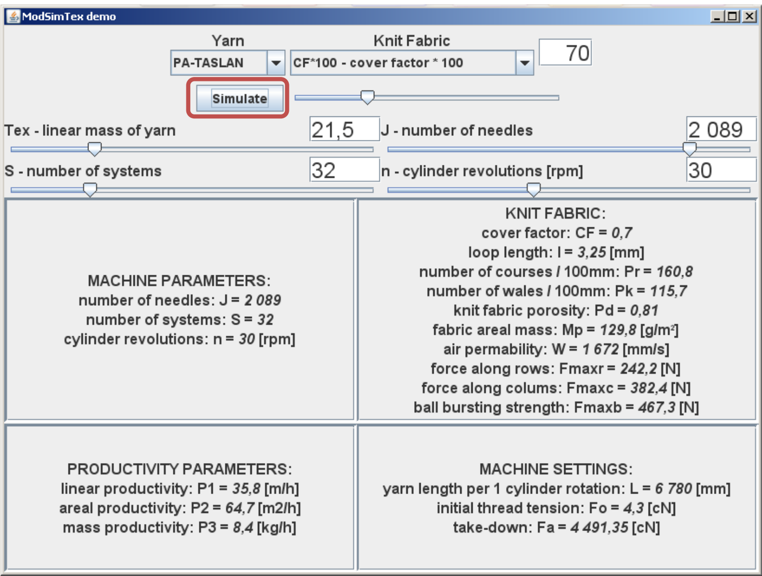
In the case of the ball bursting it was adopted, that value of this parameter is directly proportional to the product of horizontal and vertical stitch density Pk, Pr and the tensile strength of the yarn

For the mathematical description of measurement results of air permeability of knitted fabrics, equation has been adopted, in which the value of this parameter is inversely proportional to the quota of the flat projection of loop forming yarn in the loop surface

All propose de equations are there for a function of the length of yarn in the loop.

The matrix of influence of yarn parameters, machine technical parameters and process parameters (machine setting) on the structural parameters and physical properties of knitted fabrics was developed and the productivity of circular weft knitting machine for the purpose of simulation system, based on artificial intelligence AI.

An example of modelling results of knitted fabrics properties, setting up and productivity of circular weft knitting machine.



The order operations of mathematical calculation of the analytical model is to determine values for particular structural and physical parameters, whose value is determined for the extreme values of the coefficient CF. Developed model, for the first time, allows to simultaneously determine all of the knitwear structural and physical parameters, under one of the parameters, for which a knitted fabric is designed. At the same time the setting parameters of knitting machine are determined, that is, the length of yarn per one cylinder rotation, the input yarn tension, take down tension of knitwear and productivity of the machine in m /h,m2/h I kg /h. It should be noted that the mathematical simulation model was developed for fabrics with and without the participation of elastomeric yarn. The performed validation of the model confirmed the technological suitability, because obtained the difference between calculation and experimental values of the parameters from a practical point of view are acceptable. For the purpose off a setting parameter of knitting process, the concept of the automatic settings was developed. This concept refers to the three control zones:

1. The thread feeding zone–in this zone feeding device is fitted out. The length of thread segment unwinding from yarn packing and feeding to needles per one turn of cylinder. is regulated.
2. Knitting zone–here the sinking depth is regulated through the change of stitch cams setting in individual systems; this adjustment influences of the input tension of thread. The stitch cams setting has to be fitted to length yarn.
3. Knitwear take-down zone–here the force which knitwear is drawn aside from the knitting zone is regulated.

The basis of regulation is known the length of yarn per one machine rotation, determined from a mathematical simulation model. Automatically setting the length of the intended value feed thread none cylinder rotation takes place in a sequential manner by small steps. In subsequent sequences of automatic regulation, to changing the length of the yarn the pressed value of thread input tension is adjusted (0.1cN/ tex-εFo+,). (0.1cN/ tex-εFo+,). For this value of thread length the value of take down tension per one column is adapted (0,1 cN/tex). Total take down tension F_A =0,1cN/tex• number of needles + - $\varepsilon_{FA.}$).

Automatic adjustment of crochet is done with a computer while controlling adjustable parameters and their comparison with set values. In the case fulfil the conditions of the regulation of yarn length feeding, that is, when I L-L_MI <ε_L input tension is regulated to the reference Fo and take down tension F_A according to the previously described steps 2 and 3.

Modelisation and simulation algorithms for knitware made of staple fibre yarns

The objective of this project was to develop a simulation system for the physical-mechanical properties of the knitted textile structures that enables the rapid manufacturing process configuration. This virtual construction system allows the performance prediction of knitted fabrics before the starting to manufacture. The project has therefore the following main objectives:

- Development of the simulation model of the physical properties of the knitted textile structures. Mathematical models will be developed to simulate the behavior of the knitted fabrics.
- Development of a finite elements simulation system to simulate the physical properties of the knitted textile structures, based on the mathematical models developed for these structures. Analytical and next discrete model of the product allowing for the use of FEM in order to analyze the product behavior under service load and its response, i.e. displacement, strain and stress distribution.

To create mathematical model of knitted fabric the micromechanical physical model had to be assumed. On this stage of research work the two types of plane geometrical model of repeatable unit cell were considered. The investigation was carried out for Glaskin and Doyle-Munden geometrical model. During numerical test the influence of the geometry of separated loop turned out negligibly small.

The continuity conditions between connected yarns were assumed in two different manners. The one of them was assuming rigid connection while the other one was assuming that normal displacement and angels of rotations of cross-sections are the same in point of connection of yarns, but tangential displacements can be different allowing mutual slipping of yarns. The mutual slipping of yarns cause local forces of unknown characteristics. In the simplest case the relations between internal force and difference in tangent displacements of connected yarns was assumed linearly proportional. With respect to difficulty of defining of proper factor of proportionality, having the physical sense of the stiffness of the yarns connection, this type of continuity conditions was no further considered. Consequently, the physical model of repeatable unit cell was taking into account Glaskin geometry and rigid continuity conditions and with respect to large deformations of yarns large strains was assumed.

Based on above considerations the mathematical model of knitted fabric was created.

The mathematical description corresponds to description of coupled curvilinear beams with proper continuity condition between mate yarns. The system of equations describing behavior of knitted fabric consists of linear physical relations, nonlinear geometrical relations and equilibrium equations of curvilinear arch. These relations were supplemented with proper continuity and boundary conditions.

To solve mentioned mathematical model of knitted fabric the system of finite element method was created. On the stage of solving of nonlinear set of equations (generated by FEM) the Newton method was used. The created FEM system allows predicting deformations of knitted fabric subjected to elongation process.

Modelisation and simulation algorithms for knitware made of filament yarns

For the purposes ofmodelingthe properties ofyarns, mathematical model for prediction of multifilaments' strength was developed

Mathematical model for prediction of multifilaments' strength is enabled to modeling the breaking force and elongation at break of multifilaments.

The model has general character and can be applied for simulation of strength for every type of multifilaments and for optional length of their segments.

For model the input parameters are the properties filaments: raw material and density, linear mass, breaking force and elongation at break. The modeling is executed for assumed parameters of multifilaments: linear mass, number of filaments and number of twist, the distribution of thickness of multifilaments.

The results of tests of the distribution of thickness of multifilaments have allowed that the uniform distribution can be accepted, because the unevenness of multifilaments' thickness is usually on low level.

The computer programme was worked-out, which enables to input of optional data of filaments and assumed parameters of multifilaments. The programme calculates the breaking force and elongation at break for chosen length of segments of multifilaments and also gives the possibility of selection of these parameters through the change of values of input parameters.

The results of tests of PA and PES multifilaments indicated the good conformity between the calculated and experimental values of breaking force and elongation at break.

4.1.3.3. Woven group

Main results of group weaving can be divided to these main parts:

1. General system for prediction of two-ply yarn and weaving fabric properties
2. System for prediction of glass leno fabric properties
3. Contribution to modeling of weaving resistance
4. Prediction of selected yarn and fabric properties for system Penelope
5. Contributions to soft modeling, finite elements methods (FEM) for woven fabric properties prediction, proposal of complex quality criterion.

General system for prediction of two-ply yarn and weaving fabric properties

Two ways for prediction of fabric properties were proposed. First way is prediction of fabric properties based on the fabric geometry, i.e. trajectory of threads in weave repeat, crimp, waviness, yarn deformation in binding point, number and distribution of structural elements. By using of this information areal density, areal porosity, strength and deformation at break can be calculating. Calculation of fabric density and total porosity including intra yarn and inter yarn pores is second way leading to thermal conductivity, thermal comfort, air permeability and penetration of liquids prediction. General system is composed from these parts:

- Prediction of two-ply yarn properties based on properties of single yarn – fineness, twist, take-up, characteristic diameter, mass unevenness, strength and deformation at break.
- Prediction of woven fabric properties based on yarn properties and fabric construction (weave type, sett of warp, sett of weft, density) – areal density, areal and volume porosity, density, strength and deformation at break, thermal conductivity and comfort.
- Relations between woven fabric parameters and loom setting.
- Prediction of weaving resistance model.

1.1 Production of special yarns and woven fabric samples

Special samples of two ply yarn and fabrics were produced by SINTEX s.r.o and weaving lab TUL. Samples of yarn were produced with different twist. Samples of fabrics were produced with different weave (plain, twill, satin), weft sett and yarn fineness and from different material, i.e. polypropylene (PP), polyester (PET), Lyocell. Two kind of loom were used for samples production, Somet at Sintex and Picanol at TUL. At the production ofsamples the setting parametersof looms were described.

1.2 Relations between woven fabric parameters and loom setting

Customer's requirements are oriented to the fabric properties in the relaxed state. On the base of these requirements the fabric construction parameters are estimated. Parameters of fabric during weaving are different from parameters in relaxed state (removed from loom). The fabric construction parameters are serving as base for adjustment of warp pretension, back rest location, warp sett, weft insertion based on connection with shed closing and beating. It is necessary to adjust diameter of warp beam, loom rate, whip roll, weft tension, warp stop motion sensitivity, etc. Loom setting optimization covers a number of optimization objectives and optimal setting is always a compromise.

Quite new contribution to theoretical description of the beat-up process leading to calculation of weaving resistance was proposed. Trajectory of the reed in contact with the front end of the fabric is called beat-up pulse. During the beat-up the reed affects the fabric by the beat-up force. The force creates a reaction inside the fabric, it means a resistance force that is called weaving resistance. It must be balance between the beat-up force and weaving resistance. New model for calculation of weaving resistance and method for its measurement were proposed and verified.

1.3 Development of methods for measurement of two-ply yarn properties, fabric geometry and selected fabric properties and specification of material and technologyparameters for PP, PET, Lyocell fabrics

New methods for evaluation of two-ply yarns and fabrics structural parameters were created. These methods are based on using of image analysis, i.e. evaluation of two-ply yarn characteristic dimension, trajectory of yarn in weave repeat, yarn deformation in binding point, waviness. Characteristic parameter as relative thickness, relative widening and yarn flattening in binding point were found. Parameters of waviness described by Novikov were applied. Using thesemethodsnew materialand technological parametersfor predictingthe properties of two-ply yarn and fabrics have been found.

1.4 Validation of mathematical models

The proposedmodels werevalidatedon a set of real PP, PET, Lyocell yarns and woven fabrics.

1.5 Implementation of results to Modsimtex system

For implementation of results the Modsimtex data structures were prepared. These structures contain description of:

- raw fibers,
- warp and weft yarn,
- woven fabric parameters,
- individual fabric formulas,
- fabric parameters matrix,
- individual threads on loom,
- loom disposition,
- threads disposition on loom,
- warp threads on loom,
- end product.

2. System for prediction of glass leno fabric properties

Leno fabrics were produced on air jet loom CAMEL 220 from glass multifilament. Producer of this loom is TFA. These fabrics can be used for building industry. Structure of leno fabrics is different in comparison with fabric from polypropylene (polyester, Lyocell) two ply staple yarn. Input parameters, output parameters from point of view of mathematical models and setting loom parameters were collected. Requirement of customers on properties of product were specified. Parameters for technological process were specified. Glass fabrics samples (leno weaves) were produced and analyzed.

For implementation of results the Modsimtex data structures were prepared. These structures contain description of:

- leno threads (multifilament),
- leno fabric parameters,
- Camel loom parameters,
- individual formulas,
- final leno fabric parameters matrix.

The optimal position for placement of contact less device for measurement of fabrics geometry was specified and corresponding construction modification was proposed. The prototype for contact less capturing of weft sett based on image analysis was created.

3. Prediction of selected yarn and fabric properties for system Penelope

In cooperation TUL and InformaticaTextil algorithms for calculation of yarn diameter and mass unevenness for cotton spun yarn and for prediction fabric porosity, thermal conductivity and comfort were proposed.

4. Contributions to modeling technique

4a. Contribution to soft modeling

For prediction of fabric properties some soft modeling techniques were compared. These techniques are based on the following approaches:

- neural networks,
- piecewise smoothing functions
- smoothing splines
- MARS – multivariate adaptive regression splines

4b. FEM for woven fabric properties prediction

The FEM was used for prediction of some mechanical and thermal transport characteristics of woven structures.

4c. Pseudo-distance

Pseudo-distance in the interval <0, 1> is created from degree of satisfaction of individual properties averaged in proper manner. In the case of pseudo-distance computation the target properties are usually used instead of properties for an absolutely satisfactory product.

The main scientific contributions and contributions for industrial partners are:

Scientific contributions

- New models – weaving resistance, two-ply yarn properties, thermal conductivity and comfort
- New methods – new material and technology parameters

Contributions for industrial partners

- Fastening of design process
- Creation of database for machine setting connected with fabric parameters

4.1.3.4. Non-woven group

Main objective of the MODSIMTex nonwovens group has been the analyzing and finding of mathematical functions and models of the nonwovens process for two selected nonwovens product groups and the integration of the results in the development of a software tool (integrated in the software platform of MODSIMTex) able to provide a technical solution for the product development and process optimization of the nonwovens process.

Doing this, the whole process of nonwovens production could be separated into defined sub-processes and main dependencies like:

- Fiber
- Pre-needling
- Finish-needling
- Calendaring

Analyzing these sub-processes as separate isolated processes on the one hand and in relation to the whole process makes the production of nonwovens more understandable. As a result of this consideration, an ordered overview of producing a special nonwoven product like paper machine felt (PMF) or filtration needled felt (FNF) was developed as a dependency matrix. This matrix as a set of 75 different material-, process- and product parameters is an important instrument for deeper mathematical analysis. It is also base for abstraction to general nonwovens production.

Based on this overview, an analytical description of the sub-processes and the full production process with machinery, material and parameters was made. Referring to this a collection of 18 parameters (such as permeability to air, permeability to water, mass per unit area, thickness, tensile strength length, tensile strength trans, elongation length, elongation trans, ratio of pore size) of the respective final product was detected as important for the industrial partners.

After discussion and evaluation the main parameters were selected as dependent values for mathematical and statistical analysis. Based on a set of about 6000 records, suspected and new relations of quantitative parameters were proved using regression analysis. Qualitative data was analyzed with statistical methods to show further dependencies.

Using discrete formulas, relations for the nonwoven products was described

- in area of fibres
- between fibre properties and machine parameters in the pre-needling step
- between fibre properties and machine parameters in the finish-needling step
- between fibre properties and needled PMF/FNF in
  - the pre-needling step
  - in the finish-needling step
- between parameters of finish-needled and calendared PMF/FNF

The collection of these formulas was re-transferred into the dependency matrix. Therefore a powerful instrument for describing and calculating the production of specific nonwovens was evaluated.

Furthermore, the establishing of a common retrieval system for the Nonwovens group is realized by a modular configuration as well as the unification of several database structures and parameters. As result, a common basic consisting of several product examples and the collected mathematical functions was implemented. The general analytical functions and specific PMF/FNF formulas were programmed by STFI and tested. The implementation of such retrieval system was done by means of browser-oriented and application-oriented tools within the user Interface-level and the business logic-level embedded into the MODSIMTex module. The data stock will be temporarily rearranged and shown by using algorithms depending on the favored Nonwovens equation.

Summary of modeling:

- The modeling of the two selected nonwoven product families is a very complex process.
- The relations/connections of the parameters are describable in a dependence table / matrix.
- Approx. 30% of the 313 detected relationships between 75 relevant parameters can be described in analytical mathematical functions.
- More than 40 functionalities for the special application (PMF and/or FNF) were found out.

4.1.3.5. Software group

The MODSIMTex system was born to be a tool for helping to adjust the parameters of a process. This system starts when a user wants to create a new product. The user will specify some of the parameters that he/she wants to obtain for the required product. These parameters can belong to the raw material, to any machine in the process or to the final product. So, with an artificial intelligence method it is possible to approximate the rest of the parameters learning from the past executions of this kind of process.

In this problem more than one parameter must be predicted and depending on the query, these parameters are not always the same. Moreover, these could change any time that there is a new query. Besides, the database will grow as more process executions are finished.

So with these requirements, the algorithm with applies the available models and techniques must be:

- Incremental: The algorithm should adapt over the time with the new data
- Non-dependent of some attributes because depending on the required parameters the importance or influence of the other parameters could change.
- Able to predict more than one parameter
- Able to predict all attribute types (numerical or categorical).

In addition, some of these parameters have extra information that can be used to know its value in a determinate situation like the parameters that can be defined by a predefined empirical formula. So these parameters are not going to be predicted, because it is more reliable the exact value. Another kind of information that guides the predicting process is the knowledge of the relations among parameters.

The solution adopted in this Project was the Case-based reasoning (CBR). CBR is a problem solving paradigm that uses the human reasoning model as a base: humans use past experiences to solve new situations or problems.

This solving paradigm is based in collecting a lot of relevant cases that are the past experiences of the system. The CBR consists of:

- Obtain the problem description by the user
- Measure the similarity of the current problem to previous problems stored in a case base (or memory) with their known solutions, retrieving one or more similar cases
- Adapt (reuse) the solution of one or more of the retrieved cases, possibly after adapting it to account for differences in problem descriptions
- The solution proposed by the system is then evaluated (revised) by the expert
- The problem description and its new solution can be retained (stored) as a new case, and the system has learnt to solve a new problem.

In this project, the last two points has been discarded, due to the fact that the project cannot rely on this as it cannot be assure it will be done or at least, done with a minimum quality.

Modeling a CBR software

The CBR software has 4 phases:

- Retrieve
- Reuse
- Revise
- Retain.

The retrieve phase involves findind the most similar case/s to a given case. This task starts with a (partial) problem description and ends when best matching previous case has been found. It is usual to divide this task in two parts. The first one tries to select similar cases and the second one chooses the best matches. The similiratiry is a function that gives a scalar distance between two arguments (case element and case problem). This value is also calculated also with a weight given for each parameter.

The reuse phase is the most complex tasks in the CBR cycle. It is a phase based on the principle:

"Similar problems have similar solutions"

In this project, several systems has been coded. The user can choose which one to use.

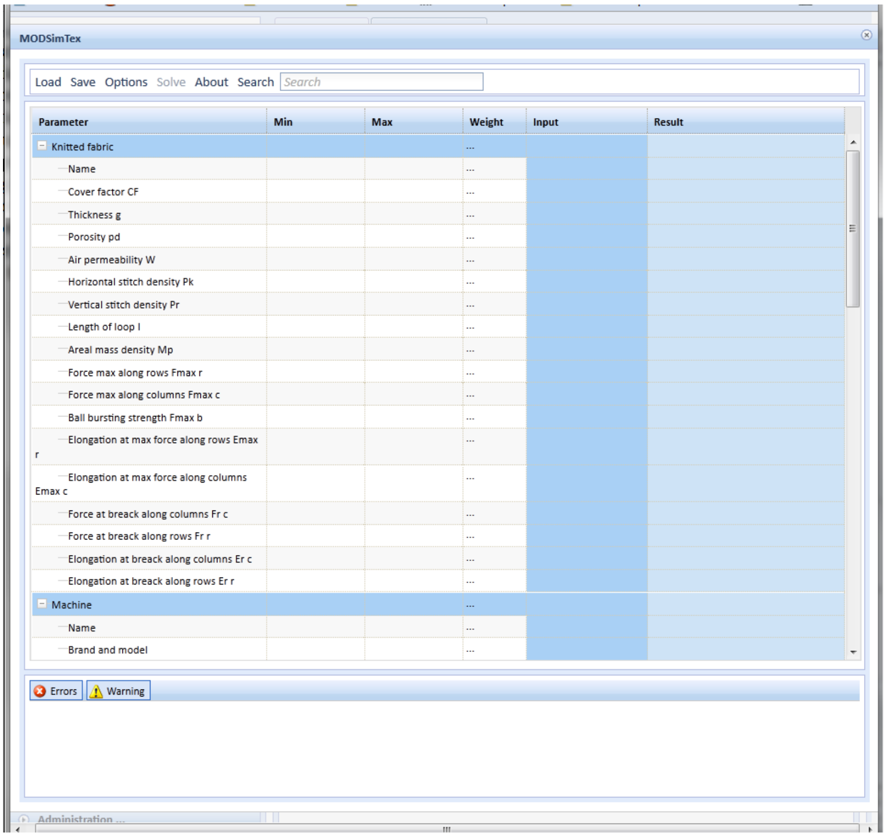
The revise and the retain phase has been discarded, as previously mentioned, due to the fact that the system cannot rely whether the expert has revised and evaluated the solution provided by the system.

Software interface

The software interface is a web based application that eases the task of adding data and retrieving data to the user. It is based in a web framework called dojo toolkit that increase the user experience. This development ables anyone to use the full system in any place of the world, as the real system process and data is centralized in a server.

The interface has several options added to give the experienced user or the expert the opportunity to adapt the software to their business reality. The expert can choose the different CBR options and the experienced user can lock/unlock values, set weights during the execution...

During a session, all the previous queries are shown, so the user can see the different solutions gaved by the system to the user. The system allows storing the query and loading it later. Also the configuration used is possible to save and load later.

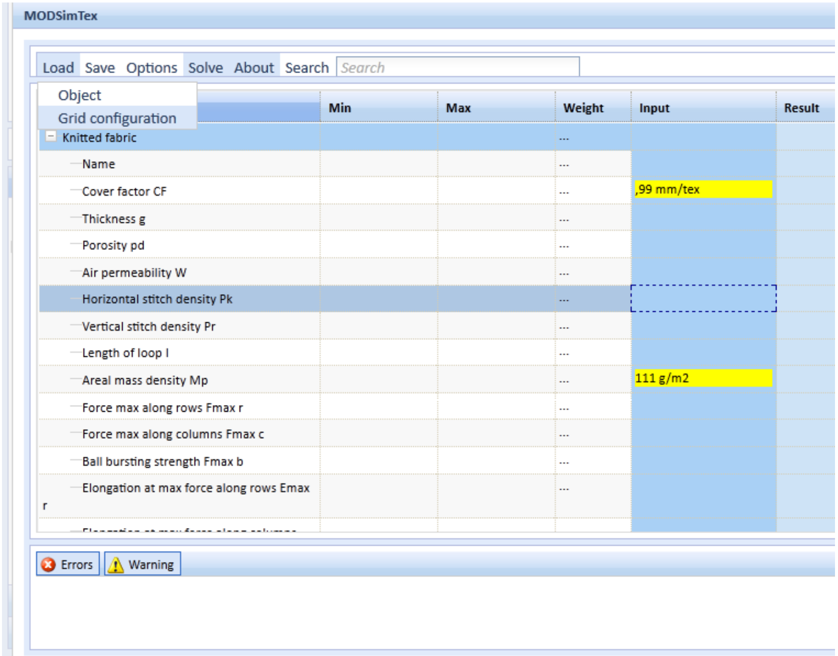


At this picture, the complete list of parameters and objects is shown. The user can navigate expanding and collapsing the different objects. The parameters are grouped inside the objects and every parameter associated to the element is listed so the user can set a value for it. The values can be as different as string, dropdown list, number…

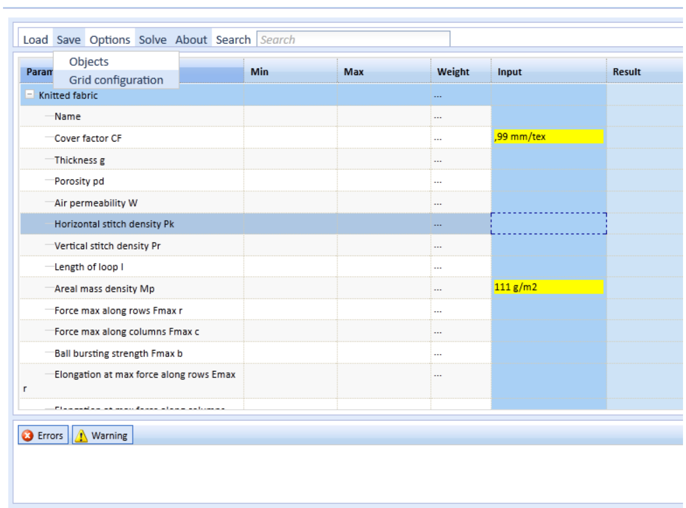
Also can appreciate the different columns designed for the system. The columns called min and max are columns designed to set the maximal and minimal desired values for the user. The user can set here values that constrain the problem. One or both can be set, totally independent one from each other.

The column called Weight is oriented to set a special weight to the parameter, overriding the one that is set by default in the system. For example, one parameter can be always neglected, but for one product, this parameter can be really important, so we don't want to change this parameter weight only for this query to the system, so we have the chance to modify this weight parameter at the query, overriding the default weight for the query, but the default value remains unmodified.

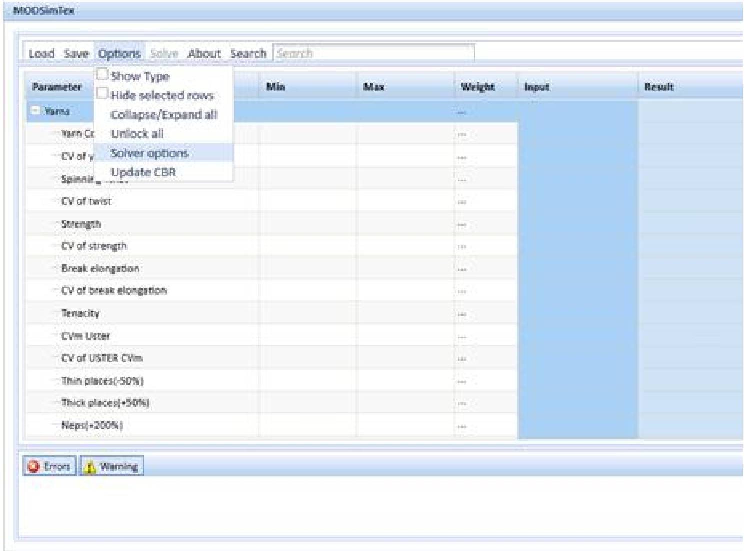
The following column is the Input column. This column is the data entered by the user for the next query. As long as the user finishes entering data in these columns, he can revise the different values and then execute the query to the system and show in the next column the result. The data entered is keeped between queries facilitating the interaction with the system to achieve the right answer. The previos queries are also shown at the right columns as they are entered, so the user can see the historical evolution of the query. These previous queries can also be deleted, in case has no meaning or interest for the user, just clicking with the right mouse button and selecting delete column. At the end, the user will be able to see the different answer get during a session.



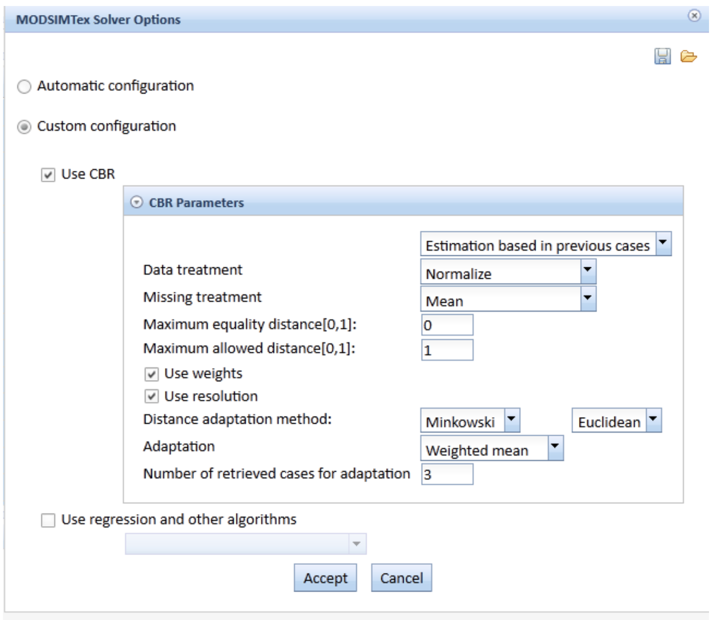
At thisscreenshot, theuser has enteredtwovaluesandtheyareshown to facilitatetheuserquerysupervision.



Thefollowingscreenshot shows theoptions menú. Heretheuser can set diferent options for the System andactivatesomeaids, likeseetheparametervaluetype, hideand show comecolumns, lock/unlock all the paràmetres, Update thehistorical data base andeditthe CBR options.



Bydefault, the System is configuredwiththe automàtic configuration. The System has analgorithmalreadyimplementedthatthe System follows in order to achievetherightanswer, but in some cases, this can be a not so goodalgorithm, andtheuser has thepossiblity or theoption to adjustthe System in order to obtain a moreaccuratesolution just adjustingthe elements andtheprocessfollowed to solvethe System. Thisoptionsarereallyoriented to a technicalpersonwithsome mèdium skills in Artificial Intelligence as theyusetheirvocabulary, andsome paràmetres alterations can really be significant andinfluence in highmessuretheresults of the System. So theyarereallyoriented to reallyskilledperson.



4.1.4. Potential impact (including the socio-economic impact and the wider societal implications of the project so far) and the main dissemination activities and exploitation of results

Acording to BussinessVibes[2] and Eurostat[3], the textile and clothing industry has been an important global trading industry in European Union for decades. The EU currently is the world's largest market of textile and clothing products, and the textile sector plays a crucial role on the EU's economy and social well-being in many regions of the EU-27. In 2006, there were already 220,000 companies employing over 2.5 million people and generated a turnover of 190 billion Euros in EU's textile industry. The textile and clothing sector accounts for over 3% of total manufacturing value added in Europe.

According to the data from The European Apparel and Textile Confederation, in 2010, the overall size of the textile and clothing industry in the EU-27 represents a turnover of 172 billion Euros with investments of around 5 billion Euros. Despite the strong effect of the global economic recession in the previous year, the 127,000 textiles and clothing companies still employ over 1.9 million workers. EU external trade was more dynamic than the previous year with 34 billion Euros of textile and clothing products exported and 84 billion Euros imported from Third markets in 2010.

Textile production in EU has developed its focus from simple mass production to more expensive, specialty products in recent years. According to European Commission, the target of EU's textile industry is shifting to technical and industrial purposes, as well as for high quality garments with high design content, rather than clothing and apparel markets.

It is worth noting that the USA and Japan have a little advantage in the race for the leadership of this market, since this type of products represents already more than 35% of the total textile production. In Europe, these percentages are misleading because **the raise on the percentage of technical textiles production is due to the disappearance of conventional textiles production** (moving to other countries), and therefore the proportion of technical textiles is increasing although the absolute production is stagnated. This is an indication that the battle to achieve competitive advantage is in its peak, and any advance that allows quicker and cheaper development of new technical products will be an important step forward.

The tendency indicates clearly that since the year 2000 this percentages of technical textiles in relation to conventional products has been considerable increased, mainly in the developed countries, and there is no ceiling for this tendency. At European level, the production of technical textiles is distributed 60/40 between the 15 countries of the old EC and the 10 countries of recent incorporation. The demand of these technical textiles raised a 25% in the Europe-25 during the period 1995 to 2002, which is an important increment that is not slowing down. In addition, the European textile manufacturers are leaders in the world market of technical/industrial textiles and non-woven structures (for example, filters, geo-textiles, hygiene and health textiles, textiles for the automotive industry, etc.), as well as leaders in the high quality products with important design component.

This data shows the increasing importance of the technical textiles, and suggests uncertainty when it comes down to decide who is going to be the leader in the immediate future. For this reason it is

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[2] http://www.businessvibes.com/blog/textile-industry-european-union
[3] EUROSTAT, 2006-2010

crucial to put efforts from the European Commission to support this leadership that could be at stake in front of the rich countries and also in front of emerging countries that will also produce technical textiles in the short term.

The main strategies for the sector are summarized in the document COM (2003) 649 “The future of the textile and clothing sector in the enlarged EU”. It is worth noting the necessity of developing highly specialized products and new materials with multiple and intelligent properties. This projecy was focused on the development of new innovative tools to help the start-up of the production machinery and decreases the time to begin the production, in order to make real the introduction in the market of these new products.

The software developed can be applied to a specific textile production machine (spinning, weaving, non-woven) and set the production parameters for a physical and mechanical properties specified of the multifunctional technical textiles, or the inverse: give the textile parameters from the machine configuration. The competitive advantage that this system provides is spectacular. In the following table the impact is analyzed in relation to the previous situation:

	Situation today *(textile SMEs with no design software applications)*	**Situation today** *(textile companies with CAD software applications to support the design processes)*	**Situation with MODSIMtex**
Impact in the manufacturing processes	No significant impact on the manufacturing processes.	No significant impact on the manufacturing processes.	- Detection of defects or other problems that may appear during the posterior manufacturing process. - Integration of the simulation results and parameters into the textile machinery for the rapid configuration of the machine as well as the precision manufacturing of the virtual textile structures developed using this software
Impact on the supply/customer chain	Limited to manufacture external products, usually being subcontracted by a bigger company.	The company is capable of offering a varying range of products, and is able to offer services to the customer, like visual presentations of the products on screen.	The software allows the company to predict the performance of the textile product before serving it to the customer. The wide range of innovative customized products is an added-value to satisfy multiple customer’s needs and guarantee the precision and quality of the products. The customer can participate in the customization. It is also possible to create digital fingerprints of the semi-finished products traveling through the value chain.
Economical/ Competitiveness impact	In the short/medium term this model is not sustainable and it can lead to the disappearance of the company.	The conventional visualization and design tools don’t bring added value since they are of little help to design multifunctional technical textiles. The company that follows this pattern is only able to offer conventional textile products.	The capacity to design any kind of multifunctional textiles has a great impact in the capacity to offer added-value from the company and its products.

Community societal objectives

The main contribution to the Community's societal objectives is the improvement in the speed and flexible development of new technical textile products. The simplification of the production process to obtain such products increases the rate of new products successfully finding a niche market, and covering new society necessities, and at the same time, giving added-value opportunities to the European textile companies. The new generation of textile products that will be produced will be responsive to their surrounding and environment and be capable of providing monitoring and protective functions (often vital) to the users. These products will be highly customised so that it will be possible to incorporate the functions that will address the particular needs of the user. In some cases, the applications will exists in performance garments for work-wear, where protection is an issue, so that there will be a significant contribution to health, safety and the working conditions of workers, especially those employed in hazardous occupations. **The possibility of monitoring the properties of these products in the computerized model of the textile will accelerate enormously the configuration of the production machines**. At the same time, the companies are capable of generating added value with the design and manufacturing of technical textiles, and they will be capable of moving towards the innovation-driven type of company.

TYPES OF COMPANIES → moving towards a knowledge-based textile industry →		
RESOURCE DRIVEN	**INVESTMENT DRIVEN**	**INNOVATION DRIVEN**
• Manufacturing processes are the most important aspect. • Local and regional relationships with suppliers/customers. • Trying to lower costs, fighting a war of prices. • Very little attention to new designs or new products.	• High investments. • Moving towards high-tech products and processes. • New design tools to develop new products. • Specialized suppliers.	• Highly innovative. • Constantly generating new products and applications. • Design is key to add value. Cutting edge tools for the design of new products. • Advanced manufacturing processes.

In relation to the employment, the software tool developed in this project requires a staff with profound textile technological knowledge, but combined with simulation knowledge and ICT capacities. The staff must be trained so the employees can extract the maximal performance from it. The consequences on the employment are the increase on the job quality and the necessary skills to perform design tasks, and the **generation of new attractive job positions** to change the traditional image of the textile industry as an obsolete industry.

The document COM (2003) 649 "The future of the textile and clothing sector in the enlarged EU" addressed the need to create better jobs, with user-oriented environments and new management methods. The sustainable development of the textile-clothing industry is possible if given this kind of toolsthat are focused in aspects like the innovation, design and use.

Dissemination actions:

The following actions havebeen carried out regarding the dissemination of knowledge:

- *17th November, 2008:* Modsimtex website inauguration (http://www.modsimtex.eu/)
- *21th November, 2008:* Piece of news in Terrassa TV (Modsimtex kick off meeting) (http://www.youtube.com/watch?v=O7_zgi-RMYs)
- *21th November, 2008:* Press releases in SINC, Europe bets for textile innovation (http://www.agenciasinc.es/Noticias/Europa-apuesta-por-la-innovacion-del-textil)

- *22th November, 2008:* Press article in www.fibre2fashion.com, MODSIMTEX project to transform manufacturing of textiles (http://www.fibre2fashion.com/news/textile-news/newsdetails.aspx?news_id=66248)
- *25th November, 2008:* Press article in enews Terrassa (http://enews.terrassa.upc.edu/numero/16/activitats/)
- *21th January, 2009:* Modsimtex project presentation at UPC Terrassa (Barcelona)

- *21th January, 2009:* Modsimtex project presentation, piece of news at TV Terrassa (http://www.youtube.com/watch?v=2zkmIxIIzuY)
- *26th February, 2009:* Article published in La Vanguardia, INTEXTER: An internatinal reference centre (http://www.guiadeprensa.com/prensa/la_vanguardia/2009/02/26/nuevas_tecnologias_investigacion_y_desarrollo_maquinaria_industrial) (page 26)
- *1st March, 2009*: STFI website (http://www.stfi.de/en/transfer/international-cooperation/seventh-framework-programme.html)
- *1st -2nd April, 2009:* Presentation of the Project in the IV annual Euratex Conference, Brussels
- *April, 2009:* Conference 7.th FP EU ModsimTex. Textile in new Milenium VII, Faculty of Textile Engineering, Technical University of Liberec.
- *7th July, 2009:* Publication: INTEXTER leads MODSIMTex, an EU project that will be a revolution for the textile sector (Chemical Textile Magazine 193, page 57)
- *September 2009:* Computer Aided Textile Design LibTex. The 38th Textile Research Symposium at MtFuji conference, Japan.
- *November 2009:* Modsimtex 7 RP – Review of the project objectives. 16th International Conference, Structure and Structural mechanics of Textiles, Faculty of Textile Engineering, Technical University of Liberec.
- *February 2010*: Conference: Leno fabric stability and strength. Leno-Weaving: the past, present and future of a promising weaving. University College Ghent Belgium
- *April 2010*: Modsimtex 7. FP – project description. Textiles in new Milenium VIII. Faculty of Textile Engineering, Technical University of Liberec.
- *15th April, 2010:* Presentation of the Project in the AEQCT (Spanish textile chemical and dying industrial association) Conference Barcelona
- *May 2010:* Scientific Conference: Using Adina System for Numerical Modeling of Textile Structure. Faculty of Material Technologies and Textile Design, Lodz
- *May 2010:* Publication. Cotton yarn and fabric production: current and future trends. Czech republic
- *May 2010:* Publication ICCE-19 Shanghai Proceedings, World Journal of Engineering. Shanghai.
- *3rd May, 2010:* José Antonio Tornero Interview at UPC TV (http://tv.upc.edu/continguts/simulacio-textil-el-fil-de-la-innovacio)
- *11th June, 2010:* Explanation of the Project activities inside NMP Workshop organized by CDTI in Terrassa
- *October 2010:* Prediction of fabrics thermal conductivity, 5th International Textile, Clothing, Design conference. Dubrovnik, Croatia.
- *18th October, 2010:* Modsimtex 7 RP – Review of the project objectives. 17th International Conference, Structure and Structural mechanics of Textiles. Faculty of Textile Engineering, Technical University of Liberec.
- *24th May, 2011:* Flyers distribution at Techtextil fair in Frankfurt
- *24th - 27th May, 2011*: Modsimtex pylon inside Euratex booth at Texprocess fair (Frankfurt)
- *24th - 27th May, 2011*: Flyers distribution at Texprocess fair (Frankfurt)
- *August 2011*: Conference: Utilization of Special Complex Criterion for Computer Aided Textiles Design. The 40th Textile Resear (Kyoto, Japan)
- *22th - 30th September, 2011*: Showing and demonstration of the Project results in the ITMA fair booths of the partners Intexter, Santoni, Infotex and DITF-MR in Barcelona
- *28th September, 2011*: Presentation of the project at the ITMA Speaker's Corner

- *29th September, 2011*, presentation of Project Results to a textile industrial delegation visiting ITMA
- *October 2011: Conference:* Computer Aided Design Systems. Report for Czech Technology platform and for cluster of technical textiles. Faculty of Textile Engineering, Technical University of Liberec.
- *November 2011*: Conferenece: Description of Fabric Thickness and Roughness on the Basis of Fabric Structure Parameters. Faculty of Textile Engineering, Technical University of Liberec.
- *November 2011*: Complex Criterion for Computer Aided Textiles Design. 18th International Conference, Structure and Structural mechanics of Textiles. Faculty of Textile Engineering, Technical University of Liberec.
- *14th December, 2011:* organisation of a Workshop in Intexter showing project results to local industries of the sector
- *30th December, 2011:* Complex criterion for computer aided textiles design. Chap. 23. Part IV. Textile fabrics. Selected Topics of Textile and Material Science (Czech Republic)
- *30th December, 2011:* Thermal conductivity prediction of textile materials. Chap. 28. Part IV. Textile fabrics. Selected Topics of Textile and Material Science (Czech Republic)
- *January 2012:* Press release at STFI news (http://www.stfi.de/uploads/media/news_12_01.pdf)
- *27th March, 2012:* Publication: MODSIMTex profile and description in Public Service Review: european union - Issue 23, pages 28-29 (http://www.publicservice.co.uk/article.asp?publication=european%20union&id=556&content_name=Overview)
- *29th March, 2012:* Presentation of Project results in the annual Euratex Conference, Brussels
- *May 2012:* Publication: Prediction of polypropylene yarn properties. Czech Republic
- *May 2012:* Conference: 7th Framework Programme EU ModsimTex, review of project objectives. Textiles in new Milenium. Faculty of Textile Engineering, Technical University of Liberec
- *24th May, 2012:* Conferenece: Influence of elastomer threads plating of cotton single jersey knitted fabrics on their estructural behaviour (Kroczyce, Poland)
- *June 2012:* Conference: STFI-training course Nonwovens. STFI (Chemnitz)
- *3rd September 2012:* Conference: Case-based Reasoning applied to Textile Industry Processes. 20th International Conference on Case-Based Reasoning, Lyon, France

4.1.5. Address of the project public website, if applicable as well as relevant contact details.

Project web site: www.modsimtex.eu

Contact:

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