<u>Confidential</u> Final Activity Report

Project No.: COOP-CT-2004-005864

Project acronym: WashControl

Project title: Development of an online-sensor-based WashControl system and water recycling for use in textile dyeing houses and laundries

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Revision [1]

Publishable executive summary

Washing and rinsing processes represent very important and cost intensive steps in SME dyeing houses and laundries. Rinsing and washing is mostly performed under weak process conditions and without any controlling due to lack of suitable sensors. In order to get high quality products and excellent fastness properties the goods are usually washed too long and too intensely. Such a non-controlled washing process is very time consuming and requires a lot of water and energy.

Within this project, a very innovative online sensor-based WashControl system was developed for use in discontinuous dyeing ranges and in laundries, which enables water savings and economic recycling of process water with membrane technology. Prior to the development of the online-sensor device, an evaluation of rinsing and washing processes took place. It became obvious that a recipe control of existing recipes enables large potential for water savings in dyeing houses and laundries as well. Due to a modification of recipes, water savings in rinsing and washing of up to 30% could be realized. Further on, existing dyeing, rinsing and washing procedures were analysed with online sensors and reasonable controlling parameters for process control were identified and collected in a data base. A combination of sensors, which determine pH, conductivity, temperature and color as well as redoxpotential and active oxygen content was considered. Reasonable sensors for online-control of theses individual processes could be identified, tested and were implemented in pilot plants and real production environment. At the same time, the software WashControl was developed and optimized for proper process control in pilot plants and practice.

The most reasonable online-sensor device was the online-measurement of the color content in rinsing and washing compartments, which was measured with a newly developed sensor system by ITCF. This online sensor was combined with pH and conductivity measurement and implementeed in industry, as shown in Figure 1. A relevant sensor for laundries is based on measurement with UV-light, which can be used for the identification of some individual surfactants and detergents.

Fig.1: Online sensor device for measuring color, ph, conductivity and temperature

With the help of this multi-sensor device, rinsing and washing in dyeing houses and laundries could be simplified and a water saving of up to 50% could be realized. The sensor device was implemented in industry and adapted to electronic controlling devices. Sensor signal is processed online in dyeing machines and a rinse control was realized with the help of controlling parameters. The online-technique was totally implemented and verified in dyeing houses. In addition, the sensor devices were adapted to existing control devices in dyeing machines. The use and further development of this technique resulted in an online-sensor-controlled rinsing and washing process with reduced water and energy consumption. In individual cases, a reduction in process time of up to 70% could be realized.

Water recycling in laundries and dyeing houses was realised using a combination of ultrafiltration and reverse osmosis. Recycling water was colorless and was successfully reused in dyeing and in rinsing without any influence on product quality. This was done in lab, pilot plants and in practice.

The use of the optimised WashControl system guarantees a minimum of process time and water consumption. In most cases, savings in water and time are much more than 30%. At the same time, the reuse of recycling water for rinsing and washing as well as for dyeing was developed, which enables closed water loops. Results of this research project are very profitable for the involved SMEs, which are coming from machinery industry and dyeing houses as well as laundries. The outcome of this project ensures a clean and proper production in an ecological and economical emphasized production environment and will refresh the competitiveness of the European SME textile industry, which suffers from cheap production in low cost countries.

The involved organizations in this project are:

Partic. Role*	**Partic. Type****	**Partic. no.**	**Participant name**	**Participant short name**	**Country**
CO	RTD	1	Intitut für Textilchemie und Chemiefasern Kötschtalstrasse 26 73770 Denkendorf Contact: Dr. Reinhold Schneider, Tel +49-711-9340-103 reinhold.schneider@itcf-denkendorf.de	ITCF	Germany
CR	RTD	2	Institute for Textile Chemistry	ITEK	Slovenia
CR	RTD	3	Institute for Product Development	IPU	Denmark
CR	OTH	4	Thies GmbH & Co. KG	Thies	Germany
CR	SMEP	5	Beti Tekstilna Industria-Program Pletiva d.d	Beti	Slovenia
CR	OTH	6	F.O.V. Fabrics AB	FOV	Sweden
CR	SMEP	7	Pralnica Lucija d.o.o.	Lucija	Slovenia
CR	SMEP	8	Punto Bianco S.R.L..	Punto Bianco	Italy
CR	SMEP	9	MDS-Prozesstechnik GmbH	MDS	Germany

*CO = Coordinator
CR = Contractor
SMEP= Small and Medim Sized Enterprize
RTD= RTD-Performer
OTH= Others

Section 1 – Project objectives and major achievements during the reporting period

General Objectives

Within this project, a very innovative online sensor-based WashControl system shall be developed for use in discontinuous dyeing ranges and in laundries, which shall particularly enable water savings of at least 30% and economic recycling of process water with membrane technology.

In the first reporting period, relevant sensors and control parameters for rinsing and washing shall be identified. Conventional washing processes shall be analyzed in order to display inefficient process conditions and the potential of water saving. On the basis of this, inefficient washing and rinsing conditions shall be eliminated. There shall also be performed a critical check of dyeing and washing recipes and hazardous chemicals shall be substituted by less hazardous compounds or eliminated. Relevant sensors for online-measurement (Colour detector (WashProf), conductivity, pH) shall be identified and tested and the washing off properties of removed dyestuff and contaminants shall be determined for further use in simulation processes. Finally, control parameters (limiting values for conductivity, pH, colour...) for a perfect result (high fastness) in rinsing and washing shall be established and verified. The effect on wastewater depollution shall be determined and measured.

Within the second reporting period of the project, the identification and development of further relevant sensors shall be continued as well as further process control parameters shall be collected. The WashControl system shall be developed for discontinuous dyeing ranges and laundries, which consists of a multi-detector system and a controlling software. Relevant sensors shall be put together in order to get a detector array for use in process control in rinsing and washing. The implemented sensors shall be modified according to demanded properties and be tested. Furthermore, advanced sensor and sensor arrays (3-wavelength spectrophotometric sensor and IR-active sensor) shall be developed, which enable adaptation of the sensor to various fields of application. A software shall be developed for processing of online data on the basis of the very latest washing algorithms and with respect to identified control parameters. The wash control software shall enable to minimize the costs in washing and rinsing at high fastness level. The whole system has to be tested for stability and reliability.

The whole controlling system shall be tested and optimized in rinsing and washing in laboratory. The system has to be calibrated with different dyestuffs and proper data transmission of the adapted sensors and data processing of the software has to be tested and verified. Controlling parameters and algorithms as well as their advanced combination have also to be checked and improved. The efficiency of the controlling system referring to high fastness properties and water saving shall be evaluated for standard processing and hot washing and longtime stability of sensors will be investigated. After successful testing and optimization in lab, the WashControl system shall be installed in dyeing houses and laundries and tested under real industrial process conditions in washing. The multi-sensor system shall also be tested for use in membrane plants.

A water recycling technique for rinsing and washing water on the basis of membrane technology shall also be developed. Most reasonable membranes have to be selected and applied as well as the effect of process chemicals and the type of wastewater on membrane performance and permeate quality has to be investigated. These studies shall also include the identification of cleaning methods and cleaning cycles for the membrane. The sensor device shall be tested for these purposes. Industrial wastewater coming from laundries and dyeing houses shall be recycled and tested for reuse in rinsing and dyeing. The economy of the membrane recycling process shall be evaluated.

The most significant innovation within this research project is the development of a online multi-sensor detection systems and WashControl software, which will enable the optimization of the rinsing process on the basis of online data with focus on economic and environmental benefits. Such a sensor controlled process would save at least 30% of water and time, which is a significant step forward beyond the state-of-the-art. Moreover, recipes for dyeing, rinsing and washing will be optimized with respect to the substitution of hazardous chemicals by less hazardous compounds or the elimination of them. Dyeing and rinsing water as well as water from laundries will be purified using membrane technologies in order to reuse the water in washing and dyeing processes. This technique will be improved with respect to membrane performance and be applied in combination with the WashControl system, which should result in rational use/reuse of water. In addition, these are also highly efficient methods to prevent water pollution. These innovations will support the competitiveness of SMEs through producing their textile products very clean and at highest quality level. SMEs will also profit by providing licenses to the machinery industry, which in turn produce innovative machines with a high added value for the SMEs.
The outcome of this project will ensure a clean and proper production in an ecological and economical emphasized production environment and will boost the competitiveness of the European SME textile industry, which suffers from cheap production in low cost countries.

State-of-the-art

The project´s approach is based on an intensive documentary study, including literature, publications, patents, standards and data-base searches. Up to now, online-sensors for process control are neither used in dyeing houses nor in laundries. The controlling still depends on the experience of the operating staff.
Washing and rinsing can be performed on different machines. In continuous textile finishing, the most important rinsing machines are represented in the rope washing range and the open width washing machine or combinations of them [6-16, 35]. Laundries mainly use tunnel washers and drum type washer.
The washing result can be described with the level of efficiency for washing, since this universal parameter directly indicates the extractable stain [8, 17-18]. The definition of this parameter (WWWGRD) is:

$$WWWGRD = \frac{C_0 - C_{End}}{C_0} \cdot 100\,\%,$$

C_0 represents the degree of soil on the textile good before washing and C_{End} represents the condition after rinsing. The washing effect depends on washing time, temperature, liquor ratio, circulation of liquor, size and number of compartments, diffusion coefficient, exchange factor and others [11-16, 19-32]. The washing efficiency increases with an increase in the number of washing compartments and using a counter current [10]. Moreover, textile goods have to be squeezed very good in order to get a perfect separation of washing compartments. This was confirmed for rinsing of reactive printed [19] and dyed materials [20, 32-33]. The use of hot rinsing water was recommended. The positive influence of these parameters [21-34] on washing can be described with the diffusion controlled exchange factor (g) according to the 1. Fick´s law [8, 21]:

$$g = \frac{D}{h} \cdot (C_w - C_B) \qquad \text{(1. Fick´s law)}$$

According to this law, the exchange rate (g) is proportional to the coefficient of diffusion and to the gradient of concentration (C_w-C_B) and reverse proportional to the thickness of the diffusion boundary layer h, which is dependent on the substrate and the liquor flow through it [26]. C_w represents the concentration of the stain on the fabric and C_B is the concentration in the washing bath. The exchange rate (g) and thus the washing effect increases with the increase of the diffusion coefficient and with increasing gradient of concentration as well as by a decrease of the distance of diffusion h. The diffusion coefficient and concomitantly the exchange rate g=D/h can be increased by increasing the temperature and liquor flow through the substrate and by a decrease in viscosity [8]. The gradient in concentration can be significantly influenced by means of fresh water supply, whereas the coefficient of diffusion and the distance of diffusion is influenced by temperature and liquor current. According to this and in order to improve washing efficiency, rinsing and washing is recommended at high temperature [19-20, 32-33 36-38]. Washing/rinsing with hot water significantly reduces rinsing time and saves chemicals, which was confirmed in industry [29-30, 36-37]. So far, these investigations were performed with only a few reactive dyes, but nevertheless this technique is very promising referring to the minimization of water consumption. It is expected, that the application of the hot washing technique can reduce water consumption up to 30%.
The time-dependent concentration (C_t) of the removable pollution on the fabric depends on the initial contamination (C_0) and the kinetic constant of the washing process, which is influenced by the exchange rate (exchange factor) g=D/h and the liquor volume (V_0) and washing time (t). The level of adjustment (EINSTGRD) indicates, how far the level of washing efficiency is equilibrated and is represented by the following equation [8, 17]:

$$EINSTGRD = f_E = \frac{C_O - C_t}{C_O} = \left(1 - e^{-k_w \cdot t}\right) = \left(1 - e^{-\frac{D \cdot t}{h \cdot V_o}}\right)$$

$$\Rightarrow C_t = C_O \cdot e^{-\frac{D \cdot t}{h \cdot V_o}} = C_O \cdot e^{-k_w t}$$

In order to enable a complete removal of the contaminant during washing, fabric speed must not be too high (sufficient washing time required), since diffusion is a time-dependent procedure. A high efficiency in washing ($f_E \rightarrow 100\%, C_t \rightarrow 0$) is also achieved by a high fresh water supply, because this prevents saturation.

The minimization of water consumption in rinsing and washing requires to meet exactly the demanded values of washing efficiency and level of adjustment. This can be only be realized by using online measurement of removed contaminants and applying control algorithms.

Practical control algorithms are based either on the measurement of the temporal change of the washed off contaminants or depend on the interdependence between the fastness properties and the quantity of residual contaminants on the fabric, whereby the optimal washing procedure takes place on the relationship between totally removable contaminants and the actually removed pollutants [2,3]. It is well-known that a pollution of up to 0,1 g/m^2 dyestuff can remain on the fabric, without causing a decrease in fastness properties. In addition the coloration of the final rinsing bath can also be used for process control. Rinsing must be continued until the concentration of the dyestuff falls below 3 mg/l. Rinsing will be stopped when the amount of dye in the rinsing bath reaches a certain limiting value. This procedure enables a maximal loading of rinsing baths and at the same time long rinsing processes can be avoided, whereby the water consumption and washing time can be significantly shortened. Such a process controlling can be done online, as far as the removement of the contaminants is measured continuously [1-3]. But up to now, online-sensors for process control are neither used in discontinuous dyeing nor in laundries. Usually, the washing result is evaluated visually (stone age method), which causes a high water consumption and long rinsing time.

In the past, methods like the measurement of conductivity and pH were tested for use in rinsing and washing [2]. These online-methods are cheap and easy to use, but the real values of washed off dyestuffs or contaminants were purely met by accident, even when desired values for pH and conductivity were met. Material-specific measurements are additionally demanded. A well-known method for the determination of dyestuffs in washing liquors is the ECOD-technique (electro-chemical-oxygen-demand). This method enables the electro-chemical determination of the chemical oxygen demand of the liquid medium, which is considered as a characteristic parameter for the amount of dye [1]. Another method for the quantification of dyestuff content is the determination of the TOC-value (TOC= Total Organic Carbon). However, both methods are not really online-measuring methods because the measuring time per sample is more than 2 minutes and hence a significant delay between actual value and measured signal occurs. Due to this high response time, these methods are not suitable for controlling rinsing and washing processes.
As a matter of principle, optical spectral spectrophotometers can be used for the determination of the amount of dye [17-19]. However, such equipment is very expensive and expendable, since the rinsing water must be supplied to the measuring instrument by means of pumps. This also results in a high response time of the sensors signal and thus causes significant delays and errors in process controlling. Another measuring method is recognized in the photoacoustic, since this method was especially developed for the identification of non-colored and highly concentrated substances [40]. This method is a

real online-measuring method, but very complicated in use, very maintenance-intensive and too expensive for any application in process controlling.

The very latest development in online-sensor technology is represented in an online-immersion sensor (WashProf) [42-48], which is based on an absorptive color measuring technique in a electronic semiconductor construction [2]. Due to its simple modular structure, this immersion sensor can be manufactured at a very low price (price category of a conductive sensor), which is accepted by the market [42-48]. The measuring head consists of a lights transmitting unit with an emitting semiconductor element (LightEmittingDiode) and a receiving unit with a semiconductor receipt element (photoresistor, photodiode, phototransistor). The semiconductor element is formed of a light emitting diode (LED), whose maximum radiation power is within the absorption spectrum of dyestuffs. The most reasonable light emitter consists of a high power LED with a wavelength of 470 nm and a maximum band width of 100 nm. All colored materials are light-absorbing at the emitting wavelength of the well selected light emitting diode. The absorption distance is typically at 2-3 mm but also adjustable, which enables the measurement of very low and very high amounts of dyestuffs. Non-absorbed light is registered by a semiconductor receipt element and the received signals are evaluated for the determination of the amount of dye on the basis of Lambert-Beer´s law. The dependence of the absorption measurement on sensor-specific parameters is eliminated by accomplishing only one calibration measurement of a well-known solution of dyestuff. Further dyestuff measurements will use this calibration measurement. The WashProf-sensor is still not commercially available, but the research institute ITCF provide some prototypes to the project partners.
A substantial advantage of this optical sensor is the fact, that the measuring head is designed as a totally capsulated and almost maintenance-free immersion sensor, which can be placed anywhere in a rinsing bath. The sensor is suitable for the online-measurement of low and high concentrated liquors, which is provided by typical rinsing and washing liquors. In contrast to previously reported methods, this sensor provides a real online-measurement without any time-delayed transmission of the signal. Moreover, this sensor exhibits a very small but compensatable drift with temperature, which allows its use in hot washing compartments of fastness wash. This sensor was already reported for successful use in online-measurement of up to 2 g/l dyestuff in continuous hot rinsing. In addition, this sensor can also be used for turbidimetric analyses. Further benefits are recognized in a modification and suitable selection of advanced sensor elements, which could expand the measuring range significantly. The initial costs of such an innovative sensor will be less than 1/100 of an ECOD equipment, which meets the requirements in textile and laundry industry [42-48].
This WashProf-sensor is recognized as a powerful tool for the measurement of colored and non-colored washing water. Especially in its advanced combination with pH-measurement and conductometry, this sensor may offer an innovative and realistic controlling of rinsing and washing processes in dyeing houses and laundries, which is not realized up to now. Such a multisensor would be capable of online-measurement of pH (alkaline), conductivity (salt) and extinction (removed dyestuff) as well as quantity of

colorless pollutants in the rinsing water, which is demanded for a safe rinsing and washing process. It is expected that such a multisensor can be used in cold and hot rinsing at low and high concentration of pollutants. Moreover, this advanced multisensor will provide much more precise and exact measurements of water pollution (especially for dyestuff mixtures) compared to prevailing measurement techniques.
Up to now, no competing online sensor device could be identified. So far, an online-sensor device for colored componente was promoted in 2005 by the company MATHIS, Switzerland. However, the costs of this device are in the range of € 35.000, which is much more higher than the expected cost for the ITCF-online sensor (sensor costs about € 1000). It was also indicated by the Italian company Brazzoli to introduce an online-sensor device similar to WashProf. The Coordinator has contacted this company, however, no reply was granted so far. It is estimated that Brazzoli cannot provide a corresponding online device for color measurements. So far, no online multi-sensor-device was published which could be used or replace the online-sensor-device of ITCF (WashProf). Previous research activities on multisensor use in textile applications carried out at national level under European initiatives unfortunately cannot provide a new impetus in this matter (no relevant multisensor for rinsing and washing processes was developed).

Due to the increasing local taxes, regulations on energy and water consumption, there is also a need for a closed loop for water systems in textile industry. Textile and laundry industry can be considered as a source of significant amounts of re-usable effluents. Thus, industry should be encouraged to invest in better water efficiency, more recycling, and management. Wastewater recycling is emerging as an integral part of water demand management, promoting as it does the preservation of high-quality fresh water supplies, as well as potentially reducing pollutants in the environment and reducing overall costs. In order to have water that can be used recycled in production cycles, the water needs further treatment (called tertiary or advanced treatments). The most promising wastewater treatment methods are membrane separation processes. Developments in membrane technology have resulted in increased applications in many areas, such as the biochemical, food and beverage industries, including wastewater reclamation. Interest in membrane technology for various industrial processes is growing noticeably, thanks to new technological innovations that enable it to become safer and more economical than other alternative systems. The attractive features of membranes are: low weight of the equipment, reduced use of chemicals, a constant quality permeate and a high potential for automation in comparison with conventional wastewater reclamation processes.
The interest in membrane processes applied to textile wastewater reuse is increasing thanks to recent technological innovations that render them reliable and economically feasible as an alternative to other systems. Several approaches have been proposed to implement membrane technology to the treatment of textile wastewater from different production streams. Microfiltration (MF) allows a simple clarification of the effluent, removing suspended particles (micro-organism, inorganic particles, colloids). Ultrafiltration (UF) is effective for removal of particles and molecules of dimensions higher than 10 nm, bacteria, viruses and proteins. MF and UF are generally proposed as reverse osmosis (RO) pretreatment. The first RO membranes were made out of cellulose acetate (CA). The

advantage of this membrane material is that it is relatively hydrophilic and the adsorption of organic matter onto the membranes is thus relatively low. The disadvantages of this material are it is very sensitive to thermal, chemical and biological attack. For instance, the pH of the filtration solution must be controlled between 4 and 6, 5 in order to prevent hydrolysis of the membrane material. RO membrane based on polyamide (PA) show a better resistance against thermal, chemical and biological attack and can be used in alkaline (till pH=10) conditions. These membranes are normally preferable to those made of cellulose acetate for the treatment of industrial waste streams. Their disadvantage, compared with cellulose acetate, is that they are more susceptible to membrane fouling as PA membranes are less hydrophilic. In the textile wastewater treatment, pilot plant tests with reverse osmosis, nanofiltration and ultrafiltration of wastewater from continuous washing processes subsequent to reactive dyeing processes have been investigated. The ultrafiltration does not totally decolourise the waste stream. The reverse osmosis membrane also desalinates the waste stream considerably (NaCl retention of 93%), however, the retention for the reactive dyes is somewhat lower in the nanofiltration process. Severe membrane fouling is observed if the waste stream contains dispersed dyes, which are applied together with reactive dyes in some dyeing processes. The recycled water coming from continuous processes was successful reused in rinsing [2]. Up to now, this promising recycling concept was still not investigated and applied in discontinuous dyeing and rinsing processes and in laundries.

According to the state-of the-art and the targeted objectives, it becomes obvious that the research project WashControl is up to date and very innovative. Research has to be performed regarding the applicability of this new WashProf-sensor [42-48] in combination with other sensors in rinsing and washing. Facilities in application as well as the limits of this immersion sensor in rinsing and washing has to be identified and evaluated in dyeing houses and in laundries. But also the influence of washing temperature and washing mechanics on washing result and textile quality has to be investigated with this sensor, in order to estimate corresponding diffusion coefficients and exchange factors, which could be important for simulation studies. The use of this sensor in dyeing houses will demand a well controlled temperature compensation of the sensors signal, since some dyeing processes are performed at 130°C. Moreover, multiple signals from different other sensors (pH, conductivity…) have to be processed and intelligently linked in a Control software. The system has to be tested and verified for different dyestuffs and complex mixtures on different substrates and control parameters have to be fixed as decision criteria for the WashControl system. The knowledge of these parameters would offer for the first time, that rinsing and washing processes could be easily controlled and optimized on the basis of online data with focus on economic and environmental benefits.

The most significant innovation within this research project is the development of a online multi-sensor detection systems and WashControl software, which will enable the optimization of the rinsing process on the basis of online data with focus on economic and environmental benefits. Such a sensor controlled process would save at least 30% of water and time, which is a significant step forward beyond the state-of-the-art. Moreover, recipes for dyeing, rinsing and washing will be optimized with respect to the substitution of hazardous chemicals by less hazardous compounds or the elimination of them. Dyeing and rinsing water as well as water from laundries will be purified using membrane technologies in order to reuse the water in washing and dyeing processes. This technique will be improved with respect to membrane performance and be applied in combination with the WashControl system, which should result in rational use/reuse of water. In addition, these are also highly efficient methods to prevent water pollution. These innovations will support the competitiveness of SMEs through producing their textile products very clean and at highest quality level. The successful performance of the project demands the inclusion of a manufacturer of dyeing and rinsing machines. Since no important SME manufacturer of dyeing and rinsing ranges is left, a main supplier of dyeing and rinsing machines for SME companies was included in this project, which will benefit as licensee by producing innovative machines with a high added value.

Summary of the work performed and main achievements

The project is performed within 4 main research and innovation related workpackages which include 10 tasks (T) in order to achieve the objectives. The whole project is managed through the management workpackage. Within this workpackage, project meetings were organized and technical teams were built. These teams carried out the specific tasks. The project run was assessed according to deliverables. Reports and contractual matters were managed successfully and with the agreement of the consortium. Within the first reporting period no important deviations occured. Considering the whole project, there were only minor changes in the budgets of the partners. IPU was not able to perform water recycling tests as planned and handed over some responsibilities to MDS. All project partners accepted that MDS took over water recycling tests and remaining budget (about 70% of 2nd year budget) of IPU. The consortium also agreed on the request of some individual project partners, to perform some tasks with lower skilled people than planned in order to increase the number of tests which guarantees a better performance of the whole project. No serious problem occured during the second reporting period.

The main objectives for the first reporting period are to complete WP1, which deals with the identification of relevant sensors and control parameters. Further on, the development of the washcontrol system should be started as well as water recycling in lab should be performed. The main objectives for the second reporting period are to finalize remaining tasks of WP1 (identification of relevant sensors and control parameters). Further on, the washcontrol system has to be developed and optimized as well as implementation in pilot plants and industry had to be performed. In addition to this, water recycling shall be implemented in pilot plants and industry as well as reuse of recycled water in dyeing and rinsing should be performed.

The **first workpackage** can be described as the identification of relevant sensors and control parameters. This workpackage includes the identification of weak process conditions and the optimization of dyeing and washing recipes referring to the chemical substitution of hazardous chemicals by less hazardous compounds or the elimination of them (T 1.1.). This task was mainly carried out by the research institutes ITCF, ITEK and IPU. Laundries and dyeing houses performed improvement and monitoring of the washing and rinsing processes for displaying the potential of water saving on their own machines. Recipes were modified in dyeing houses and laundries, which results in a depollution of the wastewater. The development of relevant sensors was an ongoing process which was also of relevance within the second project year. Relevant online-sensors (conductivity, pH, VIS-spectroscopy (WashProf), turbidimetric analysis (WashProf), redoxpotential, oxygen content, temperature) were identified within the first project year and used for the analysis of washing processes referring to removal properties of chemicals and stain from the fabric wich gave very important data on availability and linkability of fifferent sensor types for this purpose (T1.2. ITCF). With the help of these sensors and simply by analysing the rinsing and washing process itself, a reduction of water and energy consumption could be realized with the optimized recipes and process conditions. The dyeing house Beti was involved in the analysis of rinsing and washing and determination and setup of controlling parameters for their production pallet (T 1.3). These online-measurements gave support to Thies (manufacturer of dyeing machines) in installation and integration of the online sensors in the hard- and software environment. The reasearch institute ITEK took care of analyses of wastewater and was responsible for quality control of rinsed and washed goods. The industrial partners (including Beti) carried out dyeing, rinsing and washing on different machines and articles. It became obvious that a sensor controlled dyeing and rinsing can be performed simply by using the ITCF-color-sensor (Washprof) in combination with measurement of pH, conductivity and temperature. However, the identification of a reliable sensor-setup for use in laundries was much more difficult. In addition to relevant sensors (redoxpotential, oxygen) a UV-sensor was developed, which can be used for identification of some individual surfactants and detergents. With the help of the involved laundries, the list of control parameters (laundries) could be ammended and parameters were verified. Finally, further tests referring washing off properties of dyestuff and stain were performed in order to identify the influence of temperature and salt on the removal properties and exchange factors. It became obvious, that the presence of salt reduces the washing off performance of dyestuffs at low temperature whereas rinsing at high temperatures is not significantly influenced in the presence of salt. The interdependences between washing/rinsing effects, fastness properties and sensor signals were determined and collected in an ongoing database and control parameters (limiting values, washing off rates) were evaluated and established. This was done in collaboration of the research institutes ITEK and ITCF and the industrial partners.

Within the **second workpackage** the development of the WashControl system took place. The most reasonable sensors and/or combination of sensors were used for the setup of the multi-sensor detection system (T 2.1) by the research institute ITCF. The multi-sensor-system includes pH, conductivity, temperature and color measurement, which is of interest for dyeing houses. For laundries, the multi-sensor-system consists of pH, conductivity, temperature, redoxpotential and oxygen content measurement as well as UV-sensor (identification of some surfactants). Color measurement is optional. All industrial partner supported the ITCF in extensive testing of the sensor-array referring to practical construction and self-cleaning properties. ITEK did further evaluation tests in lab and industry referring to determination of active chlorine with conductometric tests. ITEK found a linear interdependence between conductivity and chlorine content. A 3-wavelength (RedGreenBlue) spectrophotometric sensor was also developed by the experts of ITCF, which can be used for identification of individual colors in a complex mixture. The whole multi-sensor-systems were successfully tested for stability and reliability within the second reportin period. The design and development of the WashControl software was carried out by ITCF and Thies in very close cooperation (T.2.2), resulting in a color sensor with selfcleaning properties. The software was programmed by integrating latest control algorithms and control parameters and was adapted to the sensors via interfaces. The software enables the use of up to 9 different sensor devices and it was successful tested on mobile control computers in lab as well as in dyeing houses and laundries. The software represents an open system with easy integration of further sensor devices via RS232 linking. Thies already did the implementation of the data acquisition tool and process control tool in their dyeing machines. Dyeing houses and laundries partners gave an input referring to demanded functionality and user friendliness of the software. The dyeing house Beti was involved in testing and implementation of the WashControl system and multi sensor system to short and long liquor ratio dyeing machines in pilot plants and real production. The sensor system was installed at Beti and at FOV for testing of longtime performance on different dyeing machines. Testing has been perfomed on 2 different batch dyeing machines at Beti, on an Ecomaster and on a Jigger-dyeing machine in the pilot plant at Thies and on a Then-Airflow machine at FOV. This testing was done by the dyeing houses with the support of ITCF, ITEK and Thies using the washControl software and the software Colormeasurement. Furthermore, a simulation tool was developed and used for optimization of the rinsing conditions. The industrial partners provided economic data of their rinsing and washing processes which were used in the WashControl system for most economic processing. With the help of the industrial partners, most relevant processing parameters and efficient washing algorithms were identified (see deliverables).

The **third workpackage** was the testing and optimization of the WashControl system. This workpackage was originally planned to start within the second year of the project. However, the consortium decided to start earlier with this work, since the sensors could be tested and used under industrial conditions, which results in much more reliable and verificable results/applications. The early installation of the sensor housing and interfaces as well as implementation of software to dyeing machine enables a more efficient and better testing of the sensors and their implementation. The whole sensor-system was continuously tested and verified in lab (T 3.1) on batch dyeing machines and washing machines and was then approved and optimized with different dyestuffs and verified on different materials in dyeing houses and laundries. At the beginning, the testing was mainly performed by the research institutes ITCF and ITEK and then stepwise integrated in the processing of the dyeing houses and laundries. The manufacturer of dyeing machines Thies gave significant support in optimisation of software and adaptation of

hardware by numereous testings and verifications in their pilot plants. Dyeing houses Beti and FOV supported this testing and optimisation by supplying a big pallet of dyed goods of different qualities for testing within the second reporting period. The WashControl system was fully implemented in pilot plants and industry (T.3.2.) and proper working conditions of the sensors and acquisition/control software have been studied and evaluated. Dyeing houses have used the system day by day in hundreds of batch dyeings and rinsings. The sensor was tested up to 130°C without any problems. It became obvious that no staining of the color detector with lints occurs, when the sensors gap is > 1mm. If the gap is less than 1mm, a special cleaning of the sensor surface by removing sharp edges is required. The color detector not only enables the control of rinsing after dyeing but also makes it possible to determine the dyestuff concentration within the dyeing process. Due to these measurements, the dyeing process and rinsing could be shortened and at least 2 rinsing baths could be safed, which was verified in the optimization phase and during monitoring. The dyeing house Beti and FOV supported Thies by performing longtime performance tests in pilot plants and practice. The dyeing houses and laundries tested the system referring to proper working conditions and reliability on different dyeing/rinsing and washing machines with different articles. Such testing and optimization was also done in laundries. The result was, that the WashControl system works very proper and that a monthly cleaning of the sensors is recommended.
During the monitoring, cost savings could be quantified for dyeing houses. At Beti, the online-measurements/process control has shown that the dyeing processes as well as the rinsing processes could be shortened significantly. Furthermore chemicals such as alkaline could be saved, since there was an overdosage. In most cases, time for dyeing and rinsing could be shortend by 30% and the water consumption for each kg of textile material could be reduced from 160 l/kg to 92 l/kg without any negative influence on product quality (tested and verified by ITEK).
At FOV, the time reduction per rinsing cycle is 20 min per batch and 15 min time reduction in dyeing. The amount of rinsing water per batch was reduced from 10 to 3 m^3. Especially for light fabrics, the total amount of rinsing water could be reduced from 30 l/kg to 6 l/kg as well as a lot of chemicals and energy could be saved. Their total savings per year (4300 batches) is calculated with 161.000 EUR.
At the laundries, productivity increased due to better operation of washing machine with less defects and minor time (10-20%). Onlinemesurement with multi-sensor device indicate the presence of detergents and bleaching agents. On the basis of data obtained, desinfection of main wash was controlled.

Water recycling was performed within the **fourth workpackage**. The basic development of water recycling was done in lab by selecting and testing reasonable membranes and characterization of permeate quality within the first reporting period. The membrane selection and testing was carried out by the experts of IPU and MDS (T4.1) and reasonable membranes could be identified. Reasonable membranes could be identified and ITEK continued characterization of the permeates and concentrates in the second reporting period. This was done in lab and pilot plants and was extended to industrial recycled process water coming from dyeing houses and laundries. Implementation (T4.2)

of water recycling in rinsing and washing was successful done in dyeing houses and laundries by MDS with the support of ITEK and industrial partners. Water recycling could be realised using ultrafiltration and reverse osmosis membranes. A huge number of water recycling tests and implementation took place in the second year of the project and colorless recycled water was tested for reuse in dyeing and rinsing (T4.3) by ITEK. The research institute ITEK characterized the permeates and performed laboratory trials for reuse of permeates in batch dyeing and rinsing. It could be concluded, that permeate coming from selected NF or RO membrane treatment can be used for rinsing and dyeing without any negative influence on the fastness properties. Water recycling was also successful performed at Beti by MDS in pilot scale. Recycling water was reused in dyeing and rinsing without the necessity of modification of the dyeing recipes. The dyed material (reactive dyeing on cotton) had the same color shade, color depth and fastness properties as the standard dyed material. This was confirmed by the lab trials of ITEK.
Reuse of recycling water in laundries was successfully tested in lab scale at ITEK and Lucija. According to the calculations of Lucija, a water 100% of recovered water could be reused in rinsing and washing.

Details of the work performed and achieved results are provided in the deliverables reports.

The estimated time-to-market for introduction of the new sensor is expected to be less than 1 year after the completion of the research project. When the research project is finished, the involved machinery industries will install some multi-sensor systems in the machines of the involved SMEs and will perform long-time performance studies in order to eliminate any errors in software and to get important information on maintenance intervals. At the same time, these studies demonstrate the performance of the innovative system. This procedure will guarantee marketable rinsing and washing machines with a high added value and upgrading of existing washing machines with the very latest sensor technology. The availability of the WashControl system on the market will enable the European dyeing houses and laundries to produce at a higher quality level and much more cheaper, since this innovation brings the most significant return of investment in HighTech countries, where costs for personal and environmental protection are very high.

Section 2 – Workpackage progress of the period

Within the 1st reporting period no negative deviations occurred and the project runs largely according to the scheduled plan. About 52% of the proposed budget is consumed after 1 year for this 2 year project. The sensor housing was installed earlier than planned, which enables a more efficient and better testing of the sensors and their implementation. According to the efficient planning and working of the individual partners, the whole workpackage 3 (testing and optimization of the WashControl system) as well as task 4.2 (implementation of water recycling) could be started within the first year of the project. This means that the progress of the project is better than expected and deliverables are available as well as milestones were reached in time.

Within the 2nd reporting period no negative deviations occurred and the project runs largely according to the scheduled plan. About 50% of the whole budget was consumed in the 2nd reporting period. In general there were only minor changes in the budgets of the partners, where the consortium agreed on. IPU was not able to perform water recycling tests as planned and handed over some responsibilities to MDS. All project partners accepted that MDS took over water recycling tests and remaining budget (about 70% of 2nd year budget) of IPU. The consortium also agreed on the request of some individual project partners, to perform some tasks with lower skilled people than planned. According to this they were able to increase the number of tests and trials which gave a better performance of the project. This procedure increased the total number of man-months and benefits the project without overstretching the whole budget. The most significant deviation in man-months happened during implementation and adaptation of the lab-system in industry, since some modifications in sensors and software were required. No serious problems occured during the second reporting period. The progress of the project is excellent and deliverables are available as well as milestones were reached in time. The following tables give an overview on the workpackages and tasks as well as on deliverables and total man-months.

Table 1: Workpackage list (full duration of project)

Work-package No	Workpackage title	Lead contractor Short Name	Person-months	Start month	End month	Deliv-erable No
0	**Management**	**ITCF**	**12 (5+6)**	**0**	**24**	**0,20,21**
1	**Identification of relevant sensors and control parameters**	**ITEK, ITCF**	**64 (86+2)**	**0**	**8 (10)**	**1-5**
2	**Development of WashControl system**	**Thies**	**48 (32+39)**	**7**	**16**	**6-9**
3	**Testing and optimisation of WashControl system**	**ITCF**	**51 (25+65)**	**14 (4)**	**24**	**10-14**
4	**Water recycling**	**IPU, MDS**	**44 (28+51)**	**0**	**24**	**15-19**
	TOTAL		**219 (176+168)**			

Numbers in brackets ( ) are actual values (1st year + 2nd year)

Table 2: Task list (full duration of project)

Task	Task	Lead contractor	Person-months	Start month	End month	Deliv-erable
0	**Management**	**ITCF**	**12 (5+6)**	**0**	**24**	**0, 20,21**
1.1	**Recipe control and process analysis of the conventional process**	**ITEK**	**17 (25+0)**	**0**	**3 (6)**	**1-2**
1.2	**Analysis of rinsing and washing using online-sensors**	**ITEK, ITCF**	**29 (37+0)**	**0**	**6 (9)**	**3-4**
1.3	**Evaluation and setup of control parameter**	**ITEK, ITCF**	**18 (24+2)**	**3**	**8 (10)**	**5**
2.1	**Development and setup of a reliable multi-sensor system**	**ITCF**	**26 (20+20)**	**6**	**15**	**6-7**
2.2	**Design and development of the WashControl software**	**Thies**	**22 (12+19)**	**7**	**16**	**8-9**
3.1	**Testing and optimisation of detectors and software**	**ITCF**	**25 (11+29)**	**15 (8)**	**20**	**10-12**
3.2	**Implementation in pilot plants and industry**	**Thies**	**26 (13+36)**	**18 (4)**	**24**	**13-14**
4.1	**Development of water recycling in lab**	**IPU**	**14 (18+2)**	**0**	**12**	**15-16**
4.2	**Implementation of water recycling**	**IPU**	**17 (8+26)**	**11 (8)**	**22**	**17-18**
4.3	**Reuse of recycled water in dyeing and rinsing**	**LUCIJA, BETI**	**13 (2+23)**	**19**	**24**	**19**
	TOTAL		**219 (176+168)**			

Numbers in brackets ( ) are actual values (1st year + 2nd year)

Table 3: Deliverables List, whole project

Del. no.	Deliverable name	Workpackage no.	Date due	Actual/Forecast delivery date	Lead contractor
0	2.Activity Report	0	15.5.06	25.5.07	ITCF
1	Values of water consumption and pollution in rinsing and washing	1	1.08.05	5.08.05	ITCF/ITEK
2	Improved recipes and improved process parameters	1	1.08.05	5.08.05	ITCF/ITEK
3	Washing off properties of dyestuff and stain	1	20.12.05	18.01.06	ITCF/ITEK
4	Online-sensor data for washing off curves	1	20.12.05	18.01.06	ITCF
5	Setup of controlling parameter	1	20.12.05	18.01.06	ITCF/ITEK
6	Multi-sensor system	2	1.5.2006	25.5.07	ITCF
7	3-wavelength sensor	2	1.7.2006	25.5.07	ITCF
8	WashControl software	2	1.8.2006	25.5.07	ITCF
9	Simulation tool	2	1.7.2006	25.5.07	ITCF
10	Calibration data	3	1.12.2006	25.5.07	ITCF
11	Proper control algorithms	3	1.12.2006	25.5.07	ITCF
12	Sensor controlled rinsing/washing system	3	1.12.2006	25.5.07	ITCF
13	Data on longtime stability and maintenance	3	31.3.2007	25.5.07	ITCF
14	Optimized WashControl system	3	31.3.2007	25.5.07	ITCF
15	Membrane specifications and properties	4	10.03.06	31.03.06	IPU
16	Membrane filtration performance, damaging chemicals	4	10.03.06	31.03.06	IPU

Del. no.	Deliverable name	Workpackage no.	Date due	Actual/Forecast delivery date	Lead contractor
17	Process parameters referring to high permeate performance	4	1.1.2007	25.5.07	ITEK
18	Cleaning & regeneration procedure for membrane	4	1.1.2007	25.5.07	ITEK/IPU/ MDS
19	Washing results with recycled water referring to salt concentration	4	31.3.2007	25.5.07	ITEK
20	Plan for using and disseminating the knowledge	0	15.5.07	15.05.06	ITCF

Table 4: Milestones List, whole project (included in deliverables)

Milestone no.	Milestone name	Workpackage no.	Date due	Actual/Forecast delivery date	Lead contractor
1	Mid-Term-Assessment	0	1.04.2006	15.05.2006	ITCF
5	Multi-sensor-system	2	1.07.2006	1.07.2006	ITCF
6	WashControl software	2	1.08.2006	1.09.2006	ITCF/Thies
7	Control algorithms	3	1.12.2006	1.12.2006	ITCF
8	Optimized WashControl system	3	1.12.2006	1.12.2006	ITCF/Thies
9	Reasonable membranes	4	1.04.2006	1.04.2006	IPU
10	Cleaning & regenaration of membranes	4	1.05.2006	1.07.2006	IPU/MDS
11	Washing and dyeing with recycling water	4	31.03.2007	31.03.2007	ITEK

Workpackage 0: Management

DWP **Workpackage description**

Workpackage number :	**0**								
Start date or starting event:	**1.Month**								
Participant codes :	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**
Person-months per participant:	**11**								

1 **Objectives**

The project and the consortium shall be managed and coordinated. Coordination structures and plans for a successful management have to be established. The management shall cover contractual aspects as well as the technical management of the project. This also includes the assessment of the progress of the report.

2 **Description of work**

Within the first reporting period, the Coordinator of the project arranged a very first meeting in order to built the Project Coordination Committee (PCC), which is formed by a representative of each partner and is chaired by the coordinator. Decisions are taken by the majority of the votes. The coordinator acts as a link to the EC and he prepare the consortium agreement. In the first and second meeting, technical teams were built according to the workpackages in the proposal description. Each technical team performed the actual workpackages and is composed of one technical representative from each of the partners involved in the workpackage/task. It is headed by the task leader, who belongs to the partner being responsible for the workpackage. The technical team informed the coordinator regularly about the progress of the work. Deliverables were delivered without significant delays according to table 3. Best means of communication (email, telephone, working meetings) were choosen in the first meeting to guarantee frictionless and efficient exchange of know-how.

The PCC met periodically in order to assure a common critical study of the deliverables and their quality. Project meetings took place at ITCF, ITEK, Thies and Lucija. Within these

	meetings, results achieved were thoroughly discussed and assessed as well as tasks precised, conclusions drawn and task planning for the following period was approved. Technological gaps were identified and the state-of-the-art was updated. The dissemination of the results was also fixed within these project meetings. Publications and papers have to be approved by the consortium prior to publication. The Progress and Management Report was written for the first reporting period by the coordinator on the basis of the reports delivered by each partner. The Coordinator collected cost statements, made the payments and drafted the plan for using and disseminating the knowledge. Within the second reporting period 3 further project meetings took place at FOV, Beti and ITCF. The project coordinator organized a Mid-Term assessment meeting with all partners at Lucija. Within this meeting, it was concluded that the project runs largely according to the scheduled plan. The consortium decided to continue the project as planned. Within the further project meetings, tasks were precised and conclusions were drawn. The project was performed according to the scheduled plan and no major deviation happened. The Intellectual Property Right (IPR) of the SME-participants is managed by the project coordination committee (PCC) by majority of votes and in the final project meeting an exploitation manager (coordinator) was appointed. The SME consortium as a whole shall protect the Intellectual Property Right for the improved washing technique and controlling techniques as well as for the combination with membrane filtration in patent applications, if patentable. The involved machinery industry (THIES) will act as a licensee of the patent for the ControlSoftware and the multi-sensor device for use in discontinuous dyeing apparatus, whereas MDS shall hold the patent for the multi-sensor controlled membrane filtration process. The dyeing houses and laundries will be a licence-free user of the patent applications and gather licence-fees according to their contribution to the patents. Their share in patent rights will be established in the final PCC-meeting, according to their contribution to the patent and according to their risk and in agreement with MDS. A decision will be taken by the majority of SME votes. A final plan for using and disseminating the knowledge gained within this project was provided at mid term of the project. The dissemination and exploitation plan was updated at the end of the project and includes the plan for the management of any Intellectual Property Rights. All deliverables and milestones were achieved as planned.
3	**Deliverables** - progress & management report giving an assessment of activities and achievements, detection of technological gaps and update of state-of-the-art of technology, plan for using and disseminating the knowledge
4	**Milestones** - Mid-Term-assessment

Workpackage 1: Identification of relevant sensors and control parameters

DWP	**Workpackage description**								
Workpackage number :	**1**								
Start date or starting event:	**1.Month**								
Participant codes :	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**
Person-months per participant:	**22**	**20**	**2**	**3**	**24**	**4**	**8**	**5**	**-**

1	**Objectives** Conventional washing processes shall be analyzed in order to display inefficient process

	conditions and the potential of water saving. On the basis of this, inefficient washing and rinsing conditions shall be eliminated. There shall also be performed a critical check of dyeing and washing recipes and hazardous chemicals will be substituted by less hazardous compounds or eliminated. Relevant sensors for online-measurement shall be tested and identified and the washing off properties of removed dyestuff and contaminants shall be determined. Finally, control parameters for a perfect result in rinsing and washing shall be established and verified. The remaining objectives have to be considered within the second reporting period.
2	**Description of work** **Task 1.1. Recipe control and process analysis** All tasks were performed within first reporting period. Rinsing and washing processes of the involved dyeing houses (Beti, FOV) and laundries (Lucija, Punto Bianco) were analyzed by the research institutes ITCF and ITEK in order to quantify the water consumption of these processes with respect to the type of washing machine, fabric, color depth and contaminants. The cooperation with 2 different dyeing houses and 2 laundries guarantees a proper basis for testing and verification of representative washing processes. The analysis in laundries was performed by ITEK with support by Lucija and Punto Bianco, whereas the analysis in dyeing houses was headed by ITCF with support of Beti and FOV. Industrial partners performed rinsing and washing trials with their most important products and ITEK and ITCF mainly focused on wastewater analysis. In order to display inefficient process conditions, the water consumption for each phase of washing (pre-cold-rinsing, soil wash sector, fastness wash) was measured and compared with the quantity of removed contaminants. This procedure identified inefficient steps in rinsing and washing, which were improved using more efficient washing mechanics or higher temperatures (i.e. hot rinsing). The water consumption of the improved washing process was monitored in lab and industry. In order to reduce wastewater pollution very efficiently, different dyeing and washing recipes were analyzed referring to the chemical substitution of hazardous chemicals by less hazardous compounds or the elimination of them. This was done on the basis of biodegradability and toxicity of the textile auxiliaries. Special emphasize was given to any overdosage of textile auxiliaries, urea and detergents. This work was performed by the experts of the research center ITCF (for dyeing houses) and ITEK (for laundries), who are very experienced with this method. The application of the optimized recipes did result in improved water quality and rinsing/washing effects, which was tested and monitored by the industrial partners. **Task 1.2. Analysis of rinsing and washing using online-sensors** A number of different online-sensors (temperature, pH, conductivity, color detector, redoxpotential, oxygen content) were used and tested for the analysis of rinsing and washing processes by ITCF. ITCF focused on relevant investigations in dyeing houses and laundries whereas ITEK gave focus on laundries. Thies was responsible for installation of a sensor device in Thies machines. A conductive sensor was used for the detection of residual salt in the washing water and a pH-electrode was selected for the measurement of the alkalinity. Further potential online-sensors are recognized in ion-selective electrodes, which could be used for the quantification of heavy metal (Fe, Cd, Cr….) and for determination of water hardness (Ca-ions) in laundries. So far, these sensors have not yet been tested, since these sensors only work up to 40°C. The removal properties of colored components (dyestuffs) was measured online with the previously described VIS-immersion-sensor (WashProf) by ITCF. This sensor was also tested for turbidimetric analyses of non colored components (stain) in washing liquors in laundries, but without success. A setup of representative textile materials (cotton, PET and blends) from the dyeing houses were dyed with representative dyestuffs and subsequently rinsed/washed at different temperatures and with variable washing mechanics in lab (ITCF, ITEK) and industry (Beti, FOV, Lucija, Punto Bianco). The washing process was recorded

	simultaneously with each sensor and stored in a database. These data shall be used for the determination and calculation of exchange factors and coefficients of diffusion within the second reporting period. The investigations have also shown the beneficial influence of temperature and washing mechanics on the washing result and on water saving (hot rinsing). The measurement of temperature, pH, conductivity, color detector, redoxpotential and oxygen content was identified as very significant online parameter in rinsing and washing as well as how to measure them. Moreover, the applicability and reliability of the sensors were determined. With the exception of oxygen measurement, all sensors work up to 130°C. Remaining online-analysis of washing with new detergents was done in laundries within the second reporting period. **Task 1.3. Evaluation and setup of control parameters** The database from task 1.2. was completed with fastness properties of the rinsed/washed goods (Beti, FOV, Lucija, Punto Bianco). Special emphasize was given to the influence of washing temperature and washing mechanics on the quality and properties of the resulting goods. For this purpose a variety of cellulose based substrates were investigated at different washing temperatures with respect to further quality parameters like fabric handle and especially with respect to the visual appearance of the washed goods (ITEK, Beti, Lucija, Punto Bianco). The collected and combined data built a reliable basis for the selection of best process conditions referring to high quality products. In order to get control parameters for rinsing and washing, the interdependence between washing/rinsing effect, fastness properties and sensor signals and offline measurements were evaluated. As a result, the very complex interdependences between sensor signals (characteristics of washing liquor) and washing results for the textile material can be described with the datamatrix of the optimized rinsing/washing process and its absolute values. In dyeing and rinsing, the most important sensors are temperature, pH, conductivity and color content. The final rinse of dyed materials should be neutral with a conductivity < 1 mS/cm and a dyestuff concentration of < 3 mg/l. In the case of laundries, the most significant parameters are conductivity, pH, temperature, oxygen content and redoxpotential. In addition to these fastness based control parameters, further data referring to national and international standards as well as the experience of the industrial partners were considered for the process control (ITEK, Beti). All deliverables and milestones were achieved with a delay of 3 months. The database for rinsing and washing conditions was amended as well as further limiting values for laundries were found and evaluated. Further limiting values for acid dyeing and disperse dyeing were established
3	**Deliverables** - Water consumption and pollution in standard rinsing/washing processes - Improved recipes and improved process parameters - Washing off properties of dyestuffs and stain , washing off curves - Online-sensor data for washing off curves - Setup of controlling parameters
4	**Milestones** - Improved recipes and process conditions - Washing off properties (exchange factor=kinetic data) & sensor identification - Control parameters

Workpackage 2: Development of WashControl system

DWP	Workpackage description

Workpackage number :	**2**								
Start date or starting event:	**7.Month**								
Participant codes :	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**
Person-months per participant:	**27**	**10**	**-**	**12**	**17**	**1**	**4**	**-**	**-**

1 **Objectives**

A wash control system shall be developed for discontinuous dyeing ranges and laundries, which consists of a multi-detector system and a controlling software. Relevant sensors should be put together in order to get a detector array for use in process control in rinsing and washing. The implemented sensors shall be modified according to demanded properties and shall be tested. Furthermore, advanced sensor and sensor arrays shall be developed, which enable adaptation of the sensor to various fields of application. A software shall be developed for processing of online data on the basis of the very latest washing algorithms and with respect to identified control parameters. The wash control software shall enable to minimize the costs in washing and rinsing at high fastness level. Within the second reporting period, focus is given on extensive testing and verification of the system as well as monitoring had to be performed and further sensors have to be tested.

2 **Description of work**

Task 2.1. Development and setup of a reliable multi-sensor system

Suitable sensors for the detection of salt, pH, oxygen, temperature, redoxpotential and colored substances were put together in a detector array (Thies, ITCF). A flow cell made of stainless steel, which is resistant to pressure (Thies), was also constructed and tested in practice. The influence of sensor design on self-cleaning properties was evaluated and optimized in practice. It became obvious that no staining of the color detector with lints occurs, when the sensors gap is > 1mm (ITCF, Beti). If the gap is less than 1mm, a surface cleaning by removing of sharp edges was performed in order to get a selfcleaning sensor device. The color detector not only enables the control of rinsing after dyeing but also makes it possible to determine the dyestuff concentration within the dyeing process. The signals of the sensors were linked together and were adapted to a multi-channel AD-data recorder, which built the hardware interface to the controlling computer (ITCF).

The influence of temperature on sensor signals was eliminated by use of electronic online compensation methods (NTC and PTC restrictors). In addition, the measuring capabilities of the VIS-immersion sensor was extended for advanced measurements at 3 wavelengths (ITCF). For this purpose, the emitting semiconductor diode was replaced by a RGB-diode, which emits light at 3 wavelengths as well as a white emitter and a RGB-sensitive receiver was used. With the help of a multi-wavelength sensor, individual dyestuffs could be identified in a complex mixture of dyestuffs. The emitting radiation power was adjusted for each wavelength in order to get a normalized signal at the receiver. The signal of such a modified sensors resulted in a higher sensitivity and reliability for the whole VIS-spectrum, since the standard VIS-immersion sensor detects only in a small wavelength range. Further beneficial sensor modifications are an UV-sensor, which enabled the identification of colorless substances such las detergents (ITCF). The advanced multi-sensor modul was tested in lab for rinsing (ITCF) and washing (ITEK) and in industry (Beti, Lucija) using standard dyed textiles and stained textiles. Furthermore, the sensitivity of the multisensor towards individual chemicals (alkaline, acid, detergent, chlorine…) was investigated.

Task 2.2. Design and development of the WashControl software

The very latest and approved control algorithms for rinsing and washing were implemented

	and tested in the WashControl software and have been linked with the multi-sensor system (ITCF, Thies). This enabled a fully automatic online control of rinsing and washing. ITCF focused on the final software development and programming whereas Thies adapted and implemented the software tool in different Thies machine-equipment (Softstream, Ecomaster, Jigger…). The following algorithms were programmed in the ITCF-software and intelligently linked to each other: (a) Control of rinsing and washing on the basis of control parameters, (b) Control of rinsing and washing by means of washing off rate and (c) Control of rising and washing by means of the interdependence between the residual contaminants on the fabric and the fastness properties (0,1 g/m^2 dyestuff can remain on fabric without influence on fastness). The software and algorithms were successful tested in lab, pilot plants and practice referring to correct data acquisition and programming errors have been eliminated. Data acquisition of sensors signals and fresh water supply was done via the AD-interface, which also acts as a data recorder. Extensive testing and analysis have been done at Beti , Lucija and Punto Bianco with support of ITCF, ITEK and Thies. The controlling system was designed and developed for the use and testing in laboratory but is also a open system for the integration of further relevant online-information such like the newly developed UV-sensor (identification of some detergents). Further tasks within the second project year have been completed. The software was successfully tested referring to process controlling and fully automatic online control of rinsing and washing in lab and industry. The rinsing was performed and optimized on the basis of provided economic data. The software was programmed and verified to calculate the very best fresh water supply on the basis of measured and entered data. The software displays the effect of temperature, bath volume and washing mechanics on the rinsing and washing effect and indicates the very best numbers of filling or draining cycles for the dyeing/rinsing machine. Signals of the control system are provided at a Digital-Analogue-Interface enabling a fully automatic washing and rinsing, which was conducted in lab and industry. All deliverables and milestones were achieved as planned, however, the most reasonable setup of relevant sensors for laundries was ongoing in the 2nd reporting period.
3	**Deliverables** - Multi sensor system - 3-wavelength sensor - WashControl software - Simulation tool
4	**Milestones** - Multi-sensor-system - WashControl software

Workpackage 3: Testing and optimisation of WashControl system

DWP	**Workpackage description**								
Workpackage number :	**3**								
Start date or starting event:	**4.Month**								
Participant codes :	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**
Person-months per participant:	**14**	**21**	**-**	**11**	**25**	**3**	**6**	**5**	**4**

1	**Objectives** The whole controlling system shall be tested and optimized in rinsing and washing in laboratory. The system has to be calibrated and proper data transmission of the adapted sensors and data processing of the software has to be tested and verified. Controlling parameters and algorithms as well as their advanced combination have also to be checked and improved. The efficiency of the controlling system referring to high fastness properties

and water saving shall be evaluated for standard processing and hot washing and longtime stability of sensors will be investigated. After successful testing and optimization in lab, the WashControl system shall be installed in dyeing houses and laundries and tested under real industrial process conditions in washing. The multi-sensor system shall also be tested for use in membrane plants.

2

Description of work

Task 3.1. Testing and optimisation of detectors and WashControl software in lab

The whole controlling system was tested and optimized in lab. First, the system was calibrated with standard chemicals and the accuracy and reproducibility of the measured signals were evaluated by ITCF and ITEK. The color detector provides stable calibration for > 6 months. ITCF focused on rinsing tests whereas ITEK gave focus on washing processes (laundries). These measurements were performed with typical washing liquors from rinsing and washing in industry (Beti, FOV, Lucija, Punto Bianco). The response time of the sensors and the time for data transmission were analysed (less than 1 sec) and the data acquisition was optimised on the basis of this data (ITCF, Thies). Furthermore, normalized extinction values were determined for both color-detector and 3 wavelength-sensor for calibration pruposes.

Rinsing and washing of differently deep dyed and stained textiles was performed and compared by applying both the standard process conditions and the new WashControl system. Beti and Thies did testing and optimized the software and sensor system in lab. These investigations were also performed for the hot washing procedures. Applicability and efficiency of controlling parameters and algorithms (i.e. testing of different washing off rates) as well as their combination were checked and evaluated referring to fastness properties and water/energy savings. These investigations gave additional information on the maximum valid loading in washing liquors and the best algorithm and combination of algorithms. A setup of most reasonable limiting values and processing algorithms was established. The system and rinsing conditions were optimised on the basis of the measured data and water savings were displayed (ITCF and ITEK). The positive mechanical influence on washing result and hot water was demonstrated and documented in a catalogue of criteria (ITCF, ITEK).

Task 3.2. Implementation in pilot plants and industry

The WashControl system was installed by Thies in their own pilot plant and in the dyeing house Beti. ITCF provided equipment for online measurements in laundries (Lucija, Punto Bianco) for testing under real industrial process conditions on different substrates/products. Dyeing houses were assisted by ITCF and laundries were supported by ITEK in measurements. The system was installed and tested at different rinsing and washing machines (Thies-Softstream, Rotostream, Senking-washing machine, Jigger, Then-Airflow) and the performance and reliability of the online WashControl system was investigated referring to potential water saving and cost savings (Beti, Punto Bianco, Lucija). These investigations did help to identify weak process conditions and machines with a high potential for savings. These investigations were done by an external WashControl device. The color detector was also installed and successfully tested in membrane filtration for quality control of permeate and concentrate.

The color detector and multisensor device was installed at FOV and exemplary process optimisations were performed at the involved dyeing houses and laundries with respect to low water consumption and economic processing at high productivity. This was done by using the WashControl software and by giving focus on short time processing (most economic processing will result if rinsing velocity is > 2 mg/lsec). Process control parameters were verified and optimised through the huge number of processes and different economic parameters (Thies and ITCF), which were provided by the industrial partners. The cost savings were calculated for different machines and process parameters

	in comparison to the standard process. The online controlled hot rinsing process was introduced in practice (Beti, FOV) and the online-data of the WashControl system was monitored in order to get data on any interferencing and instability and basic data on the longtime stability of the system (ITCF, ITEK). At the same time, the multi-sensor device was also used in membrane plants for proper process control (MDS). All deliverables and milestones were according to the scheduled plan. WP3 was started earlier, since this benefits the project in terms of reliability and reproducability in industry.
3	**Deliverables** - Calibration data - Proper control algorithms/combinations - Sensor controlled rinsing/washing system - Data on longtime stability and maintenance - Optimized WashControl system
4	**Milestones** - Proper control algorithm combinations - Optimized WashControl system

Workpackage 4: Water recycling

DWP **Workpackage description**

Workpackage number :	**4**								
Start date or starting event:	**1.Month**								
Participant codes :	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**
Person-months per participant:	**-**	**32**	**4**	**-**	**21**	**-**	**4**	**13**	**3**

1	**Objectives** A water recycling technique for rinsing and washing water on the basis of membrane technology shall be developed. Most reasonable membranes have to be selected and applied as well as the effect of process chemicals and the type of wastewater on membrane performance and permeate quality has to be investigated. These studies shall also include the identification of cleaning methods and cleaning cycles for the membrane. The sensor device shall be tested for these purposes. Industrial wastewater coming from laundries and dyeing houses shall be recycled and tested for reuse in rinsing and dyeing. The economy of the membrane recycling process shall be evaluated.
2	**Description of work** **Task 4.1. Development of water recycling in lab** Water recycling was developed in lab within the first reporting period. Reasonable membranes were selected and very best process conditions were evaluated in lab as well as permeates and concentrates were analysed. Different commercial available membranes were tested with “synthetic model wastewater”, rinsing water from reactive dyed cotton fabrics and with wastewater from laundries referring to membrane performance and surface characteristics (IPU) and permeate quality (ITEK). Some residual dyeing liquors were also considered for recycling of salted water for later reuse in dyeing (ITEK, IPU). The membrane performance was determined at different pressures as well as the salt content in the permeate was quantified (IPU). The selection of the membrane was performed on the basis of membrane performance and retention properties by IPU and MDS. Water recycling could be realised using ultrafiltration and reverse osmosis membranes. Recycling water was colorless and offers the opportunity for reuse in dyeing, rinsing and washing. Process conditions for efficient water recycling were investigated in detail. This included the very first investigation and development of best process conditions for cleaning and regeneration of the membrane as well as the

identification and substitution of potential membrane damaging chemicals (IPU, ITEK). These investigations will be continued and completed in the second project year. The effect of cleaning temperature as well as pressure on permeability was quantified and optimized for ceramic membranes (MDS). The influence of temperature and water pollution on membrane performance and permeate quality was investigated and determined in order to get detailed information about economic process conditions for the recycling unit (MDS, IPU). The resulting permeates were characterized referring to salt content, pH and color.

4.2. Implementation of water recycling

Water recycling with membrane technology was implemented in dyeing houses (Beti) and laundries (Lucija, Punto Bianco) by MDS using ceramic membranes. Water recycling was realised using ultrafiltration and reverse osmosis membranes. Recycling water was colorless and offers the opportunity for reuse in dyeing, rinsing and washing. Further water recycling tests and implementation in practice took place with a huge number of dyeings.

Most reasonable types of membranes were applied and tested with rinsing and washing water from different plants (IPU/MDS), but focus was given on ceramic membranes due to their stability. Hot washing processes were preferably considered, since membrane performance is better at higher temperature. The membrane filtration performance as well as the water quality referring to salt content was characterized and compared with the result from lab (ITEK, Beti). The membrane performance was optimized on the basis of the previous obtained data in order to get the most reasonable process conditions (MDS). The variation of temperature and pressure on permeate quantity and quality gave a proper basis for any further optimization of the membrane units (MDS). The process conditions for water recycling with membrane technology was varied and optimized with respect to demanded permeate quality as well as water saving values were determined (MDS, Beti). At Beti, a 100% recovery of process water was possible (closed loops). In the laundries, rinsing water could also be recovered by 100% and it was successful tested for reuse in lab. However, no recycling tests in industry scale had been performed, since the capacity of the membrane unit (100 l/h) was too small compared to the required capacity (400 l/min). It should also be mentioned, that membrane treatment of the effluents from laundries produce some concentrates, which should be reused or need a special treatment befor waste disposal. So far, the reuse or treatment of the concentrates needs further investigations. Reuse of rinsing water in the main wash section contributed to water savings of 5%. Finally, the water quality of recycling loops was measured. Recycling water was colorless and of better quality than the standard process water. According to this, closed loops could be realized in the dyeing house Beti. The multi-sensor system can be used for automatization of the recycling plant (quality control of permeate and cleaning cycles) (MDS/ITCF).

4.3. Reuse of recycled water in dyeing and rinsing/washing

Task 4.3 was performed within the second project year. Membrane plants were installed at Beti by MDS. Water recycling was performed at Beti and was successfully tested for reuse in reactive dyeing and rinsing. Recycling water from laundries was also tested in washing in lab scale at ITEK and Lucija. The influence of the quality of the recycling water on washing off properties in rinsing and washing was determined and quantified for different permeates with respect to washing time and temperature as well as fastness properties (ITEK). The potential for reuse of reclaimed process water was studied on the basis of fastness properties (Beti, Lucija). This procedure resulted in a data collection, indicating the most reasonable parameters referring to permeate quality and washing results. As a main result, recyled water provides better quality than the standard process water. Limiting values for reuse of recycling water had been determined by ITEK. In addition to this, the identification of possibilities for utilization of recycling water in batch dyeing processes took place at Beti with the support of ITEK. For this purpose, dyeing liquors were prepared with

	recycling water by adding the required amount of dyestuff, which could be controlled with multicomponent analysis.. The addition of the required salt and alkaline (reactive dyeing) was controlled by means of conductometry and pH-measurement. Dyeing results were comparable with the standard in trms of color depth and fastness properties (Beti, ITEK). All deliverables and milestones were achieved according to the scheduled plan
3	**Deliverables** - Membrane specifications & properties - Membrane filtration performance, damaging chemicals - Process parameters referring to high permeate performance - Cleaning & regeneration procedure for membranes - Washing results with recycled water referring to salt concentration
4	**Milestones** - Type of membrane & process parameters referring to high permeate performance - Cleaning & regeneration procedure for membranes - Washing & dyeing results with recycled water

Section 3 – Consortium management

Within this project, a very innovative online sensor-based WashControl system was developed for use in discontinuous dyeing ranges and in laundries as well as an evaluation of rinsing and washing processes took place. It became obvious that a recipe control of existing recipes enables large potential for water savings in dyeing houses and laundries as well. Due to a modification of recipes and process parameters, water savings of up to 30% could be realized in rinsing and washing. Further on, existing dyeing, rinsing and washing procedures were analysed with online sensors. Within the second reporting period, a combination of sensors, which determine pH, conductivity, temperature and color as well as redoxpotential, active oxygen content as well as an UV-sensor for detergents was considered. Reasonable sensors for online-control of the individual processes could be identified, tested and were verified. In addition, reasonable controlling parameters for process control were identified and collected in a data base. The most reasonable online-sensor device was the online-measurement of the color content in rinsing and washing compartments, which was measured with a newly developed sensor system by ITCF. This online sensor was combined with pH and conductivity measurement and implementeed in dyeing houses. For laundries, redoxpotential as well as UV-absortion was measured too. With the help of these multi-sensor devices, rinsing and washing in dyeing houses and laundries could be simplified and a water saving of at least 30% could be realized. The sensor device was implemented in industry and adapted to electronic controlling devices. Sensor signal is processed online in dyeing machines and a rinse control was realized with the help of controlling parameters and the software WashControl.

Activities focused on the total implementation and verification of a sensor and software controlled rinsing/washing and the use of further online sensors in rinsing and washing as well as its electronic adaptation to existing control devices. The software was tested and verified referring to automatic process control. The development of this technique resulted in a online-sensor-controlled rinsing and washing process with reduced water and energy consumption.

Water recycling in laundries and dyeing houses could be realised using ultrafiltration and reverse osmosis membranes. Recycling water was colorless and offers the opportunity for reuse in dyeing and rinsing. This was first done in lab and pilot plants and was extended to industrial use. Membrane plants were installed in dyeing houses and water recycling was performed and successfully tested for reuse in reactive dyeing and rinsing. This enables closed water loops and results in much less pollution.

Within the first reporting period, the Coordinator of the project arranged a very first meeting in order to built the Project Coordination Committee (PCC), which is formed by a representative of each partner and is chaired by the coordinator. Decisions are taken by the majority of the votes. The coordinator acts as a link to the EC and he prepared the consortium agreement. In the first and second meeting, technical teams were built according to the workpackages in the proposal description. Each technical team performed the actual workpackages and is composed of one technical representative from each of the partners involved in the workpackage/task. It is headed by the task leader, who belongs to the partner being responsible for the workpackage. The technical team informed the coordinator regularly about the progress of the work. Deliverables were delivered without significant delays according to table 3. Best means of communication (email, telephone, working meetings) were choosen in the first meeting to guarantee frictionless and efficient exchange of know-how. The Coordinator is in charge of controlling the development of the project according to the scheduled plan and the Coordinator controlled the program run on the basis of the deliverable list as well as by a critical check of the results. According to this, the progress and management report was prepared by the project coordinator on the basis of the data supplied by the partners and sent to the European Commission. These reports are written in English. At the same time, cost statements were collected and sent to the European Commission. The project coordinator made the advance payments of the contribution of the European Commission to the partners in the project for the budget as specified in the contract. According to a delayed start of this project, these payments were made at the end of May 2005 after the official letter for starting the project was received.

The PCC met periodically in order to assure a common critical study of the deliverables and their quality. Project meetings took place at ITCF, ITEK, Thies and Lucija. Within these meetings, results achieved were thoroughly discussed and assessed as well as tasks precised, conclusions drawn and task planning for the following period was approved. Technological gaps were identified and the state-of-the-art was updated.

The project coordinator organized a Mid-Term assessment meeting with all partners at Lucija at the beginning of 13th month with all project partners in order to report on the progress to date and to redefine the Project Programme for the remaining part of the contract. Within this meeting, it was concluded that the project runs largely according to the scheduled plan. The consortium decided to continue the project as planned. The assessment was made against the following items: (1) Controlling parameters, (2) accesability of multi-sensor-system, (3) feasibility of WashControl software (4) Membrane filtration performance. Within this meeting, partners were also instructed in filling in the Financial Form C (cost statements). Procedures for managing future exploitation of results

were discussed and assessed. The dissemination of the results was also fixed within these project meetings. Publications and papers have to be approved by the consortium prior to publication. The Coordinator drafted the plan for using and disseminating the knowledge.
Within the first reporting period, the coordinator arranged a very first meeting in order to built the Project Coordination Committee (PCC) and to precise tasks and responsibilities. During the whole lifetime of the project, the PCC met periodically in order to assure a common critical study of the deliverables and their quality. Project meetings took place at ITCF, ITEK, Thies and Lucija. Within these meetings, results achieved were thoroughly discussed and assessed as well as tasks precised, conclusions drawn and task planning for the following period was approved. Technological gaps were identified and the state-of-the-art was updated. The dissemination of the results was also fixed within these project meetings. Publications and papers have to be approved by the consortium prior to publication. The Progress and Management Report was written for the first reporting period by the coordinator on the basis of the reports delivered by each partner. The Coordinator collected cost statements, made the payments and drafted the plan for using and disseminating the knowledge.

Knowledge, intellectual property rights and other innovation-related activities were managed according to the recommendations and agreements in the consortium agreement and according to the dissemination plans. Inventions will be kept strictly confidential in order to assure the inventors intellectual property rights and to avoid illegal copy by certain Asian competitors. At present time, the consortium is strongly faced with illegal copies from certain Asian countries. According to this, inventions referring to sensor controlled rinsing/washing and water recycling procedures shall stricly kept confidential as well as Progress reports and deliverables shall be kept confidential. A final plan for using and disseminating the knowledge gained within this project is provided at the end of the project. The dissemination and exploitation plan was updated and amended at the end of the project and includes the plan for the management of Intellectual Property Rights.

The following project timetable reflects the status of the research project.

Total Overview of budgeted person-months and actual ()person-months (actual Person-months in brackets) , no permanent staff of AC-contractors

Workphases, Workpackages and tasks	MONTH (6 / 12 / 18 / 24)	P1	P2	P3	P4	P5	P6	P7	P8	P9			Σ
0. Workpackage Management Meetings, reports, assessment	X X	12 (11)											12 (11)
1.Workpackage Identification of relevant sensors and control parameters													
Task 1.1: Recipe control and process analysis of the conventional process (Critical check of recipes, analysis of weak process conditions, identification of potential savings for water and energy)		6 (7)	3 (5)	(2)		5 (6)	1 (2)	1 (2)	1 (1)				17 (25)
Task 1.2: Analysis of rinsing and washing using online-sensors (conductivity, pH, spectroscopy, turbidimetric analysis, IR-absorption, exchange factor, coefficient of diffusion, influence of temperature and washing mechanics on washing off, fastness properties)		7 (9)	5 (7)		1 (3)	11 (12)	2 (1)	1 (3)	2 (2)				29 (37)
Task 1.3: Evaluation and setup of control parameters (setup of database, interdependence of sensor signals and fastness properties, statistical analysis, intelligent linking of different control parameters, standards)		4 (6)	6 (8)		-	5 (6)	1 (1)	1 (3)	1 (2)				18 (26)
2.Workpackage Development of WashControl system													
Task 2.1: Development and setup of a reliable multi-sensor system (Linking of different online-sensors (pH, conductivity, spectroscopy, IR-absorption..), development of 3-wavelength spectrophotometer, maintenance, self-cleaning, temperature stability)		18 (19)	2 (6)		1 (4)	5 (9)	-	(2)					26 (40)
Task 2.2: Design and development of the WashControl software (Installation of sensor interfaces, programming of algorithms, setup of data-base, integration of economic processing algorithms, simulation tool)		7 (8)	1 (4)		7 (8)	5 (8)	1 (1)	(2)	1 (0)				22 (31)
3.Workpackage Testing and optimization of WashControl system													
Task 3.1: Testing and optimization of detectors and WashControl software (initialization, calibration, sensor adjustment, testing of advanced algorithms, data transfer, program optimization, characterization of rinsing and washing results (fastness, wastewater analysis, residual components on fabric))		8 (8)	5 (11)		2 (4)	5 (11)	1 (1)	1 (2)	1 (1)	2 (2)			25 (40)
Task 3.2: Implementation in pilot plants and industry (Installation and adaptation of control device in dyeing houses and laundries, monitoring, longtime stability of sensors)		5 (6)	4 (10)		1 (7)	9 (14)	2 (2)	1 (4)	3 (4)	1 (1)			26 (49)
4.Workphase Water recycling													
Task 4.1: Development of water recycling in lab (membrane selection, testing of membrane performance for different wastewaters, characterization of permeates)			7 (11)	6 (4)					(1)	1 (2)			14 (20)
Task 4.2: Implementation of water recycling (Water recycling in dyeing and printing houses under real industrial conditions, performance of recycling unit, characterization of permeates and concentrates, membrane cleaning cycles)			2 (9)	2 (0)		6 (12)		2 (4)		5 (9)			17 (34)
Task 4.3: Reuse of recycled water in dyeing and rinsing (matching formulation for dyeing, quality of dyeing, rinsing, washing,			6 (12)	1 (0)		3 (9)		2 (0)		1 (4)			13 (25)

Work in 2nd year and Actual status of the project

Section 4 – Other issues

The realization of the research project requires the application of newly developed sensors and controlling techniques as well as water recycling technology under real process conditions in textile industry and laundries. This was performed by a close cooperation between research organizations and innovative thinking and experienced textile dyeing houses, laundries and machinery industry, which contributed their whole and very specific knowledge to this project. The successful performance of the project demands the inclusion of a manufacturer of dyeing/rinsing machines. The SME-Consortium is composed of three renowned European research organizations (ITCF, ITEK, IPU) which perform essential research on sensor development and membrane filtration as well as quality control, one important manufacturer of piece dyeing machines (Thies), one manufacturer of recycling units with focus on membrane plants (MDS), two laundries (Lucija, Punto Bianco) and two partners from European textile dyeing industry (Beti, FOV), which guarantees the combination of dispersed established know how in the special field of rational use and reuse of water in textile dyeing industry and laundries. The representatives of these companies and research organizations , which are coming from 5 EU member states, are experts in their specific area and have a plenty of experience at their disposal. There are no financial or legal links between the partners.

When finalizing the project, the total contribution of the RTD-Performers is about 49% to the project costs. Other partners have contributed 18% and the share of participation for the SMEs is about 33% of the total costs. The contribution of the individual partners is well balanced and a clear transfer of knowledge to SME partners is guaranteed.

The involved research organizations contributed to the development of the sensor controlled rinsing in dyeing houses and laundries as well as in the development of water recycling in lab and industry. The involved resesearch organisations performed the sensor development and its verification. Online measurement in lab, pilot plant and in industry were done and the whole system was optimized and implemented in industry. Furthermore, a recipe analysis as well as process analysis was performed in dyeing houses and laundries, which directly contributed to significant water savings in SME companies. Rinsing and washing processes were analysed as well as a setup of controlling parameters was performed by the research institutes. In addition, innovative rinse control software was developed and implemented by RTD-performers. Moreover, water recycling was developed in lab by the research institutes. A furture contribution was granted in the implementation of water recycling with membrane technology and its reuse in dyeing and rinsing. Recycling water could be successfully reused in dyeing and rinsing.

No important SME manufacturer of dyeing machines is left so far. Therefore a Non-SME partner is involved in this project, which is also a main supplier of dyeing/rinsing machines for SME textile companies. Through this partner, the SME dyeing houses (most dyeing houses are SME) have access to innovative dyeing and rinsing technology, which helps them in a sustainable way. They will become more and more competitive due to enormous savings of water and electricity as well as the SMEs will benefit by producing high quality products with a high added value. The manufacturing SME industry (textile dyeing and laundries) will met their interests in being more competitive through highly eco-economic and safe production of high added-value products. FOV was included in this project to complete the consortium to its optimum.

The involved SME dyeing houses and laundries (Beti, Lucija, Punto Bianco) as well as the SME supplier of membrane technology (MDS) did their contribution according to their bussines activity. Beti as well as Lucija and Punto Bianco contributed with dyeing, washing and rinsing on their production machines and MDS did water recycling with their pilot plant. As a result, a smooth technology transfer from RTD performers to SME took place and results were assimilated by SMEs.
The SMEs will exploit the results according to their business activities and the full range of application. Machinery industry will met their interests in this project, since they are supplier of equipment for the manufacturing in textile dyeing houses and laundries and they will benefit by getting a competitive edge through producing innovative and significantly improved dyeing machines and recycling plants.

Literature

Previous research activities on multisensor use in textile applications carried out at national level under European initiatives (52 projects) unfortunately cannot provide a new impetus in this matter (no relevant multisensor for rinsing and washing processes was developed), but was considered during lifetime of this research.

EU-Projects:

1. International Conference on Multisensors Fusion and Integration for Intelligent Systems (IEEE MFI 2001) in Baden-Baden, Germany
Date: 2002-11-05, Programme Acronym: HUMAN POTENTIAL

2. Data Integration in Multisensor Systems
Date: 1994-08-19, Programme Acronym: ESPRIT 2, Project Acronym: DIMUS

3. Post consumer plastics recycling from waste streams : on-line pick-up, on-line analysis, on-line sorting
Date: 1995-07-05, Programme Acronym: ENV 1C

4. Multisensor Image Processing
Date: 1994-06-17, Programme Acronym: ESPRIT 2, Project Acronym: MUSIP

5. Multisensor Systems
Date: 1993-06-17, Programme Acronym: ESPRIT 2, Project Acronym: MULTISENSOR SYSTEMS

6. MULTI-SENSOR HIGH RESOLUTION INTELLIGENT MARINE OBSERVATION OF OCEAN FLOOR IN CONTINENTAL SHELVES

Date: 1993-06-21, Programme Acronym: MAST 1

7. Data Integration in Multisensor Systems
Date: 1994-06-21, Programme Acronym: ESPRIT 3, Project Acronym: DIMUS

8. Optical Fibre Sensors For Small Office Home Office
Date: 2003-02-24, Programme Acronym: IST, Project Acronym: OFFSSOHO

9. Intelligent Modular Multi-sensor Networked False Alarm Free Fire Detection System
Date: 2002-10-24, Programme Acronym: IST, Project Acronym: IMOS

10. Innovative magnetic and optical sensors using advanced material for non destructive testing applications
Date: 2001-12-07, Programme Acronym: BRITE/EURAM 3, Project Acronym: IMOSENS

11. AUTOMATIC CELL WITH INTEGRATED ON LINE QUALITY CONTROL FOR PANTYHOSE FINISHING
Date: 1994-01-18, Programme Acronym: BRITE/EURAM 2

12. Advanced Intelligent Multisensor System for Control of Boilers and Furnaces
Date: 1994-06-17, Programme Acronym: ESPRIT 2, Project Acronym: AIMBURN

13. DEVELOPMENT OF AN INTEGRATED MULTISENSOR BOREHOLE EXPLORATION SYSTEM
Date: 1991-11-28, Programme Acronym: MATREC C

14. MULTISENSOR VISUAL INSPECTION IN HIGH SPEED GARMENT PRODUCTION.
Date: 1991-04-02, Programme Acronym: BRITE/EURAM 1

15. Pedestrian Monitoring In Public Places
Date: 1993-06-18, Programme Acronym: ESPRIT 3, Project Acronym: PEDMON

16. Assimilation of multisensor & multitemporal remote sensing data to monitor vegetation and soil functioning.
Date: 2002-04-19, Programme Acronym: ENV 2C

17. Autonomous forest fire detection and prevention aid system integrating remote multisensor terminals.
Date: 1998-09-18, Programme Acronym: ENV 2C, Project Acronym: AFFIRM

18. Process control and air cleaner application with recognition of gases and flavours using a smart microsystem
Date: 1996-05-08, Programme Acronym: ESPRIT 4, Project Acronym: PARFUM

19. GAS SENSORS AND ASSOCIATED SIGNAL PROCESSING FOR AUTOMOTIVE APPLICATIONS
Date: 1994-06-26, Programme Acronym: BRITE/EURAM 2, Project Acronym: ECONOX

20. Continuous tread density control by intelligent low-cost sensor system and integrated machine control
Date: 1994-07-14, Programme Acronym: CRAFT

21. Development and Performance Assessment of Containment and Surveillance Techniques; Surveillance and Teleoperation, 1988-1991
Date: 1992-04-14, Programme Acronym: JRC-SAFEFM 5C

22. MULTISENSOR TECHNOLOGY SYSTEMS FOR CONDITION MONITORING AND PREDICTIVE MAINTENANCE OF INTEGRATED PRODUCTION EQUIPMENT
Date: 1992-06-16, Programme Acronym: SPRINT 1

23. Development of Containment and Surveillance Techniques, 1992-1994
Date: 1993-08-30, Programme Acronym: JRC-SAFEFM 6C

24. TELEMAN 15: Assistant navigation block
Date: 1994-10-19, Programme Acronym: TELEMAN, Project Acronym: ANB

25. Development Of An Optical Detection System For Diseases In Field Crops With A View To Reduce Pesticides By Targeted Application
Date: 2003-07-03, Programme Acronym: LIFE QUALITY, Project Acronym: OPTIDIS

26. A Virtual Reality Intelligent Multisensor Wearable System for Phobias Treatment
Date: 2004-02-17, Programme Acronym: FP6-IST

27. Development of an intelligent sensing instrumentation structure
Date: 2002-10-30, Programme Acronym: INTAS, Project Acronym: ISIS

28. Development of Generic Earth Observation Based Snow Parameter Retrieval Algorithms
Date: 2003-05-16, Programme Acronym: EESD, Project Acronym: ENVISNOW

29. Industry NGO fieldtest of improved efficiency multisensor landmine detector
Date: 1999-07-30, Programme Acronym: ESPRIT 4, Project Acronym: INFIELD

30. A Mobile VTMIS using innovative technology
Date: 2002-10-21, Programme Acronym: TRANSPORT, Project Acronym: MOVIT

31. Development of multi-sensor techniques for monitoring the quality of fish
Date: 2001-03-26, Programme Acronym: FAIR, Project Acronym: MUSTEC

32. Low-cost sensor system for the fast sensor-assisted-inspection of textiles
Date: 2002-06-25, Programme Acronym: BRITE/EURAM 3

33. Mediterranean forecasting system pilot project
Date: 2001-12-07, Programme Acronym: MAST 3

34. EUropean Take-up of essential Information Society Technologies - Integrated Machine Vision cluster
Date: 2002-06-10, Programme Acronym: IST, Project Acronym: EUTIST-IMV

35. Spatial indicators for European nature conservation
Date: 2003-04-01, Programme Acronym: EESD, Project Acronym: SPIN

36. Automated water analyser computer supported system
Date: 2003-04-01, Programme Acronym: EESD, Project Acronym: AWACSS

37. Concept for Low-risk Efficient Area Reduction based on the Fusion of Advanced Sensor Technologies
Date: 2001-03-09, Programme Acronym: IST, Project Acronym: CLEARFAST

38. Production improvement by new optimised method in wood quality control and cutting with an high-performance on-line system

Date: 2003-06-11, Programme Acronym: BRITE/EURAM 3, Project Acronym: PINOCCHIO

39. IMPROVED AIRPORT A-SMGS BY INTEGRATED MULTISENSOR DATA FUSION
Date: 1998-11-02, Programme Acronym: TELEMATICS 2C, Project Acronym: VISION

40. FOOD & ANIMAL MONITORING EXPERT
Date: 2003-06-04, Programme Acronym: INNOVATION, Project Acronym: FAME

41. Low-cost sensor system for the fast sensor-assisted inspection of textiles
Date: 1997-03-13, Programme Acronym: BRITE/EURAM 3

42. Ground explosive ordnance detection system-multisensor fusion system for APL detection localization and classification
Date: 1999-10-06, Programme Acronym: ESPRIT 4, Project Acronym: GEODE

43. A Mobile VTMIS using innovative technology
Date: 1998-09-30, Programme Acronym: TRANSPORT, Project Acronym: MOVIT

44. SI-based multifunctional microsystem needle for myocardial Ischemia monitoring
Date: 1999-10-06, Programme Acronym: ESPRIT 4, Project Acronym: MICROCARD

45. Software-supported prototyping and real-time implementation of intelligent multisensor-based safety control systems
Date: 1999-10-06, Programme Acronym: ESPRIT 4, Project Acronym: PROSAFE

46. Flexible Real-Time Environment for Traffic Control Systems
Date: 1994-06-17, Programme Acronym: ESPRIT 3, Project Acronym: TRACS

47. A GIS decision support system for the prevention of desertification resulting from forest fire
Date: 1995-03-23, Programme Acronym: ENV 1C

48. General-Purpose Sensory-Controlled Systems for Parts Production
Date: 1992-11-24, Programme Acronym: ESPRIT 1

49. Intelligent Signals, Sensors and Surveillance
Date: 1994-06-17, Programme Acronym: ESPRIT 2, Project Acronym: ISSS

50. Data Fusion for Environmental Monitoring System
Date: 1994-06-17, Programme Acronym: ESPRIT 3, Project Acronym: AZZURRO

51. Signal and Knowledge Integration with Decisional Control for Multi-Sensory Systems
Date: 1992-11-25, Programme Acronym: ESPRIT 1, Project Acronym: SKIDS

52. Flood hazard control by multisensors storm tracking in Mediterranean areas
Date: 1995-06-08, Programme Acronym: ENV 1C

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Annex – Plan for using and disseminating the knowledge

Section 1 Exploitable knowledge and its use

When the project is finished and goals are met, the project partners will be directly involved in launching the research results to the European and world-wide market. The developed tools and techniques could lead to a significant decline in water consumption as well as to wastewater depollution in the European textile factories, which will bring benefits to the whole European textile industry and be particular profitable for the involved SME partners.
Exploitable results are the (multi)sensor system, the interlinking of the sensor signals as well as the data acquisition and control function of the software. The system can be applied in dyeing houses and laundries but also process controll in membrane filtration and wastewater analysis and applications in beverage industry are possible. However, the combination of different sensors and the interlinking of different sensor-signals cannot be patented, since this does not represent an invention but it represents confidential knowledge which can be commercialized. This also applies for the software. According to this, these project results will be kept strictly confidential and no patent application will be made in order to avoid illegal copy by certain Asian competitors. At present time, the consortium is strongly faced with illegal copies from certain Asian countries. According to this, inventions referring to sensor controlled rinsing/washing and water recycling procedures shall stricly kept confidential. The consortium appointed the Coordinator (Dr.R.Schneider, ITCF) as an exploitation manager for identification of potential applications of the developed tools and techniques in other application fields (e.g. textile industry, manufacturer of washing machines, beverage industry, sewage treatment plant...). It is planned to establish a company for commercial exploitation of project results. The income by way of selling knowledge will guarantee benefits for all SMEs.

Thies, as a main supplier for dyeing and rinsing ranges for SMEs, will exploit the research results as licensee by way of implementing the validated sensor technology and WashControl software in their machines. The extensive testing and adaptation of the sensors and software on Thies machines will ensure that Thies will assimilate and exploit the results. They will become a main supplier of the most innovative dyeing and rinsing machines and they will be able to modernize more aged machines with innovative sensor technology and Control software which brings profit for them and for the involved SMEs. Moreover, they will use this technology for further improvement of the constructive arrangement/design of their whole pallet of dyeing machines.

MDS (SME) will exploit the results by entering the new market of water recycling in textile and laundry industry. Also MDS will assimilate and exploit the results very effective due to extensive testing and implementation of their membrane plant in industry. They will become supplier of the most innovative sensor-controlled membrane technology since they have the unique knowledge on membrane selection and cleaning as well as sensor-controlled automation for use in dyeing houses and laundries. The will also enter new markets due to the availability of this innovative membrane technology.

The involved dyeing houses and laundries will use the gained knowledge in recipe control and process analysis for the further improvement of their ecological situation.

They will directly benefit from the developed sensor and WashControl system as well as from the water recycling technique by using these innovative technologies in their dyeing or washing machines for the production of high quality products with an added value at reduced production costs. Closed water loops will be realized with membrane technology. They will gather a lot of experience and will also test the sensor controlled technique on other washing machines and processes. At the same time they will directly contact their individual suppliers of equipment in order to adapt and optimize the developed techniques to their specific machines. This will ensure a transfer of knowledge to the machinery industry and guarantees income through selling of knowledge.

The implementation and verification of RTD on the SMEs machines during project run will ensure that the involved SME dyeing houses and laundries will successful assimilate and absorb the results. They will get and extend their competitive edge in innovation which will also bring them a daily saving in energy, water and time consumption. Dyeing houses and laundries will use the water recycling and online sensor-controlled washing technologies in processing of different textile articles (cotton, cotton blends, synthetics) on totally different machines (tunnel washer, drum washer, air flow, jet, jigger ; short and long liquor ratio), which will contribute to validation of the whole technology. The validation will be performed according to the quality of products. Their specific tasks in validation are precised in the description of consortium.

The involved research organizations (ITCF, ITEK, IPU) will place their cooperation and consulting at the partners disposal, also when project is finished. This will secure further cooperation in questions related to environment, sensor-techniques, wash control, quality control and recycling technique. This will also contribute to further fruitful collaboration in other research areas. Results obtained from the research project will be especially used for education and training of staff, which in turn benefits the European textile industry directly. Furthermore, the research organizations will use and implement the results of the project in further research and demonstration projects in order to improve this innovative strategy/technology to its optimum continuously.

The following table provides a summary of exploitable knowledge and its use.
Overview table

Exploitable Knowledge (description)	**Exploitable product(s) or measure(s)**	**Sector(s)** of application	Timetable for commercial use	Patents or other IPR protection	**Owner** & Other Partner(s) involved
WashControl system	*(Multi)Sensors* *Interlinking of sensor signals* *Software*	*Dyeing house* *Laundries* *Membrane filtration* *Wastewater analysis* *Beverage industry*	*2008/2009*	*Confidential knowledge*	*ITCF, Thies, SME*

Exploitable Knowledge (description)	**Exploitable product(s) or measure(s)**	**Sector(s)** of application	Timetable for commercial use	Patents or other IPR protection	**Owner** & Other Partner(s) involved
Recipe and process analysis	*Service delivery*	*Dyeing house Laundries*	*2007/2008*	*Confidential knowledge*	*RTD, SMEs*
Wastewater management	*Service delivery*	*Textile industry*	*2007/2008*	*Confidential knowledge*	*RTD, SME*
Membrane specifications	*Membrane types Performance*	*Textile industry Beverage industry*	*2007/2008*	*Confidential knowledge*	*MDS*
Membrane cleaning	*Chemical Cleaning procedure*	*Dyeing house Laundries*	*2007/2008*	*Confidential knowledge*	*MDS*

The members of the consortium have discussed, if any project results shall be patented or not. The whole consortium argreed on the final decission, that no patent applications will be applied for and that inventions and research results will be kept strictly confidential in order to assure the inventors intellectual property rights and to avoid illegal copy by certain Asian competitors. At present time, the consortium is strongly faced with illegal copies from certain Asian countries. According to this, inventions referring to sensor controlled rinsing/washing and water recycling procedures shall stricly kept confidential.

The *WashControl system* enables process control in rinsing and washing. Exploitable results are the (multi)sensor system, the interlinking of the sensor signals as well as the data acquisition and control function of the software. These project results will be kept strictly confidential and no patent application will be made. The expected timetable for commercialisation is in 2007/2008 and ITCF, Thies and SMEs are involved. Commercial contacts to sensor manufacturers have been already undertaken (see section 2).

The *recipe and process analysis* can be directly commercialized in 2007 by the involved RTD-performers and by SMEs as a service delivery for dyeing houses and laundries.

The same applies for the *wastewater management.* The involved SMEs and RTD-performers will be able to act as consultants and to provide a service delivery for textile industry, since they have been educated and well trained within this project in efficient and rational use of water and wastewater and how to make closed loops.

The knowledge on *membrane specifications* enables the company MDS to select reasonable membranes for use in textile and beverage industry as well as they will be able to adjust the processing parameters for high performance.It is expected, that commercial use will take place in 2007.

The *membrane cleaning* is very important for a proper running membrane plant. The cleaning procedure for use in dyeing houses and laundries shall be commercialized by MDS.

Section 2 Dissemination of knowledge

The project commenced with the Kick off meeting and was completed with the organization of the final project meeting in Denkendorf. In between, individual members of the consortium organized workshops. In these workshops knowledge gained in labs and universities were transferred to people from the European textile and machinery industry as well as laundries and they were encouraged to visit the involved dyeing houses and laundries in order to provide knowledge very efficiently. Since this project directly addresses the ecological dimension, the results obtained would be disclosed also to relevant European policy makers entangled in preserving/enhancing the environment.
The research team and individual members of the consortium will aim to publish non-confidential results in relevant scientific journals, textile magazines and possibly through all other applicable electronic media. This will also include the oral presentation of the results on international conferences, seminars and round-table meetings.

The research team is aiming to disseminate the results of the project at national and international level at different congresses not only aiming at textile industry. This will help to a wide spread awareness of the project results. People from textile industry as well as people from water industry will be informed about most significant developments in potential water savings and sophisticated technologies for wastewater treatment. Newsletters shall be provided to scientific journals and through all electronic media as well as news of the project shall be provided to national and international magazines, which will widen the scope of this project. The availability of research results in magazines and newspapers will highly contribute to the awareness of a very new water saving textile processing technology. Such a aggressive dissemination strategy may also reach people outside the specialiced general audience and may provide information on the nature of the activities carried out during the project and benefits the society.

The dissemination of non-confidential knowledge took place according to the following table:

Overview table

Planned /actual Dates	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved
May 2005	*IFVTCC Conference, Poster for project promotion*	*Research & Industry*	*World wide*	*600*	*ITCF*
April 2005	*Direct contact, sensor manufacturer*	*Industry*	*Germany*	*8*	*ITCF/Thies*
22.3.06	*Direct contact, sensor manufacturer*	*Industry*	*Germany*	*6*	*ITCF/Thies*
27.06.05	*Publications, AUTEX*	*Research, Industry*	*World wide*	*200*	*ITEK*

Planned /actual Dates	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved
27.06.05	*Conference, Autex*	*Research, Industry*	*World wide*	*200*	*ITCF*
7.4.2006	*Conference VDTF*	*Industry, Research*	*Germany*	*80*	*MDS*
Sept 2007	*Posters, Flyers, Prototype*	*Industry, ITMA*	*World wide*	*>100.000*	*MDS, Thies, ITCF*
9.2.2007	*Direct contact industry, VDTF congress*	*Research and industry*	*Germany*	*50*	*ITCF*

ITCF provided a poster with the project objectives for project promotion at the IFVTCC conference in Weimar, Germany. Together with Thies, three direct contacts to sensor industry were performed in order to find a producer for the WashProf-sensor. ITEK did several publications as follows:

[1.] SIMONIČ, M., ŠOSTAR-TURK, S. Određivanje neionskih tenzida u otpadnim vodama [Determining non-ionic surfactants in wastewaters]. *Tekstil*, 2005, vol. 54, no. 9, p. 433-439.

[2.] FIJAN, S., ŠOSTAR-TURK, S., FIJAN, R. Introduction of chemo-thermal disinfection laundering procedures for hospital textiles. V: The Conference on industrial pollution and sustainable development IPSD 14-17 December 2005, Maribor, Slovenia. *Conference proceedings*. Maribor: Faculty of Chemistry and Chemical Engineering, 2005.

[3.] ŠOSTAR-TURK, S., SIMONIČ, M., MAJCEN LE MARECHAL, A.. Treatment of waste water after laundering of the hospital linen. V: 7th world congress of chemical engineering, Incorporating the 5th European congress of chemical engineering, SECC, Glasgow, Scotland, 10-14 July 2005. *Congress manuscripts*. Institution of chemical engineers, 2005.

[4.] PETRINIĆ, I., RAJ ANDERSEN, N. P., ŠOSTAR-TURK, S. The retention of compounds using nanofiltration membrane. In: MAJCEN LE MARECHAL, A. (ed.), STJEPANOVIĆ, Z. (ed.), KOKOL, V. (ed.), ŽUNIČ-LOJEN, D. (ed.), FAKIN, D. (ed.), FUŽIR BAUER, G. (ed.), ZIMŠEK, D. (ed.), KRIŽANEC, B. (ed.), VOLMAJER, J. (ed.), VONČINA, B. (ed.). 5th World Textile Conference AUTEX 2005, 27-29 June 2005, Portorož, Slovenia. *Proceedings*. Maribor: Faculty of Mechanical Engineering, Department of Textiles, 2005, p. 998-1003.

[5.] PETRINIĆ, I., RAJ ANDERSEN, N. P., ŠOSTAR-TURK, S., SIMONČIČ, B. Characterisation of polymeric membrane hydrophobicity by contact angle measurement. In: GLAVIČ, P. (ed.), BRODNJAK-VONČINA, D. (ed.). *Slovenian Chemistry days 2005, Maribor, 22nd and 23rd September 2005*. Maribor: FKKT, 2005.

[6.] Meglič S.: diploma work.

[7.] Štruc D.: diploma work.

ITCF presented a lecture at the AUTEX-Conference concerning an online-sensor-controlled rinsing as well as poster presentation took place. IPU presented objectives of WashControl in Tampere.

- „Minimization of water consumption in rinsing processes using online-sensors“
R.Schneider: Proceedings 5th World Textile Conference Autex 2005, 27-29 June 2005, p1023, Portorose, Slovenia

- „ECOLOGICAL IMPROVEMENT OF RINSING PROCESSES”
S.Sostar Turk, R.Schneider, I. Petrinic, R.Fijan: Proceedings 5th World Textile Conference Autex 2005, 27-29 June 2005, p945, Portorose, Slovenia

“Strategies and technologies in water savings and reuse in the wet treatment of textiles”.
Hans-Henrik Knudsen, Denmark. COST Action 628 Conference Tampere, Sept. 2005.
http://www.itv-denkendorf.de (catchword "COST").
Oral presentation at VDTF Meeting at Münchberg and Muehlhausen 2006.
“Waste Water Treatement - Energy Saving – Costs”

Section 3 Publishable results

The consortium will not publish any exploitable results. A publication will be presented within 1 year after the project is finished. This publication will present the benefits of the project results. At present time, exploitable results will be kept strictly confidential in order to avoid illegal copy by certain Asian competitors.