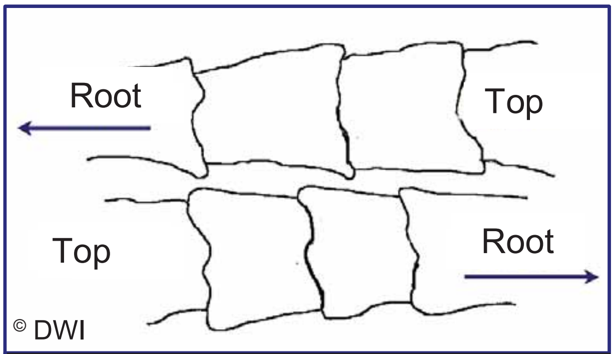
Layman´s Report

1. Summary of project scope and objectives

The washability of native wool and the guarantee for anti-felting or anti-shrinkage of wool textiles is not achievable without any chemical treatments so far. Today the anti-felt equipment reached by the Chlorine-Hercosett-Process is the favourite and only economical way to serve these requirements in the yarn production. This process works on the basis of an oxidation and subsequent coating with resins, by which the surface of the fibre material can be „smoothed“ resulting in a reduced friction among the fibres (refer to figure 1). However, the environmental impacts of this technology are very crucial due to high waste water pollution by absorbable organic halogen compounds (AOX), an enormous consumption of fresh water and the use of critical chemicals. AOX pollution can be as high as 40 mg/l and results mainly from the chlorination step but also from the resin treatment.



Each fibre move in its direction
until an intensive felt is formed

Figure 1: Felting of wool; chemical or physical treatment can partially remove the edges of the scales, which effect a reduction of friction

To prevent such negative effects in textile finishing this project aimed to demonstrate the replacement of the Chlorine-Hercosett process by a sustainable plasma pre-treatment of wool for the first time in a realistic application scale. The overall aim was to set a new best available technology (BAT) for this wool finishing step. Plasma is generated by electrical discharge between opposite electrodes while the wool tops are carried through the gap formed by the electrodes. The resulting effect is similar to the Hercosett process but obtained by a pure physical treatment instead of a chemical process. The main goal of this new technology is the complete elimination of AOX-emissions and the dramatic decrease of used chemicals without any restrictions to the quality of wool and its industrial process ability. Therefore the preliminary defined qualitative properties of the treated wool according to the “SuperWash” standard had to be achieved. That means that shrinking of test samples has to be 8% at most. Secondly a possible production throughput of 5.000 kg of wool per day had to be demonstrated.

The basic feasibility of a technical implementation in a continuous process had already been demonstrated in laboratory scale ahead of the project. However, there were still a number of problems to be solved and technical risks in connection with the resin and electrode system, which so far prevented the use of the plasma treatment in full-scale industrial production.

With support of the LIFE III program of the EU Richter Färberei und Ausrüstungs-GmbH wanted to transfer the promising results from former R&D activities into a working industrial application. For this Richter obtained scientific support by the German Institute for Wool-Related research at the RWTH Aachen e.V. (DWI) and cooperated with the machine manufacturer Softal regarding the realisation of the plasma plant.
As a result of the project a demonstration plant had to be assembled to show the whole process of yarn production including the new anti-felt equipment. This was to demonstrate the industrial usability of the process and to revolutionise yarn production from the perspective of the environmental compatibility.

2. Description of the techniques/methodology implemented and the results achieved

One main aspect of the work was the development and successful testing of applicable electrode systems to enable an appropriate plasma discharge to ensure a consistent and reproducible treatment of wool fibres. In order to realise the process upscaling under acceptable risks at first a pilot plant was developed and used for testing of the new electrode design (ref. to fig. 2).

Figure 2: Scheme of the pilot plant

It turned out that so called knife electrodes were suited best for that purpose and therefore were used as substitute for the former roller electrodes. The new electrode design can be considered as one of the technical key innovations of the project. During the optimisation phase of the technical components of the pilot plant as well as of the process parameters of plasma treatment, such as electrode distance, energy input or time of exposure it was important to test continuously the resulting wool quality with respect to anti-felting, shrinking and handle properties. Therefore laborious subsequent processing and testing cycles along the textile chain, such as spinning, knitting, finishing/dyeing and garment manufacturing followed by washing trials had to be carried out. Intermediate results at this stage indicated a product quality near to that obtained by the Hercosett process and in line with the Superwash Standard.

Parallel to the development of the plasma plant suitable resin systems for the anti-felt equipment had to be selected, enhanced and adapted to the new process parameters.
After extensive test and optimisation trials a modified resin system based on the DWI approach has been identified as the best solution.

All these results have been implemented in the upscaling concept of the demonstration plant. The detailed engineering and the construction of the components of the unit have been accomplished in cooperation with Softal. Thereafter the demonstration unit was installed and commissioned. Now 20-30 wool tops could be processed in parallel instead of one single strand as for the pilot plant. Initial technical difficulties such as material burning caused by too high local plasma discharge energies and problems regarding the subsequent winding of the treated wool tops could be overcome by constructional and process modifications (refer to figure 3).

Figure 3: Photo of demonstration unit in operation

As a result of extensive optimisation steps a process velocity of 8 m/min could be achieved which corresponds to an extrapolated amount of 3000 kg wool per 8 h shift and therefore fulfils the production requirements. The product quality of the samples obtained after further treatment in our own test spinning facilities was in accordance with the former results obtained from the pilot plant trials. However for certain wool products the results could not be reproduced when the material was processed further under industrial spinning conditions on site of by our distribution partner Stöhr. Therefore process optimisation has to be continued after project expiration in order to find out the reasons and overcome the problem.

Up to now the plasma process delivers good results with respect to product properties mainly in case of fine structured wool products, i. e. the found shrinkage of 6-10% is within the range of the Superwash Standard. In order to start dissemination of the results a preliminary market segmentation into two product groups was defined: socks, underwear and fine sweaters as first and hand knits, coarse socks and heavy sweaters as second segment. Market introduction shall initially concentrate on the first segment. Distribution will be supported by technical marketing methods instead of pure sales activities to communicate cleary the differences of the new process.
In parallel further research work is performed to overcome the current restrictions. This consists both of establishing an appropriate testing method which is suitable for the wool characteristics obtained by the new process and further optimisation of the plasma treatment process and collaboration with industrial spinning companies to adapt the subsequent processes resp. When the plasma process can be applied also to course wool structures we will have fully reached a new BAT.

3. Assessment of the environmental impact of the project

Environmental benefits have been reached according to the initial assumptions at project start. Compared to the Chlorine-Hercosett process the plasma pre-treatment enables a 100% elimination of emissions by absorbable organic halogen compounds (AOX). Thus the prerequisites for the reduction of a total amount of 535 t of environmental hazardous additives (150 t sodium hypochlorite, 220 t resin, 165 t auxiliaries such as sulphuric acid, wetting agents and defoamer) and of about 30.000 m^3 of polluted waste water p. a. are given.

Although the consumption of electrical energy is considerably greater compared to the Hercosett process this is overcompensated by the energy savings for steam generation which is used for the drying procedure only in the Hercosett process (refer to table 1).

Process	Water	Chlorine	Resin	Electricity
Hercosett	6.000 l/h 17 l/kg wool	50 l/h 10 l/h	8 l/h 2% to wool	Power: 0,02 €/kg Steam: 0,06 €/kg
Superwool	no extra water	--	--	Power: 0,055 €/kg

Table 1: Comparison of environmental impacts of the Hercosett and Superwool process

4. Cost-benefit discussion on the results

In long term, i. e. after further optimisation and adaption of the subsequent manufacturing steps the wool treatment by plasma has the potential to be more profitable than the Hercosett process. Not only because of the avoidance of waste water and pollution fees cost savings but also because of omission of resins in large part a significant reduction of production costs is possible. Thus prices for the obtained intermediates could be competitive compared to those of Asian manufacturers in the future. European spinning companies will only be able to survive in the long run if they can rely on innovative technologies such as the plasma pre-treatment of wool. Furthermore environmental friendly produced textiles are expected to be preferred by an increasingly ecology-minded customer community (organic textiles).

5. Transferability of project results

In the long term the environment-friendly plasma process has the potential to define a new BAT and could therefore substitute the Hercosett process worldwide. This would affect about 10 installed plants in the EU (Germany, England, Italy, France and Czech Republic) as well as about the same number of plants in Asia. Hereby the ecological impact can be increased dramatically. World –wide the potential quantity of wool processed amounts to more than 10.000 tons p.a.

The established plasma technology has the potential to be extended to other areas of textile finishing such as needle felt production, where even more positive effects on the environment can be expected. The large scale process established in this project may also be used in related fields such as treatment of synthetic surfaces, e. g. for medical technology in order to obtain specific effects.

Already after publication of the preliminary data increasing activities in R&D of other companies regarding chlorine free processes were observed. Other companies showed interest to cooperate with RICHTER. Further companies in the EU besides Stöhr asked for the possibility of commercialisation of RICHTER´s products.
Furthermore RICHTER and Softal are planning a joint distribution of the plasma unit where RICHTER brings in the procedural and Softal the machine know-how. That could significantly boost up the dissipation of the new technology.