The Hohenstein Institutes and the Virtualisation of the Clothing Industry

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1. The Hohenstein Institutes - Textile research and testing as the basis for innovative products and commercial success

An old castle in a tranquil setting (see Fig. 1). At first glance, no-one would suspect that this was the backdrop for the world's only research and services centre providing expertise from all areas of the textile supply chain, textile care and other associated sectors. The Hohenstein Institutes, set between forest and vineyards in the Swabian village of Boennigheim, are a modern communications centre with the latest research equipment, where highly qualified scientists carry out their research and exchange knowledge. This combination of high-calibre staff and the philosophy of the unity of research, training and application have guaranteed the Hohenstein team of their position as an internationally respected institution offering high levels of expertise in all areas of the textile chain. At the beginning of the 21st century, the head of the Institute, Dr. Stefan Mecheels, and his team of scientists at Hohenstein made the research and development of high-tech textile innovations their number one priority. They recognise a rapidly developing market for "intelligent textiles" capable of adapting their function to the existing environmental conditions. This includes clothing with built-in climate control and textiles offering reliable protection against UV radiation. The Hohenstein team are also researching clothes with integrated microelectronics, a "work suit" with integrated mobile phone, computer and camera system.

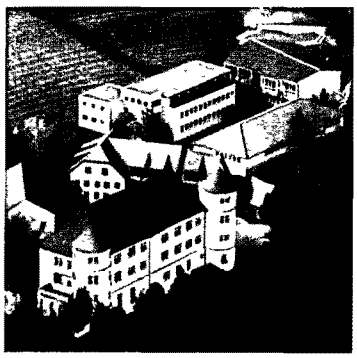

Fig 1. The Hohenstein Institutes

1.1 Hohenstein Institute for Clothing Physiology

Clients for the research projects, which are often carried out in conjunction with other institutions and industry, include the Research Association of the German Textile Industry, Association of Industrial Research Organisations (AiF), the State of Baden-Wuerttemberg, the Federal Ministry for Research, the Federal Ministry for the Environment, the European Union, the Foundation for Industrial Research and numerous leading companies both in Germany and abroad. Sequential measurements on 1,500 women carried out on behalf of the Clothing Industry Research Association have recently generated a high level of public interest. The measuring subjects were measured without the need for contact using state-of-the-art 3-D body scanners. The results are to be used by the industry to help improve the fit of

support garments (Fig. 2). This has since been put into practice by the manufacturers.

Another project is focussing on the target group of older women. Women aged between 50 and 80 were measured at Hohenstein and throughout Germany using a mobile "scan truck". The objective is to determine how our body proportions change as we grow older, and to identify ways in which the clothing manufacturer can engage this target group with high purchasing power by developing special ranges (Fig. 3).

Another high-profile project at the turn of the millennium was "Clothing made to measure", which also made use of the new scanner technology. Researchers at Hohenstein, in conjunction with partners in industry, succeeded in manufacturing men's outerwear based on individual body measurements on an industrial scale. A manufacturing concept which is set to revolutionise the clothing market over the coming decades. A fully equipped model factory in Hohenstein made each of the individual processes transparent. Several pilot shops have already opened up in Germany and abroad. There,

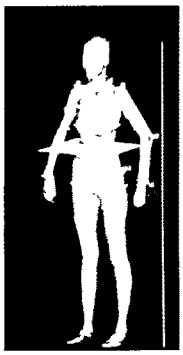

Fig. 2. Virtual illustration of a measuring subject

Fig 3. Measuring a test subject using a 3D body scanner for the "50-plus" project

customers can have themselves measured without need for contact and have their clothes made to measure. All at affordable prices.

Numerous manufacturers are supported by the Hohenstein Institutes in the development of new products. Researchers at Hohenstein have been involved with innovations such as clothing membranes, microfibres, multi-layer sports underwear and microporous coatings. These functional textiles are now taken for granted around the world. To take just one example: At the football world championships and the European championships, several teams sported extremely modern kits, whose construction had previously been accurately adapted to the climate of the host country by the Hohenstein Institutes. The researchers' pleasure is all the greater when the team wearing their "product" goes on to win the championship.

1.2 Hohenstein Research Institute

Textiles are increasingly developing into high tech products. Dr. Stefan Mecheels, head of the Hohenstein Institutes, is therefore anticipating a boom in textile innovations for the beginning of the 21st century which will involve all areas of life. According to Mecheels, one brand new trend is for "intelligent textiles which actively react to their environment". Depending on whether it is warm or cold outside, these high-tech clothes heat up or cool down, they can communicate with the outside world, help people find their bearings, raise an alarm or treat diseases. The possibilities are boundless. According to the Hohenstein Institutes, these and other "intelligent" textiles are rapidly on the increase. "In the coming decade, there will be advances in the field of textiles on a scale never before experienced". The products involve virtually all areas of life, including medicine.

In the well-equipped, modern medical textiles competence centre, the Hohenstein researchers are working on textiles to which "molecular repositories" are applied. Active substances can be embedded in these repositories. When the textile comes into contact with the skin, the substances are slowly and continuously released. It is hoped that this type of "cream to wear" will help to relieve skin complaints

such as neurodermatitis and skin allergies. Textile constructions in which active substances are embedded can also help to accelerate the healing process of chronic wounds. In addition to the textile specialists, specialist doctors employed at the Institute are also engaged in this project, working closely with several medical institutes and hospitals. Another focus of the research work at Hohenstein is clothing which can offer reliable protection against harmful UV radiation both on the coast and in the mountains. A special UV protection test centre has been set up to evaluate such products.

Another area deals with so-called "Smart Clothes", in other words, clothes with integrated microelectronics, sensor technology and actuator technology. In the foreseeable future, mobile phones, computers and camera systems will become part of our everyday clothing. This will allow people to communicate with each other - if they so wish - wherever they may be. The products will offer more than pure entertainment value, however; they will also promote personal safety and health. Dr. Stefan Mecheels: "This opens up fascinating opportunities for the clothing manufacturers, giving them the chance to develop into high-tech companies".

In another project, researchers are looking into the possibilities of cleaning textiles with compressed (liquefied) carbon dioxide in the future (Fig. 4). The prototype machine at the Institute is the first to go into operation in Germany. If the project is successful, it is possible that the textile care industry may be able to establish itself as global market leader in this sector.

Industrial laundries and textile leasing companies also form a central aspect of the work at Hohenstein. Here, the focus is on quality, environmental and

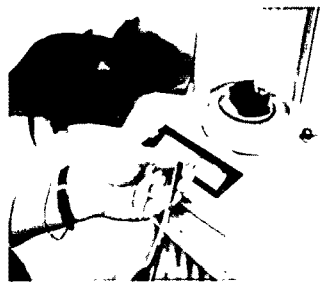

Fig. 5. Testing for damage in textile cleaning

hygiene issues, as well as questions such as how often workwear or protective clothing can be subjected to care cycles before the protective effect for the wearer is lost (Fig. 5).

This is not always easy for manufacturers or leasing companies to assess, although major investment decisions are often based on this. In addition to the research and development of innovative products and processes, another of the Hohenstein Institutes' principal tasks is testing, product testing and certification. As a textile test centre, Hohenstein has an excellent reputation worldwide. It is regarded as completely independent, respectable and extremely competent. Several of the staff have been appointed as sworn experts. Thanks to the testing and certification of textiles carried out at the Hohenstein Institutes, a large number of complaints and damage events have been avoided in preliminary stages. The results of the test programs provide Hohenstein's clients with criteria on which to base decisions concerning product development, evaluation and marketing. In the area of textile ecology, the Hohenstein Institutes have played a crucial role in developing the internationally recognised "Oeko-Tex Standard 100" label (Fig. 6). This stipulates comprehensive criteria and stringent limit values to be used for test-

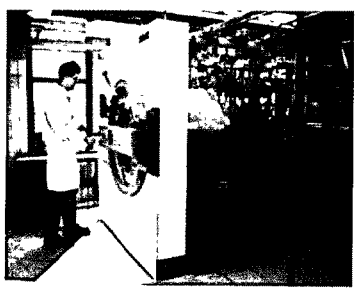

Fig. 4 Pilot CO_2 machine at the Hohenstein Institutes

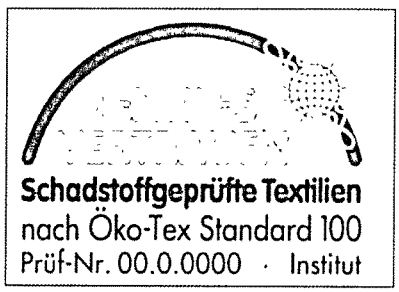

Fig 6 The Oeko-Tex standard 100 label

ing textiles for harmful substances and provides the consumer with peace of mind, and the confidence that they are purchasing a textile which poses no risk to their health.

1.3 Technical Academy Hohenstein

Another important branch of the Hohenstein Institutes is practical - based basic and advanced training and advice in all textile fields. The philosophy of the institute involves combining research with practice and advanced training. This philosophy was established by the founder of the Institutes, Prof. Otto Mecheels, who, at Schloss Hohenstein in 1946, founded the research institute of the same name. At the beginning of the 1960s, his son, Prof. Jurgen Mecheels, took over the Research Institute and the Hohenstein Technical Academy and expanded the complex to include the Hohenstein Institute for Clothing Physiology. Since 1995, the grandson of the founder, Dr. Stefan Mecheels, has been head of the institutes. He has set the course for the 21st century, while respecting the institutes' traditional philosophy. Transferring the research results into practice is given a very high priority within the company. Over 4,000 clients in Germany and abroad use the service potential of the Hohenstein Institutes. Hohenstein's research results have helped secure the future of many small to medium-sized companies. In the Hohenstein Technical Academy, a well-equipped training centre, the knowledge acquired is continually being passed on in courses and seminars. This makes it possible to react in a rapid, flexible manner to the constant changes in the textile and clothing sectors.

The Academy is also a popular conference centre, where experts from the entire textile chain come together regularly from around the world to take part in conferences and symposiums (Fig. 7).

Fig. 7 Conference room at the Hohenstein Technical Academy

Hohenstein employs over 170 staff in ten specialist areas. The specialist areas are divided into:

Textile Innovations, Clothing Technology, Clothing Physiology, Material Testing, Consumer Tests, Textile Cleaning, Laundries, Textile Leasing, Medical Textiles, Hygiene and Biotechnology. Each specialist area is headed by a highly-qualified specialist. A sense of personal responsibility, motivation and the desire to put the customer first are all attributes which the head of the Institute, Dr. Stefan Mecheels, values highly in his staff. The Hohenstein Institutes have set in place all the foundations for a successful future in the 21st century.

Textile and clothing manufacturers, textile retailers, textile service providers and the textile care sector, together with the end user, all stand to benefit from this. Mecheels' vision for the future for himself and his staff is as being pioneers at the forefront of the textile industry. "Our greatest source of satisfaction in our work at Hohenstein comes from seeing a new product or process which we have helped to develop become a commercial success for the manufacturer".

2. Clothing Technology - The virtualisation of the clothing industry

Recent research developments of advanced technologies are enabling a virtualisation of the clothing industry and bring the possibility to optimise the entire textile-clothing-retail-chain. The key-technologies are 3D-body scanning, 3D-CAD and networking-technologies with the aid of the internet. But, it is not imperative, that all these developments come into practice within the next few years. The introduction of complex systems such as 3D-CAD need a long time and a long process of re-learning. Today's way of developing and manufacturing garments is the result of decades of co-operating and led to an established division of labour. This process can't be completely re-engineered by the sudden introduction of virtual technologies. The introduction has to be a step by step process and many new systems will have to run in parallel with the tradition-

al ones first.

The successful virtualisation of the clothing industry and the re-engineering of the textile clothing retail chain have a close link to the possibilities of networking. Therefore, a powerful and useful instrument is necessary to bring the subcontractors, the textile industry, the clothing industry, trade and even the customer together with the aim to offer the desired products.

For that reason, an effective exchange of information is necessary. This is developed at present in the so called "MyNet" research project (1). A platform to exchange all necessary information is set up. The customer data from the customer, the order data from trade, the date of delivery from clothing industry and the material availability from the textile industry and from subcontractors are exchanged through a communication platform. This exchange of data has the aim to optimise the exchange of goods between all partner within the manufacturing and delivery process of customised garments. Only if all necessary information are available at the right time in the right place, the exchange of goods can be done in a satisfying and, most important, in a fast way.

If all necessary information are available on the platform,

- the textile information from the textile industry
- the clothing information from the clothing industry
- the customer information from the customer, collected in a shop

the system can be put into operation. For example in a shop, the individual virtual garment can be simulated by combining the information of the garment collection with the textile information and the result can be draped on the virtual customer, who was scanned a few minutes before. The result will be shown in a virtual mirror and the customer can decide, which combination of products he wants to order without picking up several garments from the hanging rail and without the necessity to change clothes several times.

The required information from the textile industry for such a system are physical and optical parameter for the product portfolio of each textile enterprise. Therefore the KAWABATA tests can be used. The KAWABATA tests have the aim to describe the feel and touch of textiles. We determined the KAWABATA data of several textile materials (some of them were sewn or fixed) and handed the data over to the simulation process. We used the KAWABATA tests within the scope of the research project Virtual Try-On (2), for example the bending test which bends the material in two directions. The result is a graph of the power of resistance for the whole process. Fig. 8 shows the testing equipment and a graph with different coloured curves from different textile materials. For the determination of all necessary parameters for textile-simulation, we carried out several physical tests in addition and handed the data over to the simulation tool.

But, these tests are very time consuming and very expensive. For this reason, we are developing at the moment a method for a simplified determination of

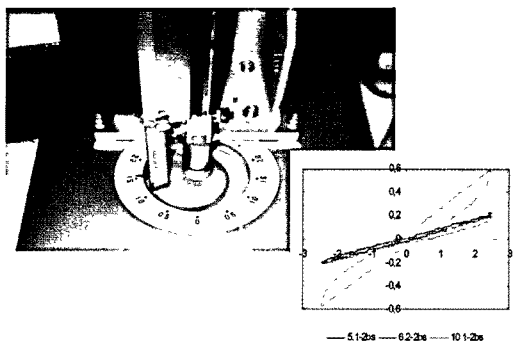

Fig 8 KAWABATA-bending-test and results for different textiles

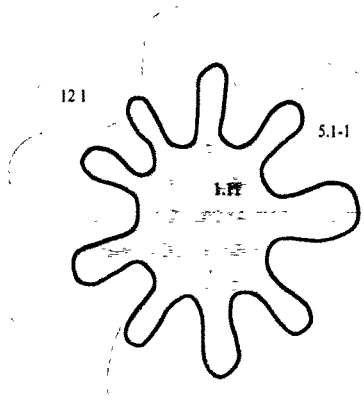

Fig. 9 Comparison of fold formation images

material parameter. Our work is based on former developments on fold formation of textile material. We are trying to group the materials and the aim is to develop a prediction system to forecast the physical parameters by comparison of fold formation images.

[Fig. 9] shows the projected fold formation images of three different textile materials. The materials are draped over a defined circular plate and the image is taken from below. The number of folds, the inner and outer circumferences and the plane of the folds are used to group the materials.

This may be an easy, fast and cheap test method for the textile industry. It is not practicable to test all textile materials with KAWABATA and other equipment. But if it were possible to determine the physical parameter of a new textile material by comparing it with the fold image of a known one, this could bring the system a huge step forward.

The second main job for the textile industry is to provide optical parameter from the product portfolio of each textile enterprise. Therefore it is necessary to generate and model so called bi-directional texture functions (BTF). These measurements of the textile surface, that is to say the reflections of a sample from different views and light influence, can be measured automatically. Within the scope of Virtual Try-On, our research partner University of Bonn developed a method to take the optical look and feel of a textile sample automatically (Fig. 10). Because of the automation degree this service can be offered cheap and for the textile industry it will be possible, to deliver this additional information along with other material information for their product portfolio.

As a result of this development, a huge number of images are ready for the simulation process. This is important for a realistic representation of textile materials in the virtual world. It is much more important in combination with a simulation of a natural environment where light and reflections come from different directions. For example, a walk on the beach etc. The basis to use these data properly is detailed information on the shading of the garment when it is worn and when the virtual customer moves around. This makes it possible to get a nearly natural impression of textile materials, so that denim looks like denim and corduroy looks like corduroy (Fig. 11).

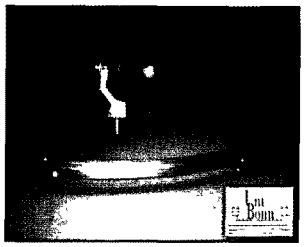

Fig 10. Laboratory setup at University of Bonn

Fig. 11 BTF rendering of cloth material by University of Bonn

The third main job for the textile industry is to provide always up-to-date information about the availability of each single textile material they are offering. This is one of the main problems within the order process of a made to measure product. The textile material and its availability is the most crucial point within the sales talk. Most customers want to touch and feel the textile material. Therefore it is very counterproductive, when the availability of the textile material is not known. The worst and frustrating case for the customer is, when he or she has to come back to the store some days later to select another material when it turned out that the material of first choice is not available.

A very simple way, how the material availability could graphically be represented, is shown in [Fig. 12]. A Fig. of the textile material is shown, a short description is given and the stock rate and order possibility is displayed by the use of coloured symbols.

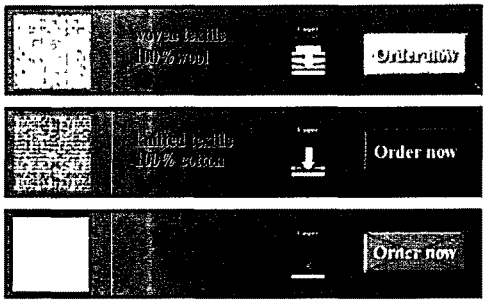

Fig 12. Display of different materials and their availability

The second partner within the network is the clothing industry. For the system, respectively the network described above, the clothing industry has to provide extensive information on the company specific collections of garments.

Each virtual or 3D solution for the clothing industry has to ensure, that the existing data on garments (CAD data, markers etc.) can be used further on. A totally new way of garment design in a 3D environment will only come into being within a very long process of relearning.

As a first step into a virtual environment the existing markers have to be processed and transferred into a DXF-file which consists of the edge-curves of the patterns. This is not very complicated but the option to generate such a file has to be integrated into today's running CAD-systems.

The second step is an extension of the DXF-file by adding further information such as:

- a body reference point
- pattern pieces
- seam information and sewing lines
- material and material-area information
- direction
- design

and the transfer into a XML-file (Fig. 13).

The workmen in the clothing industry know how

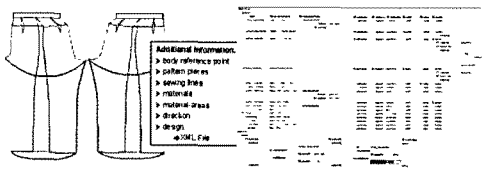

Fig. 13. Transfer of a DXV-file into a XML-file by adding information

the patterns have to be handled, so that the result will be a good piece of clothing. But the computer doesn't have this expert knowledge and you have to tell him everything step by step.

For a realistic garment simulation on a body, the preparation of a virtual model or a virtual customer is important. The system needs to have the decisive information on the body-geometry and the cutfile-geometry for the virtual try on. You have to teach the computer where he has to put the clothes on the human body. Everybody knows, that a blouse is for the upper body and a skirt is for the lower body. But the computer doesn't know! You have to give him a feature point on the human body and a reference point within the marker of a garment to bring them together (Fig. 14).

A prerequisite for a virtualisation of the clothing industry is a very strong link to existing 2D-CAD systems and to the future 3D-CAD systems. Research work in this huge area has already been done and nearly all CAD systems provider are developing 3D-CAD tool as a next step for their running systems. This step by step development ensures the transfer of existing data into the new systems. Furthermore, the link between 3D-CAD and the textile material which remains flat, has to be guaranteed.

But, some tools will be really new ones, such as

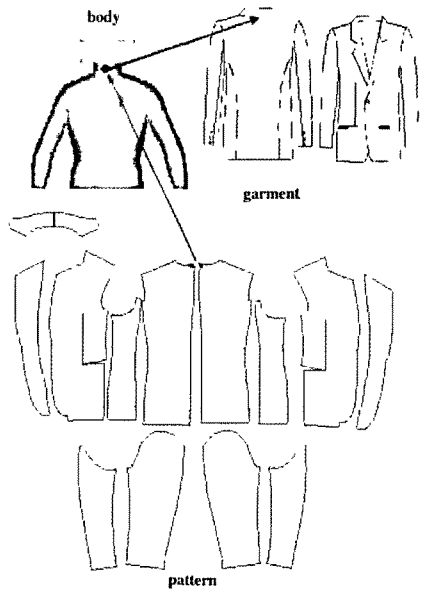

Fig 14 Reference points on the body and in the pattern

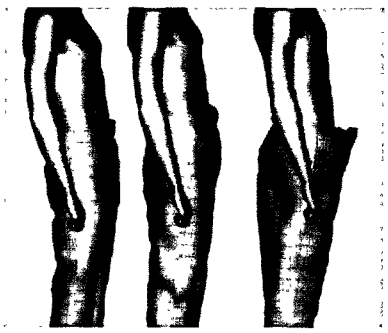

Fig 15 Fit simulation

3D-draping or virtual cutting on a 3D-garment, and they will initiate a process of relearning and rethinking of traditional ways of working. The developments in research and in industry are still running with a good chance of practise-oriented results.

In a direct connection to 3D-construction, the fit simulation is another huge challenge for the clothing industry. [Fig. 15] shows a result of the research project "Virtual Try-On" - three simulated trousers in side-view. The left one fits, the trouser in the middle is a bit too large and the right one is too large. The important think is: these Figs are not draped but really calculated with the information of the textile material and the information from the CAD-system! The simulation quality is already satisfying and a specialist from the clothing industry can judge the fit of a garment as well as a customer can.

By now, it is possible to simulate different garments on an animated virtual human. The novelty is, that the simulation is no longer designed Fig. by Fig. (as it is done for example in simulations for movies) but it is calculated on body information, textile information and garment information. The gravity and the inner- and inter-textile influences are also taken into account and play an important role. The developments and the research are still running in this special area but makes good progress.

These developments may be a very useful instrument for trade too. As a powerful advice-tool for the salespersons and a helpful decision-tool for the customer.

Just imagine

- you scroll through a clothing catalogue with your digital twin as a model
- you descide to buy ready made garments or made to measure clothes
- you create your individual garment in 3D
- you can try-on the result of your co-design in a few seconds
- you can decide immediately if the garment meets your requriements or not
- you can do this at home or in a shop and the garment fits!

This is the aim, but still not existing, for a virtual clothing distribution.

Today, some existing solutions offer web based shop environments where it is possible to choose between different standard models or an individualised avatar. This works already for women and for men but is still based on standard sizes and only Fig.s of the garments. The main disadvantages are: the virtual catalogues contain only 2D-Fig.s of the products, the chosen samples fit always on the model and there are no possibilities for an interactive configuration of the products.

In other solutions, the customer has the possibility to create a virtual model by answering several dialogues. These dialogues deal with the body shape, the weight, the posture, the look of the face, the eyes, the nose and the lips and with the colour of the skin. Further on with the hair style, hair colour and in the case of men with a beard or no beard. The result is a 3D avatar, but they have also large disadvantages: the avatars change only in very small ranges for the

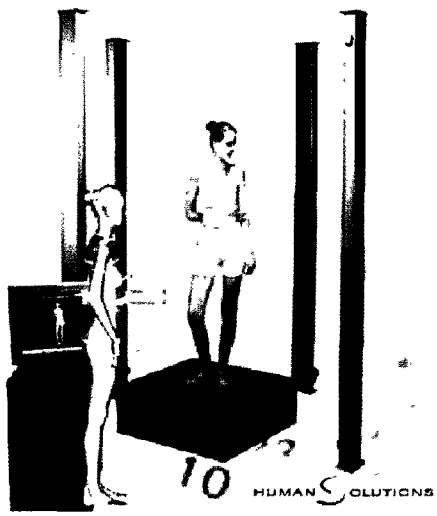

Fig. 16. 3D-body scanner

given information, they have only a little similarity to the customer and they can not be used to get a realistic fit information.

For the retailer of the future, and especially for those who want to offer made to measure garments, a so called customer co-design is important to get the necessary customer information.

First, the personal customer data are collected. This should be done with the aid of a 3D-body scanner (Fig. 16). The main advantage of this instrument is the permanent availability of a 3D image of the customer. The designer, the clothing technician in industry or any other expert with the necessity to have a 3D-image of the customer, can have a look at this digital twin of the client whenever there is a need for it. The salesperson don't have to call the customer and ask to come into the shop again if there is any question on body geometry or posture.

The scanning process takes about 10 seconds time and results in 450.000 to 600.000 3D-points. After the scan process the raw data are processed and transferred into a watertight surface with about 12.000 polygons. This closed surface is now suitable for the simulation processes.

But for a realistic simulation of the try on process a textured avatar of the customer is necessary. Therefore the static avatar is combined with coloured Figs of the customer which are taken during the scan process. These Figs show the real colour and texture of the skin. The textured avatar is important to enable the customer to identify his or her personal digital twin. This is on the one hand helpful for a positive shopping experience and on the other hand for a realistic impression of chosen combinations of garments.

To go one step further, the implementation of a skeleton is necessary for an animated avatar. Therefore the body is automatically segmented in the main parts and after this first step the virtual skeleton can be calculated into the body.

The last steps to collect all necessary data for the virtual try on process and the virtual fit simulation is to extract measurements. Therefore it is necessary to extract nearly 50 feature points or so called landmarks. This is the basis for the measurement extraction.

Within the measurement extraction up to 70 measurements are taken on the human body. The feature points extracted before are used for orientation and for interactive corrections of the measurements. A list of the measurements can be transferred easily to the clothing manufacturer, where the data are integrated into the CAD-system and used for design and manufacturing of made to measure products.

In addition to this process of obtaining a digital customer, the salesperson has to go into detail about the product the customer desires. Style preferences, material preferences and so on. An interactive catalogue (Fig. 17) with images of the options can be a powerful assistance to this process. Step by step, the customer creates an individual product together with the advice of the clerk. At the end, the order is com-

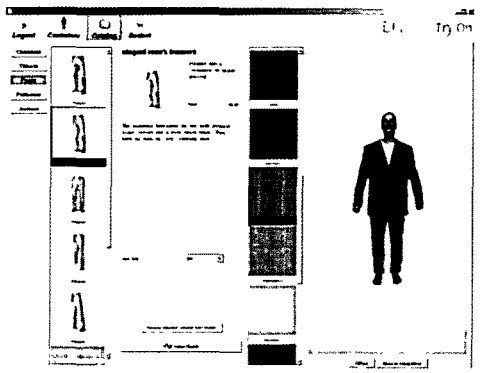

Fig 17 Interactive catalogue

Fig 18 Virtual mirror

pleted and transferred into the network, which gets automatically in contact with the clothing manufacturer as well as with the textile industry and provides the proper information for each expert there. In return, trade and the customer gets information on delivery dates, on product details and on price.

A very strong instrument to assist the salesperson and the customer in a shop may be the virtual mirror (see Fig. 18). This should be a head-high display where a digital twin of the customer can be shown and different clothing ensembles can be chosen and displayed. This device was basically developed within the "Virtual Try-On" research project by the partner Human Solutions.

Sure, the described system is more a vision than something coming into practice within the next few months. But we believe in this virtualisation of the clothing industry. We hope to support the entire textile-clothing-retail-chain with these developments to optimise some processes. We would be very happy if this could ensure the existence of the mainly small and medium-sized enterprises and of the jobs in this branch. We lost a lot of jobs in the past, mainly in production, but there is a chance to protect the rest. Even though the research and development still needs some time, the attainments so far are very promising. There is a good chance for a valuable cooperation in the entire chain with extensive benefit for every participant.

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Director of the Department of Clothing Technology, the Hohenstein Institutes(responsible for Quality Management and Certification of Personal Protective Clothing according to the EU-directive 89/686/EWG

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