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Sustainable and Cleaner Production in the Manufacturing Industries
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1

Training Workshop for Leather and Tanning Sector Independent Equipment Manufacturers (IEMs)

Bremerhaven – Germany

14th December to 17th December 2009

PROJECT PARTNER



2nd Floor, Al Maalik, 19 Davis Road, Lahore, Pakistan
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1. Training Workshop for Leather and Tanning Sector Independent Equipment Manufacturers (IEMs)

Commencement Date: From 14th December to 17th December 2009

Workshop Coordinator: Hanyork Von Marees

Project Co-ordinator Organization Name: Verein Zur Forderung des
Technologietransfers an der Hochschule Bremerhaven e.V. (TTZ)

Venue: TTZ Bremerhaven, Water, Energy and Landscape Management, An der
Karlstadt 6- 27568 Bremerhaven – Germany

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2. Introduction

The workshop was held at TTZ Bremerhaven, Germany from 14th December to 17th December 2009. (Photographs from the workshop are attached as Appendix C)

Short listed IEMs, supplying industrial equipment and machinery to leather and tanning sector, were taken to Germany for attending the training workshop. These IEMs were short listed based on their capacity to undertake technology transfer initiative, their involvement with the targeted industrial sector (tannery), influence over the industrial procurement process, and most importantly their interest to participate in the energy efficiency and resource conservation drive. (List of participants is attached as Appendix B)

Knowledge transfer in Sustainable Production (SP) techniques and technologies and networking between European and local IEMs were the key objectives of the workshop.

Implementation of training and study tour programme for IEMs is an integral component of the project, and the aim is to transfer technology from Europe to Pakistan, with a strong emphasis on building local vendor capacity so that they are able to serve the target SME sectors with energy and resource efficient products and services. The training and study tour was focused to ensure that indigenisation of the Sustainable Production (SP) techniques and technologies can take place, whereby the IEMs will have the capability to undertake sustainable production initiatives in the future. (Workshop Agenda is attached as Appendix A)

After the conclusion of training workshop, networking event took place where representatives from European IEMs, having proven record with demonstrable and transferable knowledge in SP techniques and technologies, shared their knowledge and experiences with the participants of the workshop. The activity provided local IEMs with ample opportunity for networking and establishing relationships for technology transfer from Europe to Pakistan.

The workshop was conducted by the BLC, a leading leather technology centre working with hundreds of companies in leather and tanning sector. With over 80 years of experience BLC has the technical pedigree in leather technology for ensuring fast accurate solutions to technical, management or environmental leather problems. Clean Leather Manufacturing, Intensive Leather Technology, and



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Leather Finishing are the focus areas of BLC. The reason for selection of BLC is their technical skill and comprehensive coverage of leather and tanning sector.

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3. Official Welcome and Partner Presentation

Dr. Ing. Gerhard Schories (Technical Director TTZ) welcomed all the participants on behalf of European Commission and project partners. He delivered a brief presentation on history of TTZ and its core areas of expertise. He informed that TTZ Bremerhaven was created as a public sector initiative to protect local industry and has four different facilities around Bremerhaven working in capacity building and research in the areas of food technologies, sensory evaluation, water management, sustainable land use and sustainable energy management.

Dr. Schories formally introduced Mr. Stuart Booth (lead trainer from BLC) and Mr. Hanyork Von Marees (workshop coordinator) to the participants.

This was followed up with format introduction of all participants of the workshop.

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4. Workshop Discussions and Presentations

a. Short Term Preservation of Raw Material

Mr. Stuart Booth briefly introduced himself. He has over 25 year of experience in the tannery sector and he has seen tanneries around the globe. He explained how BLC is helping tanneries around the world in a move towards sustainable production processes.

At the start of the presentation, he delivered a brief presentation on the leather industry and informed the participants that almost 80% of raw material used in the tannery ends up in waste. He presented general breakdown of economic costs associated with the raw materials and highlighted the fact that these constitute the major portion of overall cost. Hence, measures undertaken to increase the efficiency of raw material usage ultimately result in extraordinary savings. He also briefed the participants on different types of solid, air and liquid pollutions associated with tanneries.

8 In the second part of presentation, he explained different phenomena associated with raw stock. He briefed the participant about autolysis, bacterial contamination, putrefaction and stalling of raw hides and explained various factors, which increase the rate of occurrence of these phenomena. He also described the mechanisms used normally to gauge the degree of putrefaction of raw hides. He discussed different conventional methods of conserving the hides, which ranges from drying, salting, brining, chilling, icing to the use of biocides. This was followed up with a detailed discussion amongst workshop participants to evaluate each method with respect to it's benefits and drawbacks. Mr. Booth was of the view that tanneries should move towards icing instead of salting as it will result in considerable water conservation and up to 1.5 percent improved yield.

In third part of the presentation, different conventional and advanced methods of soaking were discussed, which includes pits, paddles, drums using water and soak additives. Impacts and actions of different additives on leather structure were discussed in detail and Mr. Booths suggested mechanisms for better process control in soaking and best available techniques.



b. Cleaner Approaches to Unhairing and Liming

Mr. Booth discussed the details associated with processes of unhairing and liming. He highlighted the impact of different chemicals (Lime, sodium hydroxide, sodium sulphide, sodium hydro sulphide, enzymes and di methylamine) on leather and their relative merits and demerits. Various methods of hair removal, hair burn and hair save were discussed and their relative environmental impacts were studied. It was pointed out that hair burn is the dirtiest process of tannery and best method for the reduction of environmental impact is hair save process. Different methods of hair save and processes associated with it were discussed in detail.

In second part of this presentation Mr. Booth briefed about liming and importance of liming in hide processing and impact of better process control was discussed. The effect of chemical concentration, Ph, and mechanical action on shrinkage temperature were elaborated. While answering the queries Mr. Booth discussed the impacts of over liming and excess mechanical action on skins in details.

c. Cleaner Technologies in De-Liming and Batting

9 This part of the presentation of mechanisms, which can be adopted to improve the processes involved in De-Liming and Bating. It was suggested that splitting should be done before de-liming as the leather is thicker at this stage. The functions of deliming (removal of residual chemicals, reduction in PH and increase in temperature) were discussed. Different deliming agents and the pollution load between conventional and advanced methods were also discussed. The process control of deliming was elaborated and use of its effluent as fertilizer was pointed out. Mr. Booth explained the process of CO₂ de-liming as compared to Ammonium de-liming with the benefits and limitations associated with the process. Finally a comparative analysis was presented comparing use of Ammonium salts, CO₂, organic acids and mineral acids in the process of de-liming.

In second part, bating process was discussed with emphasis over enzyme action on leather during the process. It was highlighted that process control parameters in bating are pH, temperature and enzyme concentration, which are critical for effective bating and leather quality.



d. Pickling and Tanning

After introduction to the pickling process, detailed presentation was delivered on different pickling agents and pickling process controls. That includes salt concentration, acid penetration, pH of the liquor pH of the skin cross section and temperature. Different pickling options were discussed and it was suggested that formic and sulphuric acid solution is the most effective pickling agent. Pickle liquor recycling was also discussed and its advantages such as reduction of pollution load, and increases productivity by decreasing water and chemical use were highlighted.

In second part of this presentation, different types of tanning processes were discussed in detail, with their impact on leather structure. Process control of leather tanning, importance of masking for fixation, and mechanisms for maximizing the chrome uptake in tanning were discussed. It was highlighted that minimization of chrome offer and rate of pH and temperature change and maximization of mechanical action end temperature final pH and reaction time will increase chrome uptake substantially Aldehydic and mineral type chrome free tannage were also discussed and their cross linking with leather collagen was elaborated. Pollution load of tanning and the factors to reduce them were discussed in detail. Process of chrome recovery was discussed and participant were informed about the importance of chrome recycling since chrome recycling is much easier than chrome recovery.

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e. Cleaner Technologies in Post Tanning and Dyeing

During this part of the presentation, mechanisms for efficient usage of water and energy were discussed. Typical energy and water wastes were discussed and importance of implementing water and energy audit and conservation measures for rapidly improving the situation were highlighted. In this regard, the BLC protocol for eco friendly tannery was also discussed.

f. Cleaner Technologies in Finishing

As part of Cleaner Technologies in tanning industry different types of cleaner finishing including padding, spraying and roller coating were elaborated and relative features of each type were discussed. It was discussed that use of high volume and low pressure guns for spraying increases the process efficiency dramatically. Types of roller coating were also discussed.



The environmental impact of finishing was discussed with focus on VOC emission. It was highlighted that due to the VOC emission and owing to stringent environmental laws, the methods of solvent emission arrestment and replacement at finishing stage are being commonly adopted. Best practices for reducing energy consumption and material consumption during the finishing process were discussed in detail. During the discussion, several high-tech machines used for automated finishing were discussed, which are used to achieve higher lever of resource and energy conservation.

g. Sustainable Waste Water Treatment Technologies

During this part of the presentation, different options available for the end of life treatment of leather were discussed, which include incineration, land fill, gasification, biofuels and composting.

Participants were informed that for effective composting temperature, moisture, oxygen, C/N ratio, pH and size of the organic matter are the controlling parameter.

Different options available for waste water treatment were discussed including; pre treatment, primary treatment, secondary treatment, tertiary treatment and sludge handling and disposal. However, it was emphasized that it's more beneficial practically and economically to reduce the waste during the process instead of treating it at the end. Pre-treatment technologies were discussed which include screening, rotary biological contactor (RBC), trickle filters and rotating screening. For primary treatment technologies, physical treatment plant for tannery effluent and dissolved air flotation was discussed and the impact of treatment on tannery effluent was highlighted. For secondary treatment technologies, the principles and methodology of biological treatment, activated sludge process and denitrification were discussed. The Reed Bed method for alternative to other secondary treatment methodologies was discussed. It reduces energy demands for activated sludge process and requires minimum maintenance, capital and operational costs. Finally membrane technology in context of tannery effluent was elaborated. It was highlighted that use of membrane technology can recover lime and sulfides from unhairing liquor, chrome from spent chrome liquor, and pickle effluent for process reuse.



h. Sustainable Solid Waste Management Techniques and Technologies

During this part of the presentation, solid waste management mechanisms through making use of industry by products were discussed. Only 20% of the hide is utilized during the process and the rest constitutes major portion of solid waste, which poses huge problem and requires innovative solutions for solid waste management.

One of the technique used for solid waste management is gasification and during the presentation detailed discussion was held amongst the participants on the application of gasification for tannery's solid waste. Gasification can minimize waste disposal hazard, land filling costs, helps recover chrome and energy, and at the same time reduces overall consumption of energy. Benefits to the leather industry, global trends, and industrial best practices in shape of case studies for gasification process were discussed.

Since BLC has been working in the field of gasification for last 8 years, its research and development initiatives were elaborated. BLC has implemented a pilot project by making use of a mobile demonstration unit of gasification plant. Overall structure of the pilot project, plant design, operational data and its outcomes were discussed. The scope of the future project, envisaged by BLC, for full scale implementation of a gasification plant for solid waste management was also discussed.

Production of biodiesel as a second option for solid waste management was discussed. It was highlighted that biodiesel is produced by transesterification of fats and oils with alcohol by an acid or alkali catalyst to form fatty esters. It was discussed that the efficiency of the process is affected by feedstock quality and its better to remove Free fatty acids (FFA) prior to the process to prevent saponification and yield improvement.

Option of bioethanol was also discussed which can be produced from protein waste of leather industry. The process consists of novel conversion of protein into ethanol via hydrolysis (enzymatic and alkali), followed by application of a novel bacterial process.

Towards the end it was concluded that gasification process can meet all most all energy requirements of a tannery's.



i. Life Cycle Analysis

Participants were informed that Life Cycle Assessment (LCA) is practically the assessment of the environmental impact of a product or service through out its lifespan. For leather products the life cycle starts from beam house and finishes at end of life impact. In this regard, waste discharged and chemicals used at different stages of the process (beam house, tan yard, Retan, and finishing) along with their pollution load were discussed. Conventional and advanced tanning technologies were compared for their general LCA impacts. It was interesting, for the participants, to lean that LCA conducted by BLC for all three types of tanning technologies (Chromimum, Aldehyde, and vegetable) have almost similar accumulative environmental impact.

In the second part of the presentation, the concept of carbon foot printing was discussed in context with leather industry. After going though the theoretical background of the concept, different tool for the measurement of carbon footprint were discussed with emphasis over ISO 10064 and Green Index. LITE (Low Impact To the Environment) a carbon label, initiated by Carbon Trust was discussed. Carbon footprint helps organizations to achieve the target of reduction in usage of water, HFO, electricity and COD.

In the last part of this presentation, types, application, and requirements of ECO labels for the leather were discussed in detail. Finally the labelling standards developed by BLC were elaborated. The standards are given the name of SURE Family and it includes different catagories like Eco Sure, Leather Sure, Metal Sure, and Quality Sure, which are based on different requirements and parameters. Finally the suggested testing mechanisms for labelling were explained.

j. Leather Working Group:

During this part of workshop, Mr. Booth informed the participants about the initiatives undertaken by the Leather Working Group for development of a uniform environmental auditing protocol for promotion of environmental friendly practices in the leather industry. It is developed by BLC and several leading brands of the leather industy are involved in this initiative.

Mr. Booth explained the protocol, stressing that it takes a holistic approach for effective management of manufacturing processes, which in turn results in reduced



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environmental impacts and costs. In this regard, Mr. Booth elaborated on the procedure of the protocol related to restricted substances, emergency planning and operating permits, waste management, environmental management systems, energy conservation, air emissions reduction, and reduced water usage. It was mentioned that tanneries, which have implemented the protocol have demonstrated remarkable improvement in these areas. The roles brands can play in enforcements of these best practices was elaborated and discussed.

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k. An Introduction to SWITCH-Asia Project Re-Tie

The purpose of this part of the workshop was to provide a network opportunity with another SWITCH-Asia project and share experiences learned during the implementation of project activities. Mr. Gerhard Weber, Project Director Sequa gGmbH (lead partner of the project consortium) attended the event and delivered a detailed presentation about the project.

Mr. Weber briefly introduced Sequa, its structure, core expertise, and areas of activity. He explained the partner composition of the project, which includes Sequa gGmbH (lead), bfz gGmbH, UNIDO, DCCI and BFLLEA while project associates are Bangladesh Tanner's Association, local decision makers, politicians and entrepreneurs from Bangladesh and Germany/Europe.

Re-tie (Reduction of environmental threats and increase of exportability of Bangladeshi leather products) is an EC funded initiative aimed at c provision of employment and income-opportunities in environmentally sustainable SMEs in the leather sector in Bangladesh.

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Project partners have envisioned that this activity will result in more efficient use of natural resources and significant reduction in environmental pollution and waste, efficient use of energy and effective conservation measures, improved occupational safety and health, increased corporate social responsibility, improved exports of Bangladeshi leather products through adoption of international standards, effective and supportive policy framework for SCP, and a strengthened institutional structure and an outreach to SMEs for the promotion of sustainable production.

Mr. Weber informed the participants about the three main areas of activities, which include capacity building for business membership organisations and export strategy, implementation of nucleus approach with 15 – 18 sector units, and practical introduction of cleaner production technologies and occupational health and safety. Following are the activities, which are being implemented

- benchmarking and assessment of selected companies (tanneries) by International Experts,



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- practical demonstration of water management, chrome management, process control etc.
- local experts/consultants training in field of Cleaner Production,
- Practical demonstration in selected companies,
- Development of sustainable production guidelines for managers and supervisors,
- provision of personal protective equipment (for demonstration and training to selected companies).

Mr. Weber mentioned that Bangladesh Supreme Court has issued orders to shift tanneries, located at -----, outside of the city. This move has provided an opportunity for potential interventions to meet the project goal to implement nucleus approach in the tanning industry.

Mr. Weber also offered several documents prepared by UNIDO for tannery industry to the participants. The documents presented were:

1. Waste Generation in the Leather Products Industry
2. Pollutants in Tannery Effluent: International Scenario of Environmental Regulation and Compliance
3. Regional Plan for Pollution Control in the Tannery Industry in South East Asia
4. Environmental Aspects of Foot ware and Leather Product Manufacturing
5. Design of Model Tannery
6. Occupational Safety and Health Aspects of Leather Manufacturing

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1. Process Water - Best Practices

Mr. John Crowther CEO/President of Swystem Logic GmbH attended the event to share knowledge and experience related to sustainable techniques and technologies with the participants of workshop.

Swystem Logic GmbH works for the promoting efficient and sustainable use of natural resource and waste minimization in the manufacturing industry. They are focused to help manufacturers make top quality products, meet environmental targets and to cut costs by eliminating waste, by the use of proven, modern concepts of process control.

Mr. Crowther discussed methods to improve the usage of process water and the solutions Swystem Logic is offering for water conservation. He highlighted that the scarcity of water, cost of effluent treatment, need to prepare accurate recipes, and demand for consistent product quality makes it essential for the industry to control the water and use measured quantity.

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Reduction of water consumption requires restriction of open water hoses and continuous wash cycles, accurately measurement of all floats, fast stabilization of water temperature and avoiding the reprocessing to maximum extent. Tannery has a mix of slow and fast processes and chemical reactions in processing are dependent on temperature, concentration of chemicals, and time, better process control of these key parameters is the essential for efficient use of water resources.

Swystem Logic suggest to controls these parameters based on 3 ways valve, temperature sensor, and turbine flow meter. This comprehensive solution effectively controls the water temperature in minimum response time resulting in accurate and fast mixing. This will also result in high flow and increased production.



m. Solar Energy for Leather and Tannery Industry

Mr. Christian Zahler, CTO of Mirroxx educated the participants on use of advanced solar technologies for process heating in the industry. Mirroxx is a leading supplier of solar Fresnel collector systems technology for process heat.

Mr. Zahler presented different practical solar applications available for the industrial use. Photovoltaic cells are used for direct conversion of solar radiation into electricity and commonly used technologies are Flat PV, Concentrating PV, Dye-sensitized solar cells, and Organic solar cells. Leading solar technology for industrial sector is Solar Thermal Collectors, which directly converts solar radiation into heat. Commonly used technologies are unglazed solar collectors, flat plate collectors, vacuum tube collectors and air collectors. Participants were informed about the global market trends in application of different solar technologies.

Driving force and leading motivational factor for adoption of solar process heat technologies is the fact that two third of the energy requirement of the industry is for process heat out of which one third of the heat requirement is below 200 degree centigrade.

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The participants were informed that non-concentrating collectors can deliver temperature up to 120°C but many industrial processes require heat at higher temperatures and to achieve higher temperatures industry relies on fossil fuels. However, increasing prices of HFO are providing the impetus for solar thermal technologies.

Types of available technologies for solar collectors including, two axis tracking, one axis tracking and stationary collectors were discussed with their respective heat generation capacities and applications. It was mentioned that most of the area in Pakistan falls in high direct irradiation zone therefore the industrial sector can make excessive benefit from this untapped potential.

It was highlighted that linear concentrating solar collectors, small parabolic trough and small Fresnel collectors have the potential for meeting the requirement for industrial process heat. Cases of solar applications in tanneries and other industrial and commercial sectors were discussed in detail.



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Potential of solar thermal technologies for cooling was also highlighted with different available options based on performance. Industrial and commercial applications of solar cooling in different industrial sector were discussed with help of case studies.

During the last part of the presentation, Mr. Zahler briefed the participants on different technologies used by Mirroxx for solar applications. Mirroxx is in market since 1999 and delivered various successful solar applications for process heat, direct steam generation, cooling, and air-conditioning.

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n. SCADA Process Control in Integrated Tannery

Mr. Crowther of Swystem Logic GmbH Supervisory delivered a detailed presentation on use of Control and Data Acquisition software (SCADA) in a tannery.

Mr. Crowther started the presentation with the emphasis over the need of technical audit to quantify the resources wasted in the processing of raw hides. Detailed technical audits result in identification of exact resources wastage and areas for implementation of process control measures. Mr. Crowther suggested that for effective implementation these controls should be integrated through SCADA.

Mr. Crowther explained the difference between an environmental and technical audit with respect to ROI and Standard Components. He said that technical audit involves tannery layout with infrastructure of services, process control models, activities break down, forecast of benefits, and structure of audit team. The aims of the technical audit should be identification of automation features, program structure and data formats, programming and screens, integration of processes, signals and alarms, networking, process history, error handling, data management, and integration with ERP.

Mr. Crowther advocated modular approach for the implementation of automation systems. Initially measure should be adopted for effective water and volume control through use of fixed pipes and replacement of manual valves with actuated valves. Second phase activities should include installation of preparatory tanks, chemical weigh stations, chemical supply infrastructure, and control panels. Finally complete structure should be integrated through use of SCADA. SCADA is used for data collection, data correlation and generation of reports for effective production control.

Resultant benefits achieved through SCADA include access to timely and accurate information for effective decision making, process control within tolerance limits, improved quality of leather, reduction in reprocessing, and remarkable savings in terms of time, water, chemicals, energy and labour.



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o. Networking Event

A face to face networking event between European and local IEMs was held at the end of the workshop. IEMs exchanged their company profiles with each other and discussed the areas of mutual interest for future business collaborations.

The activity provided local IEMs with ample opportunity for networking and to establish relationships with their European counterparts for technology transfer from Europe to Pakistan.

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p. Visit to TTZ Facilities

Once the networking event was concluded Dr. Ing. Gerhard Schories guided workshop participant for a visit to TTZ facility of Food Processing and Water treatment and reuse.

During the visit to the food processing department, Dr. Schories informed the participants that the department is responsible for optimization of processes related to processed food and also develops advanced recipes for better food conservation. Systematic process development is being done to make the manufacturing and processing technologies more efficient in terms of energy and resources. Research is also being done on recovery of bioactive substances through the value added utilization of by products from food industry.

TTZ has developed a sensory lab which uses consumer tests to establish the sensory acceptance of products. Food technology department also works on to increase know-how regarding the methods of evaluation processes used in sensory testing to upgrade enterprises competence and forms the basis for the in-house quality management. Work is being done on baking processes and products to optimize the energy usage in the process as well as improving the aroma and quality.

During the visit of water treatment facility of TTZ, Dr. Schories informed that TTZ is working in the areas of bio filters, wetlands and aquaculture, membrane technology, advanced oxidation processes and solar distillation.

Dr. Schories also elaborated on the renewable energy research that is being conducted at TTZ which includes development of biomass production processes, optimization of biogas plants, water treatment with solar heat, and sea water desalinization. He explained different pilots that are being implemented in the area of bio-fuels.



5. Appendix A - Workshop Agenda

Day 1

| | |
|---|-----|
| Official Welcome, Agenda, Partner Presentation | TTZ |
| Short Term Presentation of Raw Material | BLC |
| Conventional System and Curing using low impact preservation systems | |
| Cleaner Approaches to Unhairing | BLC |
| Over View of Conventional Technologies | |
| Cleaner Approaches to Unhairing including hair save | |
| Cleaner Technologies in De Liming and Batting | BLC |
| Over View of Conventional Technologies | |
| Alternative lower impact technologies such as CO2 | |
| Cleaner Technologies in De Liming and Batting | BLC |
| Environmental Friendly Liming and De Liming System and hair save Technology | |
| The use of enzyme technologies to reduce impact | |

Day 2

| | |
|--|-----|
| Pickling and Tanning | BLC |
| Over View of Conventional Technologies | |
| High Uptake Chrome Tannages | |
| Alternative tanning technologies, metal free, vegetables etc. | |
| Chrome recovery Systems | |
| Water usage minimization through low float systems | |
| Cleaner Technologies in post tanning and dyeing | BLC |
| Process optimization, Control & monitoring, energy and water use | |
| Reduction of salt in processing | |
| Efficient drying systems | |
| Cleaner Technologies in Finishing | BLC |
| Pre finishing operations | |
| Efficient finish application systems | |
| Managing atmospheric emissions | |

Day 3





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Sustainable water and solid waste treatment technologies BLC

- Overview of Reed Bed Technologie
- Overview of Composting of leather waste
- Overview of biogas and gasification technologies

Sustainability in leather production BLC

- Understanding life cycle analysis for leather
- Energy efficiency and benchmarking and the use of renewable energy
- Reduction and management of water consumption

Managing customer expectation and the environment BLC

- Achieving the medal status using leather working group environment stewardship
- Understanding risks associated and testing of restricted chemicals in leather.

IEM's Questions and their feedback on tanning

An Introduction to SWITCH-Asia Project "Re-tie" Sequa gGmbH

Day 4

Short Introduction of Participating European Companies ttz

Process Water Swystem

The need for 'Best Current Practice' to reduce pollution, prevent waste and achieve leather quality consistency. Why? & How? Logic

Q&A session IEM's

Solar Energy Mirrox

Q&A Session IEM's

Supervisory Control and Data Acquisition (SCADA) Swystem

Process control in the integrated tannery - computer demo & over-view of technical and management perspectives Logic

Q&A session IEM's

Networking Event ttz

Session Closure

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6. Appendix B - Workshop Participants

Industrial Equipment Manufacturers

1. Mr. Afdash Chaudary, Director, CWG Water
2. Mr. Muhammad Amir Jamil, Business Development Manager, Aqua Regia
3. Dr. Naeem Uz Zaman, Managing Partner, Energy and Environment Engineer
4. Mr. Tahseen Ahmed Khalid, CEO, Nviropak Engineers and Consultants
5. Mr. Asad Ullah Baig, CEO, Kemia Enterprises
6. Mr. Muhammad Akbar, Consultant, So Safe Water

BLC

1. Mr. Stuart Booth, Consulting Services Manager

Sequa

1. Mr. Gerhard Weber, Project Director

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Swstem Logic

1. Mr. John C Crowther, CEO

Mirroxx

1. Mr. Christian Zahler, CTO

Project Partners

TTZ

1. Dr. Ing. Gerhard Schories, Technical Director
2. Mr. Hanyork Von Marees, Project Manager

CPI

1. Mr. Azhar

IHT

1. Mr. Usman H Malik, Director
2. Mr. Muhammad Imran, Senior Consultant
3. Mr. Ahmed Ammar Yasser, Project Engineer



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Appendix C - Photographs



Workshop Participants at TTZ



Workshop in Progress

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Participants with BLC Trainer Mr. Booth



Dr. Schories during visit to TTZ Food Technology Centre

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Group Photo of Workshop Participants

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