WURC

Annual Report

1 July1996 - 30 June 1997

WURC is a centre of competence established in co-operation with NUTEK, SLU, six companies from the pulp and paper industry and one company from the chemical industry. The centre´s main operations are at SLU in Uppsala. Research is performed in co-operation between SLU, CTH, KTH, STFI and the industrial partners.

MEMBER COMPANIES

AssiDomän EKA Chemicals Korsnäs
SCA STORA Södra Cell
Mo och Domsjö

ORGANIZATION

Board

Lennart Eriksson, vice president, STFI, Chairman
Inger Eriksson, R&D Manager, SCA Graphic
Björn Henningsson, Professor, Dep. For. Prod., SLU
Bengt Hylander, Dir., AssiDomän AB
Håkan Jöves, Dir., Korsnäs AB
Tom Lindström, Professor, MoDo AB
Steve Moldenius, Tech. Dir., Södra Cell AB
Ola Sallnäs, Deputy Dean, Faculty of Forestry, SLU

Industrial advisory group

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Anders Brolin, STORA AB
Ivan Dalin, EKA Chemicals AB
Stefan Högman, Korsnäs AB
Ulla Jansson, Södra Cell AB
Ann Marlund, MoDo AB
Ove Rehnberg, AssiDomän AB
Lars Ödberg, STFI

Director

Brita Swan, WURC (Stora Corporate Research)

Managing Group

Brita Swan, WURC
Gabriella Danielsson, SLU
Björn Henningsson, SLU
Per Jennische, SLU
Thomas Nilsson, SLU

Researcher´s group

Thomas Nilsson, SLU, Chairman
Paul Ander, SLU
Geoffrey Daniel, SLU
Göran Gellerstedt, KTH
Tommy Iversen, STFI
Knut Lundqvist, CTH
Lennart Salmén, STFI
Rune Simonson, CTH
Brita Swan, WURC
Ants Teder, KTH
Ulla Westermark, STFI

ABBREVATIONS

WURC	**Wood Ultrastructure Research Centre**
CTH	Chalmers University of Technology
KTH	Royal Institute of Technology
NUTEK	Swedish National Board for Technical and Industrial Development
SJFR	Swedish Council for Forestry and Agricultural Research
SLU	Swedish University of Agricultural Sciences
STFI	Swedish Pulp and Paper Research Institute

LOCATION

WURC is located at SLU in Uppsala, the main focus of its scientific activities. However, activities also take place at CTH, KTH and STFI which have important scientific competence and equipment for research within the field of the centre.

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Front page: macrofibrils of birch S_2 wall. X 50, 000
Photo: G.Daniel, SLU

SCIENTIFIC AND INDUSTRIAL BACKGROUND

The ultrastructure of the wood fibre plays a central role in the physical, chemical and mechanical properties of wood and wood fibres, and thereby also influences the properties of products manufactured from wood. The ultrastructure determines fibre strength when producing pulp, the processability when producing paper and in the end, paper quality.
Further, industrial production processes influence the ultrastructure and the properties of wood fibres. A number of energy requiring processes are used in the industrial chain from tree to paper. Their efficiency is ultimately related to the ultrastructure of wood.

Despite the importance of wood fibres, the knowledge of fibre ultrastructure is far from sufficient and must be improved. Obtaining such knowledge is part of a strategy to keep Swedish industry abreast of competition. To be able to develop new products, renew the production processes and optimally utilize the industrial potential of wood fibres produced in Swedish forests, requires new ideas on how modifications can be made at the ultrastructural level.

Rapid development in molecular biology, microscopy and spectroscopy has brought forth techniques which make it possible to study the basic building elements of the wood fibre and how they are influenced by external factors such as chemicals, enzymes and mechanical actions. Intensive research is also in progress on the biosynthesis of plant cell walls and interaction between the different polymers in the cell wall. These developments will help WURC to reach its goals.

MAJOR OBJECTIVE

With reference to the above background, the major objective of WURC is to significantly improve the understanding of the morphological and chemical ultrastructure and the physical interaction between the polymers of the wood fibre as a basis for industrial utilization.

Work at WURC is focused on basic research of industrial relevance. The field of work is wood and wood fibres. The task of WURC is to conduct the kind of research that the industrial partners cannot conduct themselves.
The results of the research will be used in further research and development by the industrial partners and by applied research units carrying out research along the processing chain.

The new knowledge created by WURC will support the development of resource-efficient products fulfilling the market demands.

STRATEGY AND AIMS

Research at WURC is concentrated on the morphological structure of wood and wood fibre in the range from approximately 500 nm to less than 1 nm (i.e. close to atomic and molecular bonding distance) and on the chemical structure and physical properties associated with fibre components. WURC also studies how structures and properties change when wood fibres are treated in various ways mechanically, chemically and enzymatically.

WURC shall

- Provide an inventive and stimulating environment for high quality research and post graduate education
- Create a research environment where companies within the forest industry actively participate
- Furnish industry with competent researchers
- Become an internationally recognized research unit which attracts foreign researchers
- Promote interdisciplinary research

The research within WURC shall

- Significantly increase the basic knowledge of wood and wood fibres as regards their chemistry and morphology
- Study and establish the effects of chemical, mechanical and enzymatic treatments on the ultrastructure and the influence of such effects on wood fibre properties
- Be based on co-operation between universites, industrial research institutes and forest industry companies
- Build up and maintain a source of knowledge to support further research and development in the Swedish forest industry, e.g. research of a more applied nature
- Contribute to the development of new industrial processes, new fibre-based materials and new consumer products

ACTIVITY REPORT, JULY 1996 - JUNE 1997

General information

The activities started gradually in the autumn of 1996 by establishing the organization, building up a functional administration, discussing and planning the activities in meetings with the Board and the various advisory groups and preparing detailed research plans, etc.

Research began on some of the projects late in the autumn with increased activity in early spring 1997, when the agreement governing WURC had finally been signed by all partners.

A high resolution Field Emission Scanning Electron Microscope (FE-SEM) was installed during autumn and winter at the Department of Forest Products, SLU, and brought into operation during the spring of 1997. An inauguration ceremony for WURC including a scientific seminar with contributions from internationally leading scientists was held in April 1997.

Five Ph.D students were engaged during the spring and summer. In competition with numerous other applications, two WURC-projects were given high ranking and recieved financial support from SJFR (Swedish Council for Forestry and Agricultural Research).

Revision of the work plan

The content of the original work plan has not been significantly changed during the past year. The main difference from the original plan is that the start of the research has been delayed. The major reason for this is that the activities in the projects are highly dependent on Ph.D students and the procedure of recruiting suitable students has taken considerable time. However, the activities are now in progress in almost all projects.

Research projects

The research programme, composed of the projects described below, was approved by the Board following thorough discussions with the industrial research advisory group.
The powerful microscopic equipment and the bank of living wood-attacking organisms located at SLU, Department of Forest Products, constitute an important basis for the research programme.

The specific resources for ultrastructural and related research, particularly concerning the chemical components and the physical interaction between polymers, at CTH, KTH and STFI are also important for the fulfilment of WURC´s research programme. Coupling of the four research units allows the necessary linking of knowledge regarding morphological, chemical and physical ultrastructure which is the key to successful research in this area.

The WURC projects are to a certain extent integrated. They depend partly on each other and they all generate information to be used for the construction of fibre models in project No 1 (see below). A wood and fibre raw material from spruce has been carefully selected and produced by the participating industrial laboratories. This raw material is used in all projects, which helps to create synergy between the projects.

Research is focused on spruce in the first instance, since this wood species is extremely important in the Swedish pulp and paper industry, where it is used for both production of chemical and mechanical pulp. Its ultrastructure is inadequately known and improved knowledge is expected to especially enhance industrial development, in particular regarding pulping processes. The project research at WURC has therefore started with the investigation of the ultrastructure of wood and wood fibres of spruce and its influence on modern kraft pulp production.

The Ph.D students

Eva - Lena Hult *Annica Berglund* *Jonas Brändström* *Isabelle Duchesne* *Ulrika Mohlin*

Project 1: Fibre models

Aim

The aim of this study is to generate ultrastructural models for tracheid cell walls of Norway spruce (*Picea abies* L. Karst.) including data on chemical and physical properties.

Background

Earlier generated models are out of date and do not consider new research findings. Therefore they are partly inaccurate and at high resolution the structure of the cell is shown as a small indefined area in most models.

Project description

Literature studies and results generated within WURC by this and other projects should make it possible to generate integrated fibre models of spruce tracheids.

Initially there will be a literature survey of wood anatomy with special focus on the tracheids in spruce xylem. After that data for macro-, micro- and ultrastructure will be collected, for example on tracheid dimensions, cell wall layers, microfibrillar orientation etc. In cases where information is lacking in the literature, TEM- and SEM-studies will be carried out.
Data for ultrastructure may come from studies on conifer species, other than Norway spruce. Further on, there will be a survey to find software dealing with structure modelling.
The first model generated will show the whole tracheid at low resolution. The first study will focus on the distribution of pits in tracheid walls. The data will be used for creating models for pit distribution. Thereafter more models should be generated at higher resolution and over smaller, well- defined, areas. Since the other projects within WURC will contribute their results it should be possible to generate a model at very high resolution.

Project report

Literature studies have been undertaken searching for facts about fibre structure, particularly pits, in spruce wood.

Project group

The group consists of Ph.D Jonas Brändström.
Thomas Nilsson and Geoffrey Daniel, SLU.
Ulla Westermark and Lennart Salmén, STFI.
Inger Eriksson, SCA, and Anders Brolin, STORA.

Project 2: The ultrastructure of wood fibre surfaces

Aim

The project´s overall aim is to characterise the surface ultrastructure of "wood fibres" and investigate how this changes after various enzymatic, mechanical and chemical treatments.

Background

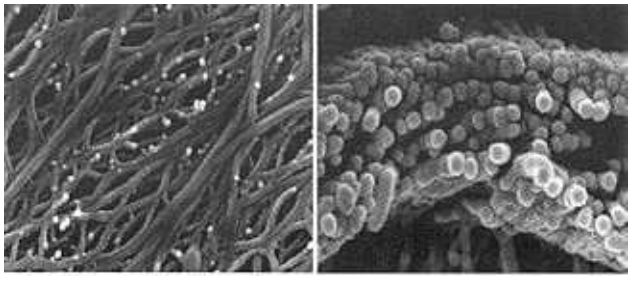
The surface structure of wood fibres has been insufficiently characterised previously, partly because of the unavailability of good analytical techniques and partly because of a lack of information on the native ultrastructure of wood fibres.

Project description

In the present project the surface characteristics of wood fibres will be studied using a variety of complementary microscopical methods including: high resolution scanning electron microscopy (FE-SEM), high resolution SEM in conjunction with cryo-techniques, transmission electron microscopy (TEM), environmental scanning electron microscopy (ESEM), and atomic force microscopy (AFM). Emphasis will be placed on spruce wood fibres which will be used to develop a model representing a "reference surface structure of softwood fibres". This reference wood fibre structure will then be compared with standard fibres subjected to prior enzymatic, mechanical or chemical treatments.

Project report

During the latter part of 1996 and early 1997 a new Hitachi 4500 FE-SEM equipped with micro-analytical and cryo-facilities was installed at the Department of Forest Products, SLU.
After some problems the instrument is now up and running. Studies have primarily begun using the cryo-facility of the microscope where it is possible after rapid freezing to observe wood fibres in almost a natural state.



Typical cryo-FE-SEM micrographs showing surface details of "macrofibrils" from a sulfate pulped softwood fibre (left photo) and cellulose "macrofibrils" comprising the fractured S_2 secondary wall of birch wood (right photo) .

Preliminary aspects of this work were presented at the opening ceremony for WURC as a lecture and poster. Additional results will be presented at the forthcoming TAPPI Biological Science Conference to be held in San Francisco, USA, October 1997.

Project group

The group consists of Ph.D student Isabelle Duchesne. Geoffrey Daniel and Thomas Nilsson, SLU. Ulla Westermark and Bert Pettersson, STFI. Inger Eriksson, SCA and Bo Wigge, STORA.

Project 3: Dislocations or nodes in wood fibres

Aim

The aim of this project is to study dislocations or weak points in the fibre wall and the ultrastructural background to why they occur and their impact on properties of paper fibre.

Background

It is well known that greater fibre strength can be obtained during pulping processes if the fibres are not damaged or subjected to deformation forces.

During various treatments of fibres fairly regular dislocations occurring in the fibre wall have been observed. The dislocations can be "developed" for example by mild swelling in a cellulose solvent (LiCl/ DMAC). The dislocations occur regularly at a distance of 100 - 200 µm over the whole fibre length in more than 40% of the fibres from a chemical pulp. In co-operation with G. Daniel and P. Ander, (SLU), it has been observed that cellulases can also readily locate the nodes and that the cellulolytic enzymes preferentially attack pulp fibres at the nodes. The nodes can also be "developed" by ultrasound and by chemical treatments.

The origin of nodes is not clarified. Nodes were reported in the early wood morphology literature but were later ignored. There are many theories for their formation and they have for example been linked to pits in the fibre wall. The explanation seems, however, to be more complex. There are many things that suggest that nodes may have a biological origin and are weak points in the fibre wall. This will be investigated by microscopy and structural chemical analysis.

Project description

1) Investigation on the origin and composition of nodes and how they are affected by mechanical and chemical treatments. Electron microscopy and ESEM (Environmental Scanning Electron Microscopy) will be used in the investigations.

2) Studies of the effect of enzymes on the fibre morphology and fibre properties with special reference to nodes and local swelling of the fibre wall.

3) Investigations on the effect of nodes on fibre and paper strength. The investigations will be performed using conventional paper testing methods.

Project report

The project has not yet started but a Ph.D student will be employed in the near future.

Project group

The group consists of Ulla Westermark, STFI, Thomas Nilsson and Geoffrey Daniel, SLU, Ann Marklund, MoDo and Frank Peng, STORA. For item 2, Bert Pettersson, STFI and Centre for Biotechnology and Chemistry in Umeå.

Project 4: Fibre chemistry: structure of cellulose and hemicellulose

Aim

The aim of the project is to elucidate important relations between structural characteristics of wood cellulose and hemicelluloses and the reactivities and properties of fibre substrates.

Background

Although cellulose is a simple homopolysaccharide, natural celluloses have a solid state architecture with a high degree of individuality, depending on their biological origin and the isolation procedure used. The solid state structure is expected to greatly influence the reactivity and physical properties of cellulosic materials.

Project description

The work is focused on the influence of supramolecular and surface structure of cellulose fibrils and the association to hemicelluloses on pulp and paper properties and accessability/ reactivity in enzyme-assisted fibre modification strategies.

^{13}C - CP/MAS - NMR - spectroscopy (high resolution solid state NMR) and quantification of the individual cellulose forms by line fitting is a method well suited for investigation of different solid state structures in cellulose substrates. A cluster with a distribution between 86 and 92 ppm contains fairly sharp signals corresponding to C-4 carbons situated in crystalline cellulose I α and I β domains together with paracrystalline cellulose. The C-4 carbons of more disordered regions are distributed in a broad band ranging from 80 to 86 ppm. In the disordered region a pair of signals resolved at 84.0 ppm and 84.9 ppm assigned to surfaces of cellulose fibrils are also visible. This methology allows analyses of the bulk composition of different celluloses and also supplies information about fibril dimensions, e.g. core versus surface structures.

Project report

The initial work involved investigating celluloses isolated from different anatomical parts, such as earlywood, latewood and compression wood of Norway spruce. Isolated celluloses will be examined subjecting their ^{13}C -CP/MAS - NMR spectra to non-linear least-squares fitting to search for natural variations existing in the cellulose composition of this important fibre raw material.

Project group

The group consists of Tommy Iversen (project leader), Eva- Lena Hult (Ph.D student), Ulla Westermark and Mikael Lindström, STFI. Thomas Nilsson and Geoffrey Daniel, SLU and Ants Teder, Göran Gellerstedt and Karl Hult, KTH, Torsten Nilsson, Korsnäs, Monica Ek, STORA and Ulla Jansson, Södra.

Project 5: Fibre strength of pulp fibres

Aim

The ultimate aim of this project is to deliver background knowledge to the redesign of chemical pulping processes in such a way that pulp fibres of higher strength can be obtained. The direct aim is to increase the knowledge on how conditions in the chemical pulping process affect the polymeric structure in the fibre wall and how these changes in turn affect the fibre strength.

Background

A vast knowledge has been collected on this subject over decades by pulp and paper scientists worldwide, but still large gaps remain. According to known essential factors such as: wood species, mechanical fibre damage, pulp yield and cellulose chain length (measured as pulp viscosity), pulps should be of equal strength but in reality can differ greatly in strength.

Project description

As a first step eight different pulps will be produced from the same, carefully selected, wood sample according to processes that in previous studies have shown the strength anomalies mentioned above. The pulping will be carried out at two of our industrial partners. The pulps will be ODEDD bleached by a third industrial partner and tested by two additional partners regarding more "conventional" properties.

Project report

The procedure, described above, planned and co-ordinated by civ.eng. E. Brännvall, is now in progress. The pulps will be further evaluated in this project as well as in other WURC projects. The main part of this project will start in August 1997, when civ.eng. U. Mohlin, with a background in polymer chemistry, starts her work as a Ph.D student in WURC.

Project group

The group consists of Ants Teder (project leader) and Göran Gellerstedt, KTH. Tommy Iversen, Lars Ödberg and Ulla Westermark, STFI. Thomas Nilsson and Geoffrey Daniel, SLU, Stefan Högman, Korsnäs, Ann Marklund, MoDo, Sture Backlund, SCA, Frank Peng, STORA and Martin Waubert - de - Puiseau, Södra.

Project 6: Ultrastructural modification of wood with respect to metal ions

Aim

The aim is to determine occurrence, localisation and extractability of different metal ions in wood which has been treated in different ways with chemicals in aqueous solution.

Background

The content of inorganic materials in wood is relatively low (< 1%), but it is important for processes such as the production and bleaching of mechanical pulp, ECF- and TCF- bleaching of chemical pulp, and in preservative treatment of wood.

Project description

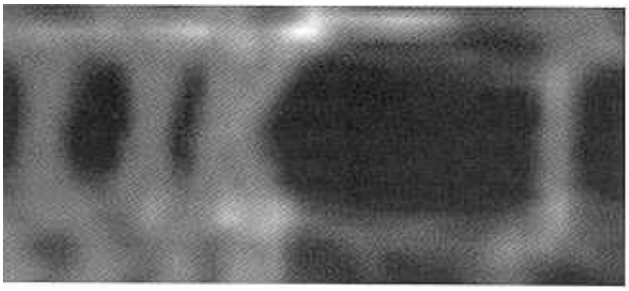
This project will involve analyses of the metal ion distribution in wood samples subjected to different metal-removing treatments to gain information on extractability and mode of chemical attachment for different metal ions.

Project report

At the beginning of this project (April 1997), an extensive literature study of the distribution, content and chemical bonds of metal ions in the different morphological regions of wood was performed. The literature study showed that very little research has been conducted on the subject of extractability and chemical modification previously, which further displays the importance and relevance of this project.

In short, it can be concluded that different metals are bound with varying strength and hence may not always be extracted with the same solutions. The torus, pit membrane, middle lamella and ray parenchyma cell wall hold the largest amounts of inorganic materials.

During spring 1997, spruce wood samples were prepared at CTH and analysed at the European Synchrotron Radiation Facility in Grenoble. The metal removing treatments used were: Chelation with EDTA, acid treatment with diluted sulfuric acid and ion exchange using solutions of $MgSO_4$, $ZnSO_4$ and $CaCl_2$. This preliminary study of the possibility to use X - ray fluorescence analyses was carried out in co-operation with Anders Rindby, Microscopy and Microanalysis, CTH. The data from this experiment are currently under evaluation. Wood meal has also been treated with the corresponding solutions to give data on the bulk content comparative to the more specific analyses made in Grenoble.



An image showing manganese distribution at the late-wood/earlywood boundary in a transverse section of an untreated spruce wood sample. The lighter the area, the higher the Mn concentration. The analysis was carried out at ESRF, Grenoble.

The next part of this project will be evaluation of the data from Grenoble and some preliminary experiments with the μ - XRF equipment available at Microscopy and Microanalysis, CTH.

Project group

The group consists of Rune Simonson (project leader), Annica Berglund (Ph.D student) and Harald Brelid, CTH. Thomas Nilsson and Geoffrey Daniel, SLU, Ants Teder, KTH, Jiri Basta, EKA, Ann Marklund, MoDo and Per Larsson, Södra.

Inauguration ceremony and scientific seminar

The official inaurguration of WURC took place on 10 April 1997 at SLU in Uppsala. The event consisted of an opening seminar followed by a scientific seminar. It attracted about 130 participants from industry, universities and research institutes. Speakers at the opening seminar were Lennart Eriksson, Chairman of the Board, Håkan Jöves, Korsnäs, Christer Heinegård, NUTEK, Brita Swan, WURC and Thomas Rosswall, Rector of SLU. The latter also officially inaugurated WURC.

The scientific seminar which followed was chaired by Inger Eriksson, SCA. Thomas Nilsson and Geoffrey Daniel, SLU, presented the historic development of wood fibre models and showed a series of SEM-micrographs on the ultrastructure of wood fibres taken with the most modern equipment. Björn Sundberg, also SLU, took the audience to the research front regarding biological wood formation. Gösta Brunow from the University of Helsinki presented recent knowledge as regards the formation of lignin in the wood cell wall. Olle Teleman from VTT in Finland talked about the three-dimensional structure of the crystalline cellulose microfibril. Finally, Derek Gray from McGill University in Montreal presented research on the chiral properties of cellulose and of the wood fibre. After the lectures the microscopic equipment at the Department of Forest Products was demonstrated including the recently installed high resolution Field Emission Electron Microscope (FE - SEM).

The role of the industrial partners

Intensified co-operation between companies and the university institutions is regarded by NUTEK as one of the key issues to be promoted in centres of competence such as WURC. During WURC´s first year, collaboration in its proper sense between industry and WURC has just started to develop. Following are a number of examples of where such co-operation or collaboration has started.

Research

The research programme came gradually into operation during the first year. One important step, which is one of the absolute conditions for most of the work in all projects, was the production of a uniform and common wood and fibre material. This has been done by the industrial laboratories in co-operation with KTH. The competence and general resources for wood, pulp

and paper analyses at the industrial partners will be increasingly involved in WURC´s research. In the future it can be expected that Ph.D students and researchers in some of the projects of WURC carry out work in the industrial laboratories.

Industrial advisory group

This group was actively involved when the research programme was set up. As a matter of fact, agreement on the research programme within this group has been a condition for approval by the Board. Joint meetings between the researchers and the advisory groups, have been of extreme value for exchange of viewpoints and ideas between industry and university as regards research and Ph.D education. This group will also be partly responsible for the industrial excursions, which are planned for the Ph.D students of WURC.

Industrial contact persons

Each project within the WURC research programme has two or more personal industrial contact persons. These persons have agreed to keep in close contact with the Ph.D students and are responsible for the contacts between the students and the companies.

Industry Ph.D students

So far, WURC has not had the possibility to engage so called "industry Ph.D students". This is, however, part of the development plan for WURC. In this context it has to be remembered that WURC is a competence centre of relatively basic nature.

Co-operation with other centres

Contacts have been established with several other research centres and postgraduate schools in closely related fields of research. Such centres are: Centre for Forest Biotechnology and Chemistry, Centre for Bio Process Technology, Forest Products Industry Research College (FPIRC) and the postgraduate school Wood and Wood Fibre. Joint courses, seminars and workshops for the Ph.D students will be organised on items of common interest. The first joint workshop and course program with participation of Ph.D students from Wood and Wood Fibre, FPIRC and WURC will take place in August 1997.

Presentation of WURC

The greatest effort to make WURC known during the year was of course the inauguration seminar in April 1997. However, WURC has also been presented in articles in Svensk Papperstidning, STFI-Kontakt, Upsala Nya Tidning and in information booklets and News Letters within SLU. In addition presentations have been made i.e. for certain members of the Swedish Parliament and members of the SLU Board.

Agreements

The main agreement, regulating WURC:s activities, its economy and the responsibilities of SLU, NUTEK and the industrial partners was finally signed by all partners in January 1997. Agreements regulating the interrelationships between SLU, KTH, CTH and STFI are also signed. The specific agreements between WURC and the researchers engaged in WURC is prepared in a final version, but not yet signed by all involved.

Management and staff

The immediate and daily management of WURC is carried out by the Management group. The group is lead by the Director, Brita Swan, and consists of five persons, each with specific responsibility. The group has met frequently and had close contacts with the Chairman of the Board, the Advisory group and researchers within WURC. The detailed planning of the research has been carried out by the project leaders. They are also responsible for carrying out the research. A substantial part of the project research will be carried out by Ph.D students. Five students are now engaged for research in WURC.

The Board consists of representatives from the companies and SLU and is chaired by Lennart Eriksson, STFI. The Board had three meetings during the year. The chairman has had frequent meetings and other contacts with the Director, the Managing group or individual members of the group.

FINANCIAL RESULTS

WURCS´s income has three sources: cash money from NUTEK and the industrial partners, services rendered by the industrial partners and services rendered by SLU and the university partners.

Financial structure

Income July 1996 - June 1997, SEK

	Cash		Services rendered		Total	
Source	Results	Budget	Result	Budget	Result	Budget
NUTEK	2 500 000	2 500 000	0	0	2 500 000	2 500 000
Industry	2 060 000	2 060 000	456 817	585 000	2 516 817	2 600 000
SLU	0	0	631 440	1 600 000	631 480	1 600 000
University-partners	100 000	0	331 573	1 400 000	431 573	1 400 000
Total	4 660 000	4 560 000	1 419 830	3 585 000	6 079 870	8100 000

Expenditure of cash, SEK

Item	Result	Budget	Difference
Centre administration	126 587	530 000	- 403 413
International WURC seminar	71 447		71 447
Project 1	97 759	973 000	- 875 241
Project 2	347 805	1 057 000	- 709 195
Project 3	96 194	500 000	- 403 806
Project 4	164 000	500 000	- 336 000
Project 5	151 200	500 000	- 348 800
Project 6	277 647	500 000	- 222 353
Total	1 332 639	4 560 000	- 3 227 361

The financial result clearly shows the effect of the delayed start-up of WURC and in particular the late enrolment of Ph.D students. This latter fact directly affects the use of cash for projects (salaries) and services rendered from SLU and the research partners, since these services were to a high degree planned to be tuition of the Ph.D students and attendant research contribution by the project leaders. Cash money not used during the first year will be transfered to the second year.

PLANNED ACTIVITIES YEAR 2

The projects established during year 1 will continue in accordance with the general work programme included in the agreement between the partners. The two projects financially supported by SJFR will be included in the work programme for next year.

A senior researcher within the field of biochemistry/ enzymology will also be engaged in order to strengthen the competence within WURC, mainly as regards projects no. 1, 2 and 3.
A guest researcher - preferably specialised in research on biological lignin formation - will be engaged in WURC for three months in the autumn of 1997. The last of six Ph.D students planned to do research in WURC will be engaged in early autumn 1997.

An international scientific seminar is scheduled to be organized in the spring term of 1998 to follow up the success from the opening seminar in April 1997.

A series of industrial study visits for the Ph.D students will start in September 1997 and special study courses will be available mainly by co-operation with other research centres and post graduate schools.

An important task during the coming year is to analyse and conclude WURC´s activities in Stage 1 and to prepare a strategy and work plan for Stage 2.

The new high resolution Field Emission Electron Microscope (FE-SEM).

OUR VIEW ON WURC

Lennart Eriksson, STFI, Chairman of the Board of WURC

Utilising successfully Swedish wood raw material for various products, will in the future require considerably more knowledge than exists today on the extremely complicated and greatly unknown fine structure of the wood fibre. The task of WURC is to produce this knowledge and disseminate it so that it can be used by other researchers and the industrial partners, thus helping them to stay ahead of their competitors.

WURC represents something quite new within a complex scientific field. A period to establish the centre and to build up its competence is therefore needed. The key to success for WURC is to be found in the creativity of its researchers and in their ability to adopt a co-operative and interdisciplinary approach. WURC has to reach a strong and recognized international position. Another condition for success is the engagement of the industrial partners which so far has been extensive. A further redisposition of resources within SLU is also needed if WURC is to achieve its goals.
The Board of WURC has adopted the working philosophy that quality is of prime importance and that WURC should maintain a clear profile in the Swedish research infrastructure.

For SLU, the formation of WURC means the creation of a new area of research, directed towards industry-relevant questions in the areas of fibre, pulp and paper.
The large number of well established researchers participating as project leaders in WURC is an outstanding feature of the centre and a guarantee of the highest quality. Another attribute, and an important perequisite for WURC, is the availability of advanced research equipment. The opportunity to co-operate with the postgraduate school "Wood and Wood Fibre" is valuable for WURC. This relationship has resulted in the financing of two projects of importance for WURC. Co-ordination of activities at WURC with research at STFI and other institutions is important if WURC is to achieve its goals.

Research at WURC must meet a high international standard and exchanges with internationally recognised researchers are to be established.
A vehicle for moving WURC in this direction is the establishment of an annual international seminar concerning the ultrastructure of fibre, the first of which took place in April 1997.

When forming WURC, representatives from the industrial partners contributed greatly to the process of formulating research projects of industrial relevance. Industry researchers are now involved in various research projects at WURC, and they are working actively to broaden the exchange of knowledge between WURC researchers and postgraduate students. The engagement of an industrial reference group in the development of WURC has been an important asset and will continue to be so.

For continued growth it is important that all participants find it rewarding to develop WURC into one of the world´s leading centres for research on wood and wood fibre ultrastructure. It is heartening to know that the management of SLU has shown the will to invest in WURC and its development.

WURC is a timely investment!

Brita Swan, Director of WURC

WURC combines in a single organisation knowledge on the biological formation and decomposition of wood and on electron microscopy existing at the Department of Forest Products at SLU with the basic and applied knowledge that exists at KTH, CTH, STFI and at the industrial partners. Consequently, WURC comprises a broad base of expertise in the areas of wood and wood fibre characterisation, fibre production and the use of fibre in various products.