Abstracts

Decision Support and Elimination of Bottlenecks in pulp and Paper Mills by use of FlowMac

Lars Nyborg , Papermac AB, Sweden

For the past 20 years computer based process and product modelling tools for the Pulp and Paper Industry has been developed by Papermac. The first commercially available software was named PaperMac, and the second one FlowMac.

PaperMac is used for modelling of paper properties and is used in product research on line simulators.

FlowMac is a knowledge based system, to be used by engineers involved in the pulp and paper industry in both project work, process research and evaluation of mill performance. Process modelling for decision support is the overall function.

When compared to other modelling tools, FlowMac is much simpler and faster to use. This is due to its modular design, graphical interfaces, and the inclusion of fully developed equipment libraries specific to the pulp and paper industry.

This means that besides just having the ability to do mass balances it includes a vast accumulation of actual process knowledge. Additionally, it is a tool that can be used to provide very accurate and dynamic estimates of production costs and even paper properties.

Fundamentals in development work and practical experience from use of these models in pulp and paper mills are provided.

Finally elimination of bottlenecks in a papermachine process is demonstrated. Critical paper grades are run in the same simulation run and bottlenecks are detected and analysed.

Decision Support and Elimination of Bottlenecks in pulp and Paper Mills by use of FlowMac

Lars Nyborg, Papermac AB, Sweden

1. Introduction

Digital modelling of processes has a significant role to play in improving the competitiveness of companies in the pulp and paper industry. By very accurately digitally imitating a process on a computer, large expenditure to achieve the same results on practical operating plants are avoided. In design phase when there is no plant to do trial work on, accurate design can be undertaken. It is therefore an important technological tool for decision-making, engineering and operation, covering the whole life span of a manufacturing facility.

Good simulation tools shall help users to:

Predict the course and results of certain actions
Understand why observed events occur
Identify problems areas before implementation
Explore the effects of modifications
Confirm that all variables are known
Evaluate ideas
Gain insight and stimulate creative thinking
Communicate the integrity and feasibility of your plans
Estimate economy

FlowMac here discussed and presented is based on Extend, the extremely powerful application for digital modelling of processes. It is the first application allowing users to develop their own libraries of customised blocks. It started with the Macintosh computer and its graphical interface and later being upgraded for Windows - 20 years of continuous efforts.

FlowMac has constantly being developed and expanded with new blocks and libraries concurrent with customers needs and their modelling work carried out in engineering departments, mills and universities. Libraries now contains more than 500 blocks developed for detailed modelling of pulp and paper processes, from wood-chips, through the wood plant, mechanical and chemical pulping, paper and paperboard machines and their power plants.

The designed models include mass balances for fiber, filler, water, power, money and any named parameter of interest. Also a good deal of pulp and papermaking knowledge. Compared to other modelling tools, it is much easier to use and has a powerful graphical format, which facilitates accurate communication between people - so important for making the correct decisions and thus remaining competitive. It has been shown to be excellent in web conferences for support, training and upgrading of the processes.

2. The Blocks in FlowMac

Blocks developed represent equipment, controls (or instrumentation), sources or inputs, demands, measurements, outputs or results, even in the form of trend recorders, paper or pulp properties, etc.. The blocks are dragged from libraries, dropped into a worksheet and connected to each other to make a flowsheet. One quite sophisticated block will be demonstrated, and is shown below in figure 1. The block is a headbox with manifold dilution to correct the basis weight profile and an upper air cushion with an overflow and showers. In total the block has 7 connectors for pipes, circular ones for demanded inlet flows, stock, dilution water and shower water, and square ones for pushed outlet flows, recirculated stock and dilution water and main flow to the wire section. Demanded flows are sized by set data in the dialog or by the script inside the block. Inlet main stock and dilution water flows and consistency in the headbox are animated in selected dimensions, LPM and % in the figure below. You can also select any variable and clone it to the screen.

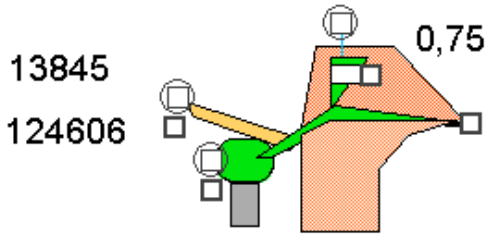

Fig 1. Block Headbox incl. Manifold dilution

Double-click on the headbox icon opens a dialog that has both input data (white boxes) and output data (grey boxes). Parts of the dialog are selected and shown in figure 2.

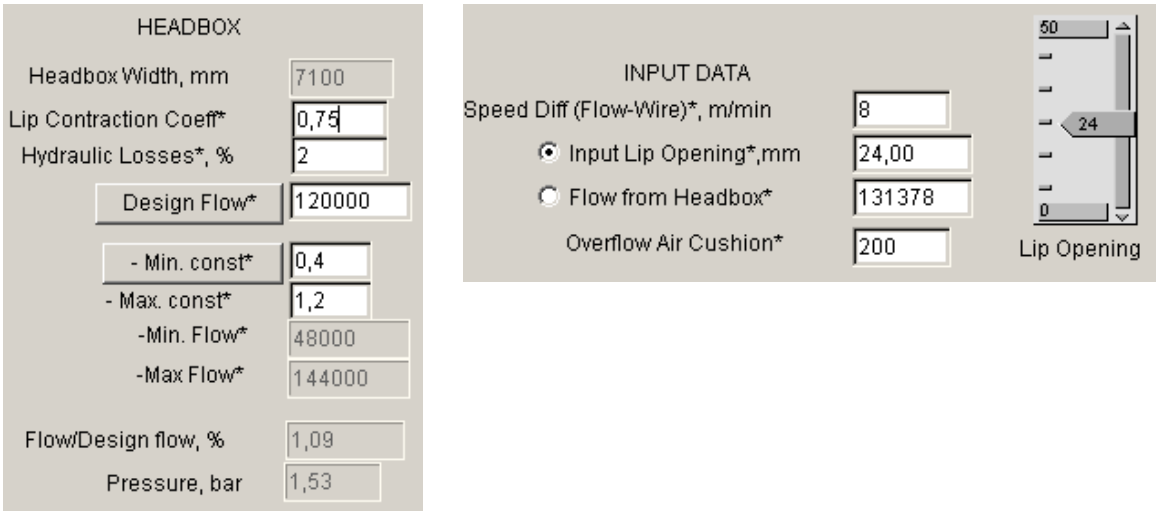

Fig. 2. Dialogs of the Headbox block.

The width of the headbox is given by a global specification block in the model and pertained to the entire model. This global block also transfers data for basis weight, pope speed, filler content, etc.. Important headbox data for design considerations are provided, such as the maximum and minimum output flows. In this way the validity of some input values can be ascertained. For instance, if the headbox outlet flow exceeds these limits a text warning will pop up " The outlet flow of the headbox is outside flow limits, Reduce papermachine speed or the lip opening". There are many similar warnings included in FlowMac to indicate bottlenecks.

It is not easy to build the headbox block in software using modular components as dilution, mixing, etc. For instance a component for lip opening does not exist in any other modelling tool. It is definitely important for the understanding of the approach flow and headbox operation. Headboxes and similar complex blocks are provided not only ready built, but purpose built through experience.

People familiar with the papermachine process can build an approach flow including the headbox, screens, fan pumps, wire section and white water silo in 10 minutes if basic data for lip opening, reject rates of screens , etc. are known. Refer to figure 3 for a typical example of such a system. Ease of use is vital and has been designed in.

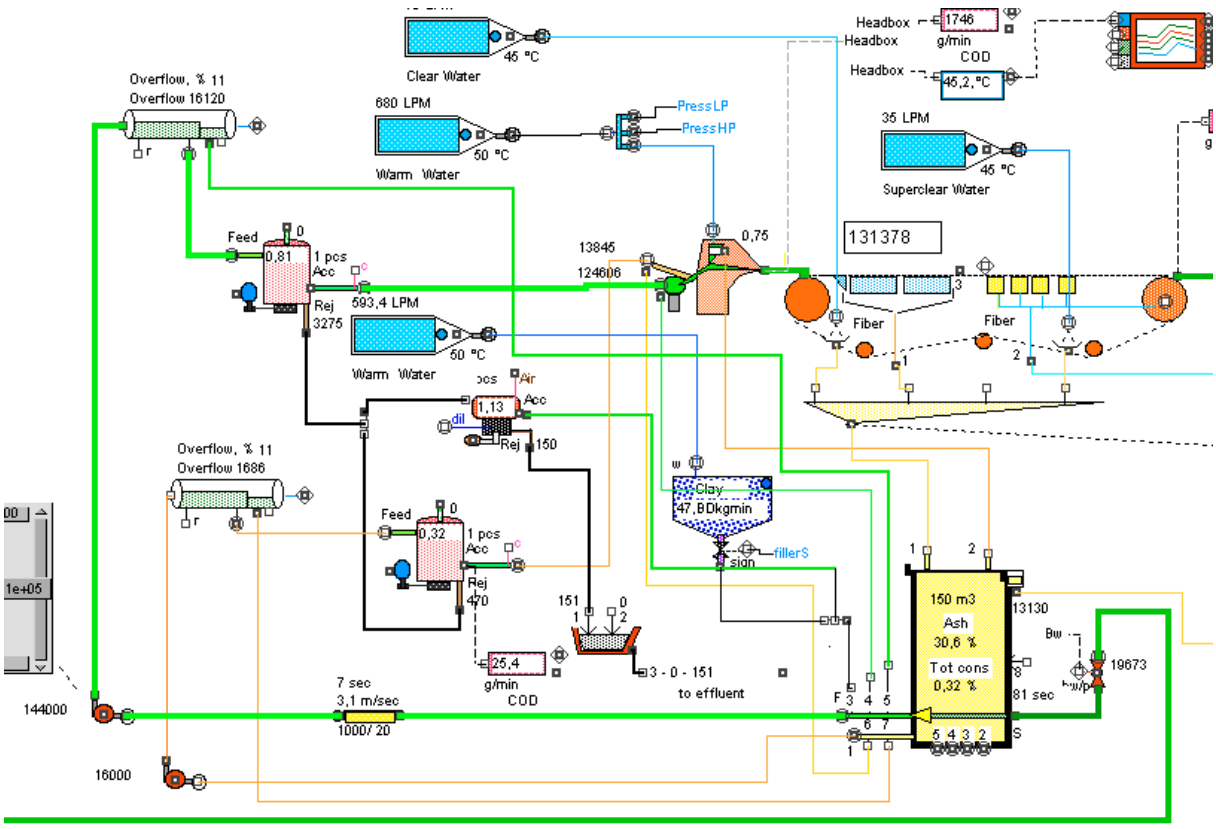

Fig. 3. Approach Flow of a papermachine having manifold dilution

3. Modelling of the Papermachine

A papermachine flow diagram is in FlowMac normally based on some key blocks:

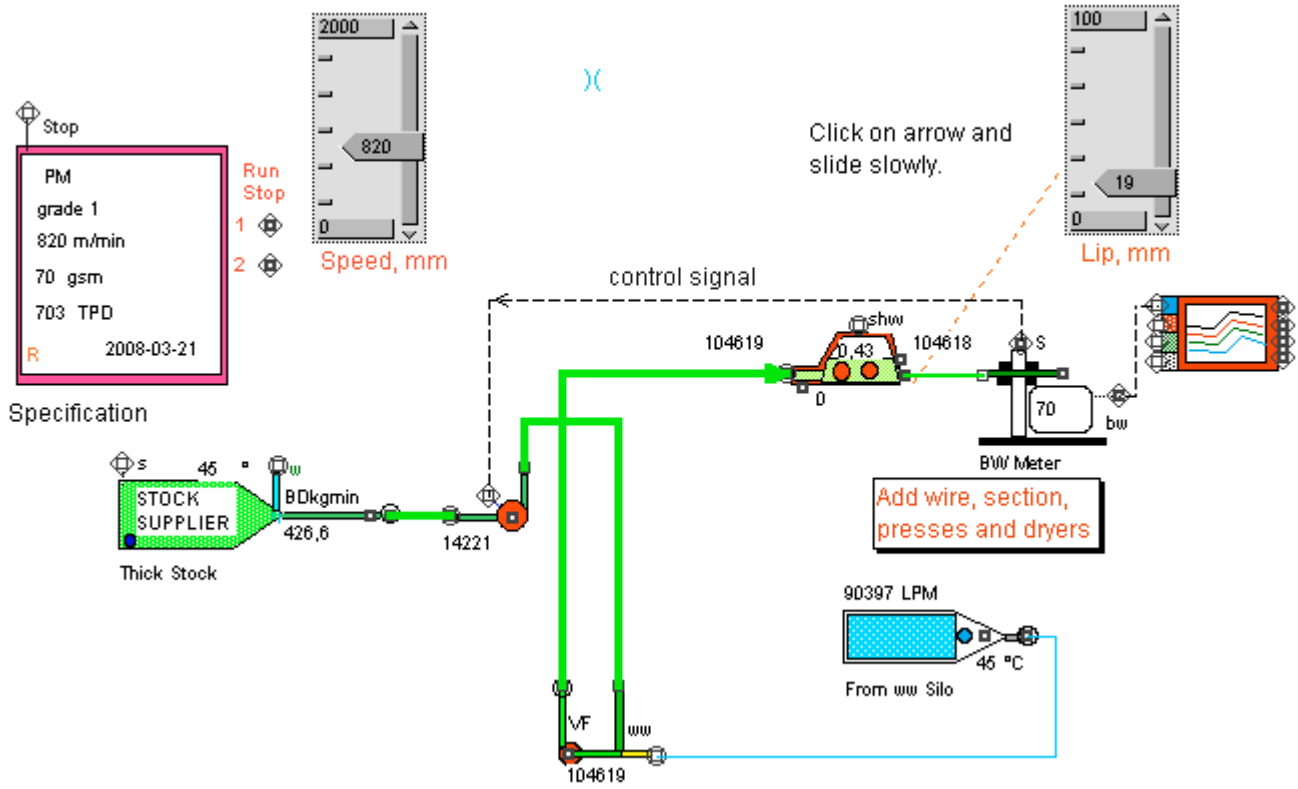

Fig.4. Papermachine principal flow diagram

The **Specification** defining global data for basis weight, machine width and speed, furnish, etc in all up to 80 data. Up to 5 grades can be specified in each block.

The thick **Stock Supplier** which can represent a complete stock preparation plant.

The thick stock flow control**, a Basis Weight valve** or **Variable Speed Pump.**

Recycled **White Water** from the wire section

The **Fan Pump** mixing thick stock and recycled white water and feeding the headbox

The **Headbox** feeding the wire section

The Basis Weight Meter controlling the Flow of thick stock

The FlowMac principal flowsheet is similar to the real one. It can now be completed with a detailed stock preparation, screens, cleaners, deaeration, wire section, press section, dryers, white water and a broke system.

The models designed shall be as simple as possible but no simplier.

4. Debottlenecking a papermachine

There are many bottleneck questions in a papermachine and its flow system.
- How much paper can be produced?
- What are the limits of stock supply?
- What are the limits of steam and power supply?
- What are the limits of main equipment as the headbox, wire section, presses and dryer section?
- What are the maximum speed of mechanical equipment? Wire and felt rolls? Machine drives?
- What are the limits of pumps and pipes?
- What are the main capital investments?

Most of these questions can be analysed by FlowMac and have so been done in more than 100 projects by suppliers and engineering companies.

One of the many tutorials in FlowMac, a newsprint machine built year 175 has been selected as a demo. The stock preparation, here not a detailed flowsheet, includes supply of DIP, TMP, broke and recovered stock from a discfilter. There is an oldfashion combination of mixing chest, machine chest illustrated in figure 5. There is in the upper part of the figure also a compacted flowsheet to illustrate the size of the model. More than 500 blocks of which 30 pumps are included in the model.

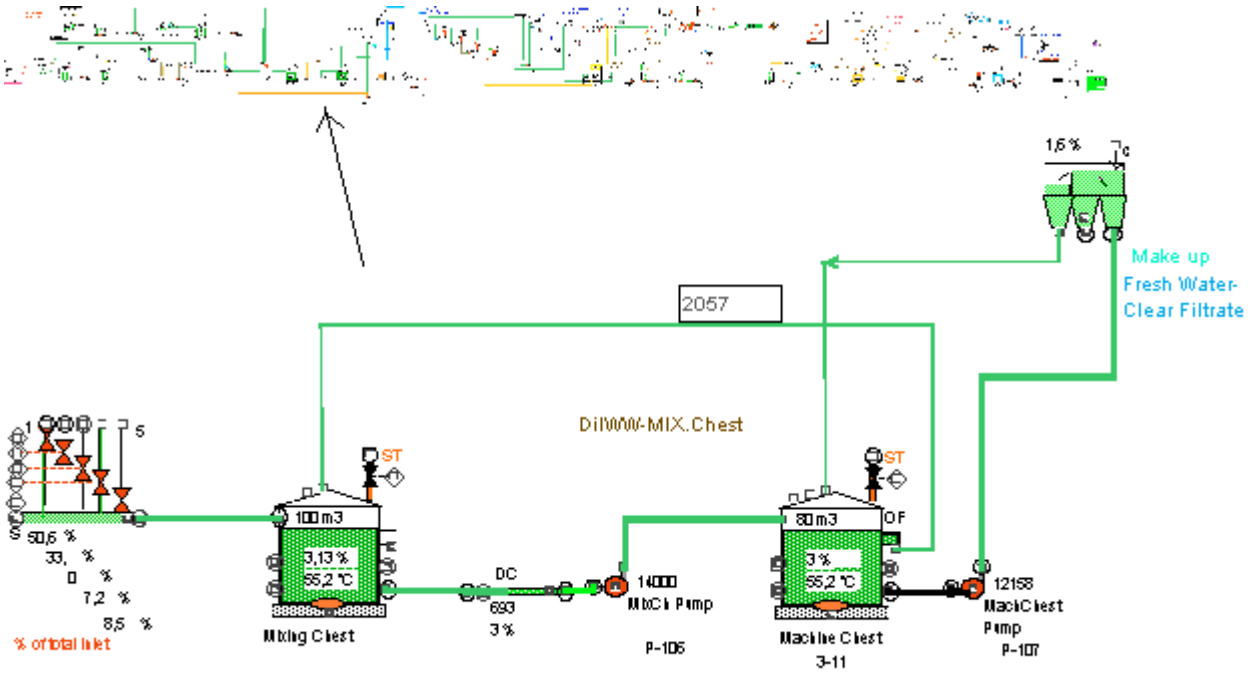

Fig. 5 The size of the complete flowsheet and a selected section

The model is selected, copied and pasted into an hierarchical block which allows animation of grade name, machine speed, basis weight and production rate. Critical data from dialogs of different blocks are cloned out to the worksheet below the hierarchical block or to an Extend notebook. The hierarchical block and the cloned data are then

duplicated twice to get a model shown in fig. 6.

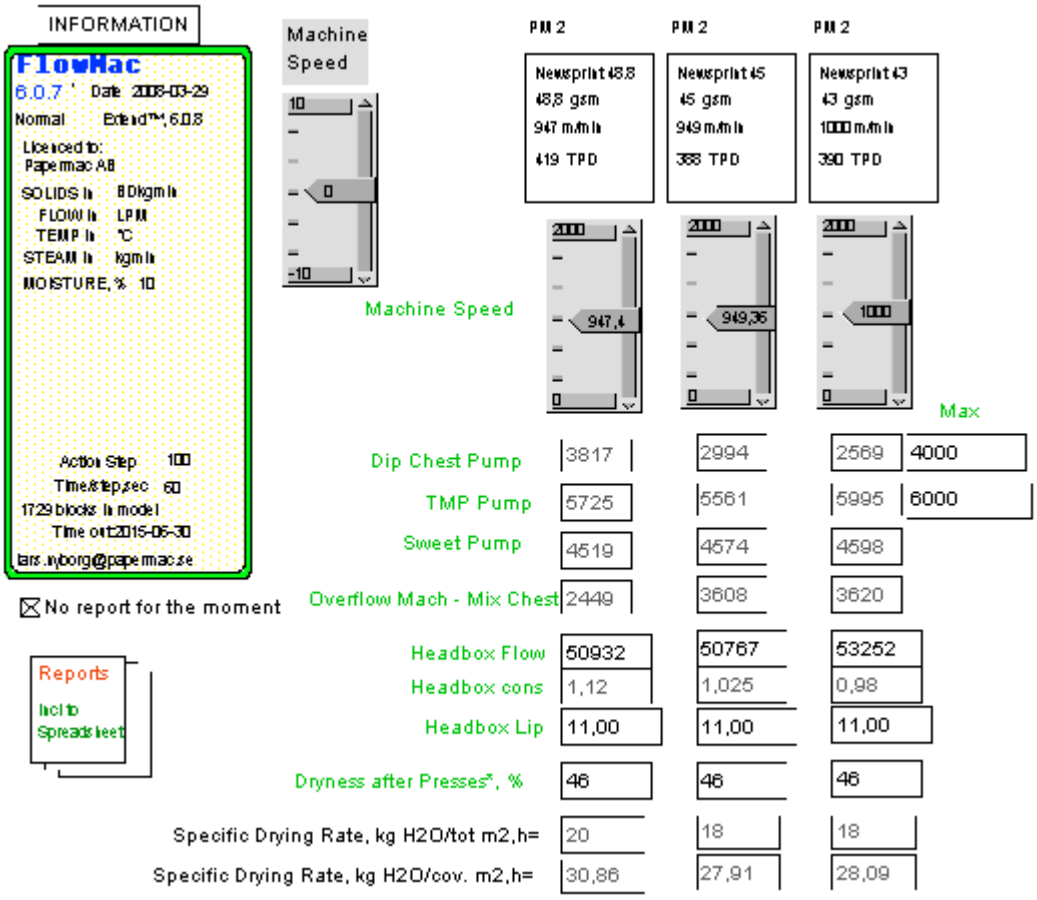

Fig 6. Three Grades in one model

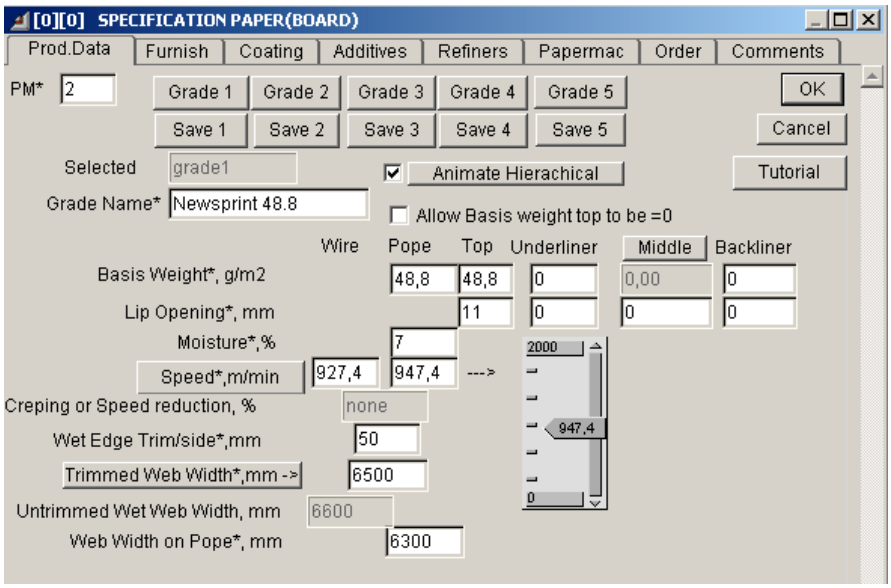

Fig 7. Finally the specification data is set for each grade.

During the simulation run machine speed can be changed individually for each grade or also for all grades in the same time by sliders. All inputs can be modified, furnish, filler content, lip opening, retention, etc until the optimal process generating a high production with accepted quality parameters is reached.

Bottlenecks are detected and eliminated with investments. The main bottleneck for each grade is mostly well known by the machine operators, also the second one but then uncertainty will successively appear.

FlowMac is the only software that can run all grades on a papermachine in the same simulation run. More than 100 papermachines have been analysed during the years by engineering companies.

A live demo will be given during the presentation of the paper in th Madrid Process simulation conference may 2008. A flash demo can be downloaded from www.papermac.se/movies Papermachine analysis.

5. Decisioneering

FlowMac dominates the European market for computer modelling tools in pulp and papermaking. Most recent big project is the new SC papermachine being installed by Stora-Enso in Kvarnsveden, Sweden - an investment of USD 600 Million. A FlowMac model has been used for dimensioning of the processes from chips to the reel of the papermachine. The energy and COD balances are important to the runnability of the papermachine and for the financial return on the investment. Closure of the white water system, less fresh water consumption and generation of heat and COD in the TMP mill, progressively lead to problems with accumulation of COD and runnability at the wet end of the papermachine. Heat and COD transfer from the pulp mill to the papermachine are reduced, by supplying TMP pulp pressed to a consistency 35%. Heat loss in the wire section of the papermachine, estimated by a special block to be 18 MW, has to be compensated by heat exchangers between TMP and papermachine white waters. Another 4 heat exchangers was preliminary included in the process.

Many pulp and paper mills are now users of FlowMac. They do modelling of their processes themselves and / or with support from Papermac AB or engineering consulting companies. Continuous in-house engineering, for complete mills, is done by Norske Skog, Billerud Gruvön and Grycksbo, Stora Enso. Gruvön includes in their model one kraft pulp mill and 6 paper and paperboard machines and Grycksbo 3 fine paper machines including stock preparations. Modelling of a complicated broke system is of interest in Grycksbo. The rebuilds in Gruvön and Grycksbo will be continually updated in FlowMac.

6. Criteria for Development of FlowMac

The following criteria are applied in the development work:

- **Easy and fun to use**

- No need for any simulation specialists. Process knowledge is most important.
- Similarity between the model and the process.
- User friendly for all categories of personnel engaged in projects.

??- One FlowMac license covers all personnel and computers in a site or office area.

- **Training**

- Training on site or by Flowmeetings on the web is included in supply of a licence.
- More than 200 tutorial models (RP, TMP, papermachines, etc..) included in a licence.
- Organise and meet customers in conferences. Exchange of ideas.

- **Upgrade**
- Continuos upgrade of blocks and tutorials published on a server for download.
- Free customising of blocks of general interest.
- New type of equipment are modelled in new blocks for free.

- **Reduction of engineering man-hour in projects**
- Much faster than any other computer tool in modelling work.
- Copy and paste from 200 tutorial models for RP, TMP, papermachines, etc..
- One papermachine including its stock preparation can be modelled in 1-2 days.
- Support "on-line" by people experienced in pulp and papermaking.
- What-if scenario experimentation with models during project and meetings.
- Fast support and upgrading to customer having a problem.
- Use of Flowmeetings in support and training. (see www.papermac.se)

- **Engineering tools**
- Tools for dimensioning of equipment, motors, pumps, pipes, etc..
- Generation of reports for Excel.
- Tools for check out of the model and its mass balance of water.

- **Presentation of a realistic model**
- Flowsheet with high performance and understanding.
- As real as possible. Basis weight meter, valve controllers, lip opening, etc..
- Accumulation of pulp and papermaking knowledge.

- **Open scripts** (source code)
- Blocks can be developed or modified by customers in their own library.
- Fulfils customers specific and confidential needs, for instance for R&D work.
- Bring a project model into a virtual Mill.

- **Engage Suppliers**
- Suppliers are invited to join the FlowMac system.
- Develop their own blocks tailored for FlowMac. Voith, Metso and GL&V are users.
- GL&V has its own library for cleaners, filters, etc. Can be downloaded from a server.

- **Communication**
- With Excel, SQL-Server, Acad, Mathlab, etc.,
- Models can easily be transferred between users and non-users.
- FlowMac and Extend are web enabled. Get and save data from the web.

- **Dynamics and Controls**
- A static model is the most common type and always fundamental in process design.
- Dynamics are now improved from chest dynamics to any selected time/step.
- Batch processes such as pulpers and their deliveries to storage towers, etc are fully integrated into the dynamic model.

5. FlowMac conference 2004 – Some Practical Examples

In June 2004 the fourth FlowMac conference was carried out with delegates from 7 nations. Papers were given by customers engaged in universities, process engineering and pulp and paper mills.

Öivind Opdal from Norske Skog, Norway, being a senior process engineer, presented the following conclusions:

- Optimisation of a plant starts with design
- Bad design or non-optimal solutions that are built into a mill may take years to rebuild
- Some of our mills have equipment that never should have passed the gate
- It is time-consuming and costly to prove bad solutions

He referred to an in-house rebuild of TMP 2 in Union, Skien, Norway. A model was made for TMP 2 to analyse its efficiency in heat recovery. It took approximately 40 hours to collect data and make the model to be used in a demonstration to the management, and another 15 minutes for the management to understand the problem and decide to rebuild the process. The result was reduced oil consumption and savings of USD 750 000/year. An excellent example of process modelling, for decision support and in house-engineering. Another successful way to improve an inefficient process and remain competitive. The decision was easy due to the dynamics, the graphics, and the reality of the model.

Another FlowMac project in Norske Skog was modelling of a bleaching plant and its bleaching chemistry. After analysis of suggested processes from 3 suppliers one of them was eliminated due to problems with too much fibres to the effluent water. During the remaining part of the project the bleaching chemistry was modelled to design water management and analyse which flow should be sent to the effluent to minimise manganese in the pulp fed to the bleach tower. Manganese will increase the consumption of peroxide to reach a certain level of brightness. The same model was then adapted and used for operator training and later on in the control room to verify responses before the operators changed chemical charges. A model is now used in the plant for visualisation of process data. One FlowMac license covers all these activities making the investment in software both simple and cheap.

The Union mill in Skien, Norway, has also used FlowMac in optimisation of the process for a special paper grade, improved newsprint. A library for simulation of paper quality, PaperMac, was used to simulate the effect of a rebuild of the bleaching plant and postrefining on optical and strength properties. Empirical knowledge collected in the mill and from laboratory tests, was loaded to blocks and its open source code. The tool is used online by machine tenders for prediction of quality at adjustment of process variables or grade change. A second system of the same kind will be installed in Saugbrugsforeningen,Halden for SC-paper.

In the same conference Christer Sandberg, Project manager, Holmen Paper, Sweden, demonstrated the use of FlowMac in process research and fractionation of fibres. The key block in his models is Screen for Fractionation in which 3 different fibre fractions, long, average and fines, were screened. The probability of acceptance was entered for the different fractions using Wahrens theory and the volume reject rate could be played with. The results presented by the modelling work has been adapted for process engineering in the Braviken DIP plant. Separate treatment and refining of the long fibre fraction will reduce energy consumption and improve strength and dewatering properties of the pulp.

7. FlowMac in a paper mill project

There are different ways to become a user of FlowMac. One is to buy a full licence and engage mill personnel and /or Papermac AB, or an engineering consulting company to do the modelling work.

A cautious initial approach could be to ask one mill process engineer to collect data, flowsheet and block diagrams for a selected area or process, and give it to Papermac AB for modelling of the process. Modelling work can be done remotely, with communications via the internet. Papermac AB supplies a model, a library of blocks used in the model and an Extend Runtime licence. The mill can run the model, modify and accumulate data, find bottlenecks, save different modifications and print the flowsheet, etc. The mill now has an in-expensive, very strong computer model for the area selected to be used in its efforts to stay competitive.

The second step can then be to do modelling of other process units and perhaps the complete environmental or energy situation of the mill. This can be done independently just with as-needs support. Use of Extend Runtime licence still makes it a low cost investment.

The third step is to buy a full FlowMac licence to be able to test and do smaller modifications of the process flow sheet and small scale engineering work. Still a cheap way to remain competitive in the short term. In larger projects an engineering consultant using a FlowMac licence should be engaged. FlowMac models are now strong tools in the co-operation with the consultant - these reduce project costs, and the likelihood of mistakes being made.

8. Final Remarks

Papermac AB has a co-operation with separately run companies and papermaking experts. Together this alliance covers a deep knowledge for pulp and papermaking, management, supply chain and IT/IS-Systems. FlowMac is not just a computer software. It is system to build and run many types of digital models. There are models for the kraft pulp mill, mechanical pulp, any paper mill, finishing departments and the complete mill and its balance situation in energy, fibres and water.

Coming back to what was said in the beginning of the paper. Decisions are promoted if you can:

Predict the course and results of certain actions
Understand why observed events occur
Identify problems areas before implementation
Explore the effects of modifications
Confirm that all variables are known
Evaluate ideas
Gain insight and **stimulate creative thinking**
Communicate the integrity and feasibility of your plans

All of this can be done and supported by use of FlowMac.