Institute of Paper Science and Technology

MAPPS VERSION 4.0 NEW FEATURES FOR SIMULATION OF PULPING, BLEACHING, AND PAPERMAKING

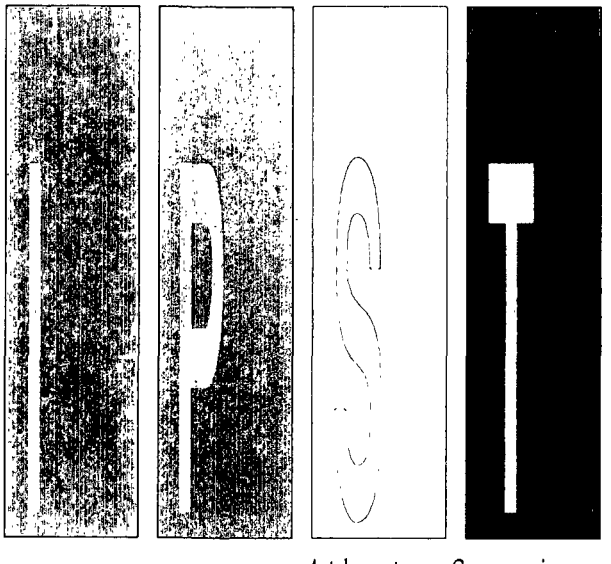
Project 3576

REPORT FOUR

to

MEMBER COMPANIES OF
THE INSTITUTE OF PAPER SCIENCE AND TECHNOLOGY

August 1991



Atlanta, Georgia

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Institute of Paper Science and Technology
Atlanta, Georgia

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To

Member Companies of the Institute of Paper Science and Technology

By

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August 1991

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SUMMARY

MAPPS Version 4.0 is a flexible and powerful program to compute mass and energy balances and paper properties for a wide variety of papermaking systems. The newest version incorporates many significant new features which make MAPPS unique in the pulp and paper industry. MAPPS 4.0 now has over 100 modules in its unit operations library making it the most comprehensive system specific to the industry.

Some of the new features include an extensive system of models to compute pulp and paper properties for a wide variety of pulp types and paper grades; detailed unit operations models for forming, pressing, converting and refining; and utilities for reporting results, converging the flow sheet, and making MAPPS easier to use. Some of the novel aspects of the new system include the ability to predict multi-ply sheet properties, the effects of different species, different furnish histories, recycle fiber effects, dye addition, and the effects of chemical pretreatment on refining.

The new version has undergone extensive testing and evaluation over the past several years. New applications developed during the course of testing include a kraft pulping model, a continuous digester model, a stone groundwood mill, several TMP mill models, newsprint forming, recycle fiber simulation, a corrugating medium paper machine, a fine paper machine model, and a two-ply linerboard simulation model.

The new version also contains two editors which make it much easier to create a MAPPS flow-sheet model and to work with MAPPS particularly for the casual user. MAPPS has also been set up to run on a variety of operating systems from IBM PC's to multi-tasking systems such as OS2, VMS, MVS and UNIX. MAPPS also runs as an application under the new Windows 3.0. These new features have also provided an incentive to integrate MAPPS with information and control systems such as PI, RPMS, and the Taylor and Bailey control systems.

In addition, the documentation, which was previously considered the best available among simulation programs, has been completely rewritten and improved making it the most extensive in the industry.

This report summarizes each unit operation module in Version 4.0. The report consists of two parts: the table of contents of the Module Technical Guide and a brief description of each module taken from the User's Guide.

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10	CHLORN	82	Chlorine Bleaching Tower
6	CLARO1	34	Generalized Clarifier
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6	CNSTCY	14	Stream Consistency and Dissolved Solids Calculation
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12	FURN01	118	Black Liquor Furnace
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7	HYFRAC	63	Fiber Separations Screening, Cleaning, and Thickening
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5	OPTPRP	75	Optical Properties
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7	PCONT1	26	Proportional Flow Controller
7	PCONT2	39	Generalized Proportional Controller
14	PRETRT	20	Steam and Chemical Impregnation of Chips
5	PRNTMV	2	Print Module Data
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7	PUMPO1	27	Generalized Pump
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13	T4PACK	127	Auxiliary Module for TURB04
10	WASH01	49	Single-Stage Washer
10	WASH02	52	Multiple-Stage Washer
10	WASH03	53	Diffusion Washer
10	WLIQ01	60	White Liquor Flow Controller
8	WOOD01	46	Wood Supply Module
8	WOOD02	66	Pulping or Paper Stream Initialization
11	WPRESS	67	Wet Pressing

UTILITY MODULES

Label (Type)	Description
CONVG2 (17)	Controls the repeated execution of modules in a calculation loop until the mass or energy balances over the entire flow sheet are satisfied within a specified tolerance.
CONVRG (1)	Controls the repeated execution of modules in a calculation loop until the component values of a test stream have converged. The test stream, convergence tolerance, and maximum number of iterations are specified.
CONVRT (9)	Converts one stream type to another. The correspondence between the constituents of the two stream types is specified.
DEBUG1 (13)	Traces simulation variables.
DUMPAL (15)	Creates a custom report output file containing all module and process stream data in a compact, formatted form. The created file is intended to be used by programs outside of MAPPS as an input data file.
ECONOM (6)	Conducts a cash flow analysis based on operating revenues and costs. A summary of the operating revenues and costs is printed.
MATH01 (10)	Calculates one or two sums. The terms in the sum(s) may be any combination of module, stream, or PAT stream parameters. When two sums are calculated, the product, ratio, or difference of the two sums can be computed. The final value (sum, difference, product, or ratio) is then multiplied by a coefficient specified by the user.
OPTPRP (75)	Determines optical properties at two different wavelengths of light (457 and 572 nm). Specifically, opacity at 572 and brightness at 457 and 572 nm are determined.
PAPSIM (64)	Initializes the performance attribute for a paper stream at any point in the process. Useful when fiber flows are known but there is little information on the performance attributes associated with the fiber stream.
PRNTMV (2)	Prints module vectors with labels. The modules to be printed are specified.
PRNTPV (5)	Prints performance attribute (PAT) stream variables with labels. The PAT streams to be printed are specified.
PRNTSV (3)	Prints stream vectors with labels. The streams to be printed are specified.
PROPS (69)	Computes properties of handsheets and machine-made papers from the material and performance attribute stream information.

UTILITY MODULES (continued)

Label (Type)	Description
PROPS2 (73)	Computes properties of multi-ply papers. Selected handsheet properties for each ply and machine-made multi-ply paper are determined.
RATIO (4)	Computes the ratio of two sums. The elements of either sum may be module parameters or stream attributes. One information stream may be supplied as the default stream for stream attributes.
REPEAT (16)	Controls the repeated execution of the MAPPS simulator until the new parameter variables, representing different case studies and read in from an external file, are converged.
RPRTO1 (12)	Prints out summary on all streams or a group of streams. The summary contains mass flow rate, total flow rate, consistency, and dissolved solids concentration.
SUMARY (7)	Summarizes selected module and stream parameters. The parameters of interest, with corresponding stream or module numbers, are specified.
SWITCH (8)	Switches independent and dependent variables. The user estimates the independent variables and specifies the dependent variables.

GENERAL PURPOSE PROCESS MODULES

Label (Type)	Description
CLARO1 (42)	Simulates a liquor clarifier. The consistency of the outlet solids stream is specified.
CNSTCY (14)	Computes the consistency and the amount of dissolved solids for specified streams. The module can make these calculations for up to 10 different streams.
COMPO1 (33)	Simulates a multiple-stage compressor. The outlet pressure and compressor efficiency are specified.
CONSIS (21)	Simulates a consistency controller that maintains a target ratio of solids flow to total flow by dilution.
CONSPL (22)	Simulates a controller-splitter that creates an outlet stream by taking material from a supply stream. The target amount of material in the outlet stream may be user-specified or determined from the difference between two control streams.
FLSHO1 (34)	Simulates an adiabatic flash. A boiling point correction is made based on the dissolved solids concentration. The flash pressure is specified.

GENERAL PURPOSE PROCESS MODULES (continued)

Label (Type)	Description
GENPRS (71)	Simulates any general process which influences performance attributes. The relative percent change is specified for each of the performance attributes.
HEXCH1 (32)	Simulates a simple, indirect fluid-to-fluid heat exchanger without phase change. The outlet temperature of the cold fluid is specified. The heat transfer rate and heat exchanger effectiveness are calculated.
HEXCH2 (23)	Simulates an indirect fluid-to-fluid heat exchanger without phase change. An effectiveness model is used to calculate the outlet temperatures of the fluid streams. Either the effectiveness or the product of the overall heat transfer coefficient and the area is specified.
HEXCH3 (24)	Simulates a heat exchanger where a water, gaseous, pulping, recovery, bleaching, paper, or waste stream is heated using condensing steam. Either the effectiveness or the target outlet temperature is specified.
HYFRAC (63)	Simulates a pressure screen, centri-cleaner, or thickener in a stock preparation system. Fiber distribution in the overflow and underflow and pulp properties are determined.
MIXRO1 (25)	Simulates the adiabatic mixing of two to nine streams of compatible types. The minimum nonzero inlet stream pressure is assigned to the outlet stream.
PCONT1 (26)	Simulates a proportional flow controller. The adjusted (i.e., updated) flow rate is equal to the old flow rate plus the product of a user-specified gain and the difference between the value of a designated parameter (e.g., temperature) and a target value.
PCONT2 (39)	Simulates a general proportional controller using any module or process stream variables as the measured and controlled variable pair. The updated variable is equal to the old variable plus the product of a user-specified gain and the difference between the value of the measured variable and a target value.
PUMPO1 (27)	Simulates a motor-driven pump that pumps a water, pulping, recovery, bleaching, paper, or waste stream. The pressure rise and motor and pump efficiencies are specified.
PVALVE (28)	Simulates a pressure-reducing valve that throttles a water, gaseous, pulping, recovery, bleaching, paper, or waste stream. The pressure drop across the valve is specified.

GENERAL PURPOSE PROCESS MODULES (continued)

Label (Type)	Description
SEPAR1 (29)	Simulates a simple separator where the separation efficiency (reject flow/total flow) of each inlet stream constituent is specified. If the inlet stream is wet steam, it simulates a steam-water separator by setting the separation efficiency equal to one minus the steam quality.
SEPAR2 (30)	Simulates a separator in which the reject ratio and all but one component separator efficiencies are specified.
SEPAR3 (68)	Based on the same separation model as SEPAR2. The difference is that SEPAR3 accounts for the effects of the component separation on performance attributes.
SPLIT1 (31)	Simulates a simple splitter that divides a single inlet stream into two to nine outlet streams. The split ratio of all but one of the outlet streams is specified.
STOMIX (61)	Mixes fiber and nonfiber streams adiabatically. The length and width distributions of the mixed pulp stream and handsheet properties are computed.
WOOD01 (46)	Generates a wood stream using the pulping stream format. The wood temperature, total flow rate, and constituent mass fractions (water, cellulose, lignin, tall oil, and turpentine) are specified.
WOOD02 (66)	Initializes a pulping or paper stream and its performance attributes.

PULP MILL PROCESS MODULES

Label (Type)	Description
BLIQ01 (62)	Splits a black liquor stream to control liquor-to-wood ratio.
BLOX01 (50)	Simulates black liquor oxidation. The excess air and oxidation efficiency are specified.
BSWASH (101)	Simulates a single, vacuum rotary drum brownstock washer. It analyzes washing in terms of diffusion and filtrate exchange. Sodium sorption can be calculated.
CAUS01 (41)	Simulates the slaking and causticizing steps of chemical recovery. The excess lime, causticizing efficiency, and white liquor temperature are specified.
DCEV01 (43)	Simulates a direct-contact evaporator. The temperature difference between the outlet flue gas and black liquor streams is specified.

PULP MILL PROCESS MODULES (continued)

Label (Type)	Description
DIGR01 (44)	Simulates a set of batch digesters or the impregnation and cooking zones of a continuous digester. Steam may be supplied directly or indirectly at one or two pressures. The digester volume and cooking temperature are specified. The pulping model, for 11 wood species, was developed by J. V. Hatton. Mixtures of two of these species may be specified.
DIGR2A (37)	Part of a two-module set designed to simulate either a set of batch digesters or the impregnation and cooking zones of a continuous digester. DIGR2A should always be used in conjunction with DIGR2B.
DIGR2B (38)	Part of a two-module set designed to simulate either a set of batch digesters or the impregnation and cooking zones of a continuous digester. DIGR2B can either be used in conjunction with DIGR2A or it can be used alone if fed a stream with chips and liquor already mixed to the desired composition.
EVAP01 (45)	Simulates a multiple-effect evaporator which can include a concentrator. The number of effects, mean heat transfer coefficient, and mean heat transfer area per effect are specified. The strong liquor concentration and the steam consumption are calculated.
EVAP02 (55)	Simulates a single, indirect transfer evaporator effect. Given either outlet pressure, outlet temperature, overall U and effective area or combinations of these, the outlet liquor concentration, steam economy, and remaining variables are calculated.
KILN01 (47)	Simulates a lime kiln. The lime conversion efficiency and availability and the outlet temperatures of the lime and flue gas are specified. The fuel consumption is calculated.
KILN02 (56)	A modified version of KILN01. Lime dust is computed differently.
MKUP01 (48)	Simulates a water and chemical makeup control strategy. The alkali charge on wood, white liquor sulfidity, and white liquor active alkali concentration is specified. Makeup water and chemicals are adjusted to meet these specifications.
MKUP02 (36)	Models the makeup of mill water and chemicals in a kraft pulp mill. The module determines the amount of required makeup chemicals, in terms of water, sulfur, and sodium, by comparing the feed white liquor stream supplied to the first DIGR2A module (end of white liquor "snake").

PULP MILL PROCESS MODULES (continued)

Label (Type)	Description
SMLTO1 (51)	Simulates the smelt dissolving and clarifying processes.
WASHO1 (49)	Simulates a single-stage washer. It analyzes the washing process in terms of dilution and thickening. Displacement is not considered.
WASHO2 (52)	Simulates a set of countercurrent vacuum drum washers. The model is taken from Perkins, Welch, and Mappus (Tappi, October 1954). It analyzes the washing process in terms of dilution, thickening, and displacement.
WASHO3 (53)	Simulates a countercurrent diffusion washer. The model is taken from Williams, McKibbens, and Riese (Tappi, September 1965). It analyzes the washing process in terms of one-dimensional diffusion of solute from cooked chips.
WLIQO1 (60)	Simulates a white liquor allocation strategy. Using the difference between white liquor supplied to the pulping lines and white liquor returned from recovery, it calculates the chemical makeup requirements and passes that information along to the MKUPO1 module.

BLEACH PLANT PROCESS MODULES

Label (Type)	Description
ALKOXY (87)	Simulates a tower for oxidative alkaline extraction of bleached pulp. If oxygen is not used, only alkaline extraction of chloro-lignin occurs.
BLCHO1 (76)	Simulates a simple, general purpose bleaching stage or a complete bleach plant. Lignin reduction and chemical consumption are computed.
CHLORN (82)	Simulates a chlorine tower in a conventional bleach plant.
CLDIOX (84)	Simulates a chlorine dioxide tower in a conventional bleach plant (both D1 and D2).
CSUBD (18)	Simulates a chlorine or chlorine dioxide tower with substitution by either chlorine dioxide or chlorine.
OXYGO2 (77)	Simulates an oxygen bleaching tower. Delignification and carbohydrate degradation reactions occur. Calculated parameters include initial and bleached pulp kappa numbers and bleached pulp viscosity.

PAPER MACHINE AND CONVERTING PROCESS MODULES

Label (Type)	Description
AIRCNT (91)	Simulates the air damper controller of a dryer hood. The air is split into two streams. The split ratio is adjusted to maintain a target air temperature in a specified stream.
CALEND (65)	Simulates the main effects of a single nip of a multiple-nip calender stack.
DRYER1 (92)	Simulates a conventional drum paper-dryer system including the hood, web, blowers, and steam drums. It can be used to simulate a whole dryer or a single dryer section.
DYEMIX (74)	Simulates the mixing of up to three dyes whose colors are red, blue and black with virgin or already dyed fibers. It is intended for use in conjunction with the optical properties block OPTPRP.
FOUR01 (70)	Simulates a fourdrinier paper machine. The model accounts for effects of headbox slice design, drainage elements, and wire design on drainage rate, retention, and formation. It can be used to simulate a single-drainage element, multiple-drainage elements, or an entire wire section plus headbox. FOUR01 can also be used to simulate a thickner, decker or a simple drum washer.
MPFORM (72)	Simulates a multi-ply forming operation. The model accounts for headbox, slice design, drainage elements, and wire design on formation, drainage and retention.
REFNR1 (93)	Simulates a stock refiner. The power required and the stock temperature rise are calculated.
REFNR2 (58)	Models a stock refiner. It differs from REFNR1 in the method used to redistribute the fibers. In REFNR2, the outlet distribution is specified directly.
SAVALL (97)	Simulates a disk filtration saveall unit. The geometry of the saveall unit and retention parameters for the inlet components are specified. The composition of the fiber mat and the clear and cloudy filtrate streams are calculated.
SCRN01 (96)	Simulates a cleaning device represented by the Nelson formulae.
STCNTI (94)	Simulates a steam controller for a dryer system. The overall steam economy of the dryer system is specified, and the steam flow rate required to maintain the outlet moisture of the paper at a target value is calculated.
WPRESS (67)	Simulates a single-nip continuous wet pressing operation. It calculates both the rate of water removal from the web and the effects of the press on web consolidation and sheet formation.

STEAM AND POWER SYSTEM PROCESS MODULES

Label (Type)	Description
BOILO1 (111)	Simulates the boiler section of a steam generator that generates steam from feed water using flue gas. The outlet flue gas and steam temperatures are specified. The mass flow rate of raised steam and the boiler efficiency are calculated.
CONDEN (113)	Simulates a water-cooled condenser that condenses superheated steam to saturated liquid.
DEAER1 (114)	Simulates a deaerator. Clean reusable process water, makeup water, and steam are mixed to produce boiler feed water. The steam needed to bring the feed water to the saturated liquid state is calculated.
DESUP (115)	Simulates a desuperheater used to desuperheat steam to the specified degrees of superheat. The required amount of water is calculated.
EBALO1 (128)	Computes the difference between the electrical power available to a system and the system electrical power load.
ELOAD1 (129)	Simulates a process electrical load. It can operate in two ways: the load can either be a user-specified constant, or it can be a function of a specific electrical power consumption and its defining component flow rate in a process stream.
FUELO1 (116)	Simulates a fuel controller. The outlet fuel flow rate is adjusted to meet a target value of a steam or power stream.
FUELO2 (117)	Simulates a fuel controller that controls the flow rate of two fuels. The fuel flows are adjusted to generate a target steam flow rate in a user-designated stream.
FURNO1 (118)	Simulates the combustion section of a recovery furnace. Black liquor may enter as a pulping stream or a fuel stream. The excess air, sulfate reduction ratio, and smelt temperature are specified. The products of combustion and the heat released are calculated.
FURNO2 (119)	Simulates the combustion section of a power furnace supplied with two different fuels. The excess air and ash temperature are specified. The products of combustion and the heat released are calculated.
GNRATR (120)	Simulates an electrical generator that generates electrical power from mechanical power. The generator efficiency is specified.
STLOAD (122)	Simulates a process steam loan, i.e., a demand for process steam. The required process steam is divided into steam consumed by the process and recoverable condensate.

STEAM AND POWER SYSTEM PROCESS MODULES (*continued*)

Label (Type)	Description
STMHTR (35)	Simulates a direct steam heater which heats an inlet fluid to a specified outlet temperature by condensing a calculated amount of steam. The mass flow rate and thermodynamic state of the supply steam and inlet fluid are known. Either the desired outlet temperature or the desired temperature rise is specified, and the amount of steam required to be condensed is calculated.
TURBO1 (123)	Simulates a steam turbine. The turbine has inlet and outlet steam lines, two extraction ports, and an output power shaft. The efficiency of each turbine section, the extraction steam flow rates, and the extraction and outlet pressures are specified. The shaft power is calculated.
TURBO2 (124)	Simulates a simple, steam turbine with inlet and outlet steam lines, and an output power shaft. The shaft power is calculated using a specified turbine efficiency and outlet steam pressure.
TURBO3 (125)	Simulates a multiple-extraction steam turbine. The turbine has inlet and outlet steam lines and up to three extraction ports. The efficiency of each turbine section and the extraction and outlet pressures are specified. Outlet shaft power is calculated. There are three modes of operation. The first mode represents a base-loaded turbine where all of the outlet flows are specified. In the other two modes, the extraction flows are allowed to float to meet steam demands. For the second mode, the last section outlet flow is fixed. In the third mode, the last section outlet flow is varied to meet a specified power output.
TURBO4 (126)	Simulates a multiple-extraction steam turbine. The turbine has inlet and outlet steam lines and up to three extraction ports. The efficiency of each turbine section and the extraction and outlet pressures are specified. The extraction flows float to meet process steam demand. The outlet flow is varied until a power target in an information stream is satisfied. The module "T4PACK" must be used with this module.
T4PACK (127)	Packs part of four information streams into one information stream for use by TURBO4. T4PACK extracts the mass flow rate from the first three information streams and the energy from the fourth information stream.

HIGH-YIELD (MECHANICAL) PULPING PROCESS MODULES

Label (Type)	Description
HYPROX (85)	Simulates a hydrogen peroxide bleaching process in a high-yield pulping process in which the absorption coefficient is reduced. Bleach pulp and paper properties are determined.
HYRFN1 (59)	Models a chip or secondary refiner in a high-yield pulping process as well as in a fiber refiner for chemical pulps. The length and width distributions of fibers entering are changed by the application of power. Pulp and handsheet properties are determined for various pretreatment conditions.
PRETRT (20)	Simulates the steam and chemical impregnation of chips. Chips are compressed to drive out air in the lumens and are then passed through a liquor bath by means of a screw feeder. Excess liquor draining from the chips after passing through the bath is returned to the bath. The chips then disengage from the screw feeder and enter a pressurized steam zone. The chips then fall into a hopper where they are kept under steam pressure before being passed mechanically to the refiner inlet.

ACKNOWLEDGEMENTS

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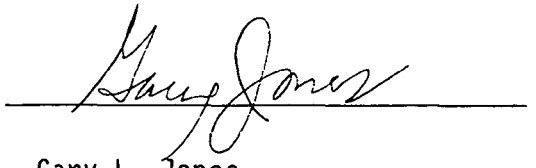

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