DIGITAL CONTROL OF SMALL AND MEDIUM SIZE PAPER MACHINE

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Modern production of paper sets very high demands to the final products. This is the reason to rise the productivity of the paper machine and to find the most economical spendings of the storages and power resources. These grown-up demands force us to look for more effective methods and technical instruments for the design and construction of control systems for paper machines.

Paper production today sets also a lot of requirements to the quality and energy and material saving areas. This can be done with the help of the optimal control theory on the basis of existing electronic equipment. But there is a problem now - how to combine these two advantages with low, cost demands. One of the possibilities is to use a standard microprocessor system and to try to apply some simple control actions, which is possible to realise with the system. The task is to find the best combination between the theory and equipments with the limit costs. Therefore the following is an attempt to satisfy this requirement.

The new control is practised with the help of the standard microprocessor multiloop controller "Honeywell" - the unit of TDC - 2000.

The TDC 2000 BASIC system is a digital process control and data acquisition system that includes a comprehensive set of algorithms and auxiliaries, and provides full control and monitoring capabilities. It is a flexible system that can be tailored to a wide range of process requirements at the loop or unit level.

The distributed control and centralized monitoring capabilities enable an operator to recognize and react to situations at all process points, quickly and positively. Built-in automatic diagnostic procedures not only alert an operator to a potential equipment problem, but in many cases, automatically take corrective action to avert the problem.

The TDC 2000 BASIC system consists of standard, modular building blocks that are linked together by a coaxial cable called a Data Hiway, into an integrated hierarchical system with a distributed architecture. Each of the major modules in this distributed architecture includes a microprocessor with its own firmware and data base. This distributed hardware and data base reduces the effect of an isolated component failure.

All TDC 2000 building block modules are task partitioned. That, each module is tailored to perform a specific, dedicated task: process interface, control strategy implementation, or operator interface, which it does independently of other blocks. In many cases, similar functions overlap at different hierarchical levels and so provide parallel, or alternate paths for control and monitoring. If a particular element falls, its function can offen be assumed by another element with a similar function. Task partitioning and distributed architecture allows the system to degrade gracefully while continuing to control the process. Graceful degradation, taken together with inherently high component reliability gives the TDC 2000 BASIC system a very high level of security.

The TDC 2000 BASIC system modules may be interconnected in virtually any combination. They are identical in any TDC 2000 BASIC system, so that no modifications are required, regardless of system size or configuration.

In general, modules are mounted in standard 19-inch or 24-inch cabinets (Figure 1). Modules mounted in the cabinets are of two types: pronted-circuit card files or interconnection panels (marshalling panels, termination panels, etc.).

The main purpose is to show the possibility for the application of a standard microprocessor control system for some technological paper machine parameter with adaptive elements.

As control units were chosen the head-box and drying section of the paper machine with working width 4200 mm and 350 m/min working speed. The head-box of the machine is closed type with compressed air (Figure 2).

1 - Pump

2 - Wire

V_2 - Air spare

V_1 - Mass space

h - Pulp mass level

m_{11}, m_{12} - Control valves

m_2 - Lips control

m_3, m_4 - Air control valves

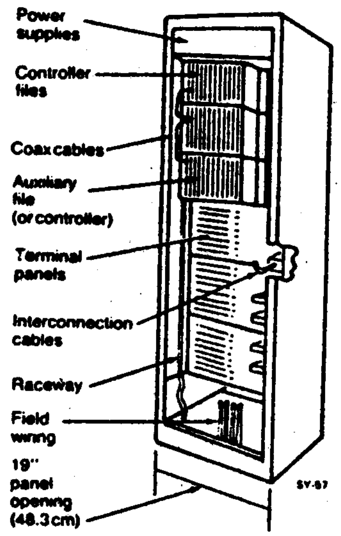

Power supplies
Controller files
Coax cables
Auxiliary file (or controller)
Terminal panels
Interconnection cables
Raceway
Field wiring
19" panel opening (48.3cm)

Fig. 1

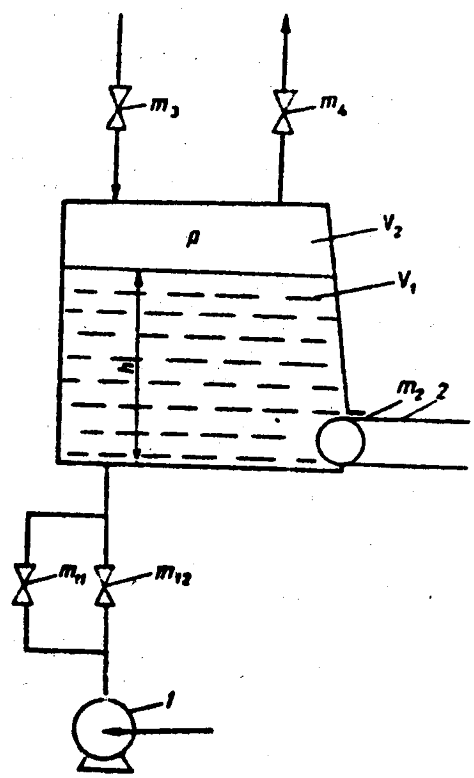

m3
m4
p
V2
V1
h
m2
2
m11
m12
1

Fig. 2

In this kind of head-box the necessary pressure of the outlet pulp mass is coming from the air space. To keep the velocity of the outlet pulp mass constant, the air pressure and the pulp mass level must be control.

The main characteristics of the head-box as a control unit are:

- output value - the speed of the outlet mass, which is not possible to measure directly;
- head-box is a double connection unit;
- the classical control algorithms does not compensate the mutual influence of both systems;
- description of the unit is analytical on the basis of hidrodynamics;
- The control of the head-box is in transient regimes.

The type of cheracteristics geaturing the outlet mass depends on:

- mass concentration;
- pressure in the air space;
- lip opening;
- mass level;
- wire speed;
- mass temperature:

The head-box control actions are:

- air space pressure;
- mass level;
- lip opening;
- inlet mass quantity.

The constant operation limits:

- to keep the definite correlation between the speed of the outlet mass and lip opening;
- to keep the definite correlation between the speeds of the wire and outlet mass.

The disturbances are:

- variations in the air space pressure;
- variations in the mass concentration;
- variations in the alkality of the underwire water;
- variations in the mass level;
- degree of dirt deposit on the perforated rolls;
- variations in the lip opening;
- variations in the inlet mass quantity.

The main control loops are:

- mass level control in the head-box through the bypass quantity;
- air pressure control through the inlet air.

By the help of the existing automation (conventional) pneumatic controllers) it can provide constant value of: mass concentration, pressure of the air, lip opening; wire speed in fixed regime and temperature of the mass.

The microprocessor control system was concentrated over the loop: mass quantity - level.

The drying section of the paper machine is also a double connection unit consisting of drying cylinders, divided in two groups - IA and IB. It was control only of IB group, which is with low number of cylinders. It is only for covering the variations of the moisture in the sheet. The IA group is controlled by digital controler in cascade mode (Figure 3).

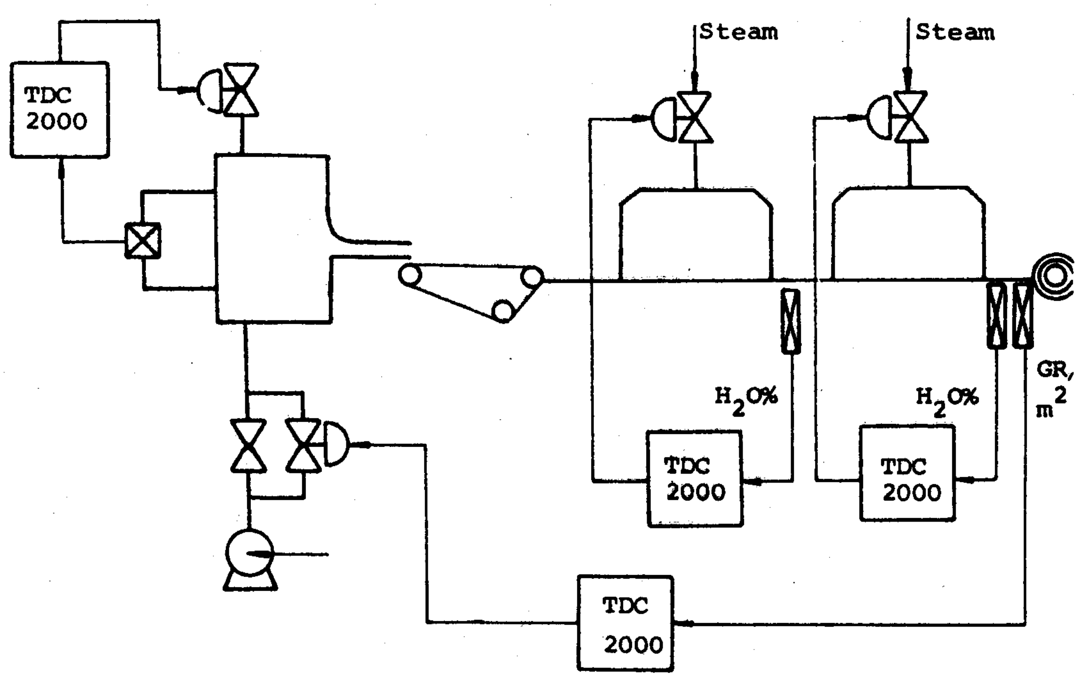
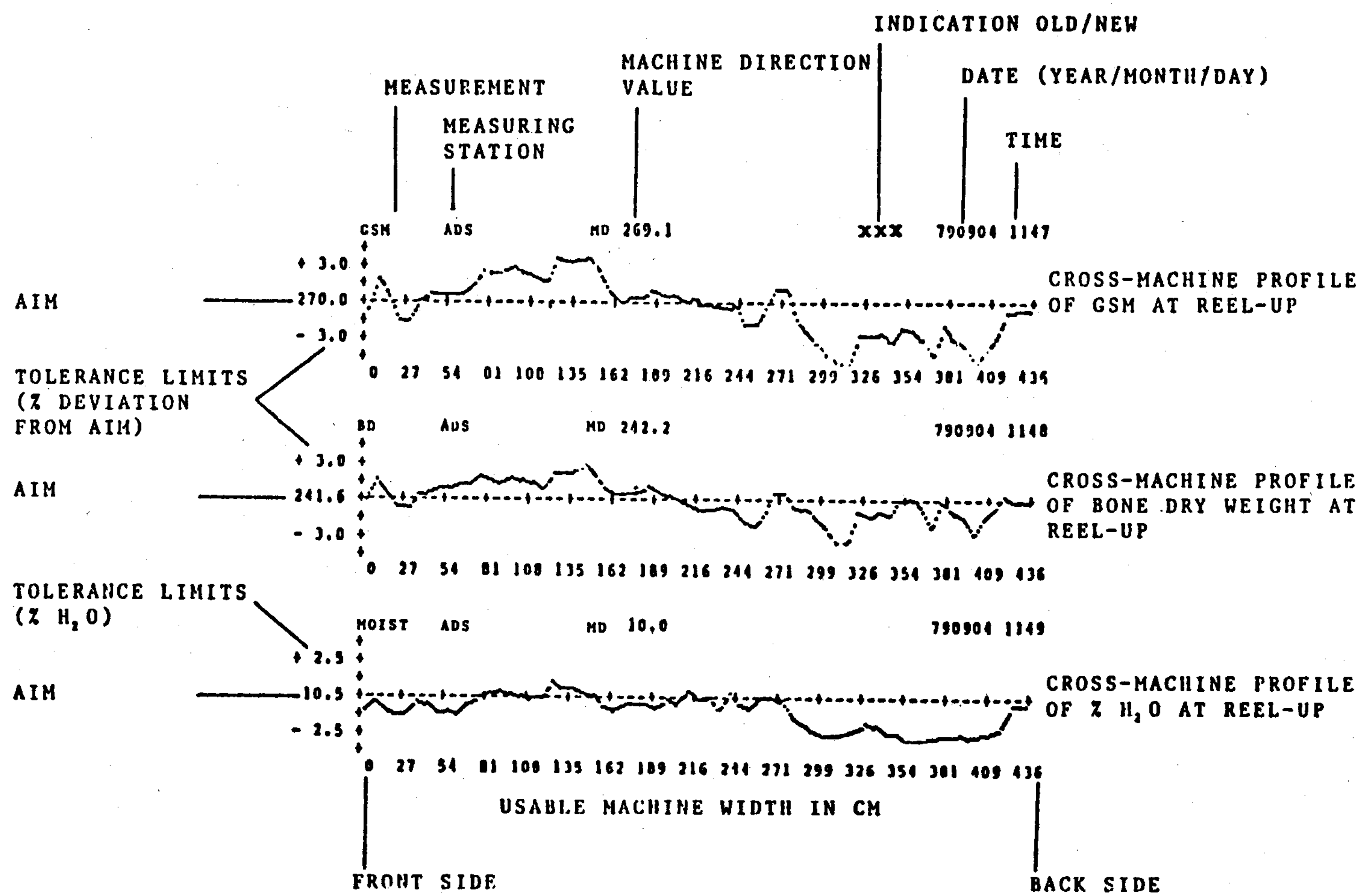


Fig. 3



INDICATION OLD/NEW
MACHINE DIRECTION VALUE
DATE (YEAR/MONTH/DAY)
MEASUREMENT
MEASURING STATION
TIME
GSM ADS MD 269.1 XXX 790904 1147
+ 3.0
AIM 270.0
- 3.0
CROSS-MACHINE PROFILE OF GSM AT REEL-UP
0 27 54 81 108 135 162 189 216 244 271 299 326 354 381 409 436
TOLERANCE LIMITS (% DEVIATION FROM AIM)
BD ADS MD 242.2 790904 1148
+ 3.0
AIM 241.6
- 3.0
CROSS-MACHINE PROFILE OF BONE DRY WEIGHT AT REEL-UP
0 27 54 81 108 135 162 189 216 244 271 299 326 354 381 409 436
TOLERANCE LIMITS (% H_2O)
MOIST ADS MD 10.0 790904 1149
+ 2.5
AIM 10.5
- 2.5
CROSS-MACHINE PROFILE OF % H_2O AT REEL-UP
0 27 54 81 108 135 162 189 216 244 271 299 326 354 381 409 436
USABLE MACHINE WIDTH IN CM
FRONT SIDE
BACK SIDE

Fig. 4

SHIFT REPORT   L I P P K E SYSTEM 4012   800520 1400

GRADE	TON	REEL	GSM	MOIST	% MEA	% CTL
12	29.722	7	246.0	5.0	100.0	100.0

PRODUCTION :	TOTAL TON	TON/HOUR	TON/HR/MTR	LENGTH	MKG %
	29.722	3.718	1.357	39584	92.0
BROKE :	MC DOWN TON	OFF SPEC TON	TRIM	LENGTH	BREAKS
	3.175	0	0.089	435	3

Fig. 5

REEL REPORT — L I P P K E SYSTEM 4012 — 810223 820

123		AIM	MEAN	PROCESS %	MEA %	CTL	2SIG-MD	2SIG-CD	STDZ
GSM	R/U	55.0	54.8	0.	100.0	100.0	0.427	5.242	9.978
MOIST	R/U	4.8	4.5	0.	97.6	97.0	0.395	6.064	
CALIP	R/U	64.2	63.5		100.0		0.505	2.230	34.231
WIDTH	R/U	******	260.7		100.0				
MC SPD	R/U			0.		0.			

PRODUCTION :	TOTAL TON	TON/HOUR	TON/HR/MTR	LENGTH	MKG %
	0.	0.	0.	0	100.0

BROKE :	MC DOWN TON	OFF SPEC TON	TRIM	LENGTH	BREAKS
	0.	0.	0.	0	0

Fig. 6

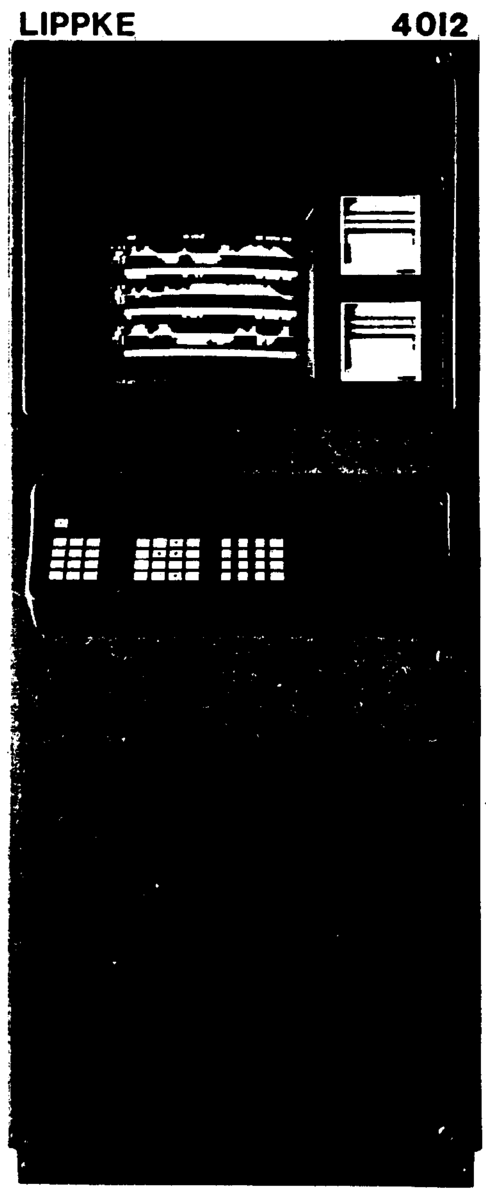


Fig. 7

As measuring equipment for the moisture and basic weight was used "LIPPKE" system "4012".

By its compact design and the use of microcomputers, the 4012 process control system is especially efficient. It is designed for the measurement and display of several parameters which are necessary for optimum operation of a paper machine.

The compact central station is designed such that there is sufficient capacity to serve one scanning frame with five measuring heads and three control loops. The storage capacity is rated so that all grades, with the appropriate data, are stored (Fig. 4, 5 and 6).

The system is easy to use and operations are performed via a keyboard and large digital indicators. A printer/plotter can copy the monitor displays and prints the information clearly including the date and time. Reporting is autmatically performed at the end of a roll, shift or day.

The "LIPPKE" 4012 system has an operator station from which the connected sensors are controlled, the data evaluated and the control loops programmed. Due to the microprocessor technique used, the complete electronics, with process interface, can be mounted in a control panel. An integrated cooling circuit ensures a high reliability, even when installed directly on the machine (Fig. 7).

The color TV monitor displays the process data as inscribed diagrams or as tables.

The large digital indicators, for the most important measured values, are controlled directly by the computer and independentl of the monitor.

A suitable interface is available for data transfer, to a hierarchical process computer. As there are only a few basic types of interfaces cards the supply of service and spare perts is eased.

The constructional principle of the "LIPPKE" 4012 system is the galvanic separation of all signal lines, and status inputs, at the input terminal. In this way, a high protection is achieved against disturbances.

The input values of IB group are initial moisture (outlet moisture of IA group) and machine speed; output - the final moisture control - steam consumption. With preliminary control actions was provided the constant parameter "m^2".

Using modern control methods for the setting of the full range of initial conditions over substantial part of the process in the control device is formed a control package.

Table 1 shows the data of transient processes before the control. M -stands for the initial moisture; M_f - for the final one; σ - for overshooting; t - for the time of the transient process; T_{ak} and A_{ak} - for the period and amplitude of autovariations.

Table 2 shows the results for the same initial conditions after the quasi-optimal control.

Table 1

Process No	M_o [%]	M_f [%]	σ [%]	t [min]	T_{ak} [min]	A_{ak} [%]
1	24	7-12	25	24	12	25
2	20	6-10	40	20	18	20
3	15	5- 8	30	18	16	22

Table 2

Process No	M_o [%]	M_f [%]	σ [%]	t [min]	T_{ak} [min]	A_{ak} [%]
4	24	8-9	16	14	4,2	7
5	20	7-8	10	12	4,3	6
6	15	7-8	8	10	4,1	6

Figure 8 compares some processes (No 1,2,4 and 6) before and after the start-up of the microprocessor system.

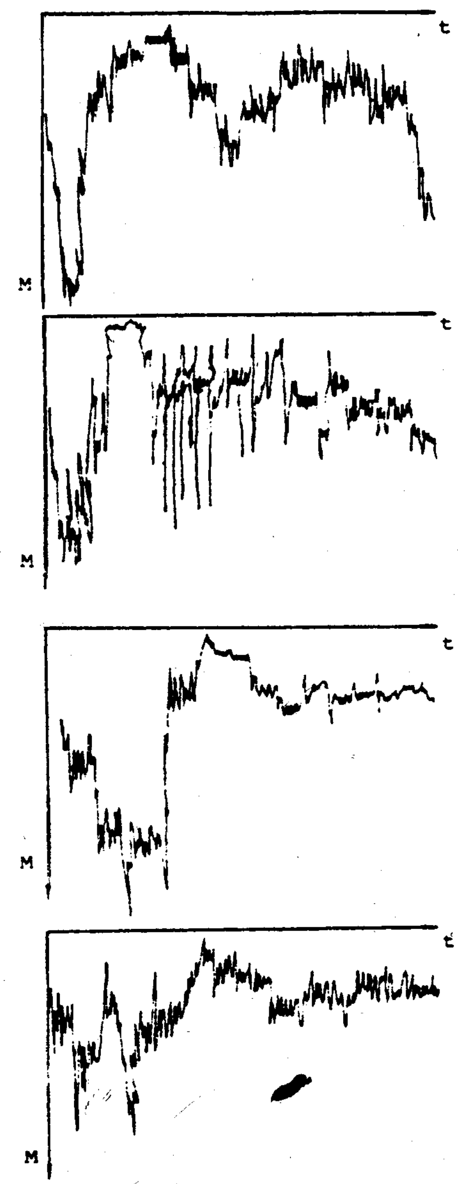


Fig. 8

The microprocessor control was applied in the years 1980-84 in five paper factories. The main purpose of the microprocessor system implementation was to have better results of the quality characteristics of the produced paper and to reach the optimal limits of moisture and base weight. The second was to reach the full capacity of the machine reducing the amount of the low quality products.

Under the control of the microprocessor system were moisture, base weight, consistency and inlet fresh steam.

The results of the controlled moisture and base weight were discussed above. In Fig. 9 is shown one simplified control structure for the moisture.

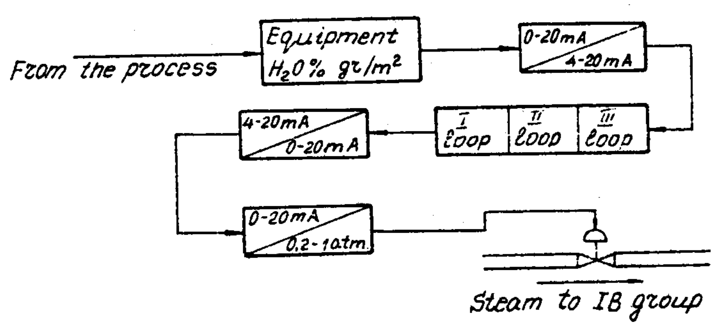


Fig. 9

In Fig.10 and Fig.11 are shown the results of the controlling consistency in the machine and composition chests, In Fig. 12 is the control structure of these loops.

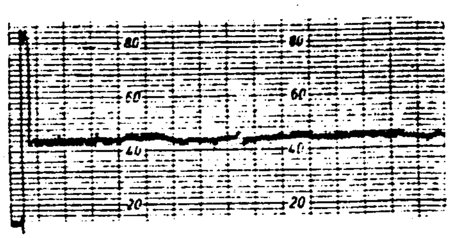
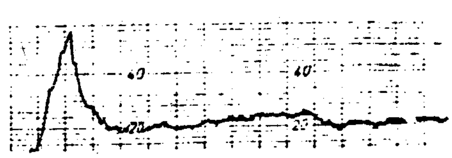


Fig. 10



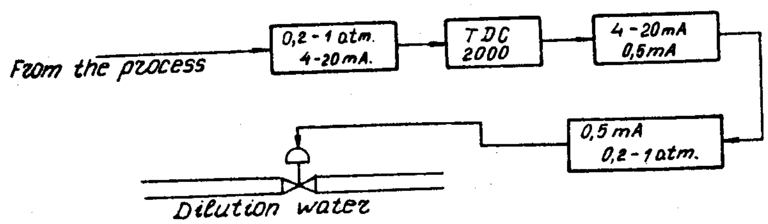


Fig. 12

The results of the microprocessor control of the fresh steam is shown in Fig. 13.

The results received show that the drying section of the discussed paper machine is sufficiently effective.

The applied criterion permits to decrease considerably the steam consumption for drying of the paper sheet, when the productivity of the controlled unit is previously assigned.

The approach used for the head-box and drying section shows that in this way it is possible to improve the quality characteristics of the process. From the comparison in Tables 1 and 2 it can be seen that moisture is stabilised, transient process time reduced and overshooting in the system is acceptable.

The payback time of the microprocessor system is less than 4 months. The limits of the controlled base weight were in $\pm$ 1 gr/m^2 and for the moisture $\pm$ 2 %.

The quality of the produced paper rises by 12 %.

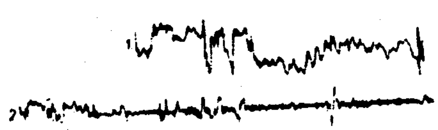


Fig. 13