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ASSISTANCE TO THE GARA BELOVO PAPER MILL

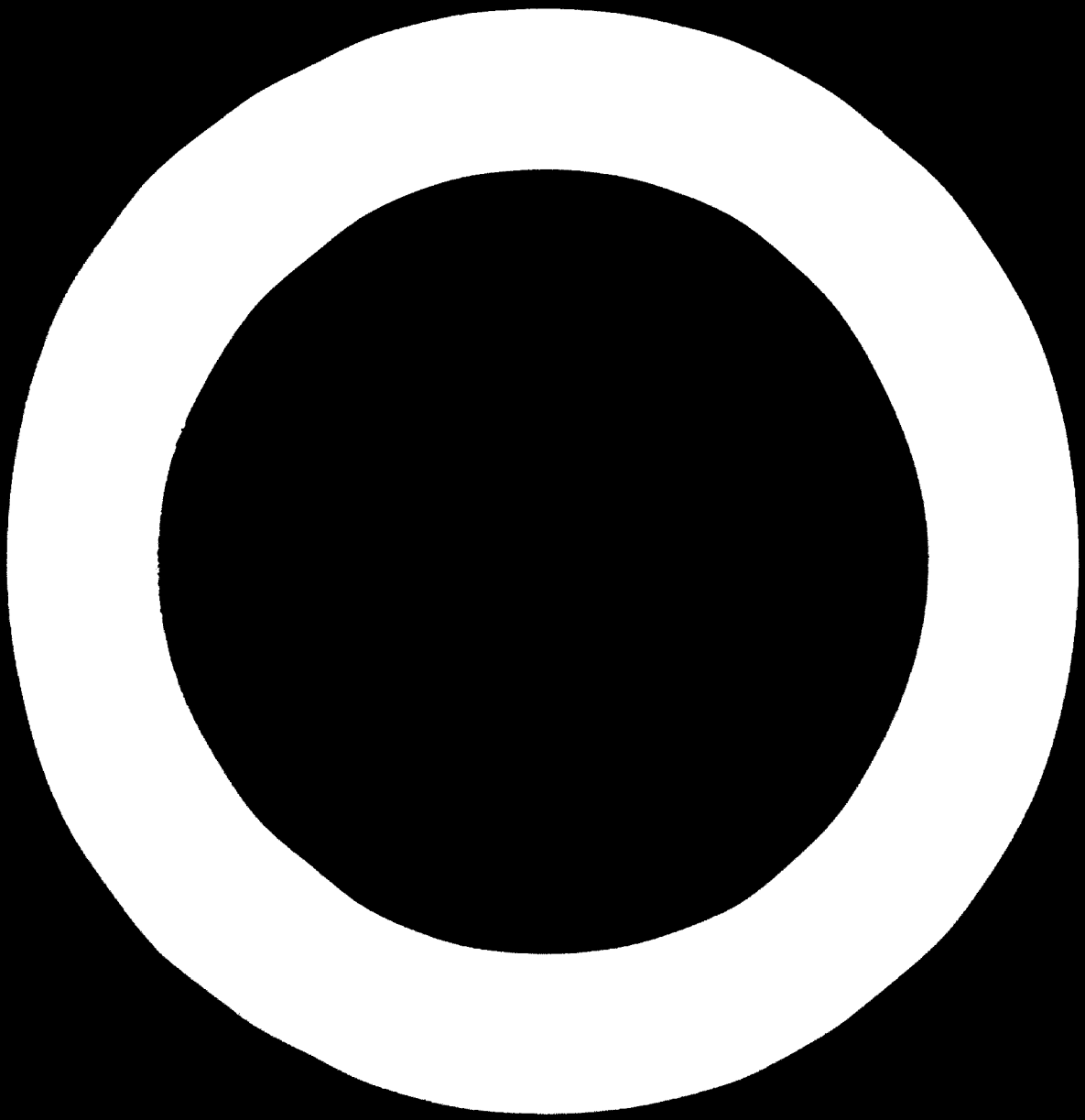
IS/BUL/74/067

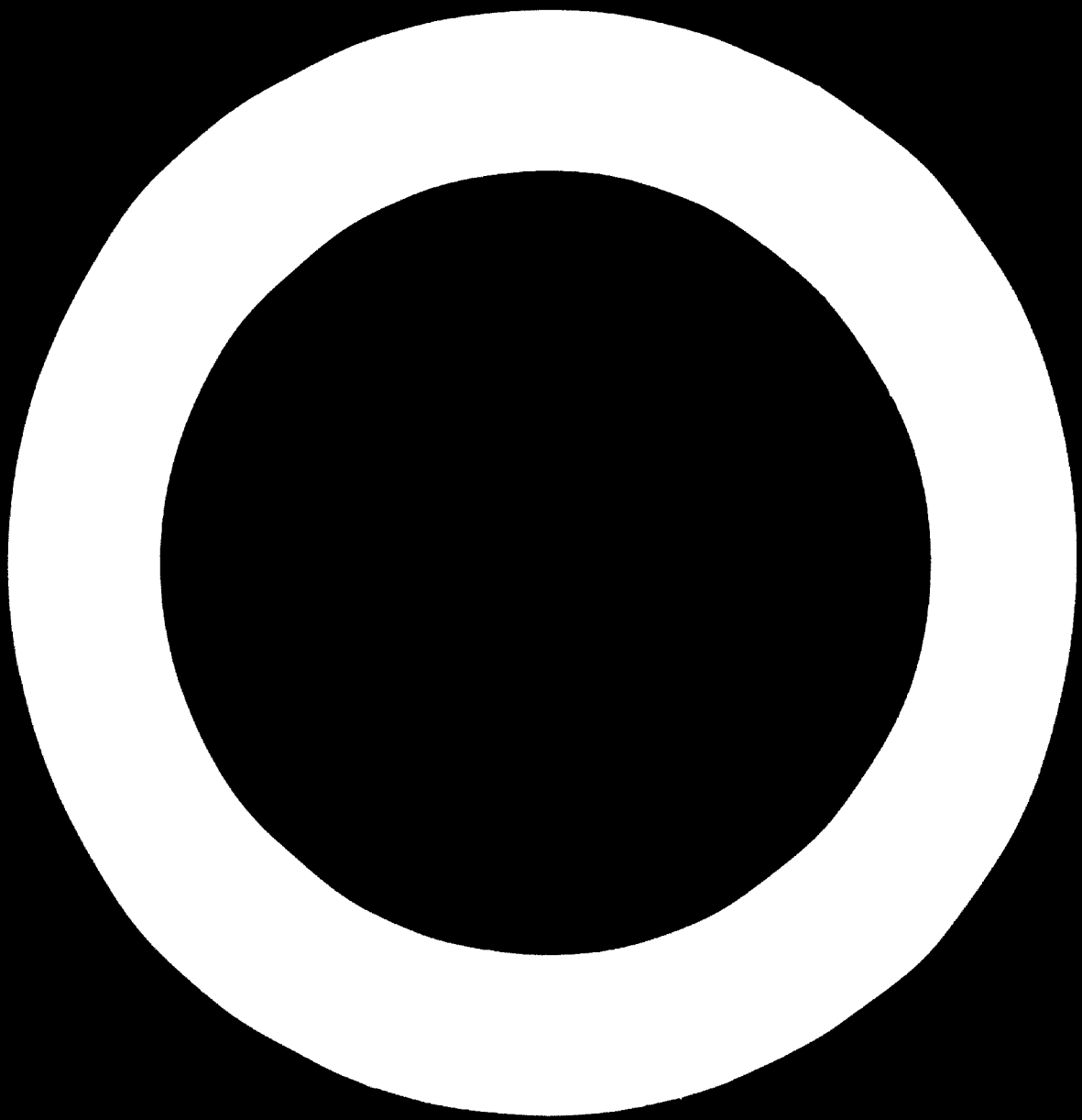
BULGARIA

TERMINAL REPORT

Prepared for the Government of Bulgaria by the
United Nations Industrial Development Organization,
executing agency for the
United Nations Development Programme

United Nations Industrial Development Organization





United Nations Development Programme

ASSISTANCE TO THE GARA BELOVO

PAPER MILL

IS/BUL/74/067

BULGARIA

Project findings and recommendations

Prepared for the Government of Bulgaria
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of Robert I. Yin, speciality paper technologist:
coated paper

United Nations Industrial Development Organization
Vienna, 1975

EXPLANATORY NOTES

Reference to "tons" indicates metric tons, unless otherwise stated.
IGT refers to the Instituut voor Grafische Techniek.

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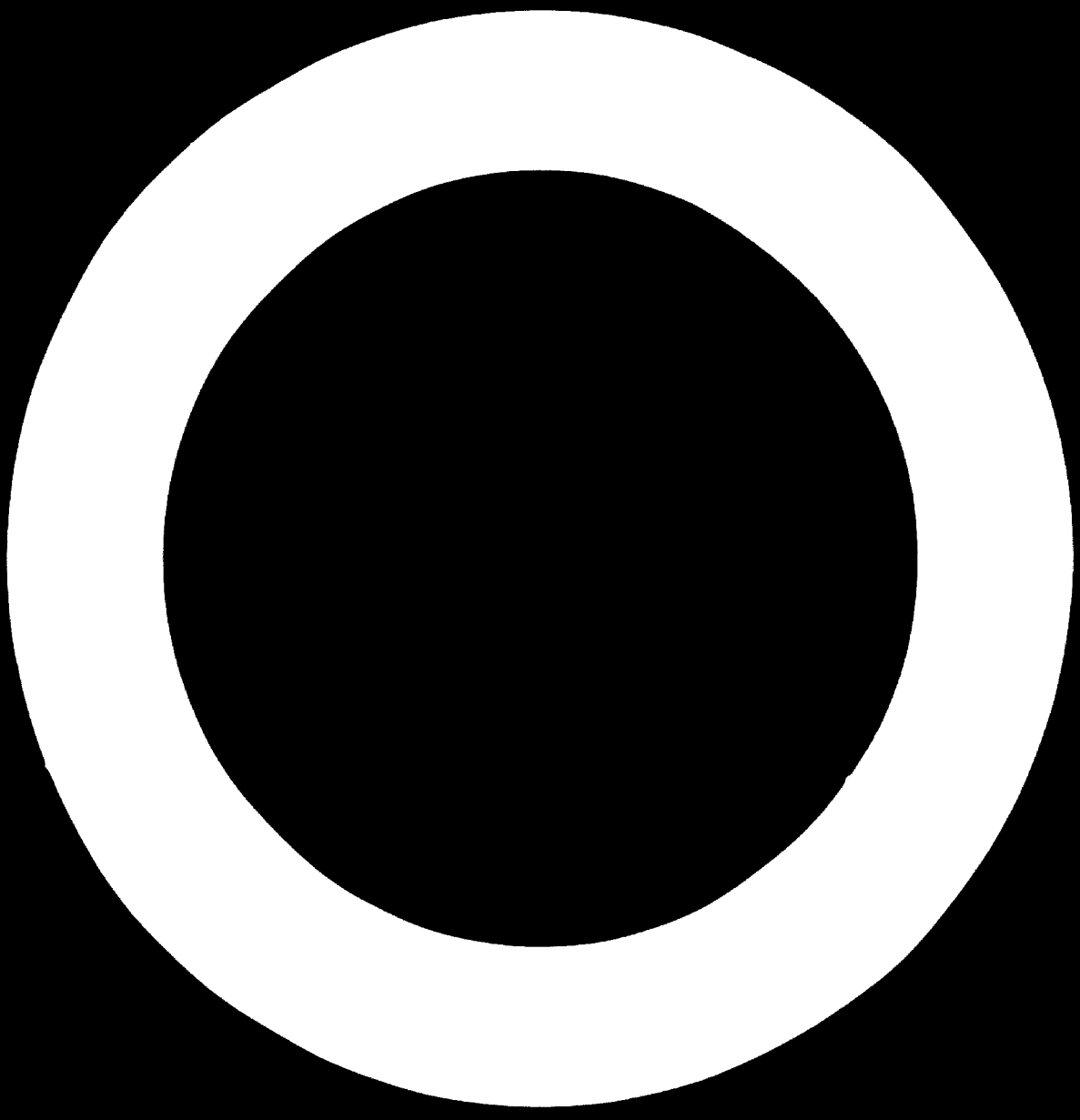


I.INTRODUCTION

Summary of official arrangements

This Special Industrial Services project, which was approved 13 November 1975, initially had the purpose of improving the production of coated paper at the Gara Belovo paper mill in Bulgaria. However, when the UNIDO expert, Robert I. Yin, a speciality paper technologist, arrived there at the end of May 1975 to begin work on the project, he found that the new multi-ply paperboard mill at Nikopol was having more problems and thus required more assistance than the establsihed Belovo mill.

Since it was the wish of the Bulgarian authorities to transfer the work to Nikopol, UNIDO approved the amended project 26 June 1975, and the expert spent his three-month assignment at Nikopol, returning for debriefing on 18 August 1975. The project budget was $7,500.

Project background

The paperboard machine at the Nikopol mill is the first multi-ply machine in Bulgaria. About 40% of the projected production is clay-coated paperboard. Until the start-up of this mill, all paperboard, coated and non-coated, was imported. With the designed capacity of about 55,000 tons per year for this mill, the impact on the import-export trade balance should be significant.

The main problem that needed solving was the excessive curl in the coated board - so bad that it could not be sheeted or printed. This report explains how the expert attacked this and other problems and sets forth his recommendations for their solution.

Main objectives of the project

The main objectives of the project were these:

(a) To improve the quality of the non-coated paperboard and to produce an acceptable grade of clay-coated paperboard using the existing equipment, through experiments and trials;

(b) To relate the qualities of the products to the converting and printing requirements. The main quality problems were curl, surface smoothness and plybond;

(c) To identify and recommend future requirements in technical skills and processes.

I. FINDINGS: EVENTS AND RESULTS

After many preliminary discussions with the technical staffs of both the Institute of Pulp and Paper in Sophia and the Nikopol mill on current technical problems related to paperboard manufacturing and coating processes, and after a brief two-day visit to the Nikopol mill, it was clear that the following problems were the major ones to be faced:

Curling of coated board

Insufficient smoothness of both coated and non-coated board

Inadequate plybond and blistering tendency

The upcurl (curling towards the coated side) was so serious that the board could not be sheeted, let alone be printed. The problem existed whether the board was coated at one or both coating stations.

There was a size press on the board machine, but it had not been used to any extent and had not been used to control the curl. There was no water box on the machine calender. An experiment (see experiment 2) was designed to use the size press to control the curl by applying more starch on the back side than to the top side of the board in the following manner: the back side of the web would enter the size press at a larger angle than the top side so that the back side would pick up more sizing to impart permanent downcurl. Then the coated board would be rewound with the coated side out for temporary curl control so that the board could be sheeted.

In this experiment the following related parameters and operations were also studied:

Roll-core diameter

Drying capacity and control

Improvisation of a decurler to control the machine-direction curl

Use of smaller diameter turning rolls to control the machine-direction curl

Cross-machine stress variations of board

Effect of water spray on the back side

Operating conditions of the brush-glazing station

Effect of wrapping pallets with polyethylene film

Inherent fibre tensions of top and back sides

Coating weight

Coating formulation

The board made in this experiment was tested at the Institute of Pulp and Paper in Sophia, printed on the sheet-fed offset presses at Pavlikeni and Sliven, perforated to forms and glued on the high-speed straight-line gluer.

From the results of this limited experiment, it was concluded that the use of the size press and the procedure of winding with the coated side outside were the most desirable ones. The influence of the other parameters investigated was considered minor, although their trends were noted (see report of experiment 2) and will be used to optimize the operation of the total process. The coated sides of the coated board were considered by the printers to be equivalent to that of imported board.

The problem of the insufficient surface smoothness appeared to have more than one cause. First, the configuration of the board machine was such that the Yankee drier was located about one third of the way towards the wet end. Thus, there might not have been enough drying capacity before the Yankee drier to dry the board for proper glazing on the Yankee cylinder. Then, the three-roll calender may not have been able to finish the surface of the board properly, even when it was operating at the maximum designed load of 40 kp/cm (see report of experiment 3). Furthermore, the configuration did not include any surface-levelling equipment, such as a calender, to finish the coated-board surface. Another cause for the rough surface of the board was the poor formation of the top liner, the use of the regular filler as the under liner and the inadequate cleaning of both the tip and the under liners.

With these situations and the concept of trying to use the existing equipment to its best of its potential in mind, the following operations were emphasized in the trials:

Use of the Yankee cylinder as the glazing cylinder

Optimization of the three-roll calender operation

Use of size-press sizing to improve the coating hold-out, i.e., to reduce the soaking-in of the coating to improve the filling of the valleys by the coating

Operation of the metering-bar coater at the highest solid content possible to fill the valleys properly

In connection with the last item it was noted that installing a back-up roll seemed to help reduce the contour-coating effect of this coater and thus minimize the causes of the uneven coating due to such raw-stock defects as board wrinkles and wet streaks. It was noted in experiment 2 that the brush-blade appeared to increase the upcurl. (It also improved the surface smoothness slightly.) Thus, it was concluded that only a moderate amount of brushing could be recommended.

Another conclusion from experiment 2 was that the water spray would not affect the curl and the smoothness of the board to any great extent on this particular system. However, the actual effects of the water spray should be further established through further experiments.

It is general knowledge that variation in the moisture content of coated board can cause problems (such as curl) in printing. Therefore, a moisture tester should be used in the coating operation, particularly during each machine start-up and, say, every shift thereafter, to avoid overdrying of the coated board. Further, softer coating formulations should be explored.

Since printers desire a flat or down-curled board, but the natural tendency of clay-coated board is towards an upcurl, more than one downcurl variable would probably be required to compensate eventually the upcurl tendency.

During the project, the printers never complained of board delamination, nor was there any serious ply-delamination detected by the test of bending the board by hand. Since there was no plybond tester available, the production of board was not tested with an instrument.

As for the blistering tendency (delamination of the board at press speed), the only tested observation was on sample 2 of experiment 3, which had a much higher blistering tendency than sample 3. However, that sample did not blister on the offset presses when low-tack ink was used. If a higher-tack ink were used on the press, it might cause the board to blister.

There are too many possible causes of blistering and plybond problems to list here. A copy of "Cylinder Machine Operating Difficulties" was presented to the Institute of Pulp and Paper for distribution. This booklet contains a useful list of trouble-shooting hints concerning these problems.

Testing instruments for the tests of both the plybond (such as the Muller plybond tester) and the blistering (such as the Institut voor Grafische Techniek

(IGT) tester with Westvaco attachment, using the cross-machine-direction board samples, with a low-tack ink of, say No. 4) can be highly recommended for the Nikopol mill, as well as for the Institute of Pulp and Paper.

Since the mill did not have a spare calender roll, it was not possible to experiment on calender pressure higher than the current designed pressure in order to see whether that would increase the board smoothness. A spare calender roll would be required for the normal operation, as well as for this experiment.

A subsequent group of experiments were designed and discussed in detail with all personnel concerned. The first of these was a production run with the size press at its position for maximum back-side sizing and an extended coating run to include all the applicable recommmendations. That would also include the maximum use of the upper and lower driers for the downcurl on the board machine.

The trial was scheduled to take place during the last two days of the expert's stay at Nikopol. Unfortunately, when the trial was begun, the sectional speed controls of the board machine broke down, and it was not possible to continue the trial.

Regarding various board-quality problems, including the problems discussed in this section of the report, further extended studies on the paperboard machine and the coating system would be required to enable the staff of the Nikopol mill and the Institute of Pulp and Paper to establish the complex parameters of this particular process system. Close working relations between the Nikopol mill and the converters and printers would also be important.

II. RECOMMENDATIONS

The Nikopol mill is a new mill located in a relatively isolated farming community where skilled workers are scarce and the living conditions are not totally attractive to technical staff and skilled workers. Paperboard manufacturing is new to this country; therefore, more time and effort are required to establish its technology. The paperboard machine and coaters are new and, like every individual paperboard machine, require systematic analysis and experiments to establish the parameters for its proper operation. The formers on this machine are the first of their kind and thus require additional studies to optimize their operation and understand their limitations.

The potential of this mill and its paperboard machine has yet to be explored, even though it is sufficiently fulfilling the present consumption requirement in the country. With some effort, great improvements in both the quality and the capacity of this mill could be realized.

With the above background in mind, the primary recommendations would be to build up a stronger technical staff and to improve further the operation and maintenance crews by the following actions:

(a) Creating attractive living and working conditions;

(b) Recruiting leaders who can motivate the crews and staff;

(c) Engaging specialists in board manufacturing technology to train the staff and crews in a systematic way. The training skills of these personnel would be the prime prerequisite. The technical staff from the Institute of Pulp and Paper in Sophia is certainly one of the main sources from which to recruit such talent. UNIDO would certainly be another possible source. The length of such an assignment should be at least six months;

(d) Training of key personnel abroad, provided they would agree to work at Nikopol after their training.

Generally speaking, the present equipment is adequate if operated properly and should meet the current market needs. However, considering future requirements, means must be found to:

Improve product quality

Make operation easier

Increase production capacity

Economize the processes

In the long term, on-machine coaters could be installed directly after the glazing Yankee cylinder. Depending on market requirements, a gloss calender or brush-glazing station would be optional. At that time, the Yankee drier could probably be moved further towards the dry end in order to increase the drying capacity of the machine and thus increase the production rate. The reason is that the board would be almost completely dried after the Yankee, say to 5% moisture, and thus only a limited number of cylinder driers would be needed after the Yankee drier. The exact requirements of the machine could be established after the present Yankee drier is used for glazing.

The change of the three-roll calender to four-roll or five-roll would provide additonal surface-smoothing capacity. To increase the flexibility of the machine, water boxes could be installed on the calender at very little additional cost; these would provide an additional facility to apply starch to the back side for curl control whenever needed. The present off-machine coater could then be used for speciality-grade coating. The addition of lamination facilities to the off-machine coater would increase the variety of specialities for this mill.

Other long term recommendations are as follows:

(a) Installation of a shrink-wrapping system for pallets would minimise the curl problem and would reduce transportation losses and damages;

(b) Change of the rewind-core size from the current core diameter of about 70 mm to, say, 250 mm diameter would probably reduce the curling and blistering problems;

(c) Change of the magnetic-tape metering-bar holder to a plastic-clip-type holder should greatly reduce the tendency for the bar to come off the holder and thus improve operation.

The immediate and short-term recommendations are numerous. Many have already been adopted by the Nikopol mill, and some are included in the following experiment reports. See annex I for a brief listing of these recommendations.

Annex I

SHORT-TERM RECOMMENDATIONS

The short-term and immediate recommendations were usually discussed and implemented on the spot. For reference purposes, they are given in the following list:

(a) As long as there is enough pulping capacity, the hole diameter of the pulper plates can be reduced for better screening efficiency;

(b) Continuous type of pulpers should usually be operated without stoppage, except for cleaning;

(c) All stock-cleaning equipment should be operated and used properly for the maximum cleaning of the stock, so as to minimize surface defects of the board caused by impurities in the fibre furnishes. Since, in future, seconda fibres will not be so clean as they are today, development of the technology and installation of stock-cleaning equipment should be emphasized;

(d) Extensive studies should be made of the operational parameters of the stock-cleaning equipment;

(e) The Yankee cylinder should be used as a glazing cylinder in order to produce a smooth board surface. The operation of this equipment requires special skills and persistent attention. The surface of the cylinder must be kept very smooth for the board to be "casted". Much practice will be needed to make it a success;

(f) The size-press formula could be pigmented to improve the pre-coating effect. The solid content of the starch must be tested regularly and the use of a polarimeter is recommended;

(g) The calender could be optimised to improve the smoothing effect. A calender roll of higher crown operating at about twice the current designed pressure should be tried;

(h) The stock furnish, such as the types of fibres used, brightness of fibres required, availability and costs of fibres etc., could be optimised through careful control and better understanding of what would be required;

(i) Increased beating of the current long-fibre top-liner stock would likely improve formation. To maintain the same freeness, the refining should be proportionally reduced;

(j) The use of the upper and lower driers to control maximum down curl is recommended;

(k) The formation of the Fourdrinier top liner must be as good as possible, because it has the greatest and most direct effect on the surface smoothness of the board. Research should be undertaken on the settings of variables, such as stock-to-wire velocity ratios, shake stroke-length and velocity, headbox lip opening and its position, speed and rotation direction of the distribution rolls, headbox consistency etc.;

(l) Installation of a water box for starch on the back side would increase the curl control facilities;

(m) Wider deckle edges would help the coating and sheeting operation; it is therefore recommended not to trim the edges on the winder when winding the coating raw stock;

(n) The coating system could be optimized through careful establishment of variables and their effects as follows:

(i) Maximize the metering-bar coat-weight in order to pre-coat the board properly and fill the valleys of the board through high solid coating, effective metering of the coating etc.;

(ii) Improve the control of the flow rate of the metering-bar cleaning water, as by installing a needle valve with a flow meter or a headbox with the overflow;

(iii) Optimise the air-knife coating operation for a levelling effect;

(iv) Optimise coating formulations through experiments with various raw materials, such as Bulgarian clay, latex, additives;

(v) Identify the brush-glassing effects and the glassing requirements needed on the market;

(vi) Experiment on the water spray system and install felts to prevent water dripping caused by the water spray mist;

Many consultations and discussions were held with individuals and groups at the Nikopol mill and the Institute of Pulp and Paper. A few of the subjects discussed are listed below for reference:

Fungicide coating for grape packaging

Silicone coating

Rust-inhibiting coating

Curling of paperboard

Fibre microscopy and photo-micrography

Stock preparation for paperboard

Printing requirements for coated board

Economic feasibility studies and organisations

Annex II

EXPERIMENT 1. PRELIMINARY INVESTIGATIONS ON NIKOPOL COATING RAW STOCK WITH HIGHER CALENDER PRESSURE

The experiment was intended to acquire a better understanding of the general physical properties of the coating raw stock and the surface smoothness immediately obtainable with a higher calender pressure. The results showed that the surface smoothness of the board could not be improved significantly with the existing rolls. There was no spare calender roll which could be ground to a thinner crown in order to explore a higher calender pressure range.

It is necessary to explain here that in this mill there is only a four-brush glazing system after the coating stations for the finishing of the coated board, and there is no calendering or other surface smoothing equipment. Therefore, the surface of the raw stock must be exceptionally smooth. With that in mind, use of the existing Yankee cylinder as a glazing (smoothing) cylinder appears to be essential, and certainly it should be further complemented by optimising other machine conditions, such as the machine calendering conditions and sheet moisture.

Table 1. Test data of experiment 1

Parameter or test / Experimental set / CMD[b] position	Set No. 98, 7 June 1975 (normal production) Calendar pressure 5 kg/cm^2				Set of 6 June 1975 Calender pressure 20 - 22 kg/cm^2 [a]			
	Front	Front-middle	Drive-middle	Drive	Front	Front-middle	Drive-middle	Drive
Board								
Basis weight (g/m^2)	296	296	302	293	291	299	301	300
Caliper (mm)	0.43	0.42	0.43	0.40	0.44	0.47	0.48	0.41
Density (g/cm^2)[c]	0.68	0.71	0.71	0.73	0.66	0.64	0.62	0.74
Smoothness, Bendtsen (ml/min)	440	699	575	414	413	940	758	344
Smoothness, Bekk (sec)	13.6	8.6	10.4	14.5	14.5	6.4	7.9	17.4
Liners	Basis weight (gm/m^2)							
Top	72	75	67	66	63	69	62	61
Under	97	93	101	95	100	98	105	105
Filler I	42	46	46	46	48	48	48	49
Filler II	47	47	49	48	47	47	48	48
Bottom	36	35	39	37	39	38	38	37
Total	294	296	302	292	297	300	301	300

a/ Calender load was beyond designed crown adjustment; therefore, the edges were much more heavily loaded than the centre.

b/ CMD = cross-machine direction.

c/ The higher density of set No. 98 was traced to the inherent higher density of the neutral sulfite semichemical bottom liner of this set. The experimental set was a news backboard.

Annex III

EXPERIMENT 3. CURL-CONTROL TRIALS OF NIKOPOL COATED BOARD

The purpose of this experiment was to determine the major factors influencing the curl of Nikopol board.

The results showed that the curl could probably be controlled by both (a) proper use of the size press and (b) rewinding of the board with the coated side out.

The experimental parameters and operations included in the investigation were:

Size-press operation

Amount of starch applied

Angle of web entering the size press

Solids content of the starch

Clay coating

Coat weights

Coating methods

Air-knife

Metering-bar

Brush-glazing operation

Back side dampening with water sprays

Rewinding the board with the coated side out

Dryer controls to minimize overdrying

Core diameter of rewind rolls

Three types of raw stock, labelled I, II and III, were prepared for this trial, as follows:

I. The control board, which did not have any size-press treatment;

II. The board with size-press treatment on the back side only. Substantial water was accidentally pumped into the starch line and the solids content of the starch solution was reduced from 10% to 1-2%;

III. The board with the size-press treatment on both sides with the angle at 70% of the total maximum adjustment providing a larger amount of sizing on the back side. The starch solids content was 4% instead of the 10% as prepared because some water entered the line.

The raw stocks were:

(a) Coated at only one station or at both;

(b) Run with and without waterspray on the back side;

(c) Run with and without the glazing station;

(d) Rewound with coated side inside and outside.

Each test board was identified and sheeted into pallets and shipped to the printers at Pavlikeni and Svoge for trials on the sheet-fed offset presses, then cut to forms and glued on the high-speed straight-line gluer.

The following comments refer to the test results:

(a) All the coated board exhibited an upcurl even though the raw stock, especially III, showed a definite downcurl. Coated board made from I and II could not be fed through the printing presses readily because of the curl. Although the coated board made from III had less upcurl, still less upcurl would have been needed for good press feeding; board with a slight downcurl or flat would have been preferred;

(b) There was no gluing problem with the polyvinyl-acetate-based adhesive currently used;

(c) Although the Bekk smoothness readings of some samples were within the Bulgarian standard of over 60 sec, it was judged to be marginal, if not inadequate, when observed at the printers' operations, where very high press pressure was required;

(d) Although the blistering tendency of the samples made from II was very high, they did not blister on the presses, probably because of the low-viscosity ink being used. Here it was noticed that some examples of boards had a definite blistering tendency. For the detection of such a blistering tendency, an IGT tester with Westvaco attachment is recommended for use at the test station of the board machine.

During the trial, several adjustments on the coating system were made:

(a) The application roll of the metering-bar coater was reversed in rotation for a cleaner operation;

(b) The baffle plate used for the protection of the metering-bar holder was lowered to facilitate the proper flowing of the metered coating;

(c) Some general improvements and adjustments were made on the air-knife coating station:

(i) Cleaner edge-wipe operation was obtained;

(ii) "Diverting strips" for the air on the air-knife were installed to prevent the blowing of the coating to the back side of the board and thus keep the deckle areas of the back-up roll clean;

(iii) Applicator-roll speed and wrap were optimized;

(d) The drying sequence and the drying temperature of each drying section were adjusted to avoid overdrying. It was estimated that only about one fifth of the total drying capacity was required to dry the coating weight of about 25 g/m² at 80 m/min machine speed;

(e) The coating formulation of the metering-bar coating was redesigned to a higher solid formula in order to provide an improved metering-bar pre-coat and thus a smoother finished sheet. Board II was run with a lower coating solid than III. The results seemed to support the theory given above, hence, it would be advantageous to run the metering bar at the highest solid content possible;

(f) The total coat weight achieved in this experiment was about 16 g/m², which was considered quite low. A total coat weight of 22-25 g/m² would be the recommended target, in view of the insufficient surface smoothness of the raw stock. The recommended target coat weight of the metering bar would be 8 g/m²;

Further actions to be taken are these:

(a) Make a longer raw-stock trial with the following conditions:

8-10% starch solution on the size press
Maximum adjustable size-press angle
Machine cylinder driers adjusted for a reasonable downcurl
Optimum calendering
Well-adjusted formation on the top and under liners
Yankee cylinder running as a glasing cylinder

(b) Conduct a longer coating trial with the high-solids metering-bar coating formula and, optionally, with Bulgarian clay in this section;

(c) Try using lower brightness but cleaner furnishes for the top and under liners;

(d) Conduct careful printing trials in the presence of an experienced ink maker, who would be able to modify and re-design the inks to optimize the printing of this board;

(e) Install an adjustable-height funnel with overflow for the metering-bar cleaning water so that the metering bar can be kept lubricated and clean;

(f) Install a back-up roll for the metering bar to keep the board more evenly on the metering bar. This roll should have about a 10-mm offset from the metering bar and a diameter of at least 200 mm. With the installation of this back-up roll, a higher solids coating formulation would then be recommended.

Table 2. Summary of test data of experimental

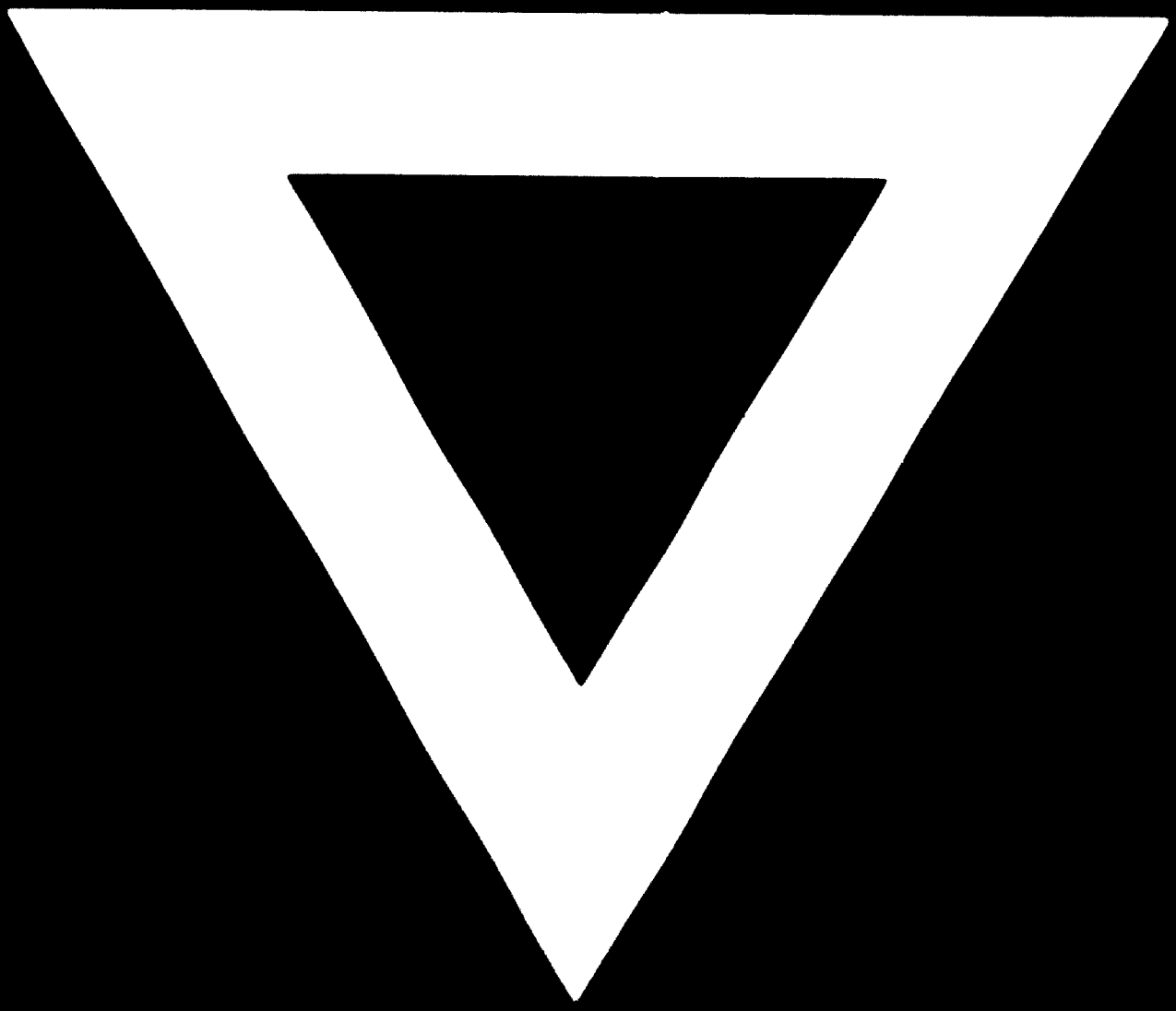
Parameter or test \ Sample number	I (control)	I_1	I_4	II_4	II	III (control)	III_1	III_4	III_7	III_{10}	III_{13}	III_{16}
Metering bar plus air-knife?	Neither	Bar only	Yes	Yes	Yes	Neither	Yes	Yes	Yes	Yes	Yes	Yes
Sheeter position[a]	2	1	2	2	2	2	1	2	3	1	2	3
Water spray, back side?	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	No
Brush-glazing?	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	No	Yes
Curl (mm)[b]	110	-	-	90	120	-15	70	50	60	60	10	90
Coat weight (g/m^2)	-	5	20	15	-	-	16	16.5	-	-	-	-
Coated side												
Smoothness, Bekk (sec)	8	-	34	50	56	11	66	67	45	74	30	43
Brightness (%)	71.2	72.8	79.6	79.7	79.6	76.0	76.1	76.2	76.2	76.1	76.5	76.9
IGT pick[c]	-	-	No	No	No	No	No	No	-	-	-	No
IGT blister[c] (cm/sec)	-	-	<5	180	200	No	No	No	-	-	-	No
IGT print smooth[d]	-	-	10	10	10	>20	8	-	-	-	-	8
Back side												
Starch (iodine test)?	No	No	No	Trace	Trace	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Water drop test (sec)	23	-	25	20	-	46	37	51	48	47	-	-
Smoothness, Bekk (sec)	-	-	-	7	-	9	-	11	-	7	-	-
Smoothness, Bendtsen (ml/min)	-	-	-	850	-	650	-	520	-	840	-	-

a/ 1 = tender side, 2 = centre, 3 = drive side.

b/ Total of four corners of a 250 x 250-mm sheet, conditioned.

c/ Machine-direction, M = 35 kg, using a press ink.

d/ Estimated, using a press ink, M = 30 kg.



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