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PRODUCTION OF FOAM PLASTICS FILMS

DP/POL/75/007

POLAND

TERMINAL REPORT

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

United Nations Industrial Development Organization

Id. 76-6730

United Nations Development Programme

PRODUCTION OF FOAM PLASTICS FILMS

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TERMINAL REPORT

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

Based on the work of K.E. Andrews, expert in production of foam plastic films

United Nations Industrial Development Organization
Vienna, 1976

Explanatory notes

References to dollars ($) are to United States dollars, unless otherwise stated.

A full stop (.) is used to indicate decimals.

A comma (,) is used to distinguish thousands and millions.

References to tons are to metric tons, unless otherwise specified.

The following abbreviations of organizations are used in this publication:

PRDC Packaging Research and Development Centre

SCME State Council of Materials Economy

UNDP United Nations Development Programme

The following technical abbreviations are used in this publication:

EPS expanded polystyrene

hp horse-power

PVC polyvinyl chloride

Symbols of United Nations documents are composed of capital letters combined with figures, e.g. ST/ECS/157. Mention of such a symbol indicates a reference to a United Nations document.

ABSTRACT

The project "Production of Foam Plastics Films" (DP/POL/75/007) was a continuation of an earlier project "Extension of the Polish Packaging Centre" (DP/POL/71/517).[1/]

The prime purpose of the project was to assist in the start-up of the expanded polystyrene process for the manufacture of trays at the demonstration plant at Białystok. Considerable help was given in this activity but delays in the start of the machinery did to an extent reduce the effectiveness of the visit in this context and a recommendation for further assistance has been made.

The waste-recovery plant is not adequate for the job and specific programmes are recommended for:

(a) Process improvement to increase the tray output per ton;

(b) A study of the thermoforming method to reduce the level of waste arisings;

(c) Additional waste-processing equipment.

Recommendations have been made in each of these areas together with an outline of the waste-recovery equipment, its costs and the basis of justification. If this particular recommendation is accepted in principle, a more detailed study will need to be made.

Because the equipment was not ready, the initial two weeks were spent in discussing a wide variety of problems associated with the plant. The most important realization was that the personnel of the plant now need to learn the skills of production problem analysis. This problem has wider implications in the context of the Polish packaging industry and presents a unique opportunity for exchange of information within the industry as a whole. This subject has been dealt with in detail and special recommendations have been made for the joint consideration of the Polish authorities and UNIDO.

1/ For terminal report see DP/ID/SER.B/48.

CONTENTS

INTRODUCTION

The project "Production of Foam Plastics Films" (DP/POL/75/007) was a continuation of an earlier project "Extension of the Polish Packaging Centre" (DP/POL/71/517).[2/] The project was approved by United Nations Development Programme (UNDP) in July 1975. The State Council for the Materials Economy was designated as the co-operating agency of the Government and the United Nations Industrial Development Organization (UNIDO) as the executing agency.

The work was originally planned to begin in the first quarter of 1975 and was postponed twice due to delays in the building and installation programme. The actual start date of the project was the 30 September 1976 at Warsaw. After initial briefing and discussion at the Packaging Research and Development Centre the expert's work began at Białystok on 4 October, continuing till 22 November when discussion resumed at Warsaw. The expert was briefed and debriefed at UNIDO headquarters at Vienna before the start of the project and after its completion.

For the period of the assignment the expert was attached to the State Council of Materials Economy (SCME) and his counterpart at the Białystok demonstration plant was Mr. T. Zegarski.

The primary objective of the project was to provide assistance in expanded polystyrene technology to the packaging development plant located at Białystok in Eastern Poland. On arrival some problems were being encountered which resulted in a two-week delay before a start could be made on the core of the work. Because of the expert's wider experience in the general field of packaging this time was adequately occupied in discussion and supervision of some direct experimental work on a variety of other problems.

A general outline of the complete activities at Białystok is therefore appropriate especially since the additional work with which the expert was concerned served to provide a much closer understanding of the whole operation than might otherwise have been possible. It also served to highlight some of the more fundamental problem areas where assistance could be provided in the next phase of development of the demonstration plant and perhaps in the Polish packaging industry as a whole.

These problems and some of the possible solutions are discussed in depth in the body of the report, but it should be understood that it is the very vitality and enthusiasm of the staff coupled with rapid growth which is creating

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2/ For terminal report see DP/ID/SER.B/48.

the problems rather than any weakness on the part of management or staff. Properly harnessed this enthusiasm will form an excellent base from which to carry the operation through the next phase of expansion.

The site at Białystok comprises in total some 100,000 m^2 of which somewhat less than half is now covered by buildings. It is situated in an area of intensive industrial development with attendant shortages of skilled labour. The work was started in November 1972 and the main objectives of phase I of the plan were three-fold:

(a) The provision of a training school to provide educational facilities for technologists and training for operators;

(b) The setting up of a research and development team to cover some of the practical aspects of packaging technology;

(c) The setting up of a full scale production operation in four areas of packaging.

The completion date for this phase was set for mid 1976 and the major part of the objectives have been achieved. Certainly by the early part of 1977 the plant and staff will be in a good position to proceed. It says much for the skill and tenacity of the directors to have achieved so much in so little time under difficult local conditions.

The expert would like to lay stress at this early stage on the importance of a continuing growth plan; any delay could adversely affect the impetus which has already been built up.

The operations at Białystok break down as follows:

1. Manufacturing

(a) A full-scale polyethylene film-blowing, printing and bag making unit;

(b) A cup-forming and printing unit;

(c) A unit for the manufacture of steam-moulded expanded polystyrene packages;

(d) A unit for the manufacture of consumer trays for meat and produce packaging and similar products.

2. Research and development

(a) Units for research and development concerned with the manufacturing operation;

(b) A small pilot plant with equipment for some experimental thermoforming and shrink wrapping.

3. A training centre

(a) Concerned with the training of technologists;

(b) Concerned with the training of operatives.

The whole comprises approximately 430 people of which 130 are directly engaged with the production activity. A brief organization chart is appended covering the sections with which the expert was concerned and in which discussions took place.

I. FINDINGS

A. General packaging topics at Bialystok

During the first two weeks a wide range of topics were discussed and it is not necessary to deal with each one "in depth". It is therefore proposed merely to list the subjects to illustrate their breadth and to discuss one particular problem insofar as it points to an area where future assistance could be of value.

Topics discussed

(a) Bag-manufacturing machines as affected by polymer properties, the heat capacity of the sealing bar, the sealing bar temperature distribution and the tension of the "take off" tapes;

(b) "Sett off" on printed bags after storage at the users' factories;

(c) Variation in test results between different methods of tensile testing;

(d) A preliminary discussion of the condux machine as a vehicle for the recovery of expanded polystyrene scrap;

(e) The general subject of print quality, the manufacture of rubber stereos and the importance of the control of viscosity on flexographic machines;

(f) The use of alternative types of printing plates on the cup machines;

(g) The design of feed channels in the manufacture of small expanded polystyrene articles by steam moulding;

(h) Regranulation of polyethylene scrap, its control and test methods with particular emphasis on shim testing;

(i) The use of alternative materials to polyvinyl chloride (PVC) for cup manufacture, especially high impact polystyrene and polypropylene, with particular emphasis on the status of legislation in developed countries concerning contact of these materials with foodstuffs;

(j) The advantages and disadvantages of flexographic versus gravure printing on polyethylene film;

(k) The printing and cutting of thin expanded polystyrene sheet for use as tray and place mats;

(l) The methodology of preparing test programmes for examination of alternative raw materials;

(m) The measurement of reversion and its implications in deep thermoforming;

(n) Tool modification in cup moulds with reference to changing the distribution of material in the formed cup;

(o) Methods of testing the efficacy of levels of treatment on polyethylene film surfaces;

(p) Normal levels of waste in the production of polyethylene film, printing and bag making;

(q) Cleaning procedure for water channels in thermoforming machines and problems of water treatment;

(r) The best materials for the manufacture of cutting rings in cup-forming and cutting tools;

(s) Anti-pinhole lacquers in the printing of polyethylene films.

Bag-making machines

The problems associated with the bag-making machines were discussed at length and some detailed experimental work was initiated to determine the real source of the problem. During high speed operation the bag fails to transfer satisfactorily from the sealing station to the "take off" tapes resulting in machine stoppage. Measurements of the temperature of the heat-sealing bar were made and some cine-film taken of the machine in operation.

The most important point which arises from this exercise is not the problem itself but its underlying implications. It highlights in what way assistance can be provided during the next phase of expansion of the demonstration plant at Białystok and perhaps to the Polish packaging industry in the broader sense.

Problem analysis

"Trouble shooting" and analysis of machine problems require different techniques from normal research and development, and in the two centres which the expert visited no facility or experience exists for training in this important area. The expert has been unable to assess the degree to which this type of experience exists in the Polish packaging industry as a whole, but it appears important that such an assessment should be made. The growth of this experience will occur naturally, but it will be slow unless positive action is taken to speed up the process. The existance of the demonstration plant at Białystok provides unique opportunity for the development of these skills on a planned basis.

A recommended course of action would be that the United Nations and Polish authorities jointly consider the following:

(a) A survey of the Polish packaging industry to identify the level to which these "trouble shooting" and production problem analysis skills already exist and at the same time make an audit of facilities for training and interchange of this knowledge;

(b) Provide expert assistance to the directorate at Bialystok to extend the framework of the training facility to include seminars, courses and training sessions in production problem analysis and "trouble shooting".

It is estimated that each part of the programme would require about four months with a gap of 4-6 months between the two halves of the programme. An outline job description has been prepared and is given in annex II.

B. Expanded polystyrene plant at Bialystok

It is necessary to give a brief description and make some comment on the equipment as it relates to one vital problem which is already apparent to the staff at Bialystok and will be difficult to solve quickly.

Equipment

The equipment which has been purchased and installed for the production of expanded polystyrene foil and trays comprise a Reifenhäuser single screw foam manufacturing line; a thermoforming machine; and a condux mill for the recovery of scrap which doubles for the reprocessing of polyethylene scrap and has been in use for the latter purpose for some time.

The first two pieces of equipment are suited to the objectives and will give no more problems than are normal with this sophisticated and technically difficult process. The only comment that the expert wishes to make concerns the automatic feed for the neucleants (collotronic). The expert's experience of these installations suggests they are unreliable and simpler premixing of polymer and neucleants give rise to less trouble. Some problems have already been encountered with this part of the installation. If they prove to be recurrent there are ample facilities within the plant to design and manufacture a simple mixing rig. Detailed mixing instructions were passed to the staff for use later if they are needed.

Waste recovery

The main problem lies in the recovery of the waste. All expanded polystyrene extrusion and thermoforming processes produce between 15%-30% of scrap, dependant on the process parameters. Good economies are not possible without total recovery of the waste material. In the expert's view the condux mill alone will not enable the scrap to be recovered effectively, because:

(a) Expanded polystyrene processes produce a high level of static and pick-up of dirt and dust is virtually impossible to eliminate;

(b) Contaminated materials disturb the balance of the extrusion process and if the level of dirt is very high it can cause frequent blockage of the die and serve to exacerbate the problem;

(c) The condux mill is a piece of equipment difficult to control and sometimes gives rise to thermal degradation;

(d) With the present process parameters, i.e. an output of 90 kg per hour from the extruder and a 25%-30% waste, the condux mill will barely process the scrap when the operation is on a 24-hour basis. It will leave little capacity for recovery of the polyethylene waste. (The present level is 38% but it will fall when the plant is in full production.)

Immediate action is necessary to overcome the problem. The steps that are possible and must be considered are as follows:

(a) Purchase a suitable waste-recovery extruder and ancilliary equipment;

(b) Seek alternative outlets for the waste;

(c) Make changes in the thermoforming process to reduce the level of arisings.

It is recommended that first a change should immediately be initiated to the thermoforming process. This would go a long way to ameliorating the problem and reduce the waste levels by 8%-12%. The steps that need to be taken to achieve the change are as follows:

(a) Design and manufacture a new forming drum for the extruder to slightly reduce the web width. Although this will marginally reduce the blow ratio it is probably not sufficient to be significant;

(b) Make changes to the thermoforming tool to eliminate the window waste;

(c) Manufacture a cutting platten with attached guillotine to be mounted in the present cutting station;

(d) Design and construct a collecting station at the end of the thermoforming machine.

These problems have been discussed with the construction department who had already initiated work along these lines. The design work is well within the competence of the staff and the workshop facilities are adequate to execute it.

The second recommendation is that every effort should be made to explore alternative outlets for the chopped waste. This type of material has been used on a limited scale for a variety of purposes amongst which are:

(a) For filling machine and instrument cases as a cushioning material;
(b) Insulation;
(c) As an additive to heavy soils and composts;
(d) For the manufacture of light weight concrete.

The first of these is the most extensive. A serious search should be made throughout the Polish packaging industry to see what outlets can be found.

In the long term the real solution is to install adequate recovery equipment to extrude and clean the waste. Unfortunately the most effective type of plant for this purpose is large and expensive and as there are no plans to extend the present EPS facility at Białystok for some years this type of equipment would be wrong at the present time.

The third recommendation, therefore, represents a compromise designed to deal with the present problem at the lowest cost and comprises the purchase of a small recovery extruder to be used in conjunction with the condux mill. The equipment required would be:

(a) A 60 mm vented extruder line with two screws, one for polyethylene and the other for polystyrene. (About 24/1 L.D. fitted with a 60 hp fixed speed motor and simple gear box speed change. Starve feeding would suffice for start up.);
(b) A screen changer;
(c) A strand die;
(d) A water bath and strand chopper.

This equipment could be used to process the output from the condux mill to a good clean pellet for reuse in the foam extruder. (Note, a discoloured product is always obtained but this is not detrimental to the finished foam.) It would also provide a facility for cleaning the polyethylene waste and probably produce an improvement in that process.

It is difficult to put a reliable estimate on the cost of the equipment without obtaining estimates, but an outside figure would be $30,000–$40,000. The strand die and water bath could be manufactured in the plant at Białystok to save foreign exchange.

Before leaving this subject it should be stressed that scrap recovery is the core of any expanded polystyrene extrusion and thermoforming process. If at any time the plant at Białystok is to be extended and further EPS extruders installed or if any other plant is built in Poland to operate this process the waste recovery plant should be given first consideration at the planning stage.

C. General topics on expanded polystyrene extrusion and thermoforming

The topics are listed and where specific recommendations were made these are referred to.

1. Theories of neucleation in expanded polystyrene (EPS) extruders and the effects of various changes in the extruder parameters were explained. Screw design, temperature control, die design and different methods of neucleation were covered. Some of the problems, which were discussed, were actually encountered during the visit. For example, build up of neucleants occurred in the feed section of the screw. The staff had been advised by the extruder manufacturer how to clear this but the expert was able to give recommendations on methods of reducing and overcoming the difficulty. A number of changes were made in the running procedures.

2. Methods of control of foil quality were discussed and a number of the staff were taught how to do cell dimension measurements.

3. The control of raw materials and their specifications were examined in depth. A specific recommendation was made to use cylinder cut pellets rather than face cut pellets as this reduces the build up of neucleants on the screw.

4. Details of different neucleant systems were given and a number of experimental runs were made to obtain better cell structures. Some improvements were achieved. The function of the automatic collotronic equipment for neucleant feed was discussed. This equipment is of a very new design and not in regular use elsewhere and during the period of the visit it showed evidence of unreliability. Detail procedures for alternative simple mixing were given in case the collotronic equipment proves to be inadequate. The plant would be well able to construct the necessary equipment.

5. Cell size and its effect on the quality of the finished product were discussed in depth. Comparisons were drawn between the density of foil used to manufacture trays in the Federal Republic of Germany and in the United Kingdom. By using finer cell structures it is possible to make trays from less dense material. In Poland any reduction in raw material consumption is important as the feedstock is imported. Some experiments were carried out to improve the structure of the material by running at lower output rates and

consequently lower melt temperatures. Very considerable changes were made in the running conditions and the foam density was reduced from 120 g/m^2 to 100 g/m^2 (at standard thickness). The weight of ten trays formed from the two materials were 90 g and 70.5 g respectively, a saving of approximately 20% in raw material usage. Further optimization of the process is necessary but the main guidelines were established. It is suggested that efforts should be made to maximize the tray output per ton of feedstock rather than the total output.

6. During one extruder run foaming at the die virtually disappeared. There can be many causes for this but in one particular set of circumstances this can result in serious damage to the extruder. If failure of freon injection occurs the pressure in the barrel and die can rise quickly. When foaming ceases, the die pressures must be checked and if they begin to rise the extruder must be stopped immediately. It is recommended that all extruder operators are made aware of this problem and are trained to deal with it.

7. Blockage of the injection point occurred and specific recommendations were made on how to deal with this problem.

8. Slight sticking was encountered on the drum caused by shrinking of the hot foam around the calibrating drum. This is a common problem and usually it is overcome by using a drum with an enlarged ring at the front. Photographs of such drums in operation were shown.

9. The economics of the process were discussed and the advantages of using minimal densities when dealing with high cost imported materials were explained.

10. The cutting and slitting of thin foils was discussed and some experiments were carried out. Recommendation of the best methods were made.

11. Detailed discussion took place on the theories of thermoforming foamed materials. Parameters to be used in the design of packages such as egg boxes and other more sophisticated packaging were considered in depth.

12. The design of screw nose cones was considered and some of the problems that can occur due to dead spots between the screw end and the rear of the spider were examined.

13. Detailed information was provided on the theories of laminar and plug flow through the narrow die of orifices that are used in EPS extrusion.

During the final week in Warsaw discussion took place on the subject of laminates. Topios, which were covered, were:

The type of material used for biscuit paokaging and ourrent trends

Quality control in laminating plants

The merits and demerits of extrusion versus solvent lamination in the Polish industry

Much stress was placed on future problems which could arise from atmospheric pollution in solvent lamination.

II. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

1. There is a need to extend the process of technical education in the next phase of expansion of the demonstration plant at Białystok to include formal training in the methods of production problem analysis.

2. There is also a need to reconsider the relationship between the various parts of the industry particularly in respect of the demonstration plant and the Packaging Research and Development Centre (PRDC) at Warsaw. A more direct connexion is required to create the conditions for closer co-operation and thus to maximize the effectiveness of the whole.

3. The PRDC could act as the focus for the interchange of information throughout the whole of the Polish packaging industry. It should be encouraged to set up the necessary mechanism to ensure that parochial boundaries within the industry are adequately bridged and the interchange of knowledge is maximized. For this purpose it will need access to the training school at Białystok.

4. Further training of the staff at Białystok in the technology of EPS extrusion and thermoforming would be beneficial when the teething problems of the equipment have been overcome. To some extent these problems reduced the effectiveness of the assignment.

5. The process used for the manufacture of EPS trays at the plant at Białystok can be changed to reduce the percentage of waste arising during thermoforming.

6. Considerable improvement in the process parameters is possible to reduce density and cell dimensions. A programme of experimental work was completed which demonstrated that 20% reduction in material use for trays can be achieved by careful study but much remains to be done in optimizing the process.

7. Further equipment is required at Białystok to effectively reprocess the waste from the EPS process. Such equipment would materially assist in the reprocessing of polyethylene waste.

8. The collotronic equipment for feeding neucleants is the first of its kind in production use and at present appears to be unreliable. It may well prove necessary to change to conventional mixing techniques.

B. Recommendations

1. It is suggested that the Polish authorities consider:

(a) A survey of the Polish packaging industry to identify the extent to which formal training in production problem analysis would materially assist in optimizing existing plant outputs;

(b) An audit of the training facilities in this special area of skill and the degree to which interchange of experience occurs;

(c) A request for expert assistance in making the surveys and analysis of the findings. (A provisional outline job description is given in annex II.)

2. A further visit to extend the training in EPS technology would be beneficial. It was agreed with the Polish authorities that a joint recommendation should be made to ask for further expert assistance for a period of two months in March/April 1977.

3. Assistance to provide the equipment for the processing of EPS scrap and thus enable the plant at Białystok to complete its objectives should be considered. Some indications from which an economic case could be prepared are given in annex III.

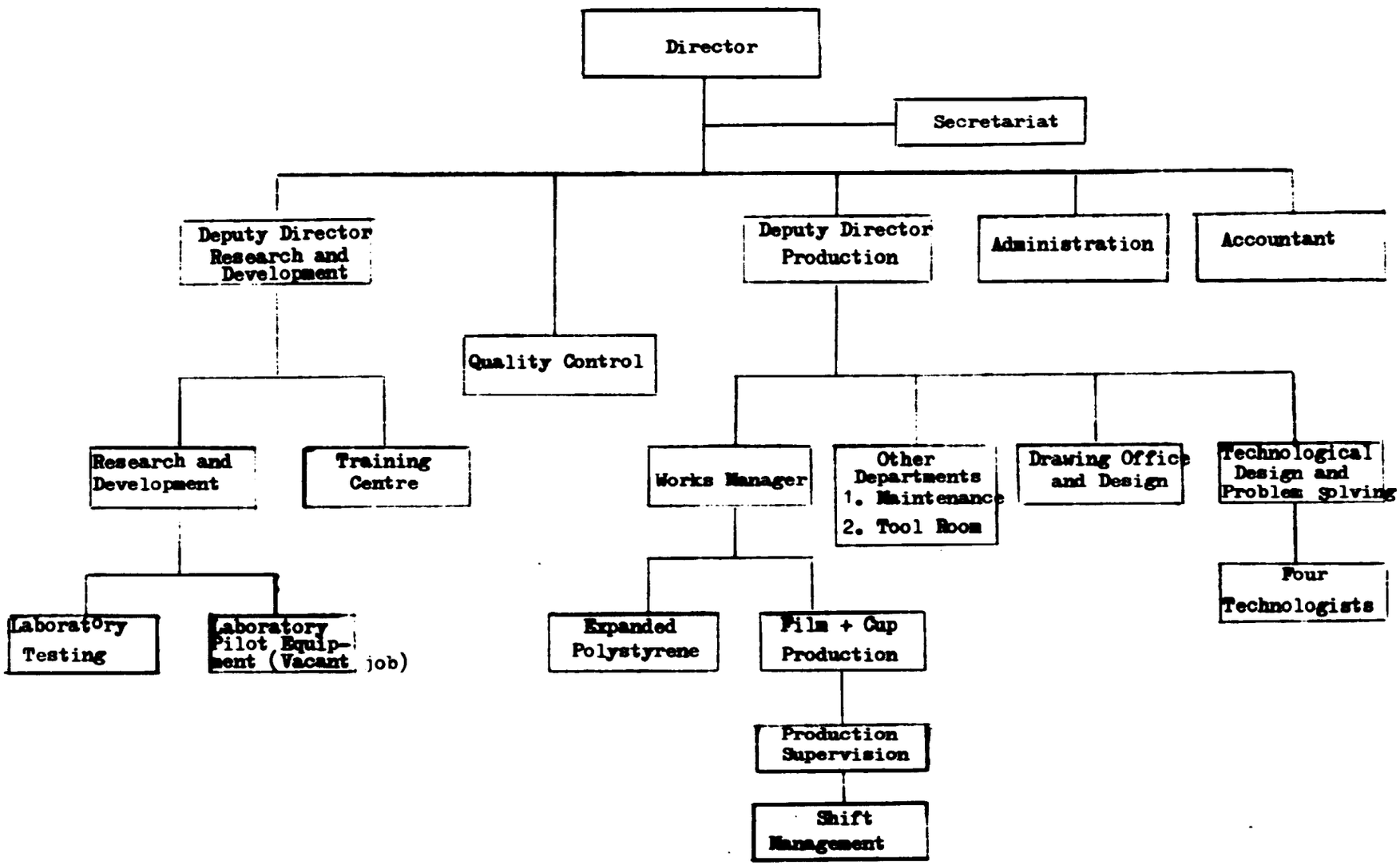
4. The directorate at Białystok should as a matter of urgency examine the thermoforming process and prepare a programme to change the method of cutting and thereby reduce the waste arising by 10%-12%.

5. The collotronic equipment should be replaced by simple mixing apparatus for a period of at least 6-9 months, until the staff of the plant have learnt to handle the process. It must be realized that the EPS extrusion process is complicated and although the staff dealing with it are of a high level of competence they have a lot to learn. The collotronic equipment is an additional unnecessary burden.

6. A programme of optimizing the tray output per ton of material should be pursued with the utmost vigour. The initial path has been outlined to the staff at Białystok but much remains to be done.

Annex I

ORGANIZATION CHART OF THE DEMONSTRATION PLANT



Annex II

DRAFT JOB DESCRIPTION

POST TITLE:	Expert in the techniques of analysis of production problems and factory trouble shooting with a packaging background
DURATION	Two periods of approximately four months each, with an estimated six months gap for discussion and planning as a result of recommendations made in the first period
DATE REQUIRED:	
DUTY STATION:	Białystok with travel to Warsaw and other packaging centres within the country
PURPOSE OF THE PROJECT:	1. To make an audit of the existing facilities within the Polish packaging industry for training technologists in the special skills required for analysis of factory problems as distinct from research and development. 2. To assist in co-ordinating available facilities to maximize the interchange of knowledge within the industry and in setting up such additional facilities as are required
DUTIES:	The expert would be attached to the State Council of Materials Economy and would co-operate with the Polish Packaging Research and Development Centre in Warsaw, the demonstration plant at Białystok and such other bodies within the Polish packaging industry as proved necessary. He would be expected: 1. To acquaint himself with the training facilities at the various centres connected with the Polish packaging industry and gain an understanding of their present functions together with their relationship to the packaging manufacturing industry. 2. To make an assessment of the present levels of skills for production problem analysis with the industry generally. 3. To advise how best to utilize the available skills within the industry to maximize the rate of interchange of information. 4. To advise on what additional steps need to be taken to train technologist utilizing the existing knowledge and resource within the industry. 5. To make an assessment of what additional outside resources would be needed if any. 6. To discuss with the Polish packaging authorities any additional training facilities required and where they should be located.

7. To assist the Polish authorities to implement any recommendations made as a result of the audit and subsequent discussion.

QUALIFICATIONS: Experienced consultant in the techniques analysis of production problems, with wide skills in the packaging industry.

Annex III

ECONOMIC ANALYSIS OF A WASTE-RECOVERY PLANT

Assumptions

1. The planned output of trays for the year 1977 is 24 million.

2. One million trays is equivalent to 8-9 tons of polymer.

3. With a 25% waste level 11-12 tons of polymer will be required for each million trays. (The present initial waste level is 38%.)

4. The waste from the planned output after optimization of the processing conditions will be at least 70 tons in a full year.

5. The present world price of polystyrene is in the region of $600 per ton and steadily rising.

6. The minimum value of the waste in the plant at Bialystok at the planned output rate will be $40,000-$45,000.

7. The capital cost of the recommended compromise recovery equipment would be very approximately $30,000-$40,000 (This figure is only a very approximate guess.)

8. Assuming that some part of the waste can be used in its present form (this is a very optimistic assumption), the worst case could lead to a "pay back" of two years and a more probable situation would be a pay back period of about one year.

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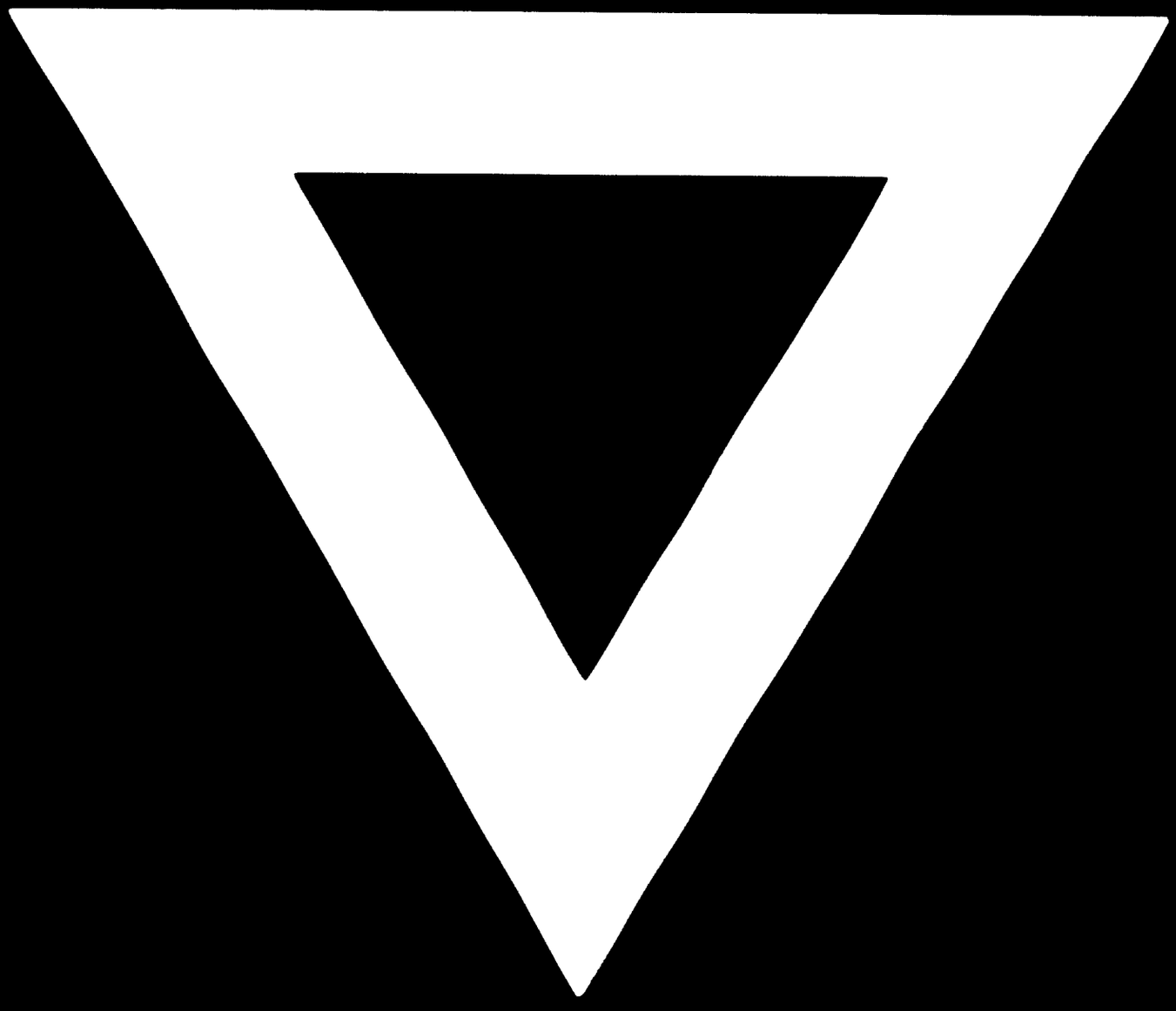

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