OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

08274

Distr.
LIMITED
ID/WG.282/5
21 Sept. 1978
ENGLISH

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

INTERNATIONAL FORUM ON APPROPRIATE INDUSTRIAL TECHNOLOGY

New Delhi/Anand, India 20–30 November 1978

WORKING GROUP No.10

APPROPRIATE TECHNOLOGY FOR THE MANUFACTURE OF PULP AND PAPER PRODUCTS

PROSPECTS FOR ESTABLISHING VIABLE SMALL-SCALE PULP AND PAPER INDUSTRIES IN DEVELOPING COUNTRIES

Background Paper

id. 78-5752

PROSPECTS FOR ESTABLISHING SMALL-SCALE PULP AND PAPER INDUSTRIES IN DEVELOPING COUNTRIES *

* A paper prepared for the FAO Advisory Committee on Pulp and Paper, Nineteenth session, Rome, 31 May-2 June 1978, document no. FO:PAP/78/Inf.6.

The description and classification of countries and territories in this document and the arrangement of the material do not imply the expression of any opinion whatsoever on the part of the secretariat of UNIDO concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries, or regarding its economic system or degree of development.

The views and opinions expressed in this document are those of the author(s) and do not necessarily reflect the views of the secretariat of UNIDO.

Mention of firm names and commercial products does not imply the endorsement of the secretariat of UNIDO.

The document is reproduced in the form in which it was received and it has not been formally edited.

INTRODUCTION

It is little wonder that the quest for economically viable, small-scale pulp and paper mills has become a matter of some urgency in recent years, particularly for developing countries. Paper is such an important commodity in the development process that developing countries naturally want to establish their own paper industry to satisfy their own need and so reduce their dependency on outside supplies.

The problem originates from the experience that the domestic consumption of paper in many developing countries is too low to absorb the output from even one mill of the capacity that is generally regarded as necessary for a viable operation.

Two ways around this problem would be to export the surplus production or to consolidate a number of national markets into a single, large regional market. Both of these solutions have encountered a number of difficulties when they have been attempted in practice. The export market has proved to be extremely difficult to penetrate, and arrangements for regional mills have proved equally difficult to bring to fruition. Because these difficulties have proved to be so intractable, the idea has grown that the only other option - to build small viable mills - must be possible. The logic is hardly impeccable, but the need is so compelling that the possibility is at least worth investigating.

However, in assessing the prospects of developing countries being able to establish mills to supply small domestic markets at reasonably competitive costs, it is necessary, but hard, to avoid being excessively optimistic, so that expectations are raised to unrealistic levels, or of being excessively pessimistic so that reasonable expectations are dashed. The twin risks arise from the simplifications that accompany any attempt to generalize about such a complex industry and such a heterogeneous community. But some simplification is necessary and indeed possible. If ordinary and not specialized paper grades are considered, then it is evident that the viability of small-scale mills depends initially on the product grade and the fibrous raw material.[1/]

1/ In this connection it must be mentioned that some non-wood plants such as abaca, sisal and various bast fibres could form a basis for viable small-scale plants, producing high-strength specialty papers.

BASIC PROBLEM AREAS

Processes and Mill Size

The basic causes of the problem of mill size in relation to developing countries are the economies of scale associated with increasing capacity. In general, the more complex the pulping process the higher the capital cost of a plant of a given capacity. Therefore, it could be expected that mills based on fibrous raw materials that are easy to pulp would be the most readily adaptable to small-scale operations.

This is in fact so. If we are talking about waste paper based paper and/or paperboard operations, a small-scale mill can be financially viable if local conditions are favourable. The same could apply to non-integrated paper manufacture, depending on the grades produced and, again, on local conditions. Integrated pulp and paper/board operations with secured agricultural residues fibre supply and in favourable environmental conditions could well turn out to be a financial success especially for low-grade board production.

However, as soon as we start talking about wood-based pulp/paper manufacture, the problems for small-scale operations are of a completely different magnitude due to the complicated process requirement especially when chemical pulp is concerned. The economies of scale here play really an important role. It is not difficult to build a small-scale technically viable wood-based pulp and paper mill but it is the economics which will play havoc.

But wood-based pulp and paper - particularly chemical pulp - cannot be ignored simply because of the high capital costs associated with its manufacture. For one thing, wood is the only fibrous raw material available in sufficient quantity to support the world demand for paper. It is, in fact, quite often the only raw material which many developing countries have or could grow in abundance. In addition the technical specifications for many paper products can only be achieved with a large proportion of chemical wood pulp in the furnish.

Thus it is the chemical wood pulp side of the industry in which the prospects for small-scale mills[1/] are the most crucial.

Wood pulping can be divided into two main categories, mechanical and chemical. From the process point of view, mechanical pulping is very simple and for small-scale mills the traditional stone groundwood process is best suited due to easy operations and maintenance as well as the relatively low power consumption. However, stone grinders can be used only for logs; for sawmill residues the refiner process must be applied, employing either non-pressurized refiner or the more recent pressurized thermomechanical pulping processes.

1/ As a general guide, within the class of 50-100 tpd capacity.

In the middle between the mechanical and the chemical pulping lie the chemi-mechanical and semi-chemical processes which could produce lower grade papers and boards perhaps at relatively low capital and environmental control costs.

In the case of the chemical pulping, the cooking process requires a rather high temperature, pressure and chemical concentration. For economic and environmental reasons, the cooking chemicals have to be recovered. This complicates the overall process design to the extent that a bleached chemical pulp/paper mill, which includes preparation of bleaching chemicals, is one of the most complex plants in the chemical industry today. This is the reason why wood-based pulp and paper mills are so capital intensive. All the various process stages must be included in any mill, whether small or big, for the plant to be both economically viable and environmentally acceptable. This is the situation today; no simpler and less capital intensive processes are proven yet on a commercial scale. There might be some new developments at a research stage but there is no indication today that they would revolutionize pulp/paper manufacture or reduce capital cost to any great extent.

Equipment

Because of the corrosive chemicals, high temperatures and pressures employed in many stages of the process, expensive equipment must be used. Practically all operations dealing with pulp, after the fibrous raw material preparation stage, involve liquids, which means that much pumping of liquids, filtrates and pulp slurries is required. To accomplish this, pumps, pipes, and electric motors are needed, hence labour intensive operations such as moving materials manually as is possible in the mechanical wood industries cannot be employed in the pulp and paper industry between the fibrous raw material preparation plant and the finishing and handling of finished products.

Energy

A factor which affects mill designs today is the high cost of energy. For this reason, the means used in the past to reduce capital costs such as not installing heat recovery equipment, not using heat exchangers for heating cooking liquors, low heat efficiency boilers, a small number of liquor evaporation stages, etc., would result in high operating costs.

Environment

Pollution abatement for new pulp and paper mills is now regarded as universally essential even in developing countries. There are very few countries in the world which would permit a mill to be built without any pollution abatement at all; in the future it is anticipated that increasingly stricter standards will be enforced. Small-scale mills have a disadvantage, compared with larger mills, in that the economies of scale exert a very strong influence on the cost of pollution abatement systems.

Economics

As mentioned in the introduction, economic factors are the most serious ones affecting the establishment of small-scale wood-based mills. There is very little that can be done about this fact of life; subsidies in one form or another are the only salvation; however, the socio-economic benefits of the mill could well balance these subsidies.

TECHNICAL ASPECTS

The purpose of this section is to review an integrated chemical wood based (sulphate) pulp and paper mill, department by department, with the aim of finding out where it would be possible "to cut the corners" to reduce the mill capital cost. The wood-based sulphate pulp mill has been selected because the sulphate (kraft) process presently is the dominating pulping process in the pulp industry and is not expected to be replaced by any more feasible process in the near future because it produces the highest strength pulp which is required by all developing countries irrespective of the possible local production of low strength pulp from agricultural residues.

Wood Preparation

This is perhaps the area where labour intensive operation could be employed to replace machinery to a greater extent than anywhere else in the mill since this involves the handling of solid material - wood. If the logs are small enough, this may allow manual log handling from the transport vehicles to the wood storage and from the storage to the debarking and chipping operations. Debarking may also be carried out manually, but from there on all handling of chips must be done by machines. A possible saving of capital in chip handling could be achieved by eliminating the expensive outdoor chip pile and using instead a rather small buffer silo between the screening and digester plant. By doing this, however, any longer breakdown in the debarking or chipping operations would cause chip shortage in the digester plant and thus lower the operating efficiency; otherwise, the buffer silos must be rather large and hence expensive. Also, there might be the need to operate the debarking and chipping plant 24 hours a day and 7 days a week instead of operating these departments as usually at present only for two shifts and 5-6 days a week. This continuous operation would possibly be the best solution from capital cost and employment points of view; at least, the debarking and chipping plant would be smaller and less expensive and additional employment would be provided.

In case sawmill residues were available either from integrated sawmill operations or purchased from outside mills, the pulp mill capital cost would be reduced by a significant amount and also the operating cost would be lowered.

Pulping Departments

The pulping departments are usually considered to include the digester plant, washing, screening and bleaching.

It is obvious that a small-scale pulp mill for developing countries cannot be designed according to today's modern sophisticated digester plants.

What can be done to reduce the capital required? The obvious answer is to go back to digester plants as they used to be 40-30 years ago with a simple non-automated design which would require minimum skills for operation and would be easy to maintain. This means that batch digesters would be employed, equipped with manual controls and minimum baeic instrumentations required for safe operation. Capital coet could be reduced by leaving out the pre-heaters though this would increase energy consumption, the eize of the boiler feed water treatment system and its operational cost. The blow heat recovery eystem could be eliminated but, again, this would mean increased energy costs and heavy air pollution as well. In warm climates the digester building would be semi-open, with only the operation floor fully covered.

Pulp washing in modern mills is accomplished partly in the continuous digester if it is used, followed by rotary filtere or continuous diffuser washers or, in the caee of batch digestere, on the rotary filters or in continuous diffusere. The waehing ie done in various stagee and the strongest fraction is pumped to the chemical recovery operations.

In a emall-ecale mill having batch digestere the choice for the waehing system is between rotary filters, the recently developed continuous diffuser or old batch diffueers. The continuous diffuser could possibly be stripped from the present sophisticated process controle to be mainly manually operated. The advantage of this system over rotary filters would be the much lower structural cost and lower energy requirement for liquor pumping. However, old batch diffusers could well be the lowest cost solution of all and safest in the operation. In the climatic conditions prevailing in most developing countriee, very little of etructures would be needed and the energy consumption would be low. If properly designed, maintenance would be minimal as well as the need for spare parts.

The next operation, the screening, is usually made on rotary centrifugal screens at rather low consistency. It is becoming more and more common today to employ a so-called closed eystem in which screening takes place before the last waehing etage to reduce water consumption in the mill; no fresh water will be added in the screening operation. For a small-scale mill a similar system should be employed because it would reduce water consumption and thus reduce capital and energy requirements.

Modern bleach plants are equipped with extremely sophisticated process controls including nowadays more and more computerized systems with the aim to reduce manpower, optimize the use of bleaching chemicals and improve quality. Due to competition, pulp brightness has reached levels unnecessary for most papers produced from this pulp. Obviously this is not the way to follow in developing countries for their domestic oriented mills and, therefore, the bleaching sequence can be simpler and avoid the use of expensive chlorine-dioxide necessary to attain a high brightness. For a small-scale mill this is even more important, even a simple system using hypochlorite in chest bleaching could in many cases produce pulp with sufficient brightness. Such a mill could import relatively cheap hypochlorite and avoid the establishment of a costly electrolytic plant to produce chlorine and caustic which in many developing countries are not available locally.

Chemical Recovery

The cooking chemicals must be recovered and returned to the process to make today's pulp manufacture economically viable and environmentally acceptable. The recovery process is complicated, involving many chemical processes, high pressures and temperatures.

The recovery boiler is one of the most expensive single pieces of equipment in the pulp mill. Because of the corrosive chemicals, and the high temperatures and pressures employed, the construction material is expensive. For the same reasons, the operation of the recovery boiler has some serious hazards and, therefore, today the modern boilers are equipped with very sophisticated process control systems which again increase the cost.

Much thought has been given in the past and present on what could be done to reduce capital cost in this very expensive stage in chemical recovery, especially for small mills. No satisfactory solution has been found so far. Use of low pressure boilers would reduce the cost but it would also reduce the amount of electric energy generated. It has been proposed and even done in practice in some developing countries to go back to old-fashioned low heat economy chemical recovery systems. In these systems most of the chemicals could be recovered but no heat would be available outside the recovery cycle itself. This would mean very high energy costs for the mill, as well as higher chemical cost than for a mill equipped with modern equipment.

Development work in the field of recovery boilers is going on in the industry with the aim of simplifying boilers and reducing hazards in the operation; it remains yet to be seen whether this research work will produce some benefits for small-scale mills.

In the causticizing plant, recently developed new equipment has eliminated some of the cumbersome and expensive clarifier tanks thus reducing capital cost but, unfortunately, the operation of this sophisticated equipment requires skilful operators and plenty of spare parts and can, therefore, hardly be recommended for developing countries.

What can be done for a small mill to reduce the cost of the causticizing plant? The first item which could be eliminated is the green liquor clarifier but only if the mill produces unbleached pulp. As far as the rest of the equipment for this department is concerned, there is not much that can be done to cut the cost; however, savings can be made by combining some clarification and washing functions in the same tank; this is already done in many large mills.

The next obvious place for capital saving is the lime kiln. If purchased lime is available, it can be eliminated; however, this would increase the operating cost and there could be a problem in finding a dumping place for the lime mud.

Paper Manufacture

Modern paper machines are very sophisticated items of equipment, equipped with modern process control devices and nowadays they are usually computer controlled to save labour and improve quality. It is obvious that these are not the machines one would like to install in a developing country where the skills to operate and maintain them are not easily available. They certainly are not for small-scale mills as they are too sophisticated and expensive for the low production rates required. What could be done to save capital and still keep the machines reasonably efficient for small-scale mills?

Because of the scale of the operation, we are not considering any high-speed machine. This will eliminate the need for a sophisticated drive. The speeds with which we would be concerned could be only around 300 metres per minute and if the machine is narrow, 3-4.5 metres depending on the paper grade, a simple open gear drive could be employed, perhaps powered by a steam turbine. At the speeds considered, even an open simple headbox could be satisfactory. Due to the high energy cost, it is not advisable to eliminate the hood and the heat recovery system of the dryer section. Some capital saving could be achieved if the machine were located on the ground floor, but this would cut down the machine efficiency and cause many operational difficulties. On the other hand, these savings in capital cost would mainly relate to structures, which would be predominantly paid in local currency and, therefore, would not cut down foreign currency payments.

One problem with these simple small machines is that there are not many paper machine manufacturers geared toward their production.

The paper sheeting operation in modern paper mills is fairly well automated. In small-scale mills there is no need for this. Only very simple low-cost equipment would be needed if the sorting and packing is done mainly manually. This would provide employment for women because no great physical strength is required to do the job.

Service Departments

Steam and power

Not even a small-scale mill can operate without steam and power. In addition to the steam generated by the recovery boiler, more steam is required for the process and, because of the scale of the operation and perhaps lesser use of heat saving devices, the additional steam requirement is greater for a small-scale mill than for a modern sophisticated one. An auxiliary boiler fueled by hog fuel, bark, sawdust and possibly by firewood is needed. The use of gas or oil as the only fuel would lower the capital cost due to the simpler boiler design, but it would most likely be more expensive to operate.

If electric power must be generated at the plant, steam must be generated at relatively high pressure and temperature to porduce power at a reasonable cost. If all power has to be generated, two steam turbogenerators, a back pressure unit and a condensing unit would be required. In addition, diesel power generator(s) for the mill start-up would be needed in this case. All these are expensive but unavoidable for the mill.

Water supply

Water supply would be from a river, a lake or wells. The only thing that can be done to reduce the cost of the water supply is to reduce the amount of water needed for the mill. Even a small-scale mill, if properly designed, can have a low water consumption but it would still be of the order of 100-150 m^3 per ton produced in an integrated mill, which would mean a daily consumption of 10-15 000 m^3 for a 100 tons per day mill. Possibly the water requires expensive treatment before its use in the process. Feed water for the boiler plant must be specially treated not to cause expensive maintenance or even hazard for the boilers. All this adds to the cost.

Pollution Abatement

Today's pollution abatement regulations add 10-20 percent to the plant capital of any mill built in developed countries depending on the degree of treatment required. Although developing countries do not necessarily follow the regulations established for developed countries, the time will obviously come when they will comply with at least a minimum of the effluent pollution control regulations. If the plant is located close to a river with high flow all the year around or on the ocean front, the treatment required could be rather simple and involve relatively low capital costs. The primary stage of the treatment to eliminate the solids could well be enough especially if internal measures to recover fibre and liquor spills in the mill are incorporated in the mill design. The extent of the treatment required has to be studied very carefully for any mill to be established.

As far as air pollution is concerned, a mill to be built in a developing country does not have any big problems and, if the Government and local population agree, it can be completely ignored. Air pollution in the form of smell from a sulphate pulp mill is mostly due to hydrogen-sulphide, methyl-sulphides and mercaptan released, which are not harmful to human beings or vegetation in the concentrations emitted. The dust from the lime kiln, if not recovered, can become a nuisance for the surroundings, as well as the dust from the boilers if no dust collection systems are used.

It can be said that air pollution is the least problem in establishing a small-scale pulp and paper mill.

Process Controls

Modern mills are highly automated; a few operators control the process from the control rooms equipped with the most sophisticated computer controls. This is done with the aim of improving the quality of the product, optimizing the use of the raw materials and lowering the labour cost. Obviously this is not the pattern to be followed generally by developing countries in establishing small-scale operations. The aim must be to produce a reasonably good product at an acceptable cost and provide employment. Starting from this the answer is very simple, provide only the process controls which are needed for safe operation and use manually operated valves, etc., when applicable, instead of remote controls. The saving in capital cost would not be a very high percentage of the total mill cost but it would reduce the maintenance and limit the number of spare parts required thus making the mill operation more efficient because of reduced shut-down time.

Structures

Due to the warm climate in most developing countries, the structures housing the operations do not have to be as extensive as in the major producing countries where the climate often is severe. However, if there is no need for protection against cold, there is a need for protection against rain, wind, insects and, in some cases, sand. Therefore, it is not possible to build all departments without protective housing although such departments as wood preparation, evaporators, causticizing and lime kiln can be built outdoors. Also many operations require more than one floor and, therefore, the cost of the structures is not negligible even if the local cost for the structures is low. In some regions special provision in the structures against earthquakes has to be included, with additional cost for structures. In addition, a local experienced construction company is very seldom available and a foreign company has to be brought in at least to supervise the work of the local contractors.

ECONOMIC ASPECTS

As mentioned earlier, the basic problem in establishing small-scale mills are economic ones. In the previous section, the technical aspects which could affect the economics have been briefly reviewed. It can be seen that savings in capital costs could be achieved by stripping the mill of equipment such as some energy and chemical saving devices which are not absolutely essential for the operation, but this would increase the operating cost perhaps to the point at which the financial result could be worse. The influence of the economies of scale is so pronounced in these types of mills that small ones may be financially sound only under very specific circumstances and perhaps usually require protection in one form or another. Socio-economic benefits, however, could be so important to the country that a financially non-viable operation might be justified.

It is also worth remembering that the economics of a pulp and paper mill could be greatly improved by integrating it with mechanical wood products manufacture, especially with a sawmill.

DISCUSSION

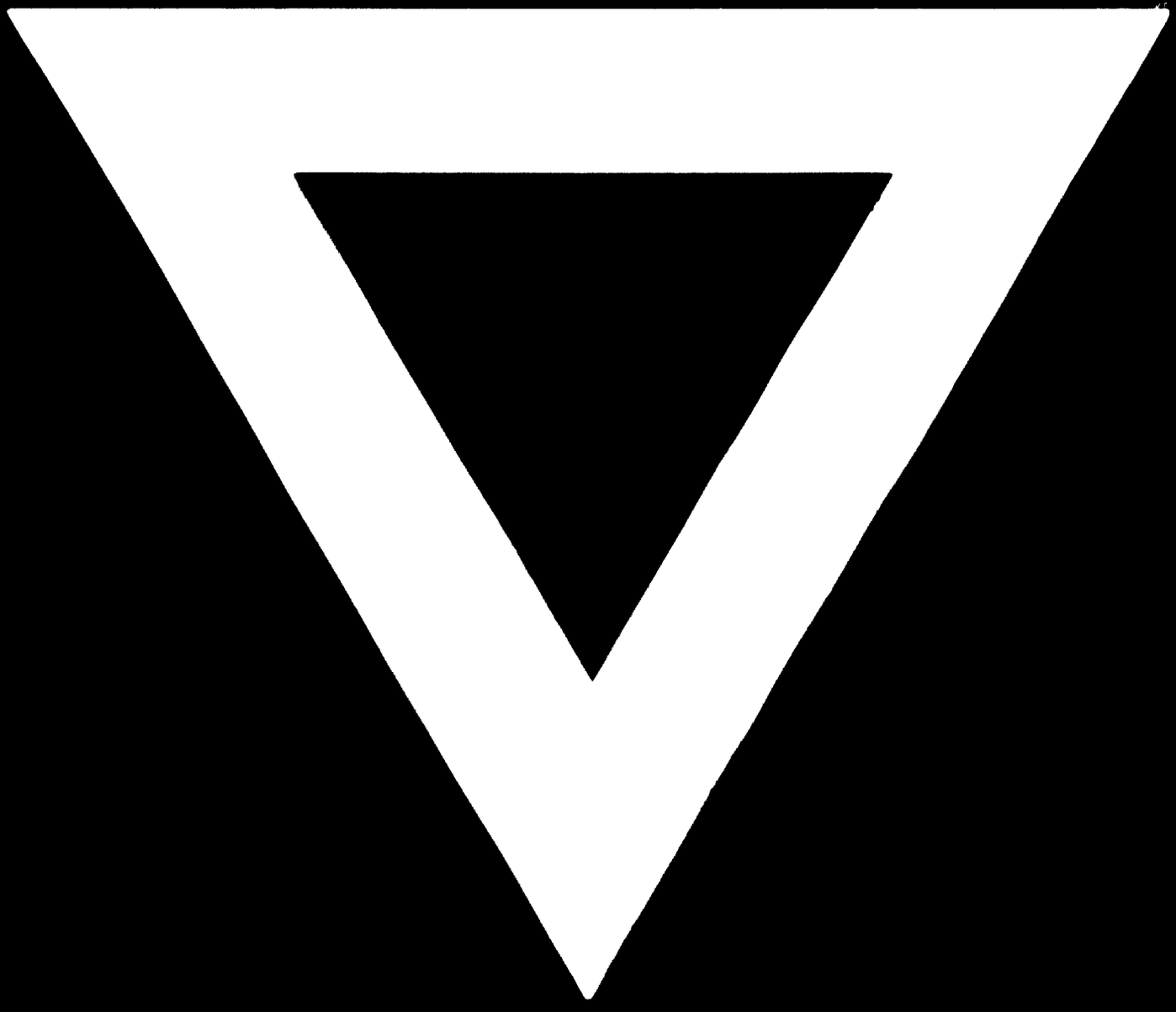
The purpose of this paper is to provide some points for discussion on this important matter; could viable small-scale mills be built in developing countries and, if so, how? In the case of simple processes involving waste paper and agricultural residues, the answer could be positive, as well as in certain conditions with operations based on mechanical wood pulp. A positive answer is much less likely with chemical wood pulp based paper manufacture. It would largely depend on the ability to reduce the capital cost without increasing too much operating costs.

From the above it would appear that by today's techniques there are only limited means to reduce capital cost. The only effective way to cut the corners would seem to be to go back 30-40 years in techniques and build the type of simple mills used those days though this would result in increased operating costs. The advantage of these simple mills would be increased employment, relatively easy operation of the plants and lower demand for spare parts which could be partly made locally either in the mill maintenance shop or in local machine works. A very important aspect would be lesser need for highly skilled operators and thus reduced need for training. However, the mills should be designed initially so that energy and chemical saving equipment can be added at a later date when the enterprise considers it to be economically advisable and can afford it.

If all these measures are taken and the operation is well managed, a profitable enterprise could materialize without heavy government subsidies.

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche

G-13



79.11.14