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HOW TO BUILD A LOW COST PAPER MILL IN DEVELOPING COUNTRIES 1/

by

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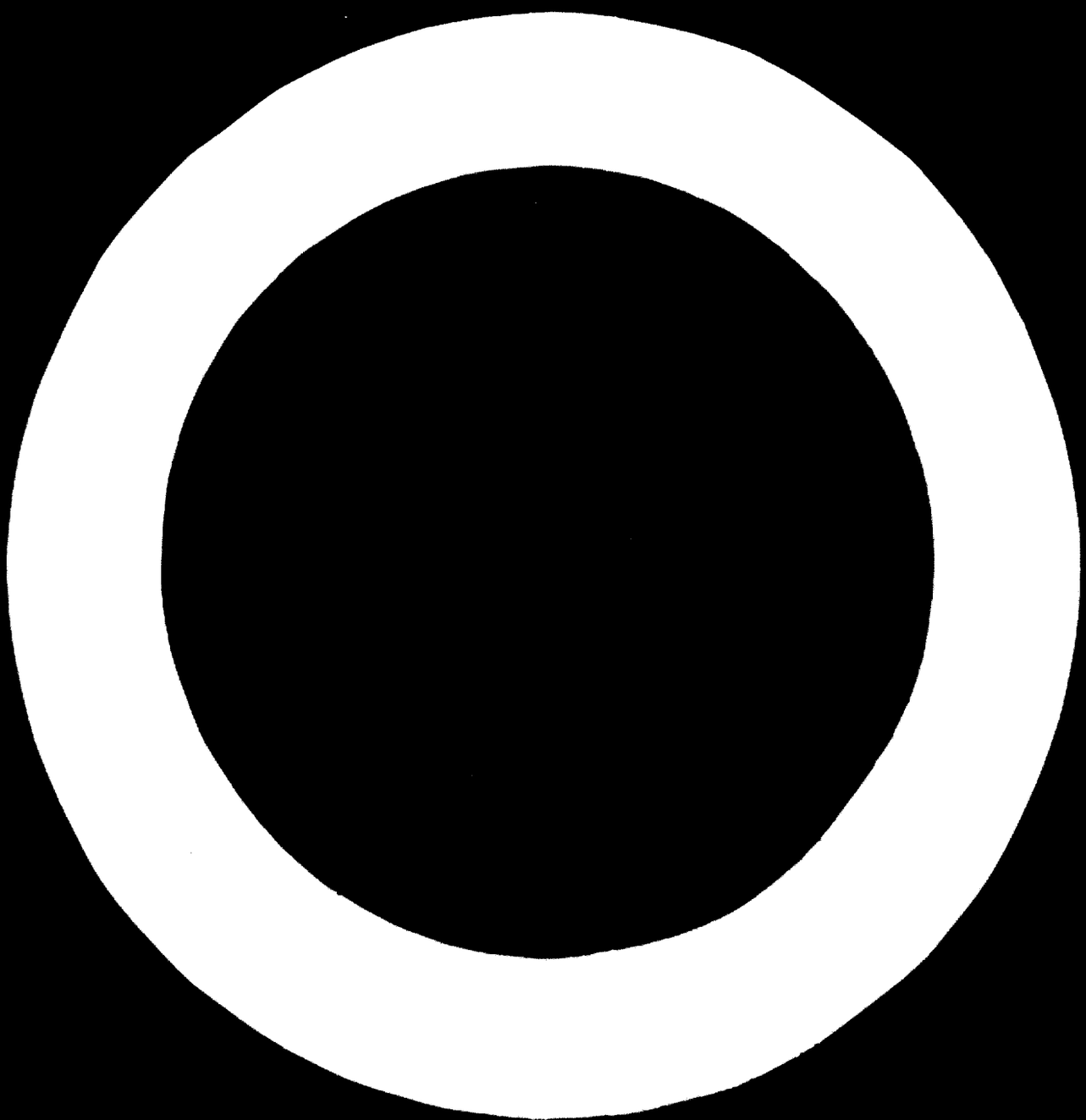


HOW TO BUILD A LOW COST PAPER MILL IN DEVELOPING COUNTRIES

Before any elaborate project for a new paper mill or even the improvement or enlargment of a paper mill in a developing country can be started the following basic conditions for such an industry must be assessed and checked:

1. Demand for paper on the home market, specifying the brands of paper mainly required.
2. Export possibilities of paper manufactured in the respective developing country.
3. Availability of raw materials (softwood, hardwood, bagasse, grass and straw, textile fibres (cotton linters), bamboo, waste paper, also chemical materials.
4. Availability of process water all the year long.
5. Availability of power from outside sources or generated by a newly created power station.
6. Availability of fuel for steam generation and power (coal, oil, gas, firewood, atomic).
7. Water and gas pollution control.
8. Establishing the most favourable site for a paper mill.
9. Transport of raw material.
10. Housing and transport of workers.
11. Availability of skilled and unskilled workers and labour laws.

After these basic industrial conditions have been assessed the basic commercial conditions must be checked as well.

12. Production costs of each brand of paper.
13. Possible selling price and profitability.
14. Investment capital available.
15. Loans available.

After these basic conditions have been sufficiently assessed the technological part of the whole project can be started and the most expensive item of that part is the choosing of the paper machine with all its belongings, i.e. buildings, stock preparation, finishing department, cranes and internal transport facilities, heating and ventilating, fibre recovery and heat recovery. In short, all technological provisions are to be considered both for the initial project and for possible future growth of the factory.

The question arises now from which point of view the cheapest solution for a paper machine must be considered. The capital cost of a paper machine depends not only on its size but also on its design. A paper machine for newsprint or mass production of kraft paper can cost twice as much as a paper machine of the same width, for the production of writing paper, or less heavy types of MG wrapping papers as well as for tissues and hygienic papers.

On the other hand a simple wet lap board machine can be built for a fraction of the cost of a modern versatile machine for the production of dry board in reels or sheets.

It is definitely advisable not to start in a developing country with a sophisticated mass production machine as advertised vividly by all paper machine builders. The wise investor starts his new paper mill in a developing country with the erection of a simple and consequently cheap machine and it happens quite often that second-hand machines in good working condition were chosen as "stepping stones" for a successful future development of a new paper industry. Before, however, explaining in detail the crucial item of the investment, which is undoubtedly the choice of the first paper machine, we want to analyse the eleven basic industrial conditions as specified above.

1. Demand of paper on the home market

In developing countries it is common that unbleached wrapping paper and thin board is the first request for a national paper production. Next to follow is bleached common grade writing paper and printing paper for school books, etc. Soon afterwards hygienic papers will be required in view of their being easy and cheap to make. The last in the sequence is high grade printing paper, such as newsprint, and certain speciality papers which should still continue to be imported until a well equipped paper industry is established.

Experience in many developing countries has proven that the start of a national paper industry should be made with standard machinery for approximately fifty to seventy-five tons per day unbleached and bleached wrapping and writing paper. Such machinery should give enough returns for the first few years and save considerable amounts of money hitherto spent for imports of paper. It therefore opens the way for future expansion and modernizing of the new paper industry.

2. Export possibilities of paper manufactured in the new industry

It seems quite likely that the new paper industry after a short time will produce more tonnage of paper than required on the home market. In that case some export from one developing country to a neighbouring developing country should soon be promoted.

3. Availability of Raw Materials

(Softwood, hardwood, bagasse, flax, hemp, grass, straw, bamboo, cotton linters, waste paper, also chemical materials.)

One of the greatest advantages for pulp and paper production of developing countries in tropical and subtropical zones is the abundance of wood and other fibrous materials which are excellently suitable and comparatively cheap for pulp and paper production. Modern technological methods permit the use of many fibrous materials for paper making which, some thirty years ago, were still considered unsuitable and the trend of paper making is now moving slowly from the climatically cold zones of coniferous soft woods to the warmer zones of tropical hardwood, of bagasse from sugar cane - the industrial importance of which has been rising from year to year - of bamboo and of many so called "vegetable" one year plants like esparto, rami, carða, flax and hemp and many species of straw. As a matter of fact, it happened quite often already that the local abundance of one or the other fibrous raw material determined the decision as to which brand of paper should be made during the initial few years and only later the paper making programme became more versatile. To cite one typical example, one African country had fairly extensive forests of indian eucalyptus and planned to make use of these resources for the production of imitation kraft paper. However, the technologists soon discovered that the existing reserves of eucalyptus could serve only for five to six years of paper production, so they immediately started new plantations of eucalyptus (obtaining by the way considerable tax relief for these plantations of national importance) and in view

that eucalyptus after only six years of growth is usually to be used as pulp wood, the new paper mill will never face any possible shortage of eucalyptus pulp again. Incidentally during the actual period of possible shortage of eucalyptus pulp the technologist tried to mix a limited amount of bamboo pulp with the hardwood pulp and succeeded in improving the physical characteristics of the product.

Regarding chemical products required for paper production, most of them must still be imported into developing countries. The bulk of chemicals are needed only for pulp production (caustic soda, soda ash, sulphur, lime, chlorine) but resin and all fillers (kaolin, blanc fix, clay dyestuffs, etc.) are used in the paper making process and it is important that the costs of these imports are low and do not affect seriously the overall production costs of all papers.

4. Availability of process water all the year round

It must always be kept in mind that next to fibrious raw material, water is the most important commodity for paper making. The fresh water consumption for paper making is still very high although many efficient water circulation and saving systems have been introduced. However, even a mill with a good recovery system requires about 120 cubic meters of fresh water for each ton of unbleached paper. In case a simple pulp plant and bleaching equipment will be added to the paper making outfit, the amount of fresh water for manufacturing processes might go up to 500 cubic meters per ton of finished products.

In addition to the proper process-water large quantities of water will be required for the steam generation at the boiler. The water consumption in a paper mill is at any rate the specific biggest water demand of practically all industries.

It must also be remembered that the paper industry operates twenty-four hours a day and very often seven days a week, which means that the water consumption is not staggered but at full demand day and night. Special attention is to be paid in many developing countries, that the rainfall is split in two or more seasons per year. It happens in many countries that they have no rain for four to six months per year and subsequently another period of excess rain. This excess must be stored in artificial lakes unless the mill can be located near a natural lake. Being in the vicinity of a big river, a lake or the sea is also very helpful with regard to the pollution problems of effluents.

The precautions to be taken for a steady water supply must therefore be studied thoroughly for many months before the layout of any new paper mill is to be discussed and designed. In tropical and subtropical countries it is an essential feature that the nearby river is dammed-up and an artificial water reservoir with a capacity of at least three months supply must be built. The normal hourly water discharge of the river must be checked through months and months (usually the local hydraulic authorities keep these records anyway) and based on these figures the height of the dam and the size of the artificial lake can be calculated and determined.

The building of such a water reservoir is unfortunately a rather heavy additional financial burden which usually need not be reckoned with in non-tropical countries where normally the water discharge of the natural rivers and lakes does not fluctuate as badly as in the subtropical and tropical countries, still untouched by industry.

However, it must again be remembered that on all projects of new papers mills in developing countries, the problem of how to provide a steady water supply must be studied very seriously and taken into account before technical specifications of the future mill are determined. Again we want to cite an example: A new paper mill had been planned in the middle of a dense forest area with plenty of cheap timber available for groundwood and semi-chemical pulp. A small mill was erected and started quite satisfactorily. The water had been provided by several local deep wells, but after a few months the wells gave less and less water and eventually became dry altogether for about six weeks until the rainy season began again. The mill management saw no way to pump water from a distant river and kept the mill completely shut down for several weeks. The losses caused by the long shut down were certainly bigger than the possible costs of a water reservoir which had been omitted in the general layout.

5. Availability of power from outsize sources or generated by newly erected power stations

A new paper mill, even if small and initially of limited production, will need a constant supply of power from the very beginning, sometimes even before it starts to make paper. After all, a certain amount of power is needed for the building construction and other preparation jobs and it is therefore a great help if a national grid of electric power already exists in the country where the new mill is to be erected and during the building period power could be purchased from the

National Electricity Board. Quite often the National power grid has enough capacity to supply power for a small mill already in production, in which case the owner of the new mill can save the capital cost of having its own hydro-electric or thermo-electric power station and just purchase power currently. This happens mainly if the new mill is to be built in or near a town. In such cases it is also advisable to omit the erection of a high pressure boiler for power generation and instead to install just one, or even better two, small low pressure boilers which supply just the steam which is required for the dryer part of the paper machine and some room heating. Such an arrangement to keep power supply and steam supply independent of each other saves a considerable amount of initial investment capital, but usually cannot be maintained for many years, especially when the paper making plants tend to grow, consuming steadily more power and steam.

The conditions are quite different when the paper mill should be erected in a remote part of the developing country where no power can be bought and where the new mill must have its own power station from the very beginning. Incidentally it is often quite feasible to install a simple provisional steam engine (locomotive) or Diesel engine, during the construction period, an engine just powerful enough to operate stone crushers, concrete mixers, water pumps, construction lifts, etc. which perhaps can even be hired and returned when the construction and erection is finished.

Independent of that provisional power station a process power station must be planned as an integral part of the whole project. Here again the question arises whether it should be a hydro-electric or thermo-electric station. If the region where the mill is to be built is hilly and rivers or streams flow through it, then a hydro-electric station should always be considered. Hydro-electric power is always by far the cheapest long term solution, in view that the initial investment, although usually somewhat higher than a thermo-electric plant, is shortly recovered by the almost negligable running costs. Wherever a hydro-electric station is feasible from the technical point of view it must always be considered seriously from the economic point of view.

When the power is then to be generated in a hydro-electric station, one, or even better two, boilers have to be installed for heating purposes only. It is always advisable to install at least two boilers in order to prevent any complete shut down of the paper making plant when any repair or overhaul of only one boiler is necessary. A paper mill of a daily production of about fifty tons requires about ten tons of saturated steam per hour. Under these circumstances two low pressure (45 p.s.i.)

boilers of six tons per hour of saturated steam should be erected. There are quite often complete package boiler units on the market which are easily installed and connected.

Things are completely different however, when no hydro-electric power is available. In that case a complete thermo-electric power station must be erected, consisting of two medium or high pressure boilers and one turbo-electric unit, the turbines of it being an extraction and condensing unit. Here again it is advisable to install two boilers to prevent any complete shut-down of the paper mill in case of any temporary failure of one boiler. For the thermo-electric power station, the boilers should be of the high pressure or medium pressure type. The size of the boilers must be based on the energy demand of the future mill. The steam turbine should be a so-called extraction condensing unit, or possibly a back pressure unit which is much cheaper than the condensing type. The final decision whether to install a back pressure turbine as an extraction condensing unit has to be taken with the turbine makers for each individual case. However, it must be kept in mind that a back pressure unit is much simpler and consequently cheaper than an extraction condensing unit but that its energy supply is very often limited by the reduced demand of back pressure steam.

Regarding the electric energy distribution, the voltage of the generator should be kept rather high because high voltage reduces the size and price of the generator. If, however, the possibility exists of buying a second hand generator in good working order, it must always be considered in view of the low cost of a second-hand machine. The voltage is then a secondary problem - after all the outgoing voltage of the generator has to be transformed in any case to the service voltage of the AC motors of the mill.

In case a national power grid exists in the vicinity of the future mill, it should be inter-connected with the mill grid even if it can only supply a small part of the power requirement. It is rather important that the mill has an outside electric energy supply for the start-up after a stand-still. Should, however, an inter-connexion with a national grid not be possible, then a small auxiliary starting unit, as for instance a Diesel generator (preferably second-hand) should be installed and inter-connected. Such a starting unit is necessary to get the electric motors belonging to the steam boilers (pumps, compressors, fans) started up after a stand still. This starting unit can be shut down again, as soon as the steam turbo-generator supplies energy.

Finally it should be pointed out that many small paper mills in developing countries have not only one single turbo-generator, but two, in order to safeguard continuous running of the mill if one turbo-generator fails temporarily. Experience has shown that the purchase of a second turbo-generator as a stand-by unit is usually not a paying proposition in view of defects or failure of the principal unit being usually short-lived. For that reason only one turbo-generator should be sufficient for the first few years, until the new mill grows beyond the energy supply of the first turbo-generator.

Again it must be emphasized that the power supply of any paper mill is a very important part of the project and should be studied with the assistance of a firm specialized in that line because the expenses of consulting such specialists can easily be repaid by savings in the cost of the equipment, and also economics in the running costs of the whole energy supply.

6. Availability of fuel for steam generation and power

(Coal, oil, gas, firewood, bagasse, atomic)

It may sound absurd but for a paper mill in a remote tropical and subtropical country, firewood and bagasse should never be forgotten as fuel for the boilers. It is evident that in tropical forests tons and tons of underbrush must be removed when the big pulp wood trees are felled and transported, and that amount of broken timber, branches, etc. gives a very cheap fuel, provided that the mills are not too far away from the forest and the cost of transport remains cheap or negligable. It is definitely better to burn this firewood in a boiler than in the forest where bush fires can cause extensive damages.

Regarding bagasse of sugar cane it must always be thoroughly investigated whether the conversion of bagasse into pulp is a paying proposition and if all the available bagasse is really required by a local pulp mill. Bagasse has been for decades a useful firewood and there is often enough surplus bagasse which can still be used as firewood when the pulp mill cannot cope with all available bagasse.

The traditional industrial fuels, coal, oil, natural gas must be usually imported into developing countries and are therefore only considered "cheap" fuel when the new paper mill is situated near a seaport or riverport and consequently the cost of transport is reduced to a possible minimum. Only in very exceptional cases are coal or natural gas found in the proper developing country. Natural resources of

that kind present an enormous economic advantage to the project, even so the furnaces of at least one boiler of a paper mill in forest areas should be adaptable for the use of fine wood as fuel.

7. Water and gas pollution control in pulp and paper mills

Every pulp and paper mill faces two pollution problems:
Waste water (effluent) pollution and smoke and flue gas pollution.

In recent years all Industry Control Authorities have issued new strict regulations regarding permissable pollution of environment of pulp and paper industries and heavy fines were applied when one or the other mill overstepped the permissable solid content or the B.O.D. (Biologic Oxygen Demand) of the effluent and the chemical purity of the smoke and flue gases from the chimney.

To prevent effluent problems, the project management for any pulp and paper mill must consider two important industrial conditions before deciding about the location of the mill:

1. The mill must be located close to an ample fresh water reservoir, that is to say, in the neighbourhood of a big river or a fresh water lake. The required fresh water must be pumped from the fresh water reservoir and the effluent must be guided into the same river or lake downstream of the mill. If the mill can be built on the seashore, the effluent can be led into the sea, but the mill must be in that case built near the mouth of a river, so the fresh water comes from the river and the effluent goes in the sea. It remains at any rate essential that the effluent must be strongly diluted.

2. Both for technological reasons and for economy reasons, most of the process water of any pulp or paper mill should be kept in circulation during the manufacturing process. This process water in circulation is called white water and always contains a fair amount of fibres and also loading material (kaolin, clay, etc.). This white water passes over special filters where most of the fibre material and suspense can be recovered. In addition to it the filtered water goes into large settling basins where the remaining fibres and other solids settle down and are from time to time pumped back to the paper stock. Those measures to filter the white water and to guide it through the settling basins achieve not only an important fibre economy but also turns the final effluent clear of solids. As said before, the

recovery of this solid content of the white water is not only requested by the water authorities, but represents an important fibre economy for the paper manufacturing plant.

The chemical contamination of the effluent is usally not a serious problem for paper mills but can become very serious for pulp mills. Paper making is after all not a chemical process and only when a bleach plant is incorporated in the paper mill a chemical contamination of the effluent can occur through the mixture of chlorine-water with the process water of the mill. However, when the amount of chlorination of the waste water is carefully kept to a possible minimum, it may happen that the effluent becomes biologically cleaner than the fresh process water. Nevertheless, the chlorine content of the waste water must be carefully controlled all the time because a little excess of chlorine causes immediate death of fish.

At pulp mills the chemical contamination of effluent, is however, a permanent and serious problem, worse at sulfite mills but less dangerous at sulfate and soda pulp mills. The cooking liquor at sulfite mills is very acid (pH below 4) and, unless the waste liquor is well neutralized and diluted, it is liable to turn the effluent and the diluting river water acid for miles and miles downstream causing bad corrosion in the whole region. In recent years new processes in sulfite cooking have been developed (Magnesium Bisulfite instead of Calcium Bisulfite) which permits burning and recovery of both magnesium and sulfur thus reducing considerably the danger of chemical contamination of waste water and also flue gases. Many old sulfite pulp mills are now converted into magnesium bisulfite plants and the environment of the region of those mills has become far less polluted.

Things are somewhat easier at so-called sulfate or soda pulp mills. There the cooking process is based on alkali which is chemically neutral and does not affect living creatures or even metal. However, that soda effluent has a very unpleasant smell and for that reason it also must get strongly diluted before it is led into the river or other water reservoir downstream from the mill. As a matter of fact, the filtering and settling in large basins must be foreseen in all pulp mills in the same way as in paper mills because of the requested fibre recovery which is at least as important in pulp mills as in paper mills.

3. The smoke and flue gas pollution at the environment of pulp and paper mills must be treated with the same attention as the effluent pollution. Near sulfite mills the air is very often much contaminated with sulfur dioxide gases which badly affects the respiratory organs of the human body (throat and lungs) without, however, causing any real permanent illness. It also affects badly all vegetation near the pulp mill, causing lasting damages on trees, cereals and vegetables which can badly affect crops and harvests for many months or even years. Agricultural organizations have protested for a long time against the installation of sulfite mills near their land and the sulfite chemists have fortunately succeeded to reduce the danger of sulfur dioxide gases by new technological methods of pulp making.

At sulfate and soda pulp mills the flue gas danger is also far less dangerous than at sulfite mills in view that the alkali gases do not affect neither the human body nor the vegetation. However, it has another very unpleasant side-affect: it smells horribly, or better it "stinks" and nobody wants to live in the environment of a sulfate pulp mill. Therefore, housing colonies for workers at sulfate pulp mills have to be arranged at a certain distance off the mill and away from the normal direction of the wind.

In independent paper mills which are not integrated to pulp mills the flue gas problem hardly exists, but the smoke from the chimneys often carries soot, ashes and other impurities which must be blown away by means of strong fans to make sure that those dirty impurities do not appear on the nice newly made papers. Here again it is considered a must that the natural or forced wind blows the smoke of the chimney away from the proper paper mill and also away from the living quarters of the workers and other employees.

Generally speaking, it is most important that all permissible figures for solid contents and B.O.D. are clearly checked and established before any new mill can be put into operation. Many future difficulties and financial burdens (fines) can be prevented when the management observes from the very beginning strictly the pollution control.

8. Establishing the most favourable site of a paper mill

After having assessed all the foregoing points 1. to 7. it seems fairly easy to establish where a new mill should be built for the lowest possible investment capital and also for the lowest running costs.

The two most important points to consider are the vicinity of forests or other source of raw material and the neighbourhood of a river or lake for fresh water supply. It is also advantageous to build a mill on or near the sea shore but even in that case it must also be near the mouth of a river. The site of the mill must be easily accessable by road, rail or sea. Good roads in the region of the mill are most essential and must be built if they do not yet exist. The area of the mill site must be fairly flat, otherwise the earth movement will cause unnecessary preparative costs. As soon as a suitable site for the future paper mill has been chosen, a flow sheet and a layout plan have to be designed without delay and based on these two flow sheets and preliminary layout drawings, the first calculation of approximate capital investment can be made.

The first layout design should involve only one paper machine with stock preparation and finishing department. Also the steam boilers, the power supply, a transformer station and the effluent control equipment. The covered shed for raw material and another big store room for finished paper reels or bales. Furthermore, it should not be forgotten to include in the original layout design enough space for future growth of the mill, that is to say room for a second paper machine with all its belongings. It is also recommended to include a small bleach plant in the original lay-out design. Although the bleach plan usually is part of a pulp mill and not a paper mill, it must always be foreseen at a paper mill project too.

The decision as to which type of paper machine should be chosen for the initial layout depends very much on the conditions of supply for the home market, as well as on the brands of paper mainly required. We would suggest to assume for the first fund project a machine of about 100" working width with a simple Fourdrinier wire part, two wet presses, one Yankee Dryer (maintain the possiblity of making M.G. or crepe paper), one after dryer part for the possible making of M.F. papers, one three roll machine calendar, one paper reeler and one slitter. The drive of that machine should be a so-called single motor drive for a new machine, but can be left as belt drive with conical pulleys in case of a second hand machine. As a matter of fact, it very often pays to convert an old fashioned belt drive into a full electric drive controlled by thyristor electronic devices. Those electronic drive controls are not

too expensive and are much more reliable than old fashioned M.G. sets, D.C. main motors and belt drives, which are very often integral parts of second-hand paper machines.

One essential addition to any new paper mill in a developing country is a workshop for repair and maintenance of the existing machinery. Especially in remote parts of tropical countries, the management can never reckon with quick repair jobs from outside firms but must have all machine tools, drilling, turning and grinding equipment, pipe laying, welding, etc. always handy at the new mill.

In the last paragraph of this survey an approximate cost calculation of such a paper mill equipment for the initiation of paper making in developing countries will be specified.

9. Transport of raw material

A new paper mill which is not part of an integrated pulp and paper industry but working as an independent enterprise uses as raw material mainly chemical or semi-chemical pulp in bales, waste paper or possibly some mechanical pulp.

Chemical pulp and waste paper are transported by road or rail and it is, therefore, most important that the haulage costs for this raw material are kept as low as possible. That is to say the paper mill should not be too distant from the pulp and waste paper supply bases and a good road and rail service must exist. By the way it happened quite often already that road and/or railways had to be built especially to connect the new paper mill with the supply centre of raw material.

A special condition exists where mechanical pulp (ground wood) is required. In that case the mechanical pulp can also come in dry bales but it can also be made at the proper mill by grinding pulp wood logs in mill-owned grinders.

A precondition to such a grinding plant at the paper mill is the availability of good soft pulp wood and enough power, in view that wood grinding requires far more kilowatts than the proper paper making. In some developing countries the use of chemically treated hardwood (Chemigroundwood) has been successfully used at grinders.

Another point of view of haulage of raw material refers to waste paper. This material is mostly collected and available in towns and consequently a paper mill which uses large amounts of waste paper should rather be located near a town than near a forest.

In case bagasse will be used as raw material for pulping, the paper mill must certainly be erected near one or more sugar mills to avoid long distance haulage and intermediate storage of such a raw material.

10. Housing and transport of workers

This is a very important topic at the preliminary study of the location of the future mill. The workers must be accomodated in a housing colony near the mill but on the other hand not so close that the noise and also the smell of the industry affect their private lives. As a matter of fact, special attention must be paid also to ensure that workers' housing is not amidst a dense tropical forest, which, in developing countries, is quite often right around the paper mill. Living quarters in tropical countries must be in open regions with plenty of fresh air and possibly cooler nights. Enough fresh water for drinking and washing must be provided.

Apart from the proper dwelling houses several other buildings must be erected in this housing colony, i.e. a school, a church, a first aid station, a small community room or workers' club, a police station and possibly a cinema. Before starting to build such a housing colony the exact number of people to be accomodated must be established - the number of bachelors, married couples and children. Two or three different types of houses must be built, different in size and style in accordance with the requirements of bachelors and families and also somewhat different for people in an advanced professional position such as foremen, resident engineers and chemists. All these people work in shifts and, therefore, their houses must be easily reached. The officers of the administrative section of the industry may live a little further away from the mill, in view that their working hours are from morning to evening only.

The transport problem for the workers depends of course on the distance between the paper mill and the housing colony. Workers in developing countries have no private cars, it is more likely that they own bycicles or motorbikes. However, one or more worker's buses which run at fixed timetables between the housing colony and the paper mill must be provided from the very beginning, already during the period of building and erection. That transport problem adds in remote parts of the countries to the initial expenditure of the new mill but can later be taken over by private enterprises which can charge a small fare for the transport of workers to and from the mill.

11. Availability of skilled and unskilled workers

Generally unskilled labour can be fairly easily arranged in developing countries but skilled labour, especially those with some practice in paper making, must be called from other countries, at least for the initial period of one to two years from the start-up of the mill. Experience has taught many paper mill managers for a limited period to train the local workers. Incidentally it proved to be advantageous for the development of new mills if some of the local workers who adapt themselves well to their job are sent for a few months to one well running mill in a developed country where they can become perfect in their professional skills and upon their return to the new paper mill will become foremen and tour bosses.

One additional problem in this connexion has to be strictly observed. The labour laws are different in different countries and it is most important that foreign workers respect the laws of the country where they work, even if that work is meant to be only temporary. Unfortunately quite a few serious clashes have occured with foreign instructors, when they did not respect the labour laws valid in the country where they worked.

APPROXIMATE ESTIMATE OF CAPITAL INVESTMENT

For a Paper Mill of 40 - 50 tons per day of unbleached paper in a Developing Country

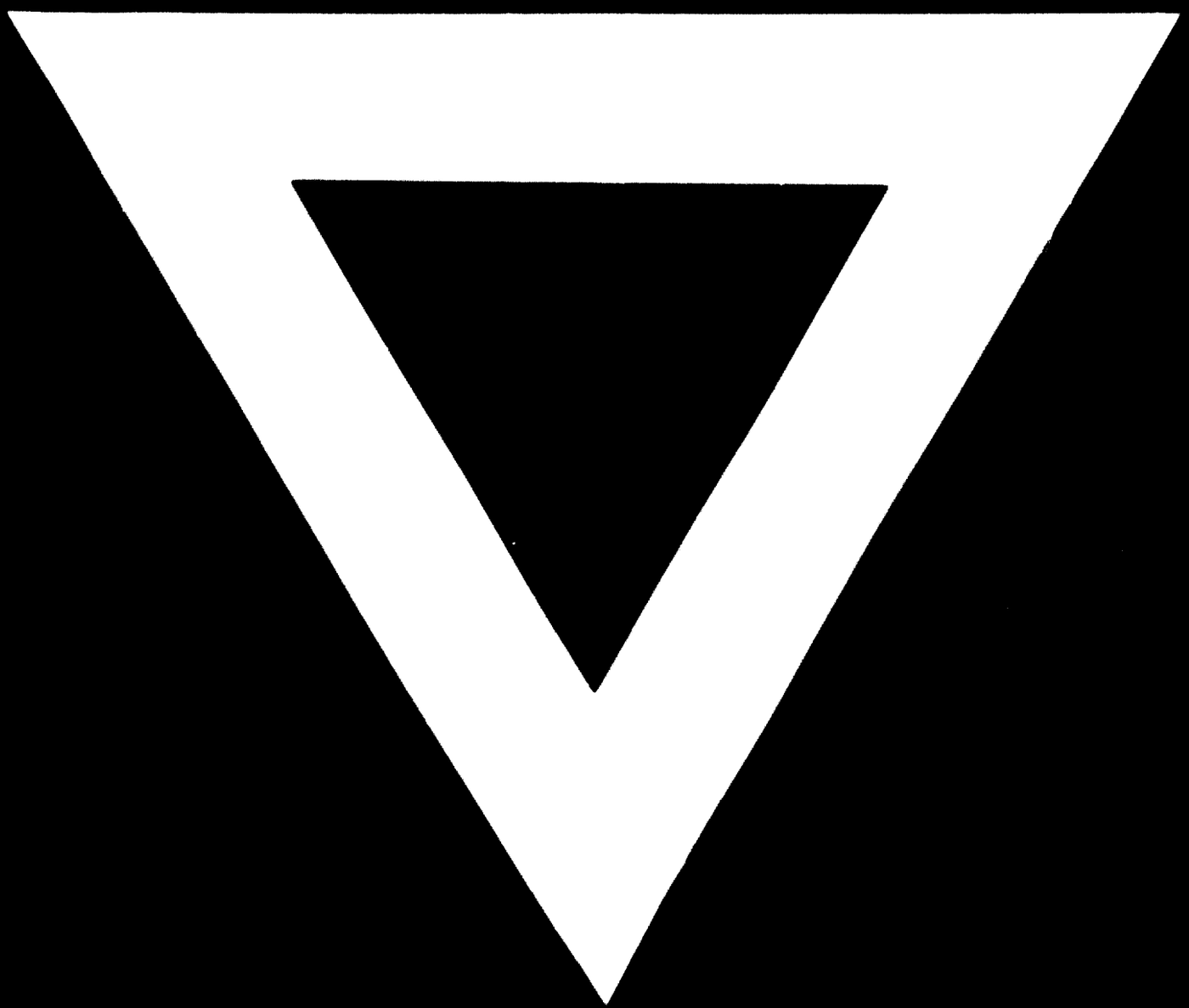
1.	Clearing and preparing the area of the future mill	$ 200,000.-
2.	Buildings	$ 700,000.-
3.	Stock preparation and de-inking	$ 400,000.-
4.	Paper machine and finishing department	$ 750,000.-
5.	Electric installation (transformer, switchboards, tyristor, driving motors)	$ 350,000.-
6.	Pumping station and fresh-water treatment	$ 250,000.-
7.	Two boilers	$ 700,000.-
8.	Turbo-generator	$ 500,000.-
9.	Workshop for maintenance and repairs	$ 200,000.-
10.	Heating and ventilating	$ 150,000.-
11.	Water and fibre recovery, effluent treatment	$ 400,000.-
12.	Spare parts, wires, felts, etc.	$ 100,000.-
13.	Training of personnel and start-up	$ 100,000.-
		$4,800,000.-

The above specified approximate estimates are based on the cost of new machinery and equipment. The figures could be considerably lower for second-hand machinery.

OPTIONAL ADDITIONAL INSTALLATIONS

(no costs estimated)

14. Bleach plant
15. Road building
16. Trucks, lorries, lift trucks
17. Dam for water reservoir
18. Hydro-electric power station
19. Railway sidings, cranes
20. Housing for employees and transport facilities



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