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ENGINEERING ISSUES IN THE MANUFACTURE OF OPEN PAN SUGAR PROCESSING MACHINERY IN DEVELOPING COUNTRIES 1/

by

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INTRODUCTION

Discussions on industrialisation in developing countries have been largely focused on the appropriateness of technological choices. This has been the result of bitter experience of establishing industrial projects or programmes which had very little or negative impact on socio-economic development in the developing countries. Consequently, many governments in developing countries have had to face the policy problem of finding ways to bring about technological choices which would be more desirable.

In the debate over the desirability of more appropriate technologies for use in industry in developing countries especially those in Africa, an important question is whether efficient alternatives for the technologies used in developed countries are actually available in Africa. Such alternative technologies are supposed to provide solutions to the central problems of growing unemployment, increasing rural-urban migration, increasing income inequalities and a host of other related problems in developing countries.

It is now generally realized and agreed that the transfer of large capital-intensive, complex technologies designed to suit conditions in developed countries has not only aggravated these problems but has also consistently imposed an ever increasing technological dependence on the developed countries. This technological dependence takes two forms, namely sophisticated imported equipment with continued dependence on imported spares and dependence on imported technical knowhow. This realisation is currently manifest in the search for more appropriate technology in all sectors of a developing economy. And it is now generally accepted that an appropriate technology is the one which takes into consideration availability of

- material resources
- human resources
- energy resources
- financial resources.

The debate over appropriate technology has assumed two dominant aspects. First, is the question of its transfer from developed to developing economics. Secondly, is the question of adaptation of the transferred technology to meet resource availability in developing countries. This paper seeks to explore some of the engineering issues surrounding the localisation of the manufacture of open pan sugar technology in developing countries.

The open pan sugar technology is well established in India and its engineering impact is already evident. It is currently being actively implemented in some African countries, like Kenya. The issues involved include the impact of such a transfer on the local engineering capacity of the recipient country, the sequential localisation process and the problems of entry by local firms. The discussion of these issues leads up to broad policy guidelines for developing countries. This paper has attempted to discuss such policy issues.

This paper also assumes economic sized plants processing fifty to two hundred tons of sugar cane as raw material per day.

I DESCRIPTION OF ELEMENTS OF OPEN PAN SUGAR PRODUCTION PROCESS.

In open pan plants, sugar manufacture may be generally subdivided into the following sequential stages:-

- cane weighing and storage
- cane preparation
- juice extraction by milling and weighing
- purification of juice or clarification
- evaporation
- crystallization
- curing (or centrifuging)
- drying and bagging

The production employed in open pan sugar plants is similar in many respects to the production processes employed in large scale sugar manufacture. The name "open pan" is derived from the fact that the purified sugar juice is evaporated and concentrated in the open pan by direct fire in the furnace obtained by burning dry bagasse.

The major elements involved at each of the above stages of the production process are as follows:-

Juice Extraction

The delivered sugar cane is weighed and then fed into the mill by conveyor. Before the cane gets to the crushers, it is cut by "cane cutters" (or knives). The cane is then crushed in a series of two or three tandem mills of three rollers each. Improved juice extraction can be obtained by spraying at the last stage either with diluted juice or water. To drive the crushers, and cane cutters gearing and appropriate electric motors with suitable starters, switches and V-Belts are required. The extracted juice is weighed on juice weighing scale.

Juice Purification

The extracted juice is lifted by a special chemical pump to sulphitation tanks. Sulphitation tanks are elevated to a height of 3.6 metres to allow for gravitational discharge of the juice from the tanks. Lime solution of 15° Besume is prepared and kept ready for mixing in the juice. Sulphur dioxide gas is pumped from sulphur furnace into the sulphitation tanks by a compressor. Before sulphur gas is introduced into the sulphitation tank it is first filtered through a scrubber. When liming and sulphitation process has been completed, the juice is passed into the "Sulphitation Bel Pans" (by gravity) and there the juice is heated to cracking point. The hot juice is pumped from the "Sulphitation Bel Pans" to the "Settling Tanks" which are placed at a height of 3.6 metres. After about one hour, the "mud" settles down in the settling tanks and the clear juice from the settling tanks is then passed to the juice boiling pans. Muddy juice from the settling tanks is pumped into filter press by a mud pump where it is filtered and the clear juice from filter press is also passed to the boiling pans.

Evaporation

The clear juice is boiled in the juice boiling pans until most of the water in the juice has evaporated and it becomes a thick syrup. The thick syrup is then transferred directly to crystallizers.

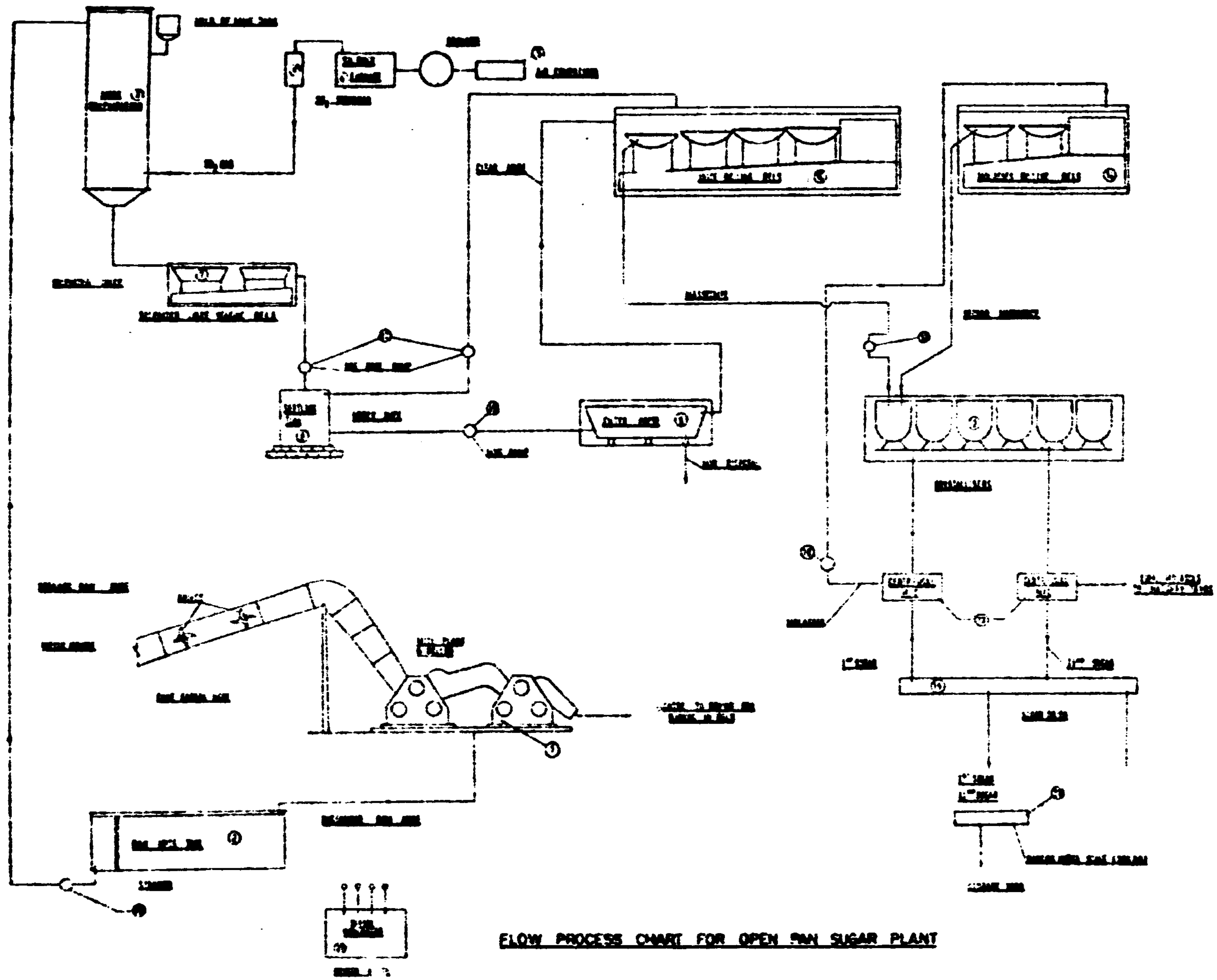
Crystallization

The crystallizers are fitted with stirrers. Here the syrup is cooled until saturated with crystals. This mixture of syrup and crystals (massecuite) is stirred for about two days before it becomes ready for centrifuging.

Curing (Centrifuging)

The heavy mixture of crystals and mother liquor in the crystallizers is also known as "magma", which is drawn into "centrifugals" driven by a fairly high speed

TABLE I



FLOW PROCESS CHART FOR OPEN PAN SUGAR PLANT

TABLE I A

25	MISCELLANOUS PLATFORM STAGING ETC	
24	INTERCONNECTION WIRING DISTRIBUTION BOARD	
23	INTERCONNECTING PIPING VALVE	
22	DIESEL GENERATION OR POWER TRANSFORMER	440V 220KVA
21	SUGAR BAG WEIGH SCALE 200 KG	1 NO.
20	CANE WEIGH BRIDGE	20 T CAP
19	MUD PUMPE (PLUNGER TYPE)	1 NO.
18	MOLASSES PUMP	2 NO.
17	HOT JUICE PUMP	2 NO.
16	RAW JUICE PUMP	2 NO.
15	HOPPER TYPE DRIER	1 NO.
14	MOLASSES BELS	5 SETS
13	CENTRIFUGAL MACHINES	4 NO.
12	CRISTALLISERS	35 NO.
11	MASSECUITE PUMPS	2 NO.
10	JUICE BOILING BELS	6 SETS
9	FILTER PRESS	2 NO.
8	SETTLING TANKS (2'x3'x1')	24 NO.
7	SULPHITATION BELS	2 SETS
6	SCRUBBER	1 NO.
5	AIR COMPRESSOR	2 NO.
4	SULPHUR FURNACE WITH LIME ADDING TANK	17 SQ. FT.
3	SULPHITATION TANK	3 NO.
2	RAW JUICE TANK	
1	MILLING PLANT CONSISTING OF HYDRAULICALLY LOADED ROLLER MILL TANDEM CARRIER AND TWO ROLLERS	
NO	MACHINERY	100T/D

FLOW PROCESS CHART FOR OPEN PAN SUGAR PLANT OF 100 TON PER DAY CRUSHING CAPACITY electric motor (2000 rpm). In the centrifugals the magma is purged of molasses and white crystals of sugar remain. The purged molasses is reboiled in the molasses boiling pans and the syrup so obtained is put into small crystallizers and then transferred to the centrifugals. The sugar crystals so far are wet.

Drying and Bagging:

The wet sugar discharged from the centrifugals may be dried in the sun on open platforms or by some other elaborated means. There are many designs/types of sugar dryers. The most commonly used is a rotating drum in which the moist sugar comes in contact with warm air. The dryer is then connected to a hopper with an outlet for bagging. Bagging can take the form of jute or paper bags, etc. The bagged sugar is then weighed on a platform weighing scale.

II MANUFACTURING STAGES ENVISAGED FOR OPEN PAN PROCESS COMPONENTS.

The technology required for components manufacture and fabrication of various parts for open pan process equipments may be to a great extent present in many developing countries of Africa but often may not be easily recognizable. Briefly the various guidelines for assessing the stages of fabrication and engineering capability for manufacturing open pan components will fall roughly under the following headings:-

1. Availability of technical manpower and presence of machinery fabrication and assembly capability of engineering machine shops,

2. Availability of mild-steel sections, plates, piping and fittings or otherwise presence of steel rolling mills.

3. Availability of forgings and shaftings or otherwise capability for forging of shafting, gear blanks etc. and machining them.

4. Foundry capability for casting of rollers, brackets, gear blanks plain bearings and various components and housings required for assembly. possibly partly from scrap materials to avoid expensive imports.

5. Precision and more technical engineering cabalilities related to such items as electrical motors and parts, highspeed centrifugals, bearings, pumps and crushers, compressors, blowers and power plant.

6. Design capability for adopting various components to suit local conditions and possible utilization of easily available materials eg. to fabricate where casting is more expensive or difficult; and creating new ideas resulting in technological improvement.

In most countries of Africa raw steel can be imported in shaft bar and plate forms. Other components such as bearing materials gear blanks and shafting can also be imported. A start can be made from the imported raw materials. However, to maximise savings on foreign exchange, domestic resources must be fully utilised to increase the engineering values added. Casting, for example using some scrap will save on imported raw material. From this, it will be apparent that behind each stage of development there must be suitable technical personel having the knowledge and understanding of what they are doing to decide correctly. There must be engineering, machining and fabrication capabilities and also assembly and installations capability.

Further the technical personel must be good enough to possess the understanding of function of components so as to be able to modify or replace some parts with those more easily obtainable or those that can be easily fabricated. The following stages are suggested:-

1. Fabrication and assembly of equipment more easily fabricated such as raw juice tank; sulphur tanks, sulphur pans, settling tanks, water tanks, oil tanks, boiling pans, scrubber, molasses pans, crystaliser tankage parts; and various holding tanks.

2. Casting of gears and gear blanks, brackets, pulleys, crusher rollers, sulphur furnace, filter press parts, pump bodies, boiling pans (C.I. sometimes cheaper), fire bars, hydraulic dead weights, plain bearing blocks, pulleys, rollers, clutch housings, etc.

3. The next components that could be manufactured are special forgings which require precision machining such as crusher shaft cutter shafts, gear shafts, centrifugal shafts, clutch shafts, counter and main shafts, crystallizer shafts, hydraulic cylinders and parts for crusher; bolts and nuts, etc. Part manufacture of dryer and conveyor assemblies for crusher may also be possible.

4. Fabrication of the main frame and fitting of centrifugals, crushers, cane cutters, conveyors, sugar dryers etc. At this stage there must be technical competence to understand the technical functions of the equipment with the capability to improve on performance and to understand basic engineering behind design and materials as dangers and waste may occur if there is lack of good knowledge of engineering science mechanics and

materials. It will also be clear that even at the final stages it may not be in the best interest of economy to set up for 100% manufacture. Equipment such as motors, chains, ball bearings, centrifugal pumps, compressors, valves etc. will be cheaper to buy in this scale of application. Again stage 1-4 may be achieved very quickly depending on engineering infrastructure, and technical expertise available in the country, and time element for acquisition of manufacturing stages, may accordingly vary.

III. IMPACT OF LOCALISATION OF OPEN PAN TECHNOLOGY ON THE DOMESTIC ENGINEERING SECTOR.

The forward linkages associated with the transfer and adaptation of open pan technology have been highlighted in other papers presented to this Seminar. Of immediate concern here are the effects of the localisation process of the open pan technology on the capacity of the engineering sector of a developing country. These are "backward linkages". The word "localisation" is used here to mean the fabrication and/or repair and maintenance of major components of the open pan sugar machinery.

The backward linkages associated with the adoption of the open pan technology would be in the form of purchased inputs and services required to produce the technology domestically. Thus the tangible economic byproducts of the adoption of open pan technology may assume the following forms in the long-run.

- expanded utilisation of the products of the iron and steel industry;
- the stimulation of expanded capacity in the manufacture of major components of the open pan technology, especially the manufacture of boiling pans, centrifugals and crushers;

- the stimulation of research and development (of certain components of the open pan technology in the engineering sector;
- the development of new or improved processes and techniques of the technology during the process of localisation (i.e. transfer and adaptation);
- cost reduction;
- the expansion in the provision of technical service to production units, such as repair services in rural areas
- open pan sugar technology could form a "spring-board" to more complex technologies such as "vacuum pan" sugar technology.

As forward (demand) linkages within the engineering sector the following are discernable:

- the dependence of the open pan sugar technology on smallholding farming may stimulate the production of simple farm implements, e.g. oxen ploughs, ox-carts and tractor-trailers; thus giving rise t expansion in the small farm implements engineering industry.
- the existence of certain byproducts of the open pan sugar technology, eg. molasses, could stimulate the manufacture of machinery to process such byproducts. Hence this could lead to expansion in the alcohol processing machinery and animal feed or yeast manufacturing machinery sectors of the engineering industry.

It is, therefore, apparent that some of these backward linkages cannot be measured in quantitative terms but also may defy identification. It is also clear that the localisation process of the open pan technology would involve granting production opportunities of the diverse components to domestic firms. This will not only broaden the domestic employment base but may also encourage the formation of specialized small, independent subcontracting engineering firms in the rural areas. Since the achievement of sustained industrialization is decisively determined by the success in developing and strengthening domestic capability in the transfer and adaption of industrial technology, these contributions would be desirable.

However, one must pose the fundamental question of manpower. The pace of adoption of the technology will be fundamentally determined by manpower development. The more technical and managerial skills are developed during the localisation process, the greater the benefits that can be derived from the utilization of the adopted technology. But it is now realised that, perhaps, the most serious manpower in developing countries is the general scarcity of entrepreneurial and managerial ability within the engineering sector. Although in most developing countries the development philosophy is conducive to full development of entrepreneurial and engineering talents, the vast potential has so far been scarcely tapped. There are two main reasons for this: Firstly, in some respects, the developing economies operate in ways which inhibit entrepreneurial ability within the engineering sector. Fiscal policies and industrial strategy have tended to favour the adoption of sophisticated, complex technologies in the manufacturing and agro-industries at the expense of simple small-scale technologies and thus discriminate against the very engineering sectors in which potential small entrepreneurs have the best chance to establish themselves. Secondly, the financial set-up and policies in many developing countries have not encouraged entrepreneurial risk-taking, particularly if the capital required is substantial. Thus the central issue is for governments and international aid agencies to provide incentives and means to the existing and potential small scale entrepreneurs to transfer and adapt appropriate technology. The localisation of the open pan technology in developing countries would definitely need this kind of encouragement.

IV. PROBLEMS OF ENTRY BY FIRMS IN DEVELOPING COUNTRIES.

Entry into the manufacture of open pan sugar machinery will be basically determined by three issues:

- Government policy toward the transfer and adoption of such technology. A positive government policy toward the adoption of open pan technology would definitely accelerate the pace of adoption. This would also include development oriented taxation policy to the factory operators.
- Availability of competence (i.e. human skills within the engineering sector).
- Availability of engineering facilities in form of raw materials and foundaries as well as the import potential of such facilities.

Entry into the open pan sugar technology is not likely to be a complex issue in African countries. Indeed the adoption of this technology has entered an active stage. Several firms in East and West Africa have already entered into the manufacture of open pan components, and some have achieved over 80% localisation of such manufacture and are examining process improvement possibilities. A number of these firms were traditional manufacturers of jaggery machinery, while others are engineering firms who are entering the industry in response to the demand for such machinery created by the adoption of the technology within the sugar industry. Close observation of these two types of open pan sugar machinery manufacturers attests that the latter firms have a more innovative approach and are likely to do better on the technological development front.

Although open pan sugar technology remains dominated by firms in India, they are not multinationals and are generally not protected by a coherent patent system. The cost of transfer and adoption is thus not likely to be prohibitive as the case in "vacuum pan" sugar technology. In order to eventually ensure maximum benefits from the transfer such transfer should be negotiated by the home government with the current manufacturers in India or elsewhere. This would allow competition in the adoption of the transferred technology in the receiving country, as the government would encourage any capable engineering firm in the country to adopt the transferred technology.

At the domestic scene entry into the open pan industry should be relatively easy because most of the major components (such as boiling pans, centrifugals, etc.) of the technology are free from patent restrictions and quite a number of reputable engineering firms in developing countries can fabricate them. The profit potential in the industry will determine the number of entrants. The profit level also could be low because the open pan industry is likely to encompass numerous small to medium-size firms, given the present set-up of the engineering industry in most developing countries. However, technical capability and financial considerations may limit entry and possibly necessitate specialization in the industry. In any case, competition in the open pan sugar technology should generally be limited to the bidding (tendering) or proposal stage. Once the tender has been awarded competition will be over.

V. SOME POLICY GUIDELINES FOR ESTIMATING THE CAPACITY OF DOMESTIC ENGINEERING INDUSTRY.

Another basic reason for failure to utilize maximally the existing and potential capacities in the engineering sectors of developing countries is the inadequacy of methods or tools used to measure the contribution of the domestic engineering industry to the attainment of given development objectives such as economic growth, employment and income distribution as well as balance of payments. This results from the very nature of the benefits that are likely to accrue from the localisation process of an industrial technology. As already alluded to, many of these benefits are intangible and may defy identification.

However, an attempt has to be made if the domestic engineering industry is to receive the priority it deserves within the context of a country's development programmes. This can best be done by relating the sector's contribution to each one of the broad socio-economic objectives of a given country. In other words, these objectives should be used as the criteria for evaluating the social and economic impact of the technology to be adopted. By virtue of the broad diversity of development objectives, the use of a multi-objective benefit cost analysis would be necessary and desirable. Within this framework of analysis specail attention ought to be given to the impact of the technology on the efficiency of resource use in the economy. Hence the use of such measure as the domestic resource cost, economic rate of return as well as measures of income distribution and employment generation ought to be given careful attention in the analysis at the project level. This is necessary because the raison d'etre of transfer and adoption of technology, such as the open pan sugar technology, is to provide solutions to the pressing problems of unemployment, efficient resource use, and income distribution. These measures must therefore be incorporated in the assessment at the project level. The use of the concept of domestic resource cost (DRC) is of particular importance in African countries where the problems of efficient resource use and foreign exchange have emerged as the most serious development problems of the 1970's. DRC does not only measure the project's efficiency to earn or save foreign exchange but also implicitly assesses the efficiency with which local resources are being utilised in the project. The use of the DRC would, therefore, lead developing countries to giving top priority to projects which use more of the local resources and hence to the promotion of appropriate technology. The use of other measures such as economic rate of return to highlight growth objectives would be a desirable supplement.

To minimize the problems of entry into the manufacture of open pan sugar machinery, governments in developing countries ought to assume the role of formulating industrial strategies and fiscal policies which minimize risks of entry. The governments should also, as a matter of policy, negotiate and reach agreements with foreign firms on the terms and conditions of the transfer of technology. This would not only minimize the transfer costs but would also discourage monopolistic or oligopolistic development in the industry.

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