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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

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Guidelines for investors when establishing a sugar industry in developing countries.

TECHNICAL AND TECHNOLOGICAL PROCESSING CONSIDERATIONS FOR BEET AND CANE SUGAR PRODUCTION [1/]

by

G. Morvai *

* Sugar technologist, S. Sremca ul. 7, 24400 Senta, Yugoslavia

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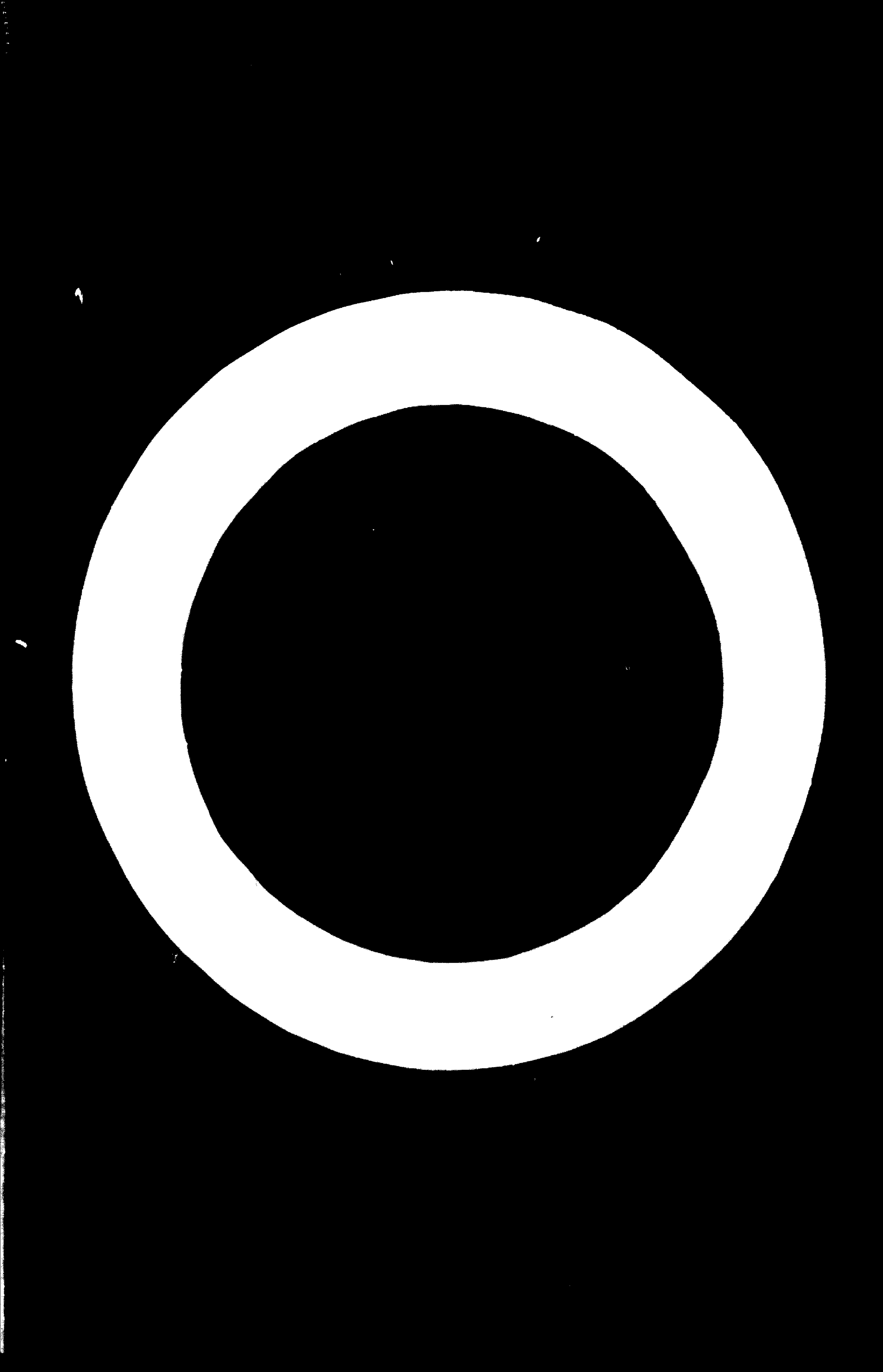

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INTRODUCTION

Sugar was luxory for hundreds of years, but nowadays it is one of the basic foods, because it became well known that sugar is indispensible in the ordinary diet of a man and because the recent development of the technology of the growing of sugar cane and sugar beet /the two most important plants for the production of sugar/ and of the tèchnology of sugar-manufacturing has made sugar the cheapest of all carbohydrates. Every country all over the world has to make use of this possibilities to produce sugar for the benifit of it's population.

The developing countries are not able to do at once a full-scale use of all recent developments, because for the production of cheapest sugar mechanical and automated, high-mass production is necessery from the field to the bins. However they ought to start with the production of domestic sugar as soon as possible in order to be able to cover the national consumption. It means that they have to produce consumption sugar in a straight way and not row sugar which is to be refined. As for concerning the quantities, capacities the overall local conditions must be taken in consideration /growing and harvesting is to be done manualy, transporting very often by ox drown carts etc./. So factory capacities are to be limited to maximum wich is still possible to supply in this way, but which is probably lower than the economically desired minimum capacity.

However, if the sugar industry should be well established, one could count on a rapid and successful further development. The aim of this paper is to give the necessery informations and to help /where it is asked/ for a good establishment and successful development of the sugar industry all over the world.

GLOSSARY OF TERMS

absolute - Juice content of the sugar cane

after product - Any material obtained after the white sugar boiling.

alkalinity - A measure of the alkaline properties of juice.

ammonia lines - Pipe vent lines for removal of noncondensable gases from steam chest.

apparent purity - The percentage proportion of sugar on solids, the solids being determined by refractometer.

ash - A measure of the inorganic constituents.

batch method - Discontinual method.

beet end - The part of the sugar factory including the process through the evaporation.

beet feeder - A device making uniform the flumming.

beet pile - Beets stored at country stations.

beet pump - Special pump elevating the beets whith water.

beet slicer - Machine for slicing of the beets befor extraction.

beet top - The upper part of the beet not suitable for the extraction of sugar.

beet yard - Part of the factory site wher the beets are received and discharged.

beet wheel - A large wheel used to raise the beets to a higher plane and separate them of water.

bins for beet - Beet storage place made of concrete.

BOD. - Biochemical oxygen demand - is the amount of oxygen required to biologically oxidise the organic matter in a sample over a period of time, usualy five days.

boiling or jet Finished massecuite of a whol pan. First-, high- or A-boiling that from which white, consumption sugar is obtained. Second-, intermediate- or B-boiling is resolved for the high purity syrup or standard liquor. Last, low, C- or D-boiling is the one from which the final molasses is purged.

bon char - Maerial as an activated adsorber for color and ash, especially in the sugar industry.

brei - Finely rasped bett particles for analitical purposes.

brix - Percent of solids /dry material/ in sugar solutions.

bucket elevator - Elevating conveyor with buckets fixed on endless chain.

buffer - A supstance acting to maintain en existing pH in the solution.

bulk bin - Silo for crystalin sugar storage.

bundle of cane - The harvested cane stalks are bounded in bundles for easier transporting.

busket - Perforated steel cylinder of the centrifugals.

cake - The solid material separated by filtration.

calandria - A common type of stea chest with tube-bundle.

calcination - Burning, converting of lime ston to lime.

campaign - The yearly period of work of a sugar factory.

cane yard - The part of the factory site where cane is received and discharged.

caramelise - conversing of sugar to colored materials by heat or burning.

carbonation - Treatment with carbon dioxidegas.

charge - Filling of a centrifugal.

catch-all - An entrainment or foam separator.

chips - cosettes Sliced beet for the extraction.

clarification - removal of solids from the juice by setling.

clump of cane - Root of cane with severel stalks grown out from it.

COD. - Chemical oxigen demand.

coil - Heating element made of a long tube.

condensate - pure hot water condensed in the steamchests.

condenser - A device to produce vacuum condensing vapours by water injection.

crude juice - raw juice Juice extracte from cane /beet/ non purified.

crushing - desintegrating of cane fibers for extraction.

curing - The crystallizing of raw massecuite in crystallizers.

cutting - Harvesting of the cane.

cyclone - A mechanical device used to remove solid particles from liquid or gas streams.

desugarizing - Recovery of the sugar from final molasses.

desweeten - sweeten off To wash a material free from sugar.

diatomaceous earth - Material used as filter aid.

diffuser - An equipment for the extraction of sugar from sugar beet or sugar cane.

division - The lenght of V graves by beet knives.

draft - Percentage of raw juice by wight of beet processed.

dress a filter - To install knew filter cloth.

drips - The condensates from the steam chests.

dry supstance - The moisture-free constituent of a solid or liquid material.

entrainement - Droplets of syrup withdrown by vapour evaporated from it.

exhaust steam - The steam leaving a turbine.

feed water - Pure water used in boilers for steam generation.

filing - The repairing of beet knives by fraising.

filling - The wight of cosettes in the volume of 1 m^3 of the diffuse. The weight of massecuite fed in the basket of the centrifugal for one cycle.

filter aid - Material which precoated on the filtermembrane improves the clarity of the filtered liquid.

filter medium - A layer of cloth, wire or paper providing actual initial filter surface.

filtrate - Liquid after passing thrugh a filter.

filter presse - A machine for filtering and desweetening composed of plates and frames.

flash - Autoevaporation by the lowering of the pressure.

footing - A quantity of high-purity massecuite used to furnish crystal surface for further crystallisation from lower-purity liquors in pan boiling.

foot valve - The valve whic discharges the finished massecuite, strike, from the vacuum pan.

granulator - Rotating drum type sugar drier.

green syrup - The first purged syrup of a centrifugal with lower purity.

hardness - The content of dissolved calcium an magnesium salts of water or juice.

high syrup - high purity syrup that used for the first boiling.

interlock - A mechanical or electrical device preventing independent operation of inter-conected equipments.

juice - Any sugar-containing liquid in sugar manufacturing process, up to the nelter station /sugar haouse/.

juice purification - The process of the possible quantity of impurities from the raw juice.

juice chember - The space in an evaporator or vacuum pan for the boiling juice and the vapour generated by it.

knife - A splitter for slicing of beets.

known losse - Losses of sugar during processing accounted for.

lagoon - settling lagoon - A space for the storage and setling of wast waters from the processing of sugar cane.

leg line - The vertical pipe comprising the barometric column in an apparatus under vacuum.

liming - Treating the raw juice with milk of lime.

lime kiln - A cylindrical shaft-kiln for burning of lime stone.

lime salts - Dissolved calcium salts in a sugar sulution expressed as percent CaO by total dry supstance.

liquor - A sugar containing liquid used for crystallie zation in vacuum pans.

losses - the of sugar in cane or beet processed and obtained as crystalin sugar an as sugar in molasses.

lining - cleading /refractory or insulating/

lixiviation - The proces of subsequent humidification an squeezing by the extraction of sugar from sugar cane.

machin syrup - mixed syrup, when the green and wash syrup are not separated by purging.

magma - A mixture of crystala /sugar/ and liquid prepared by mixing the components, as in affination.

massecuite - The mixture of crystals and mother liquor produced in the sugar boiling process.

melt - To dissolve.

mill - A machine with 3 of 4 rollers used for the ext traction of raw juice from sugar cane by pressing. More units 4-6 are assembled to a mill-plant or tandem one after the other.

mingle - To mix crystallin sugar with syrup for pumping or second centriguging.

mixer - A large receiver for a whole boiling with slow agitator and often with coolin elements.

molasse - The syrup from the last boiling whic is not suitable for further crystallization. In the cane sugar industry all the syrups are colled molasses and the final molasses as black strap molasses. To avoid missunderstandings it is recomanded to call the run of of all centrifugals syrup and only that of the last boiling molasses.

mother liquor - The solution from which crystals ar formed /grown/.

mud - First or second carbonation's precipitates.

muddy juice - The thickened rest /residue/ after clarification of the purified juice.

multiple effect - The short expression is sometimes used for the multiple effect evaporator equipment consisting of 3 - 5 effects or bodies.

nonsugar - Any material present, aside water, which is not sugar.

nucleation - seeding - graining The process and operation of forming crystal seeds.

parameter - A quantity or value to which may be assigned arbitrary value.

peptize - To bring into colloidal solution.

pH , pH value - A measure of acidity.

polarisation - A measure of sugar concentration. Pol or simply P is often used for the sugarconten of cane or beet and intermediate products.

plantation white sugar - Consumption crystallin sugar of lower quality obtaine directly from cane thick juice without refining.

plow - Discharging device

plow - A discharging device of the centrifugal basket.

polyploid - multifod

precoat - A layer of filter aid.

press water - water from the pressing of pulps.

puddle - To make fluid.

pulp - The extracted posettes leaving the difuser.

purge - To remov the mother liquor or syrup by centrifugign.

purity- The percentage of sugar on total solids.

refractometer - An instrument for the determination of total dry supstance of liquids.

roller table - A roller conveyor used for dewatering and cleaning of the beet.

sacharimeter - polariscope An instrument used for the determination of sugar concentration in liquids.

screening - sieving The separation of oversized and udersized particles from crystaline sugar.

scrubing - The washing of gases.

scroll - A screw type conveyor.

seal tank - The seal on the bottom of e barometric leg pipe.

sedimentation - The falling of solid particles in liquid.

seed cane cuttings - The stalks of cane pieced out for planting.

seedling - A plant grown from seed.

shredder - A machine used for desintegrating cane beore extraction.

sight glass - Heat-proof roung glass plate used mounted on an apparatus for the visual control of processes.

spinning - Purging or centrifuging.

silo - A storage bin for cristaline, granulated sugar.

sludge - The setled mud from the thickener.

smear - To produce fine crystals in massecuite, thus resulting in mixed-grain sizes difficult to centrifuge.

soda ash - The technical grade of sodium carbonate,Na_2CO_3.

soft sugar - Brown sugar composed of very small crystals and relativly high content of invert sugar, keeping the grains slightly moist.

spindel - A hygrometer. The conecting shaft between the centrifugal drive, or pulley and basket.

sprangled - having many roots.

steam chest - heating chamber of the evaporator or similar.

steffen house - Sugar factory using the Steffen process.

steam trap - A device for discharging condensate from a heating chambe.

straight house - Sugar factory without Steffen process.

string proof - A method to determine the consistency of the mother liquor by vacuum pan boiling.

Sugar beet - beta vulgaris

sugar cane - Sacharum officinarum

sugar end - refinery The part of the sugar factory from vacuum pan boioing station up to the sugar drier.

sucrose - Sacharose

sulphur burner - The sulphur stove an equipment for the production of sulphur dioxid gas.

sweeten - Introducing a sugar containing liquor to a supstance or apparatus, replacing the liquid previously pre sent if any.

sweeten off -,Desweeten, to wash the filter cake as to recover sugar.

sweet water - Dilute sugar solution from the washing of the filter cake or granular carbon beds.

taking stoke - The establishment, calculation of the sugar contained in intermediate products in the factory carried out by periodical factory account.

Thermolabile - Unstable to heat.

thermophilic - Heat loving organisms.

thickener - A clarifier, a settling device.

thick juice - The thickened juice leaving the evaporator.

thin juice - The purified, filtered juice ready for evaporation

third saturation - The sulphitation of thin juice.

<u>tilting platform</u> - dump platform An unloading device for tracks and cars.

<u>tandem</u> - An assambly of 3-6 cane mills for the extraction of raw juice from sugar cane by presing.

<u>tramp air</u> - The air that enters a boiler in such a way, that it does not participate in the combustion process, therby lowering the boiler efficiency.

<u>true purity</u> - The percentage proportion of true sucrose to total dry supstance. Usually sucrose is determined by an inversion method, and total dry supstance by drying.

<u>tube sheet</u> - The perforated top and bottom plate of a calandria in which the heating tubes are mounted.

<u>twin</u> - A compuond crystal composed of two or more crystals in reverse position to each other.

<u>wash syrup</u> - white syrup The second run off purged after washing having higher purity.

<u>water hammer</u> - The stresses in steam chest and steam pipes caused by mixing of steam with condensed water.

<u>vapor</u> - The steam derived from the boiling juice.

<u>zeolit</u> - A hydrous ion-exange material.

2.o. FLOW SHEET OF SUGAR PRODUCTION

2.o.1. Growing of sugar cane /sugar beet/

The main features of the growing will be discussed in details in the section 3.1.1 and 3.2.1. so there is nototning additional to be discussed. The cane and beet are received and unloaded at the"factory site" the place is"named"cane yard" or "beet yard".

2.o.2. Processing of sugar cane /sugar beet/

The processing of sugar cane and of sugar beet are in general very similar /differing only in some technological details/ so it will be possible to discass the flow sheet of processing for both simultaneously on the basis of sugar cane processing and marking the differences of the sugar beet processing.

2.o22.1. Extraction station

Preparation of the cane /beet/ - The cane is supplied to the factory mechanically by means of carriers and "feecing tables" being washed and freed from extraneous materials. The beets are commonly supplied hydraulically, by "fluming" with a water flow through the "fluming canals" or "flums".

To make possible a rapid and efficient extraction of the sugar the cane is cut into pieces by means of revolving "cane knives" and desintegrated by means of "shredders". The beets are sliced into "cosettes" or "chipps" by means of different types of "beet slicers".

Extraction of sugar - The desintegrated cane is extracted by repeated "sqeezing" and"imbibition" /"lixiviation"/ by means of a set of "crushing mill" called "mill tandem" of "tandem" or by diffusion i.e. countercurrent leaching by water in a continuous "diffuser". The beets, cosettes are extracted exclusively by "diffusion".

By the extraction are obtained "row juice" /crude juice/ 100% by weight of cane /115% by weight of beet/, and exhausted "bagacilo" 100% by weight of the processed cane /"fresh pulp" or "exhausted pulp" 70% by weight of the processed beet/

3.o.2.2. Juice purification station

The row juice ought to be purified as to eliminate the possible quantity of "impurities" "nonsugars" /dissoved inorganic salts and organic mostly colloid matters/ as to make possible the production of a"White suga" at the later crystalization.

The cane row juice is "purified" by sulphure dioxid gas "sulphitation process" or by lime milk and carbon dioxid-gas /carbonation process/. Sugar beet row juice is purified only by "carbonation method". The precipitated mus /containing crystalized $CaSO_4$ or $CaCO_3$ and a part of the impurities/ is"thickened" to muddy juice and separated from the "clear juice" for easier filtration and "sweetening off".

"Thickeners" /"clarifiers", "settlers" or "decanteurs"/ and "vacuum drum filters" are used for this operations.

Finaly, after filtration "fine filtration" by a"precoat type filter" /"leaf pressure filter", "candle filter","filter press"/ the clear, brilliant "thin juice" is obtained 1o5% by weight of cane, 13o% by weight of beet.

3.o.2.3. Evaporation and thick juice sulphitation

To obtain crystaline sugar from the purified thin juice it is necessery to evaporate water from it. This evaporation is done in two steps: by "evaporation" and by "crystalization". At the evaporation the thin juice of 11-14°Bx density is concentrated in the "multiple-effect evaporator" or simply "multiple-effect" to "thick juice" of 6o-66°Bx density. In the cane sugar industry the obtained "thick juice" is called "syrup" wat is misleading therefor not recomanded. The quantity of thick juice is about 24% by weight of cane, 31% by weight of beet.

The subsequent thick juice"sulphitation"/treatment with SO_2-gas is very important as to obtain sugar of "high whiteness" and to make easier the pan boiling and centrifuging process.

Withe the evaporation station ends the first part of the sugar factory called "cane end" /beet end/. The second part is called sugar end /or sometimes refinery/

3.o.2.4. Crytalization station

By this term is understod not only the process of crystalization of sugar, but the whole proces of the production of white,consumption sugar from the thick juice i.e. the whole sugar end. It consists of the"pan-boiling station" and of the "centrifugal station which can't be strictly devided concernign the technologic sequence. To obtain a white sugar of a good quality and highest quantity the "syrups", "run offs" or "molasse" separated from the "massecuite" /mixture of sugar crystals and mother liquor obtained by "boiling", crystalization in the "vacuum pans"/ by centrifuging, "purging" is used for boiling of a "lower product" /lower boiling, lower "strike"/ i.e. massecuite with lower purity. On the other hand,"intermediate sugar" ought to be recrystallized by melting with condensate or thin juice and renewed boiling of the obtained "high purity liquor". All this processes are carried out following a more or less complicated "boiling scheme" depending on the purity of the thick juice and on the desired quality of the"consumption", "white sugar".

The syrup purged from the last "ow row boilin" massecuite is of such a low purity, that it is not suitable for further crystalization, and it is called molasses /blackstrap molasses by cane/ and it can be used for different purposes. By beet sugar manufacturing a desugarization is supposed and presented, by cane sugar manufacturing alcohol prodaction from molasses is presented. The use of the expression "molasses" for the run offs from the centrifugals is misleading, confusing and very inconvenient, it would be avoide.

It is difficult to quote strictly the datas for the intermediate products of the sugar house without sthorough calculations on the basis of stated local conditions and parameters. However the main datas are given in the graphic flow sheet estimated on the basis of experiance. So for cane sugar manufacturing the yield on white sugar is estimated to be 11.4% by the weight of the processed cane and the same for beet procesing by "steffen house" 14,8% depending on the Pol of the cane /beet/

3.o.2.5. Pulp drying station

As the extracted "cosettes","pulp"from sogar beet is very valuable cattle feed it is to be dried to preserve its feed value.

The pulp from the diffuser is conveyed and fed into the"pulp presses". The obtaine "press water" is returned into the diffuser as to obtained somewhat more sugar and to avoide serious wast water problems. The "pressed pulp" is conveyed and fed into the rotary drying drum. The "dried pulp" is weighed and conveyed /usually pneumatically/ to the "dry pulp" store house, where it can be sacked by hand or mechanicaly.

The Common quantities are : Fresh pulp 70% by weight of the processed beet, pressed pulp 30% by weitgh of beet, dried pulp 5,6% by weight of beet.

3.o.2.6. Lime kiln station

The necessery lime and CO_2-gas for the juice purification /by beet processing/ and sometimes by cane processing/ is produced in a "lime kiln" at the factory site.

The limestone and coke are conveyed into the bunker. The accurate "feed misture" is weighed and mixed automaticaly by filling the bucket of the skip. The discharged lime /quick-lime/ is conveyed /sometimes after weighing/ to the"lime-slaker" and the obtained "lime milk" is passed to a large "ripening tank", from ther it is pumped to the rake classifier and/or to the hydrociclons for the separation of "sand" i.e. unslaked particles. The sand-free lime milk is passed to the factory storing tank.

The CO_2-gas generated by lime-burning is passed through a wet gas washer "scruber",befor the vacuum compressors, to the dewatering receivers.

3.o.2.7. Utilization of the molasses

Steffen proces for beet molasses - The produced molasse 4% on beet is diluited in amixing tank by addition of 30% /on beet/ sweet water and passed to the "reactor" for the precipitation of calcium sacharate by addition of 2,7% CaO "bold precipitation". The mixture is filtered by a vacuum drum filter and the"sacharate cake" is washed simultaneously. The filtrate is heated and treated again with powdered quicklime /hot precipitation/. The precipitate is separated by "thickening" in a "clarifier" and filtered on a vacuum drum filter and washed. The two saccharate cakes are diluited and mixed /26% vacuum filtrate is added by weight of beet/ and the obtained "sacharate milk" 31% by weight of beet is pumped into the"defecocarbonator" replacing the necessery addition of lime milk.

3. UNIT OPERATIONS AND UNIT PROCESSES

3.1. BEET SUGAR

3.1.1. SUGAR BEET GROWING

3.1.1.1. Generalities - Sugar beet is a member of the species Beta vulgaris, familiae Chenopodiaceae /goosefoots/.

The sugarbeet plant is grown very successfully in the northen latitudes, but there are many sorts of it adapted to different soil conditions, like the cold climate of Sweeden, of the Canadian provinces of Quebec and Minolta or the hot climatic conditions of Italy, Spain and of Arizona or Imperial Valley in the U.S. Concerning the temperature a day-time maximum average of 21°C and a night minimum average of 1o°C are optimal for the production of sugar in the sugar beet. The yearly quantity of precipitates needed is about 6oo-66o mm. Soils above a pH 6,5 are most favorable for the sugarbeet growing, and those below 5,2 are nto suitable.

The average root yield has reached a quantity of 17 tons per acre by a modern technology of growing. At the begining one can count on 1o-12 tons per acre and on a sugar content Pol of 15,5-16,5.

3.1.1.2. Seed production - For developing of a home grown seed production many years of systematic work are necessery. Unzil than seed material is to be purchased from a well known reliable firm. There are sugarbeet sorts with high yield of roots per acre and low sugar content and sorts with low yield of roots per acre but high sugar content and middle sorts also. Otherwise some sorts are more resistant to diseases /cercospora-resistent sorts/ and the others less. There is one more very important characteristic of the seed: the common sorts are multigerm ie. each seed after planted results in several sedlings, which are later to be eliminated exept a single plant. But there are processed monogerm seeds and new genetic monogerm sorts which are used to reduce labor and costs of production.

3.1.1.3. Planting - The successfull growing and the yield of sugarbeet depends in great part from the preparation of the soil ie. of the seed bed. The most important factors therby are: crop sequence, depth of plowing, time of plowing, fertilizer practice and herbicid usage.

Multiple-row drills are used for planting, which space out the seeds three or four inches apart from each other. The depth of seeding depends of the soil quality and varies from o,5-1,5 inche.

Concerning fertilizers the addition of animal manure is very important, but in case of limited supply, additional mineral nutrients should be used. Care must be taken of the balance between the amount of nitrogen and other minerals.

3.1.1.4. Chemical and mechanical control of weeds - To reduce the costs of sugarbeet production it is very important to minimize or eliminat labor and to do all works by chemical and mechanical methods. A very important factor is the proper crop sequence ie. after cem certain crops the numbers lf weed seedlings is lower than after others.

By using pre- and post-emergence herbicides it is possible to raplace the machine cultivation and hand hoeing. Mechanical and chemical tools can be combined together by different methods depending on : the kind of machinery, the weather conditions, the need of irrigation, the nature of soil, herbicide applicathin etc.

3.1.1.5. Control of insects and diseases - There is a lot of insects and diseases capable to destroy partly or totaly the sugarbeet plants. The most important soil insects are: cutworms, wireworms, white grubs, root lices, garden centipedes, flea beetles and root maggots. The foliar insects: webworms, leaf miners, yellow bear camterpillars, army worms, spider mites alfa loopes and others.

From the diseases some virus diseases are carried by insects like: curly top, beet savoy and various mosaics. Fungal bacteria can cause root-, foliar- and seed-borne diseases like: black root, and the vary dangerous cercospora beticola.

The chemical control of insects and diseases is carried out by different machines and tools, the simplier being carried and actioned by man power and the biggest by tractors. There are many chemical agents /plant protectives, insecticides, fumigants and growth regulants/ on the market under various commercial names. Cercospora is controlled in humid sections by preventive spraying at 1-2 week intervals with tribasic cooper fortified with special chemical agents. There were developed by different seed breeders cercospora resistent varieties of sugarbeet what is to be reguarded by purchassing the seed material.

3.1.1.6. - <u>Beet thinning</u> - For the optimal growth and the highest yield it is necessery to assure a plant pupulation of 60.000 - 75.000 beets per hectare /25-30.000 per acre/, with uniform distances between single beets. As to obtain such a desired "final stand" it is commonly practiced to plant excess seed and to thin later to the wanted final stand. The methods of thinning are different, such as: hand thinning and hoeing; cross blocking followed by hand thinning; spring-tine tools used severel times at an angle to the beet row; and finaly the labor saving and most acurate electronic selective thinning.

The newly developed monogerm seeds can eliminate the thinning, but it requires precise soip preparation, precise seed drills combined with herbicide and insecticide distribution.

3.1.1.7. - <u>Irrigation</u> - The need and method for irrigation of sugarbeets is different from producing area to producing area depending mostly on temperauture, type of soil, ammount of slope, amount of rainfall and lenth of growing season. Freequent, light irrigations are mor useful than haevy, infreequent waterings. Deficient moisture in soil decreases the crop growth and finaly the sugarbeet yield, but overirrigation can be harmful. Well aireted soil is also necessery for the normal growth of sugarbeet. The excess of soil water must be drained.

Irrigation with furrows between the rows is common. Pump irrigation systems with rotary sprinkles are also used, to avoid the expenditure for leveling the field. One of this systems will cover 40 - 70 hars.

5.1.1.8. Harvesting and transporting - Only the clean roos of the sugarbeet are suitable for processing. Therefor not only the soil particles and weeds as cast off ought to be separated from the beets befor delivery, but the leaves and beet tops also./Beet tops are not suitable for the extraction because of the low sugar content and high nonsugar content, but they are very useful livestock feed/.

The harvest can be done "by hand" proughing out the rows of sugarbeets and the single beets are afterwards taken in hand cleaned and the tops are cut off with a special knife, scalper.

Now-a-day there are many types of good root harvesters. One average-sized machine can replace 25-35 workers in the hand operation. The types of harvesters vary from the single-row machine fitting the needs of a small "fanily sized" operation, the grower doing only the harwesting of his own not extended acrage, through the two-, three-row machines up to the biggest six-row harvesters suitable for the largest size operation. At the present time the two-row harvesters adaptable from 5o to 75 cm row space are in wide use.

A good harvester ought to have the following features: To do /cause/ little damage to the beet roots by a satisfactory topping of them. - To take minimum of extraneous materials with the beetroots. - To be cpable to load the harvested roots into trucks or to collect them in a tank and to unload afterwards in trukcs. To be simple in construction and easy to handle and maintain.

The method of transporting depends on local conditions. Animal drown carts are suitable only to supply small factories. Though even if the harvesting is done by hand mechanized transport is recomanded.

For direct transporting of the beets to the factory tractors with carts or special trailors are used, which can enter in the fields in wet weather. For larger distances country piles are formed at the intermediate receiving stations and from there the beets are transported by large transporting units camions with trailors up to 25 t capacity each.

Railroad transporting if not the most suitable, can be used but water-way transporting is not to be recomanded.

3.1.1.9. Receiving and storage of sugar beets

3.1.1.9.1. Generalities - The beets are received and paid on the basis of net weight /the roots free of extraneous materials and properly topped/ and very often on the basis of sugar-content too. The physical and physiologycal condition of the beets ought to be controled by sight at receiving and discharging. Sugarbeets are very oft stored for a longer or shorter period depending on the local conditions. In the northen latitudes /Canada, Germany, Sweeden/ the processing of the beets is not to be commenced until the sugarcontent of the beets has not achieved its maximum /its technological maturity/, until the frost perios. A great part of the crop is therefor stored in long-term starages for a period of 6o-9o days. In mild climate areas the beets are stored only for 3-5 days, as a buffer quantity, to avoid temporary shutdowns of the processing in case of longer rains. The harvest is carried out paralel with the processing in this case. Under hot climatic conditions the harvested beets get so rapidly damaged, that they have to be processed not later as 24 hours after harvesting.

3.1.1.9.2. Weighing - Two balances of adequate capacity are necessery capable to weight two transport units each /5o-6o t/ By the first the loaded cars /units/ are weighed and by the second the empty units eventualy with the separated dirt and trash. The first dirt is determined by the difference of the two weights.

3.1.1.9.3. Sampling and analysing - Though the sampling can be done by hand, for more accurate and more reliable sampling a mechanical sampler is needed. By dry unloading it is a pan mounted on an arm so that it passes through the stream of falling beets and takes the necessery quantity of sample. By wet unloading a separate machine is needed with a sounding tube which is forced into the beets /mass of beets/ befor unloading as to teke the necessery quantity of beets and dirts.

As to determine the second dirt the beets from the sampler are weighed, cleaned, derowned /topped if necessery/ and weighed again. The difference of these two weighings gives the second dirt.

The determination of sugar content of the beets is carried out by a completly automated Tare Laboratory Equepment which requires high first costs. It can be done also by classic non automated equipment which provides mor labor and the capacity is limited on a fewer number of samples.

3.1.1.9.4. Dry unloading and piling - Discharching of the transporting vehicles ought to be mechanized as to be able to supply any larger factory and to deliberate the vehicles as soon as possible. Movable and stationary tilting systems are used for dry discharging and piling, consisting of one or more tilting platform, receiving hoppers, elevating conveyors, dirt screens, samplers, a horizontal conveyor and a movable piling boom, stocking the beets into the pile. Movable dry pilers are very suitable for discharging and piling the beets at "country piles". Stationary dry piling systems are in wide use for factory site storages. The beets are less cleaned and less gently handled by dry methods. The shapes of the piles depend on climatic and other conditions. Usualy the pile has a base width of 60-4o m, a top width of 4o-2o m, and a hight of 6-8m. The method is suitable also for discharging railcarts.

3.1.1.9.5. Wet unloading and piling - The beets are unloaded from trucks, trailers or railcarts by water jets directed by nozzles with electromotoric drive /sometimes by hand operation/. They fall with the water in a wet hopper and are flumed /carried away by the water/. The flumes /fluming canals/ are very suitable for mounting more efficient cleaning devices on them than used by dry unloading, as:

The beet feeder

The stone catcher

The trash cachers /the necessery number depending on the quantity and quality of trash/.

Dewatering screen

All this devices will be discussed later, at the preparation of the beets for extraction /3.1.2.1.1./

The elevation of the beets from the dewatering screen located often deep in the ground is carried out by inclined drag-chain conveyors and the further transportation by suitable belt conveyors. The piling of the beets can be done by a movable boom mounted on a reloading car moving along the central belt conveyor, receiving the beets from it and passing them to the piling boom. The beets are stocked in flat slab storages both sides along the central conveyor to a hight of 5-10 m depending on weather conditions.

A more suitable equipment is the piling bridge especialy for long term storage. On the bridge moving over a large flat slab storage of 50-70 m width and 150-300 m length are mounted the "central belt conveyor" with the movable reloading car carrying the piling boom wich can be inclined close to the "ground" and elevated up to a maximum piling hight of 10-11 m.

By wet discharging and piling the beets are far better cleaned and somewhat gentlier handled, therefor it is mor suitable for a long term storage if not indispensable. The method is suitable for discharging railcarts but the bearings of them are to be protected thereby.

3.1.1.9.6. Short term storage - It serves for the contiuous supply of the factory. Normaly it is a flat slab storage built of concrete, located at the factory site, fitted with the necessery equipment for unloading, cleaning, transporting and piling of the beets and with fluming canals for for supplying them to the factory. The flume canals ought to have a smooth surface, adequate descent /fall/, and ought not to be covered with steel-, wooden- or plastic plates. Each part of the stored beets ought to be possible to supply to the factory independantly of the piling sequence. Flat slab storages with independent compartments and with large free surfaces of the piles exposed to natural ventilation are therefor mor suitable than the long beet-flumes built deep in the ground. Country piles are simplier, loaded with movable dry pilers and by emptying frontloaders are used for loading the transporting units.

3.1.1.9.7. Long term storage - The large flat slab storage place,ought to be located at the factory site as to make possible an easy and constant control of the large quantity of stored beets and a direct supplying of them to the factory by fluming instead of a mechanical transporting with a large number of loading and transporting units. It is fitted with reliable unloading, cleaning, piling and conditioning equipment for the beets. The later is indispensable as to save the good handle-ability and processability of the beets and to bring down the sugar losses during the long time of storage. Systems of blowers with ventilation ducts /of steel tubes or concrete/ are used to blow cool night air though the beets in pile as to cool them down near to 1°C. For an efficient cooling overnight temperatures lower than 6–8°C are needed. Cool water is injected sometimes befor the blowers as to keep the relativ humidity at a necessery high level to avoid the draining of the beets. In very cool climates it is useful to cover the sides of the piles with plastic foils or similar to protect the beets from freezing. However by a very big unic pile the relativ surface exposed to freezing is small and the demages caused by freezing are not so dangerous as by small or thin piles.

3.1.2. PROCESSING OF SUGARBEETS

3.1.2.1. Extraction of sugar

3.1.2.1.. Supplying the beets to the factory

The common and most economic method for supplying the beets to the factory is by fluming. The beets are teared down from the pile by easy to handle nozzles producing a water jet of about 2 kp/cm^2 pressure, into the fluming cnals conducting the mass of beets and water to the factory by gravity. 400-600% of water by weight of the beets are necessery for this transporting. There are other methods for transporting the beets to the factory, which can all be treated as a solution for special local conditions. On the way to the factory, along the flume are located the folowing devices:

Cut off gate - Serves to stop the stream of fluming water and beets in a case of emergency.

Beet feeder - Serves to secure the uniform stream of fluming. The vertical oscilating gate is preferable to the radial spoke feeder.

Trash catchers - This devices are necessery in sufficient /aboundant/ number and capacity. Rake type devices, with countercurrent moving rakes mounted on endless chains, catching and carrying leaves, weeds and grass from the fluming mass and discharging them over the ground .

Rock catchers - One or more devices are necessery dependnding on the quantity of stones brought with the beets. There are different types of rock catchers the separation of stones and other extraneous pieces is done by all of them by annupward water stream of regulable velocity. The chain rock conveyor built in ought to be reliable and safe in operation.

Sitter gate - Serves to stop suplying of beets without stoping the stream of water.

Beet pump - Serves for elevating the beets with the flume water which arrives to the factory at a deep point under the goundto the subseqent washing and slicing. The most suitable way is to carry out this in one operation by means of a beet pump.

Lifting and dewatering weels combined with bucket elevators are not recomanded.

Dewatering screen - After the beet pump the beets are separated from the flum water and dirt by one of the different types of dewatering screens like: multiple cicker-, multiple squere foll-, spiral nip roll- or vibrating gitter screen. The vibrating screens have some advantages demaging less the beets and retaining more beet pieces. All this devices can be supplied with a system of nozzles to rinse the beets as final washing.

Beet washer - To remove adherent dirt and extraneous materials from the beets befor slicing and procesing they ought to be washed. The most common device for this is a paddle washer, consisting of a horizontal long tank with double conic bottom /The inner perforated/ and with a longe horizontal shaft, eqipped with propeller paddles of steel which agitate and move the mass of beets to the outlet end, wher the beets ar lifted and moved /discharged/ from the washer. An efficient stone catcher is the integral and essential part of the washer.

Dewatering screen - Similar type as befor washing is used for devatering and final washing what is very important to remove the bacterials of the soil.

3.1.2.1.2. Slicing of beets

To make possible the extraction of sugar the beets are sliced into "cosettes /or chipps/. Knives with V-corugated edges are commonly used for slicing with different "division" to obtain finer or thicker cosettes. There are left and right knives after the sense of rotation of the slicing table, and also A and B knives. Two knives are fixed in a "block" for an easy and rapid change of them. There are beet slicers with revolving slicing table with the bloks and slicers with stationary slicing table /knives/ and revolving drum /beets/. Both types can give a good performance. The slicer ought to have a reliable safety accessory for self stopping when an extraneous body arrives to the knives, with adequate doors and auxiliary small motor for low speed at cleaning and changing of the knives. The knives by a rotary drum slicer can be changed in march. At least half of the slicers ought to be with variable drive /revolution/ i.e. variable capacity. The capacities of slicers ar of 750-3000 tons of beet per day.

The auxiliary machines /tool/ for restoring the knives:

Straightening machine

Routing machine

Filing machine

3.1.2.1.3. Weighing of cosettes

As to maintain a continuous and uniform flow of processing belt-conveyor scales are used with measuring, registrating and counting devices. The scales ought to have a larger capacity than the maximum of processing.

3.1.2.1.4. Extraction

3.1.2.1.4.1. Generalities - The sugar is extracted from the cosettes by leaching with hot water in countercurrent process called "diffusion" by equipment called "diffuser".

The main requirements on a diffuser are: to extract the possible maximum of sugar and the possible minimum of other substances "impurities" or "non sugars" as to obtain a row juice of high purity. To do it with few water added "low draft", securing unfavorable conditions for microbiological activity by suitable construction, operating temperature and efficient desinfecting device, without demaging the extracted cosettes "pulps" by overheating. Short retention time both for cosettes and juice is required. The press water from the pulp presses ought to be recuperated, reheated and reused in the diffuser. The diffuser ought to be capable for processing beets of different quality /fresh, alterated or even frozen beets/.

The batch type diffuser the classical "Robart battery" is not suitable for a modern processing bacause of the high amount of labor needed and because of the high amount of wast water it produces and can not take back.

3.1.2.1.4.2. The R.T. Drum Diffuser - It consists of a revolving drum devided in compartments with conveying elements of cosettes. The main characteristics of this equipment are: short retention time of the juice, there are no moving parts inside the drum, easy operation and repair. High adaptability to varying extraction capacities, low drat of the diffusion juice, heating of the cosettes by reheated juice, large dimensions of the drum large space for location. Unit capacities from 8oo - 48oo tons of beet per day.

3.1.211.4.3. The D.d.S. Slope Diffuser - It consists of an inclined trough with two intermeshing scrolls for the transport of the cosettes /which enter the diffuser at the lower end/ in countercurent with the fresh water and the press water which enter at the upper end and flow down through the mass of cosettes. The main characteristics of this equipment are: soarse cosettes needed, long retention time of the juice and cosettes, a full or forced capacity processing is required for good performances and troubleles operation, simple construction and operation, easy maintenaince. Heating of the cosettes by steam jackets. Unit capcities from 15oo - 3oo t b / day.

3.1.2.1.4.4. The D.d.S.-Silver Slope Diffuser - It is in general mechanical construction very similar to the D.d.S diffusion mentioned affore. However from the technological wiew it is different. The main characteristics are: very fine cosettes are neede /well trained operator/, very short retention time of the juice and of the cosettes, low draft of row juice, cool diffusion juice, full ore forced capcity operatin is required for a good performance, simple construction and easy maintenance and operation. Heating of the cosettes by steam jackets. Unit capacities from 15oo - 3ooo t b / day.

3.1.2.1.4.5. The Tower Diffuser - It consists of a horizontal cosettes mixer /closed trough with transporting and mixing scrol/ in which the cosettes are "scalded" with hot juice and pumped into the bottom of the diffuser-tower in which the leaching out of cosettes takes place. The fresh water and press water are introduced at the upper part of the tower. The main characteristics are: good adaptability to cosettes of differant quality and to different capacities of extraction /operation/, low draft of the diffusion juice. For the heating of cosetes reheated juice is used. Unit capacities from 1500-6000 t b / day.

The De Smet Diffuser - It consists of a horizontal screen-belt conveyor on which the preheated cosettes /in an inclined trough/ are moved in a layer and are simultaneously sprayed wtih reheated juice by a system of juice distribution pumps. The cooled row juice is drown from the scalding trough. Fresh water is sprayed on the cosettes at the end of the leaching and press water a bit later. The velocity of the scren conveyor can be varied. For a good efficiency fire cosettes are required and not a low draft.

Auxiliary equipment for the extraction:

Fresh water sulphurer is the most suitable device for acidifying the fresh water using liquid sulphur dioxid. Sulphu dioxid can be produced at the factory by burning sulphur in sulprur burners descrived later /2.2.2.2.7. Preparation of the sulphur dioxid gas /. Sulphuric acid and hydrocloric acid are less suitable.

Press water depulping devices - the commonly used device now a day is an arch screen so called D.S.M. screen simple in construction /no moving parts/ easy to operate and maintain.

3.1.2.2. Juice purification

3.1.2.2.1. Generalities

There are several methods of juice purification all based on treatening the juice with lime /liming, defecation/ and on treatening with CO_2-gas /carbonation, saturation/. The main demands on a good purification method are: to produce a thin juice of high purity and good thermostability i.e. a juice which will not change its colour and pH-value during the subsequent evaporation, to produce a mud, muddy juice easy to setle and easy to filtrate. The method and the equipment for the juice purification ought to be suitable for processing alterated, deteriorated and frozen beets eventually with some modifications of the standard operation.

3.1.2.2.2. Preliming

The elevation of alcalinity, pH value of the juice ought to be executed progressivly, without local over-alkalizations, as to make the dissolved colloid materials ready for precipitation and adsorption on the surface of carbonat particles which returned by recicling a part of the precipitated calcium carbonat i.e. thickened juice /sludge/. A very suitable stepless prelimer is the "brieghel müller" type, a horizontal U-shaped trough with six or more compartments and a horizontal paddle agitator. The alcalizing agents milk of lime and thickened sludge are introduced at the opposit end to the row juice input. A desired amount of it is conveyed backwards in countercurrent to the juice by means of adjustable deflecting baffles. Required retention time 15 - 2o minuts.

3.1.2.2.3. Defecocarbonation

By this method both agents lime milk and CO_2-gas are added simultaneously. A very suitable equipment is the one consisting of two vertical cylindrical tanks. The gasing takes place in the bigger one with the additon of sacharate milk, the smaller one serves for mixing of the heated prelimed juice with the recirculated gased juice by means of a recirculation pump with a rate of 8oo% by weight of the row juice. The carbon dioxide gas is introduced by a control valve actuated by the automatic pH controller. To obtaoin a good utilization of CO_2-gas a carbonation colomn /juice level over the gas distributor/ of 5 m or more is required. A part of the carbonated juice is taken befor the recirculation pumpm and sent to the subsequent thickening.

3.1.2.2.4. Thickening /Clarrifying/

Mechanical thickeners /clarifiers, setlers/ are the most suitable types, consisting of 3-4 cylindric compartments one uppon the other separated with conic bottoms. Each compartment works as a separate unit type thickener receiving the juice from a common distribuiting tank, and discharging the thickened mud and clarified juice by two pipes common for all compartments. The precipitated mud is moved to the center of each conic bottom by raking mechanisms mounted on a common shaft. The retention time of the juice in the thickener ought to be as short as possible , not longer than 6o minuts. It can be shortened prity well by using floculating agents /carefull preparation and feeding of them is essential/

3.1.2.2.5. Sludge filtration

It is carried out mostly on vacuum filters, rotary drum filters, removing the juice and sweetening of the lilter cake in continuous operation. The drum ought to be covered with a suitable filter cloth. The sugar content of the wast cake should not be higher than 0,8%. The necessery vacuum for this filters is obtained with special vacuum pumps of the water-ring type, combined with a barometric condenser. A direct filtering of the first carbonation juice on filter presses is not recomanded because of the high amount of labor required and difficulties by sweetening off the filter cake.

3.1.2.2.6. Liming

The liming is carried out in a cylindric tank fitted with an efficient stirrer /impeller type/ as to secure a uniform alcalinity which is indispensable for a trouble free work. Liming ought to be fitted with a by-pass pipe as to be excluded alternativly. Necessery retention time 8 - 15 minuts.

3.1.2.2.7. Second and intermediate carbonation

They are carried out in cylindrical tanks /carbonators/ with countercurrent CO_2-gas distributor and automatic pH control regulating the introduced gas quantity. It is advantageous to remove the sludge by a clarifier after the intermediate or adsorption-carbonation as to obtain a thin juice with light colour and good thermostability. For a good utilization of the CO_2-gas a carbonation colomn of about 5 m is required.

3.1.2.2.8. Thickening

The sludge of the intermediate or second carbonation juice setles very rapidly, therefor a clarifier, thickener of very small sizes, with a retention time of 2o min is sufficient to remove the sludge wich is recycled to the preliming and to obtain a clear juice.

3.1.2.2.9. Filtration of second carbonation juice

This filtration must be carried out very carefuly because the obtained thin juice is passed to the evaporators. For this operation "plate and frame presses" can be used, but because of the discontinual method, necessery amount of labour they require and high cost of filter clothes, pressure leaf filters are prefairable giving also more clear juice. This type of filter consists of a tank, horizontal or vertical, with screened discs "leaves" which ought to be cowered also with a filter close of feliable quality especially when vertical "leaves" are used. The discs are precoated with a thin layer of filter aid befor evry cycle. It is very important that the filter has a relialbe and efficient internal oscilating sluicing mechanisme. The sludge from this filters can be returned to the vacuum filters to desweetening.

Auxiliary equipment for juice purification

Juice pumps - centrifugal pumps of suitable type.

Muddy juice pumps - pumps of special type are needed as not to destroy the large flocs /centrifugal pums with large canal impellers and variable revolution or volumetric pumps/.

Lime milk feeder of a suitable and reliable type.

Precoat preparing equipment for the pressure leaf filters

3.1.2.3. Evaporation and thick juice sulphitation

3.1.2.3.1. Generalities

By evaporation the thin juice of 11-14 Bx density is concentrated to thick juice of 58-66 Bx density in a multiple-effect evaporator. A quadrouple-effect evaporator consists of four unit evaporator bodies /effects/ and only the first effect is heated with exhaust steam from the turbine, the second body is heated with the vapour evaporated in the first body, the 3rd body with the vapour evaporated in the second body and so on. other heating devices like preheaters /heatexchangers/ for water and juice, are heated with vapour of an adequate effect. The last body is operated commonly under vacuum the vapour output being conjuncted with a barometric condenser. The thin juice is preheated befor entering the first body.

3.1.2.3.2. The Robert evaporator

The main requirements on a multiple-effect evaporator are: short retention time of the juice, small temperatur differences between the heating vapour and the juice evaporated. There are many types of evaporator bodies, but for a newly established sugar factory the calandria type, "Robert" evaporator is the most suitable as the most simple in construction and in operating. It has a vertical cylindrical shell with dished bottom and head. The calandria type heating chamber consisting of a large vertical tube bundle, located at the botom part has a large center tube well "downtake". An essential part of the evaporator body is an efficient and reliable separator for juice dropplets "entrainements", mounted at the head part. For a good efficiency a careful removal of the condensed water and of nonconcondensable gases "ammonia" is indispensable.

A quadrouple-effect "Robert" evaporator is recomanded with the fourth body under vacuum, with evaporating tubes of steel, with sealed downtake and with manually operated valves for juice level control.

Auxiliary equipment for the evaporator station:

Thin juice tank ought to be of large capacity 30-40 m^3.

Condensate pumps of special type for hot water.

Juice heaters as described at 3.2.2.3.1.

Condensate recuperating system /receivers with level controllers/

Barometric condenser with waterring vacuum pump

Accessories: Thermometers, manometers, safety valves.

3.1.2.3.3. Thick juice sulphitation

Sulphitation, treating the juice with sulphur dioxide, is a very essential operationenabling the production of direct consumption sugar with high whitness and easier boiling and centrifuging. It is carried out in a vertical tube-shaped sulphurrer made of normal steel with a sulphur dioxide distributor of stainless steel. The SO_2-gas feeding is to be controlled in accordance with the juice flow rate or with the pH-valu of the sulphured juice.

3.1.2.4. Crystallization

3.1.2.4.1. Generalities

The final step of the sugar production is the crystallization and centrifuging. The crystallization is carried out in vacuum boiling pans by concentrating the juice ie liquors, syrups to oversaturation. To obtain a white consumption sugar of a good quality and in highest possible quantity the intermediate and low sugars are remelted and recrystallized. There are many different crystallization-, boiling schemes used depending on the quality of thick juice and on the quality of sugar required. A very simple and commonly used "three boiling" scheme is recomanded described in the chapter Flow sheet of beet sugar manufacturing 2.1.

The main requirements on a boiling scheme are:

To secure a standard, constant quality of consumption sugar, even by changeable quality of beets ie. of thick juice.

To secure a standard, constant quality of final molasses /low purity/ ie. a good exhaustion of it.

To secure high yields on consumption sugar ie. low losses, by a straight and quick elimination of nonsugars to the final molasses.

3.1.2.4.2. Vacuum pan boiling station

The crystallization of sugar is commonly carried out in batch process, in vacuum pans similar to a Robert evaporator. The calandria type steam chest, with a large central downtake is the simpliest and still very efficient one. It is advantageous to have a minimum ratio of seeding volume to the final strike volume , by which the hight of the massecuite above the callandria should not be more than 1600 mm as to assure a good circulation. As the boiling is carried out under vacuum the pan belt must be strong enough for a long time work. The vacuum vent must assure a fine regulation of the vacuum and ought to be easy to handle like the discharging vent too. The can be actioned pneumatically or hydraulicaly. An efficient and reliable catch all built in is indispensable and an additional large one is very useful espetialy at the high boiling pan. Forced circulation of the massecuite by an impeller is very helpful at the low row pans but is not indispensable. Pan capacities of 40-50 t of massecuite are the most suitable.

3.1.2.4.2.1. Massecuite treatment

Mixers, U-shaped tanks provided with slowly agitating agitators combined with cooling and heating coils are used for receiving and further treatment of the discharged massecuits.

For the low row massecuite /last boiling/ a crystllizing buttery, consisting of for or more crystallizers /U-shaped taks with slow agitator provided with special cooling elements dommongly discs/ as to secure a maximal possible exhaustion of final molasses by further crystallization. Retention time of massecuite in the battery varies from 36 - 48 hours. The massecuite is cooled down successivly to 40°C and for the following centrifuging it must be reheated to 50°C in the last tank and in the distributing screw over the centrifugals.

3.1.2.4.2.2. Liquor filtration

A careful filtration of the liquor used for boiling the first-, A-massecuite giving the consumption sugar /standard liquor, high purity liquor/ is indispensable. The filters ought to remove all suspended metter and to produce a brillant filtrate. The use of filter aids in form of a precoat is indispensable and it is very useful to feed constantly an additional quantity of filter aid into the liquor to be filtered by a reliable feeding device.As to facilitate the filtration the liquor ought to be preheated to 90-93°C.

Filters with horizontal filter elements are safe from demages of the precoat layer, so more reliable in work. Horizontal leaf pressure filters are the most suitable, though other types /vertical leaf pressure filters, candle filters, filter presses/ can also be used.

Sweetening off the discharged filter cake can be carried out on a separate small vacuum filter or a filter press.

3.1.2.4.2.3. Barometric condensers

They are vertical recipients with downtake seal tubes of the necessery lenght and with couling water distribuiting system. The noncondensable gases are carried away by vacuum pumps of water-ring type. Each group of boiling pans ought to have his own condenser /if not each pan/. The last body of the evaporator can be attached to the low row boiling condenser. The vacuum drum filters ought to have there own barometric condenser and vacuum pump.

3.1.2.3. Centrifugal station

Centrifuging, purging by which the separation of the mother liquor from the cristallized sugar, and the washing of the sugar is carried out has a direct and essential influence on the purity and whiteness of the consumption sugar and on the adjustment of the boiling scheme on different conditions. The main requirements on the centrifugal are:

Efficient separation of the mother liquor from the sugar securing thus, and by the uniform washing, the high purity of the sugar throughout the cake remained in the basket.

A reliable dischargint device, safe against demeging the basket screen.

An electric drive causing not too strong shocks in the electric supply system.

Automatic mechanical emergency brake.

3.1.2.3.1. Batch type centrifugals

The batch centrifugal machine consists of a basket, drum made up of a perforated-plate steel cylinder, fixed on a shaft by menas of a spider forming the discharging opening at the bottom. The shatf is by a single point suspension /a ball and socket joint/. The basket is procided with a backing screen and a filtering screen, separating the mother liquor from the crystals during revolving. The massecuite is feeded through the top and the purged sugar is discharged by means of a mechanical or hydraulic plow.

Batch type centrifugals with the standard basket diameter of 48" /1200 mm/ and of filling capacity of 650 kg are recomanded. Precedence is to be given for the types by which it is possible to replace this capacity by a higher one varying only the hight of the basket without any structural alteration. With single drive by vertical threephase, two speed A.C. motor with regenerativ braking. The velocity of the basket ought to be not less than 1200-1500 r.p.m. Semiautomatic operation of the centrifugal, with automatic timing of the cycles and push button operated feed valve, pneumatic or hydraulic discharging device can suite the best for the conditions by building a new factory. A sequence timing for each battery of centrifugals is necessery as to avoid overloadings of the electric power supply and of the sugar conveyors. Washing and steaming devices are indispensable, syrup separators also except the last boilin centrifugals.

3.1.2.3.2. Continuous centrifugals

Continuous centrifugals were newly developed and are in wide use, especially those with vertical spindle and conic "basket". The advantages of the continuous centrifugals are: simple constuction, few spare parts, low first cost, easy operation and maintenance, great unit capacity at row boiling, low and constant power consumption. Disadvantages: it produces molasses with somehow higher purity, the crystals are demaged, the syrup can not be separated /wash syrup/, higher semsitivness on the massecuite quality. The continuous centrifugals are not suitable for purging the first boiling massecuite ie. for the production of consuption sugar, but they are suitable for the intermediate massecuites and in some cases for low row massecuites too.

3.1.2.4.4. Sugar drying

The white sugar from the centrifugals with 1-2% moisture ought to be dried to a moisture content of o,4% or less, and cooled down below 5o°C, as to get the necessery storage stability. The main requirements on a good drier are:

A gentle handling of the sugar as to reduce dust formation by a friction of the crystals.

The prevention of mixing of wet crystals with dust.

A final cooling down of the sugar to the environement temperature.

Rotary drum type driers are in common usewith drying and cooling compartment, with a common fan for both compartments and with an efficient dust collector of wet scruber type.

3.1.2.4.5. Sugar screening

Screening is carried out before sacking and storing the sugar with the aim to separate oversized and undersized particles and to give to the sugar a better appearence.

Vibratory or giratory sugar screens are used for sugar screening depending on local conditions, the vibratory type having the the advantages of simplier construction and easier operation and maintenance and lower power consumption.

Auxiliary equipment of the boiling and centrifugal station

Jig shaking tray for conveing white sugar

Bucket elevator for white sugar

Robust scroll conveyors for low boling sugar

Special pumps for massecuites and syrups.

Sugar melters with efficient, impeller type agitator.

Sugar minglers with robust shaft and arms.

3.1.2.4.6. Storing and handling of white sugar

White, consumption sugar can be stored in bulk form or in sacked form.

The main characteristics of the bulk bin storage are:

Reduction of labor costs for loading and unloading by complete mechanisation.

Reduction of freight costs.

Great flexibility of sacking especially small packing.

Easier conditioning of the stored sugar.

Possibility for an additional sreening, refreshment of the sugar before sacking.

Bulk bins made of steel or concrete in form of vertical cylinders are common. The main requirements on bulk bins are:

A good system for conditioning and circulating of the sugar as to prevent caking of the stored sugar.

Reliable conveying system with suitable, large capacity.

Efficient dust collecting system and a safe explosion prevention.

A suitable lining /insulation/ of the walls.

Auxiliary equipment of the sugar bins:

Conveyors for loading and unloading the bin and for loading the sacked sugar into the transporting units.

Heating and air conditioning equipment

Dust collecting equipment.

Screens, lump breakers and magnetic separators.

Scales for the sugar before storing and combined weighing sacking machines.

Storing sacked sugar in warehouses is cheaper at first costs but requires more space and more labor. It will be discussed in details at prosessing sugar cane /3.2.2.4.5./

3.1.3. PULP DRYING

3.13.1. Generalities

Sugar beet pulp is a valuable cattle feed, but to preserve its feed value and to reduce the transporting costs it ought to be dried. The greatest part of the water is removed mechanicaly by pressing the pulp before drying. Molasses, concentrated Stefen filtrate or carbamide can be added to the pulp and dried on, as to obtain a more complete animal feed. Various fuels /coal, oil, narural gas/ can be used in the dried furnace.

3.1.3.2. Pulp presses

Various types of pulp presses /vertical, horizontal types etc/ are used, consisting of a strong sceleton lined with screened shell and of a robust screw forcing the pulp into smaller and smaller volumes, the water escaping thereby through screens.

The main requirement on the pulp presses are:

High presseng effect /2o-25% dry matter of the pressed pulp/

Robust and safe construction.

Good resistenc to corrosion.

3.1.3.3. Pulp driers

Direct fired, iduced draft, parallel-flow, rotating drum driers are used consisting of the furnace /burning chamber/ and of the drying drum.

The construction of the furnace depends on the used fuel. In any case the combustion gases ought to be cooled down to about 8oo°C before entering the drying drum, by injecting additional air in the burning chamber, protecting thereby also the refractory lining especially of the plafond. An emergency stack /chimney, smoke pipe/ with a reliable rapid sluice is indispensable.

The drum is mounted perfectly level on two roller system. It contains a large number of baffles which lift the pulp and drop it throughout the hot flue gases as the drum rotates. The pulp is conveyed progressivly forward to the outlet end of the drum by the flow of combustion gases. A robust draft fan discharges the gases thrugh a cyclon separator to recover small particles of pulp from the exhoust gases as to avoid air polutions. The temperature of the exhoust gases indicats somehow the moisture content of the dried pulp. It is normaly about 120°C.

, The main requirements on the pulp drier are:

To produce dried pulp of uniform quality and light colour.

To be suitable for variations in capacity.

To have a good heat efficiency

To be safe in operation /fire risk/ and dustfree.

To have an adequate and reliable electric interlock system between all machine /technologic units/

Auxiliary equipment of the pulp drying station

Bucket elevators for pressed and dried pulp.

Belt conveyors

Scrolls for pressed pulp, dried pulp and dust /dust-tight closed/

Adeqate scales for weighing the dried pulp

Pneumatic conveying system for dried pulp.

3.1.4. LIME AND CARBONDIOXIDE PRODUCTION

3.1.4.1. Generalities

The beet sugar factory uses a large anount of lime /CaO/ and CO_2-gas which are both produced by calcining limestone /calcium carbonate/ in a direct fired furnace called lime kiln. The main requirements on the lime kiln are:

To produce lime of good slakability

To produce CO_2-gas of high and constant concentration /36-40% CO_2 by volume/

To have a good thermic efficiency more than 70%

3.1.4.2. Mixed feed kilns

They are fired by solid fuels /coke or sometimes anthracite/ and consist of a high, vericel, self supporting Cylinder made of steel plates with an adequate refractory lining. The top of the cylinder is closed by a steel hood provided with a well fitted door for the admission of the mixture of lime-stone and coke. Below the door there is a distributing arangement to spread the mixture evenly across the kiln. The quantities of limestone anc coke should be accuratly proportioned and thoroughly mixed by filling the bucket of the conveing skip. The feeding can be commanded eighter by hand or automaticaly. The bottom of the kiln is provided with an adjustable device to control and maintain a uniform discharging of the burned lime as to maintain a horizontal fire. The discharged lime is conveied to the slaking drum by a dustfree conveyor.

The necessery draft, moovement of the air thrugh the kiln is produced by vacuum compressors which bring the gasses from the top of the kiln thruogh a scrubing equipment to the dewatering recipients and from there to the carbonation devices in the factory. Rotary, water-ring type compressors are the most suitable for this purpose.

Mixed fired shaft kilns have the following advantages: They are mechanicaly very simple and require low capital investment and less mechanical attention, than other types. They have high thermal efficiency above 70% securing high CO_2 concentration 36-40%. The dosage of the fuel to the limestone is simple and predetermined in the charge. Though they have some disadvantages /sensitivity to limestone and fuel quality, laziness in changes in handling, they are still the most suitable.

3.1.4.3. Gas- and oil fired shaft kilns

They are basicaly similar to the mixed fired kilns, equiped with various systems for the injection of gaseous fuel /oil is gasified before injecting in the kiln/. The main advantages of gas fired shaft kilns are: instant control of the fuel quantity and distribution, the flame /fire/ can be controled /temperature and lenght/, reduced ash contamination of the lime by the fuel, lower sensitivity to the quality of limestone. The disadvantages of them are: higher investment sosts, higher mechanical attention is required, the internal burning devices can obstruct the flow of limestone through the kiln. As the fuel dosage is not predetermined instant overburning or underburning is possible by changes in the flow of limestone, the CO_2 concentration of the kiln gas is lower about 29%.

3.1.4.4. Lime slaking

Commonly the lime is used in processing in form of lime milk. The preparationof lime milk is carried out in a rotary drum slaker by the additon of hot water /condensate/, sometimes sweetwater.

Auxiliary equipment

Vacuum compressors of the water ring type

Limestone conveyors ans skips

Vibration- or shaking through for conveying lime

Automatic scales and mixing devices for the preparation of the feeding mixture.

Mineral rake classifier and hydrociclons for the separation of sand and unslaked particles from the lime milk.

Storage tanks with robust, efficient stirrers for lime milk

Automatic sets for the lime kiln control and slaking kontrol.

3.1.5. UTILIZATION OF MOLASSES

3.1.5.1. Generalities

Molasses can be used for many purposes as: very large quantities of molasses are used for ready-made /ready mixed/ feeds for animals. It can also be dried on the pulps in the factory for animal feeding or sprayed on whatever feed on the farm. It can be used for the production of yeats, glutamic acid, citric acid etc. The most important processing of the molasses carried out at the factory site are: the desugarizing by the Steffen process and the alcohol producton.

3.1.5.2. Alcohohol production

At present day the alcohol from ethylene can be cheaper,especially in the countries with developed petroleum industry.

3.1.5.2.1. Fermentation

Large tanks of cooper or stainless steel with a suitable agitatro are used for the diluition of the molasses with hot water, controled automaticaly or bey hand.

Fermentors are large cylindrical tanks made of stainless seelfitted with slow agitators and with a heatin-cooling device /steam coils or jackets/ to maintain a constant temperature by ant automatic control

3.1.5.2.2. Distilation

The distilling plant consists of some distiling columns / fractionating colomns/, long vertical cylinders made of stainless steel or cooper fitted with heating elements by steam and with deflegmators for a more efficient distillation. The distilled alcohol vapours are cooled down and condensed in separate coolers by cool water.

Actual yields of 45% by weight of the processed molasses are commonly obtained

3.1.5.3. Desugarization by Steffen process

3.1.5.3.1. Generalities

Depending on the price of sugar and of molasses the Steffen process can be economicaly very atractive but by other circum -

stances can be not at all rentable. The Steffen process has the advantage that the used precipitating agent, lime is the cheapest one /the beet sugar factory requires lime for the juice é purification and produces it/ and the precipitated calcium sacharate can replace the lime in the carbonation process. However with the sacharate some impurities are also precipitated and are returned to the juice purification like raffinose. When the raffinose content of the molasses riches the hight of 4% the molasses is to be discarded and the Steffen house temporary shut down /if not fed with virgin molasses from a straight house factory/.

3.1.5.3.2. Cold precipitation

Quicklime of a high quality /not overburned and with high activity is indispensable for the efficient sugar recovery.

The quick-lime is grinded to a fine pulver by special grinders /mills/ and the finest powder separated by a pneumatic classifier and conveyed pneumatically to the precipitator.

The most important equipment of the desugarization is the "eaktor", a vertical cylindric reaction tank in which the main, "cold" precipitation of the sugar from the diluited molasses is carried out by the addition of the prepared fine lime powder. Efficient cooling and maintening of the necessery low reaction temperature is indispensable. The violent agitator is an essential part of the reactor There are batch type reactors but the continuous types are mor suitable.

3.1.5.3.3. First filtration

Vacuum drum filters are commonly used for the separation and washing of the precipitated calcium sacharate. An efficient, uniform washing using small quantity of water is required.

3.1.5.3.4. Hot precipitation

A rapid precipitation of the remained sugar in the filtrate is carried out fitted with suitable heating device and efficient agitator as to recover further quantities of sugar.

3.1.5.3.5. Mixing

Mixer-tanks with suitable agitators are used for mingling and mixing the two sacharate cakes by addition of the necessery quantity of sweet water from the sweetening off the filter cake from the juice purification. The prepared sacharate milk is pumped to the factory and added into the carbonation vessel.

3.2. CANE SUGAR

3.2.1. SUGAR CANE GROWING

3.2.1.1. Generalities - Sugar cane belongs to the genus Sacharum of the grasses. For a long time the so colled nativ or noble canes of the species Sacharum officinarum were cultivated all over the world. There wer wide variations in size, color and appearence caused by the different conditions of soil, climate and cultivations At present days there are other recognized species like S. barberi, S. sinense, S spontaneum and S robustum. By crossbreading new seeding varieties were developed with better characteristics concerning sugar content, persistence to type, resistence to diseases, time of ripening, adaptability to soil and climate conditions /frost and drought/ and not last better milling and purification qualities.

Sugar cane is successfully grown throuoghot the tropical and semitropical regions of the globe. As concerning the ripening period and processing seasons it occures in the northen hemisphere during the 6 mounths of winter and in the southern hemisphere during the 6 mounths of summer.

3.2.1.2. Planting - Sugar cane is propagated by means of cuttings or whole stalks, planted in furrows which are covered afterwards with a light covering of soil. Normaly each bud produces a plant with several shoots, or suckers forming a clump or stool of canes. In tropics short pieces with two or three buds are planted /o,5 - o,8 tons per acre/. In subtropics whole cans are needed for planting as only 25% of the buds produces shoots because of the lying in the ground during winter period. Thus for times as much cane is necessery /2-3 tons per acre/. In many counties /Hawaii, Australia/ mechanical planting of cuttings is common wherby the fertilizer is addad and the covering with soil is made simultaneously.

The lenght of the growing period is different under different climate conditions. In Luisiana 7-8 months; Cuba, Puerto Rico and west Indian Islands 10-18 month; Fiji and Australia 14-18 month; Hawaii and south Africa 2o-24 month. From the stubble after the harvesting of cane, new plants called "ratoons " spring, producing a second crop which can give a third crop and so on. But commonly a restricted crop cycle is practiced, In Hawaii the everage cycle consists of the first plnalt cane and two or three following ratoon crops with lo-15% replanting, Fiji and Australia one or eventually twoo crops are practiced, folowed by a year of leguminous plantings.

The ripening of cane depands on many factors mostly on the amount of rainfall. In many countries /Australia, Hawaii/ irrigation is practiced for controlling the maturation. The highest yields of sugar are obtained in countries with pronounced dry season, Maturity is commonly evaluated from the sucrose or reducing sugar content.

3.2.1.3. <u>Control of insects and diseases</u> - The most dangerous among the insects is the sugar cane borer moth. Bacterial control of it by purposely introducing parasites has been proved effective. The white grubs of various species of beetles caose haevy demages in crops. Chemical control by means of insecticides is very effective in this case. There are other destructive insects like woolly aphis, froghoppers and sap-sucking leafhoppers.

The most destructive disease is the widely known mosaic disease, which is caused by virus. By repleacement of susceptible varieties by mosaic-resistent straines an entire destruction of the cane sugar industry was avoided. However a new virus of mosaic is still dangerous. Further destroing diseases are: the red rot, caused by fungus, gumming disease and leaf scald.

Beside the chemical control a rigid quarantine regulation of the importation of seed canes and other plant carriers of cane diseases and p ets is to be applies for an effective control the spread of cane diseases pests from one country to another.

3.2.1.4. <u>Harvest and transporting</u> - Harvesting is still mostly carried out ba hand cutting, even in countries with developed field mechanisation. The stalks are cut close to the ground, topped and freed from the leaves. Sometimes the cane is burned befor cutting as to save labor. Burned cane is more susceptible to deterioration therefor milling should follow promptly the harvesting. On the other hynd burned cane causes difficulties in processing. Hand-cut cane is cleaner than machine-harvested.

Machineharvesting is getting more and more importance because of the high effect in labor saving. A very simple device is the plushrake which can bemounted on an ordinary bulldozer replacing the blade of it. It is very simple in operation, requiresminimum of machinery maintenance and minimum skill on the part of the operator. It brings an excessive amount ot trash and extraneous materials to the mill.

A good harvester ought to have the folloing features: to do little demages to cane roots, to bring minimum of estraneous materials with the cane stalks and to be able to deposit the cane in a windrow.

The nethod of harvesting and transporting of the cane depends on the local conditions of every country, but it is an essential question by determining the capacity and the technology of a factory.

Transporting of the harvested cane is in many countries still carried out by animal drown carts /oxes, boloks or mula/. An ox drawn cart is capable of transporting nearly one ton of cane usually in bundles of 15-2o kg. This method is suitable only for small factories.

Even if harvesting is carried out by hand it is recomanded to secure a mechanical transport by means of tractors with carts or special trailers. The vihecles ought to be able to enter in the fields in wet weather too. The direct houl from the field to the factory is recomanded not only for the sake of lower cost of handling but to avoid any deterioration of the harvested cane what is of great importance.

However railro-transporting and water way-transporting by punts and barges are practiced in some countries they are not recomanded and can be accepted only if they are the only possibility under special local conditions.

Sometimes the cane is transported from the field to a transfer station and from there without delay to the factory.

5.2.1.5. Receiving and unloading - The transport units after arriving in the cane yard at the factory site, are weighed on large platforme scales when full and again when empty in order to get an accurate cane weight. The scales are to be large enough for the transport units used but not extremly large.

The quality of the cane and the quantity of extraneous materials carried with, are to be determined at the same time.

Unloading by hand directly on a long cane conveyor is suitable only for very small factories and is not recomanded.

For the mechanical discharging of cane different types of cranes /Overhead crane, derrick crane, rotary tower crane/ and different methods of operation are used.

When the cane arrives inchain bundels, the packeges of cane are lifted out of the transport units by a suitable crane, sustaining 5-lo tons, after the chain loosened the cane falls on a feeding tabl or into a carrier. For the night and eventually for the Sunday shift the cane is stored in packeges near the crane.

The so called chain-net system is a very efficient one, it is recomanded especially for larger factories. The transporting devices are fitted with a special chai-net attached to one side of it and to a manifold on the other side. The transporting device is drawn up beside a special wall made to support it . The crane with suitable hooks on his balance raises the manifold until the load of the chain-net falls over the wall on to a loading table or on a stock pile.

If the cane is cut in suitable pieces by the loading at the field /cut-load harvesters/ a dump system with hydraulicaly or mechanicaly operated dump platforme can be used for the discharging of the transprt units.

As mentioned affore the cane is very susceptible to deterioration hence an extensive storage of if is not possibleThe organisation of harvesting, transporting and receiving must be precise and very efficient in order to avoide any break down in processing.

3.2.2. PROCESSING OF SUGAR CANE

3.2.2.1. Extraction of sugar

3.2.2.1.1. Generalities

The extraction of sugar from the cane can be carried out by a set of crushing mills called "tandem" or by a diffuser. The praparation of the cans is similar in both cases. The caracteristics of a good extraction equipment are: extraction of the maximum portion of sucrose; extraction of minimum quantity of nonsugars as to obtain a raw juice high purity; to operate with low draft about 100% ; to operate at a higher temperature securing unfavorable conditions for microbiological activity, and with a goog heat economy; good resistance aginst corrosion.

3.2.2.1.2. Supplying and washing of cane

Washing is an imperative necessity by mechanicaly harvested cane to separate soil particles, trash, sand and other fine dirts which can cause plugings and abrosions of the procesing machines. But it is also useful by the processing of hand cut cane.

The common type of equipmant consists of loading and washing tables. The cane bundels are disloaded on the loading table and caried by drag chains to the washing table where they are thined to a mat and washed by condenser water-spray during the transport.

For a higher extent of dirt in the cane bundles more elaborate cleaning /with eventual rock and trash separation/ is carried out. Because of the intensive corrosion a separate short and easily replaceble conveyor is used for this purpose furnished with a water trough producing a water curtain instal-led at the high drop point of cane on to the carrier, with a subsequent kicker rotating the cane stalks during the transport and simultan washing and with a water spray at the end for an efficient final washing.

The wash water /500-600% by weight of cane/ together with dirt and trash is pumped to the settling lagoons. Befor impounding it is advisable to sreen this wast water.

3.2.2.1.3. Extraction by crushing mill.

The preparation of the cane is carried out in two steps.

The cane stalks are cut into pieces by two subsequent sets of revolving cane knives without extracting any juice.

Than they are desintegrated by a shredder whic tears them into shreds without extracting any juice.Hammer mill type shredders are very efficient and recomanded.

To avoide demages by tranp iron powerfull and reliable electric or permanent magnet catchers are indespensable before the cane knives and shredders.

Several improved types of mill tandems were developed in the last twenty years. A tandem of four 3-roller mills can give satisfactory performances for the first time, having the possibilities of enlargementto a 6 mill tandem with adequate augmentation of the capacity. It is very important to have a uniform feed of the mills and a controlled and uniform pressure of the top roller. Both can be controlled automaticaly. The rollers are driven through a set of gears by electric motors but precedence is to be given to individual steam turbine drive for each mill with a reliable and economic type of turbine.

By sqeezing in the first mill or "crusher" only 6o-7o% of the cane juice can be extracted. The remained quantity of sugar is extracted by the method of maceration ie. befor entering the next mill the bagasse is sprayed with raw juice recirculated from the following mill. Befor the last mill water of 6o°C is sprayed on the bagasse.

The bagasse leaving the tandem has a sugar conten of 1,5-3% and ought to have a moisture content less than 5o% if used as fuel for the boilers. But prior to this the fine bagacilo is separated from the bagasse by means of revolving or vibrating screens , and added to the mud from the clarifier as a filter aid for the filtration on rotary vacuum filters.

The juice from each mill is recovered in a juice pan with steep sides made of cooper or stainless steel like the juice chanals, pipework and simila/. Unlined concrete pans are not suitable. An efficient system for desinfection by steaming is indispensible with additional possibility of chemical desinfection by bactericides like "Busan 881" or formol. But the higienic and easy-to-clean designe of the whol equipment and of the individual machines is also very essential.

Mill tandems with various capacities are built from 30 - 300 t/h cane.

3.2.2.1.4. Extraction by diffuser

The continuous diffusion process has many advantages over the straight mill crushing like: higher extraction of sugar; higher purity of the mixed juice obtained by diffusion; less lime consumption and mud produced by clarification; smaller initial investment and lower cost of maintenance; less heating surface in boilers and fewer mud filters; higher feature of higienic lower losses caused by microbiological activity. By building a new factory this advantages are to be utilized and extraction by diffusers is recomanded.

The preparation of cane for the diffusion is similar as for the milling, only it ought not to be disintegrated to very fine particles /shredders are not recomanded for the desintegration/, but only to flattend pieces with maximum lenght of 10 cm, which ought to bee free from non crushed cane and with a maximum of 10% fines.

Egyptian continuous diffuser - The sugar cane is prepared for the diffusion by two sets of cane knives and partialy crushed in a three-roller mill in which about 60% - 65% of juice is extracted. The crushed bagasse enters the diffusion consisting of a horizontal chain conveyor transporting the mat of bagasse over a perforated steel plate. The bottom of the diffuser is an U-shaped trough devided into several compartments for the recovery of the diffusion juice with different concentration, which is recirculated by several pumps and after reheating sprayed over the bagasse mat for lixiviation. The exhausted bagasse with 80% moisture content is dewatered on the following two mills to 50% moisture and 1,5% sugar content. It is conveyed to the boiler house an used as fuel. The limed and clarified sweet water from the drying mills is returned to the diffuser. Overliming can be dangerous dissolving pectines and rubbers from the cane fibre which can cause very haevy trubles and difficulties by the following processing sepecially by filtration and crystallization. Accurate dosage an pH controll is required. The diffusion juice is mixed with the crusher juice and processed in a standard procedure.

The caracteristics of the Egyptian diffuser are:
Retention time for juice 24 min, for bagasse 4o min.
Temperature in difuser 6o - 7o°C.
Capacities from 1ooo to 6ooo tons of cane per day.

De Smet continuous diffuser - The type used for the sugar cane is similar to this used for sugar beet with some litle modifications. The preparation of cane is similar as descrived affore and the bagasse and sweet water treatment also. And it is so by all diffusers and is not necessery to mention.

The characteristics of this diffuser are:
Retention time for juice 35-45 for bagasse 45-6o min.
Temperature in diffuser 65-75°C.
Capacitie from 1ooo - 7ooo tons of cane per day.

D.d.S. continuous diffuser - The type used for sugar beet with some modifications is used for sugar cane. This is the most simple equipmnet concerning construction /building/ and maintenance. It was by this type that the trubles caused by overliming of the sweet water were discovered, however theoreticaly it can happen by all diffusers. To operate at lower pH level the revolving parts ar made of stainless steel nd the trough is lined with a plate of steanless steel entirely, what causes an augmentation in price of 1o-15% but gives a reliable protection from corrosion.

The characteristics of the D.d.S. diffuser are:
Retention time for juice 2o min of bagasse 3o-35 min.
Temperature 65 -7o°C - Capacitie from 1ooo-3ooo tc/day.

Silver continuous ring diffuser - This type of diffuser is newly developed especialy for sugar cane. The cane is charged directly into a "can baster" after this in a "fiberizer" both large hammer mills driven by multy-stage back pressure turbines. The so fiberiséd cane is conveyed by belt conveyors to the ring diffuser, and loaded into the uper part, a revol-

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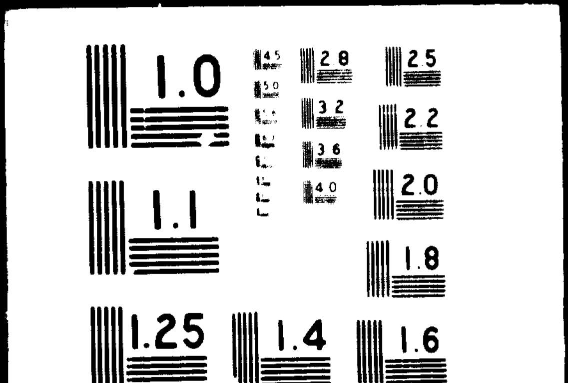

ving annular assemtly with perforated plates all of stainless steel an driven by two hydraulic racketing devices. The bagasse mat is percilated with reheated juice and the enriched juice is recuperated in the juice tanks formed by the segments of the centric part underneath the revolving annular assembly. There ar e seventeen segments and seventeen recirculations of the juice which is withdrawn at the head end of the diffuser and sent to the subsequent processing in a continuous clarifier. Recycled juice is heated to 82°C. The wet, exhausted bagasse is moved upwards by vertical screw conveyers into a horizontal screw and passed to the dewatering presse /mills/. The sugar extraction is 97% by a draft of 100%. Experiments has ben carried out to mix dry lime with the prepared bagasse. With this method a pH could be maintened within the range in which stainless steel could be replaced with mild steel in the diffuser construction. The obtained raw juice because of treatening with dry lime could be clear enough for a direct evaporation without clarifying and filtering. This method is very simple and economic however it is still under crutiny.

The characteristics of the ring diffuser are:
Retention time for juice 20 min. for bagasse 40-50 min.
Temperature in difuser 71-74°C.
Capacities from 42 -244 tons cane per hour.

Auxiliary equipment for the extraction station:
Feeder tables.
Conveyors for cane, rock, dirt, mud, trash.
Trash extractor
Rock catcher
Magnetic separators.
Chokeless centrifugal pumps for the juice and for mud.
Vibrating screens for raw juice and for bagasse.
Pressing mills or srew-type presse for bagasse.

3.2.2.2. Juice purification

3.2.2.2.1. Generalities

The main requirements on a good purification method are: An effect of purification which makes possible the production of a sugar of a desired quality; a satisfactory thermostability of the purified and filtered juice /thin juice/ without significant destruction of the invert sugar; good filtering and settling qualities of the purified juice.

3.2.2.2.2. Defecation process.

The cold raw juice is mixed with milk of lime and the mixture of a pH 7,o is then passed to a clarifier after beeing heated to over loo^{o}C. The settled sludge is mixed with bagacilo and filtered on vacuum drum filters /celless type/.

This is the simpliest an cheapest method, but is suitable only for the production of raw sugar.

Lime consumption: 1,o-1,5 lb CaO per ton of cane

3.2.2.2.3. Carbonation process

Carbonation process was introduced in the cane sugar industry with the aim to manufacture a high quality white /consumption/ sugar equal to that produced in beet sugar industry, in a direct way ie. without refining. The double carbonation method is suitable for this. In the first step the milk of lime and CO_2-gas are fed simultaneously to the raw juice /preheated/ in the carbonation tank. Continuous carbonation tank with a circulation pump and with automatic control of the pH is recomanded. The juice is to be filtered and the filter cake sweetened off using thickeners and vacuum drum filter /celles type/. The clear juice is reheated and sent to a continuous second carbonation. The filtration after it can be carried out on filter presse or by pressure filters as in the bbeet shugar industry. A sulphitation of the obtained thin juice is essential ans necessery for the production of a high quality white sugar.

The advantages of this method are:

High effect of purification - therefor higher recovery of white sugar /about 2% by the weigt of sugar produced/

Superior quality of the white sugar /color and ash/

Disadvantages of this method are:

Higher consumption of clarifying agents, 1,3-1,5% quick-lime by weight of cane processed.

Higher investment costs for the lime, milk of lime producing equipment and more thickener and filter capacity.

3.2.2.2.4. Sulphitation process

This method is commonly ised for the production of direct white sugar /plantation white sugar/, which is of somewhat lower quality than usualy produced in the beet sugar industry, at lower costs.

The raw juice after heating to 78-80°C and prelimed to a pH of 7 by automaticaly controlled additon of milk of lime passed to a continuous "defeco-sulphitation" in a continuous type sulphitator in which the liming and sulphitation are carried out simultaneously. The equipment is fitted with a large circulation pump for a 3,5-4 fold circulation per minut of the volume of sulfitation vessel. The necessery pH value of the leaving juice is maintened automaticaly by the regulation of of milk of lime added in to the sulphitator. The sulphur dioxid gas is forced in continuous flow in the juice at the bottom of the vessel. A perfect mixture of the reagents both at preliming and sulphitation is indespensable to obtain the possible good results of purification.

The sulphitate /sulphured/ juice is reheated to 100°C and sent to the settler /clarifier/. The settled muddy juice is sweetened off by vacuum drum filters /the drum lined with synthetic filter cloth/ and the mixed juice /clear juice = filtrate/ called thin juice is passed to the evaporation.

The main characteristics of the sulphitation process are:

Satisfactory effect of purification for the production of a plantation white sugar.

Lower investment costs

Lower consumption of purifying agents /0,16% quick lime and 0,8% sulphure/.

Lower recovery of sugar./

3.2.2.2.5. Thickening - Clarifying

A very high efficiency of the clarifiers is required: the shortest possible retention time of the juice and mud with the highest possible clarity of the juice leaving the thickener.

Continuous thickeners, clarifiers of mechanical type are used with rotating rake arms raking the settled mud to the central discharge. The static type of clarifiers are not suitable because of the large /long/ retention time in them. A reliable device for dissolving and feeding of settling aids /flocculants/ is recomanded.

A new type of rapid thickener is successfully introduced in the beet sugar industry with very short retention time /lo min./ and very small volume utilizing the full potential of modern settling aids. It is a single-tray unit in which the clear juice is filtered passing through the settling mud which forms a sludge-bed of permanent level. The performances concerning the clarity of the clear juice and the density of the settled mud are also exellent. This new type of thickener can be of the greatest importance for the cane sugar industry.

3.2.2.2.6. Sludge filtration

The filtration with the sweetening off of the muddy juice is carried out on vacuum drum filters. Filters with cells are suitable but not necessery. The drum ought to be covered with a higy quality synthetic filter cloth as to get a clear filtrate suitable for the evaporation.

Muddy juice pumps of special type are required as not to distroi the formed big flocs easy to filter, eventualy with variable capacity.

3.2.2.2.7. Preparation of the sulphure dioxid gas

The sulphur dioxid gas is produced by burning of sulphure in a sulphur furnace or stove. This equipment ought to suite the following requirements:

To be able tu burne sulphur of lower quality /sulphur not refined/.

To secure a constant pressure and constant concentration of the SO_2 gas.

To produce a dry and cooled down SO_2-gas.
Auxiliary equipment for a sulphur burner:
Air dryer
Air compressor
Air receiver
Instruments like hygrometer, differential manometer.
Gas cooler - sublimator.

3.2.2.2.7. Preparation of the lime milk

The preparation of lime milk and of SO_2 are essential part of the juice purification and have far reaching influence on it. So only a complete an reliable eauipment can be recomande.

The prepatation of lime milk is simple when a powdered slaked lime of high quality is used for. But quick lime is used most commonly. Revolving drum slakers are most suitable in this case normaly not insulated as hot condensate is used for lime slaking. The outlet end of the drum ought to bi fitted with a rotary screen for the separation of coarse particles. The main requirements on a lime slaker are:

Suitable retention time for a complete slaking of lime,

Robust and reliable building as to avoide irt and vapour escape.

Auxiliary equipment for lime slaking:

Robust and large milk classifiers are used for the settling and separation of fine particles /gritl, sand/ with a retnetion time of at least 45 min.

Two stirrer tanks are used for the sorage and final adjustment of the density of lime milk by water addition.

Lime milk pumps are to be of special type with open impellers an eventualy wtith changeable lining.

An automatic device, feeder of lime milk to preliming and liming is needed which must be reliable.

3.2.2.3. Evaporation and thick juice sulphitation

3.2.2.3.1. Evaporation

The profitableness of a sugar factory is affected essentially by the thermic economy ie. by the system of the multiple effect evaporator and of vapour distribuition conected with it.

The main demands on a multiple effect evaporator are:

A high rate watwr evaporation by a small temperature difference between the heating and the heated juice.

The shortets possible retention time of the juice in the evaporator.

A reliable discharging system of condensates and of non-condensable gases.

A proper hight of the juice chamber and an efficient system for entrainement prevention "catch all", especialy at the last effect wher an additional external separator is also usefull.

A possibility for easy cleaning, removal of the hard scale deposits from the evaporating tube surfaces, without breaking the processing.

A quadruple effec ot "robert" evaporator which is robust in construction and easy to handle is recomanded, with two bodies for the last effect as not to shorten the evaporator when cleaning is carried out. Evaporator tubes of a suitable seel age naw days commonly used with diameters of about 31/35 mm.

Auxiliary aquipment for the evaporator station:

Barometric condensers of counter-flow type with low injection water consumption are used for maintening the necessery vacuum in the last body of the evaporator, in vacuum pans etc. Individual condensers for each pan and evaporator body is more suitable than a central common condenser. For the elimination of non condensable gases water-ring pumps are recomande.

Condensate recuperating tankswith automatic level controll and special pumps for hot water amke the integral part of the evaporator station and essential for the efficient work of it.

Juice heaters are used at different unit processe befor the evaporation but are connected by the common vapour and cndensate system to the evaporator. The vertical cylindrical type is in common use with heating tube bundle devided in passages, through wchich the heated juice is forced as to secure the necessery velocity required for a god heat-transfer. The tubes are made of the same material as for the evaporator. A reliable system for discharging condensate and non condensable gases is necessery for a troblefree operation of the heaters. Spare heaters for each group is inevitable so that each unit can be cleaned without retarding the processing.

3.2.2.3.2. Thick juice sulphitation

Thick juice sulphitation is very usefull in general practice, but it is an essential unit operation by the production of plantation white sugar. It is carried out in a vertical tube-shaped vessel with thick wall made of mild steel and a distributor for sulphur dioxid gas of stainless steel. The density of thick juice oght to be about 6oBx, the pH value of juice about 6,5, the later auotomaticaly controlled.

3.2.2.4. Cristalization

3.2.2.4.1. Generalities

For the production of plantation white sugar of good quality a suitable scheme, system of boiling is necessery. The main requirement on such a scheme are:

To secure a standard, constans quality of the final, consumption sugar even by changeable quality of the cane ie. of hte thick juice.

To secure a standard, constant quality of final molasses ie. a good exhaustion of it.

To make possible high yields or consumption sugar ie. low losses by a straight and quick elimination of nonsugars to the final molasses.

A four boilin system is recomanded , by which the twox low boiling C and D are remelted and the two high boiling A and B are mingled with high purity syrup and affined on the second centrifugals as to improve the whiteness of the consumption sugar.

3.2.2.4.2. Pan boiling station

The designe and construction of the boiling pans is also of great influence on the quality of sugar produced. The main requirements on a boiling pan are:

A possible short boiling time /retention time of a strike/. For the high purity boilings /A and B in our case/ 2-3h, for the intermediate boiling /C/ with magma footing about 2h, and for the last product /D/ 6-8h.

Good recirculation of the massecuite during all the time of boiling. The highest level of the massecuite above the upper tube sheet maximum 1600 mm and a large downtake can secure this.

Small seeding volume.

Efficient and safe separation of the entrainements by a sufficient hight above the the maximum massecuite level, and a reliable "catch all" device.

Easy to handle vacuum vent and massecuite discharge vent.

The common, calandria type vacuum pan with central downtake is recomanded. Instruments for the temperature and pressure measurement both of vapour and massecuite chamber are necessery and for the indication of masecuite oversaturation are very usefull. Neither automatic nor continuous boiling is recomanded. A mechanical circulation by an agitator is very usefull by the last two boilings /C and D/. Unit capacities of the pans ought to be not to large about 40-50 tons of massecuite. For the first two boilings additional external "catch all" receivers are very usefull and recomanded.

Mixers are used primarily to receive the discharged strike, but they ought to be utilized for further crystallization to, by mens of a cooling system mounted on the agitator shaft. The driving shaft ought to be fitted with a simple device forslow rotation by hand in emergency cases.

For the last boiling /D/ a set of special cooling mixers is used called "crystallizer battery" with a necessery retention time of about 36 hours for a good exhaustion of the final molasses.

5.2.2.4.3. Centrifugal station

Centrifuging, purging by which the separatio of the mother liquor from the crystallized sugar, and washing of the sugar is carried out has a direct and essential influence on the purity and whiteness lf the crystalline sugar and on the adjustment of the boiling sheme on different conditions. The main requirements on a centrifugal are:

An efficient separation of the mother liquor from the sugar securing thus, and by a uniform washing, the high purity of the sugar thrughout the cake remained in the basket.

A reliable discharging device, safe aginst demaging the basket screen.

An electric drive causing not to strong shocks in the electric supply system.

Automatic mechanical emergency brake.

Batch type centrifugals with the standard basket diameter of 48" /1200 mm/ and filling capacity of 650 kg are recomanded. Precedence is to be given for the types by which it is possible to replace this capacity by a higher one varying only the hight of the basket without any structural alteration. Single drive by vertical threephase, two speed A.C. motor with regenerativ braking is recomanded. The velocity of the basket ought to be not less than 1200-1500 r.p.m.

Semiautomatic operation of the centrifugal, with automatic timing of the cycles and push button operated feed valve, pneumatic or hydraulic discharging device can suite the best for the conditions by building a new factory. However, depending on the local conditions like plant size, labor availability, vages, investment possibility etc. cane be also suitable. A sequence timing for each battery of centrifugals is necessery as to avoid overloadings of the electric power supply and of the sugar conveyors. Washing and steaming device are indispensable syrup separators also except the last boiling centrifugals.

For a new factory it is recomanded to choose the same type of centrifugals for all boilings /uniform spare parts/. However the continuous centrifugals have been improved in the last twenty years to a high performance. They have the folowing advantages:

Simplicity of building and operaiton.

Significantly cheaper in first costs and maintenance.

Constant power consumption and load on the electric power suply.

So they are to be taken in consideration for the intermediate and last boiling massecuite. For the high purity massecuite they are not suitable because of demaging the crystalls and diminishing the quality of final sugar.

3.2.2.4.4. Drying and screening of sugar

The white sugar from the centrifugals with 1-2% moisture ought to be dryed to a moisture content of o,4 or less, and cooled down below 5o^{o}C, as to get the necessery storage stability. Screening is carried out befor sacking and storing with the aim to separate oversized and undersized particles and to give to sugar a better appearance.

The following requirements are made on a good drier:

A gentle handling of the sugar as to reduce dust formation by a friction of crystals.

The prevention of mixing of wet crystals with dust.

A final cooling down of the sugar to the environement temperature.

Rotary drum type driers are in general use with drying and cooling compartment, with a comon fan for both compartments and with an efficient dust collector of wet scruber type.

Vibratory or giratory sugar screens can be used for sugar screening depending on the local conditions, the vibratory type having the following advantages:

Simple construction, easy operation and maintenance.

Low power consumption and cost.

Auxiliary equipment of the pan boiling and centrifual sation

Jig shaking tray for conveing white sugar.

Bucket chain elevator for white sugar.

Robust scroll conveyors for low boiling sugars.

Special pumps for massecuites and syrups.

Filters for high purity syrup - They ought to remove all suspended metter from the sugar liquor and to produce a brillant syrup. The use of filter aids in forme of a precoat is indispensable and it is very usefull to feed constantly an additional quantity of filter aid in to the syrup to be filtered by a reliable feeder device, as to facilitate the filtration the syrup ought to have a density of maximum 60-65 Bx and heated to 90-93°C.

Filters with horizontal vilter elements are safe from demages of the precoat layer, so more reliable in work. Horizontal leaf pressure filters are the most suitable, though other types /vertical leaf pressure filters, candle filters, filter presses/ can also be used.

Sweetening off of the discharged filter cake is carried out on a separate small vacuum drum filter or a filter press.

Melters for low boiling sugar ought to be fitted with an efficient agitator /impeller types are very suitable/ and with a heating coil or a direct steam inlet. A simple density measuring and indicating device is necessery and adjustment of meltin liquid feeding by hand.

3.2.2.4.5. Storing and handling of consumptin sugar

Consumption sugar can be stored in bulk form or in sacked form .

The main characteristics of the bulk bin storage are:

Reduction of labor costs for loading and unloading by comltete mechanisation.

Reduction of freight sosts.

Great flexibility of sacking especially small packing.

Easier conditioning of the stored sugar.

Possibility for an additional screening, refressment of the sugar befor sacking.

Bulk bins made of steel or concrete in form of a vertical cylinder are common. The main requirements on bulk sugar bin are:

A good system for conditioning and circulating of the sugar, as to prevent caking of the sugar stored.

Reliable convey system with a suitable, large capacity,

Efficient dust collecting system and a safe explosion prevention.

A suitable lining /insulation/ of the walls.

Auxiliary equipment of the sugar bin:

Conveyors for loading and unloading the bin and for loading of the sacked sugar in to transport units.

Heating and air conditioning equipment.

Dust collecting equipment.

Screens, lump breakers and magnetic separators.

Scales for the sugar befor storing and combined weighing-sacking machines.

Storing sacked sugar in warehouses is cheaper at first costs but requires more space and more labor. However in some local conditions it can be suitable at least for the begining. All the sugar comming from drying and screening ought to be sacked or packed simultaneously. Suitable larg capacity of sacking is needed. Threefold, vent type bags of unbleached kraft paper eventually with polyethylene oisture barrier are used. Bags of 5o kg are standard larger bags are inconvenient to handle. The bags are pilled to a hight of about 4o bags though sometimes also to 65 bag hight what is much higher than allowed. A tie pattern similar to brick laying is obligatory by stacking piles. Wooden rackes ought to be sprayed on the floor as to hold the bags awaym from floor moisture and to allow an air circulation.

The main requirements on a sugar warehouse are:

Good tightness of the building.

Water proof, -safe roof, walls and foor.

A bearing capacity of the floor corresponging to the total hight of the building.

A suitable air conditioning system.

Auxiliary equipment for handling of sugar:

Receiving hopper for the sugar produced.

Weighing-sacking machines.

A precise contoll balance for checking of filled bags.

Reliable and safle mounted bag counters.

Portable conveyorsfor the filled bags.

A portable and reversible bag stacker of suitable hight.

Small package machines - Completly automatic lines for forming the bag from paper rolls, weighing and filling the sugar, closing the bags are very complicated and require hig investment cost and maintenance costs. Those filling ready made bags are much simplier but the bags are more expensiv then paper rolls. The plastic film, polyethylene foil is very easy to form, fill and seal. Machines very easy to handel and maintene are available for for polyethylene packing.

Packages of 500-2000 gr are common.

3.2.2.5. UTILIZATION OF BAGASSE

3.2.2.5.1. Generalities

Bagasse /megasse/ is the woody fiber residual after milling and extraction of cane. This by-product, whic can amount one fourth of the grounded cane containing one half of fibre and one half of water, is commonly used as fuel for the generation of steam in the factory boiler house. In some cases / high fiber content, additional use of oil to force the capacity of the boilers/ large quantities of bagasse can accumulate. The handling of this surplus bagasse is quite expensive. To avoid this the surplus bagasse ought to be burned successivly after discharging from the bagasse conveyor, in a suitable burning device, or it can be briquetted for locomotiv fuel or domestic usage.

But depending on local conditions bagasse can be a valuable row material for commercial utilization, in whic case other fuels are used in the boiler house. The most important uses of bagasse are the following:

3.2.2.5.2. Paper production

Commercially successful technologies for the manufacture of paper from bagasse are developed in the past 3o years. So in some counties /Peru, Argentine, India/ large quantities of paper of every grade are manufactured from bagasse /25-45.coo tons annual production/

3.2.2.5.3. Wall board production

In about one fourth of the Luisiana mills the bagasse is no more used as fuel but for the manufacture of building and insulating boards. This process consists of shredding, cooking and refining in paper mills. The board forming is carried out by "felting". The boards from the forming machine are dyed, and cut into convenient sizes. Waterproofing, termiteproofing chemicals or cementing resins can be added to the prepared bagasse fibe to obtain special types of boards.

3.2.2.5.4. Plastics from bagasse

A successful process is developed also for the production of various plastics from bagasse /Thermoplastics, thermosetting/

4.o. SECURITY AND SANITARY GUIDELINES

4.o.1. The main security problems

4.o.1.1. Fire and explosion risk /danger/

During transporting, screening and sacking of the sugar the air inside the equipment and around it is contaminated wth finest sugar dust, forming an explosive mixture. In modern handling sugar, especially by bulk bin storage there is a hazard of serious portions, which has caused in the last years many extensive property damages and losses of life.

The main steps in explosion prevention are: A careful houskeeping as not to allow accumulating of sugardust on floors walls, structural steel and equipment. - Isolation of the bins from each other. - Dust-tight sugar handling equipment. - Static eliminators at the bucket elevators. - Special electrical system conforming the adequate rulls. - Dust collection by air-filters.

Similar fire and explosion dangerous mixer produces the dust of dried pulp by pulp drying and storing of the dried pulp. The prevention is similar as before.

An other risk of explosion can cause the hydrogen gas generated by cleaning the evaporators and heaters with hidrocloric acid. By opening this vessels after cleaning smoking or "inspection" by open fire is not allowd. Careful houskeeping can prevent fire in non processing period.

4.o.1.2. Poisonos, toxic materials

Poisonos materials in the sugar factory are: CO_2-gas especially by the ignition of lime kiln and by break downs in processing. The personal ought to be intructed to recognize the presence of this gas by characteristic smell and to learn the preventions and help. - SO_2-gas if not dry it is very agressive and can distroy tubes and valves contaminating the air and causing very haevy conditions for operating. Tubes of lead or stainless steel and special valves and gaskets are to be used. - Lime powder can be very inconvenient and disturbing in work if the quick lime transporting and handlig equipment is not suitable for a dust free operation, especially when the hardness of the limestone and/or quick lime is low. - Caustic soda, Formol, and lime milk are also materials to be handeld carefully.

4.o.1.3. Electricity safety

These problemes are regulated by norms and presctiptions. However it can be useful to take in mind the folloing ideas of prevention: All live conductors are to be inclosed in grounded metal, or provide a ground conductor in a nonmetalic raceway.- Only adequate and reliyble circuit protedtive and switch off equipment can be used. - The electric system ought to be reliable so that working on energized conductors will be not necessery.

4.o.2. Sanitary problems

At the manufacture of direc-consumption sugar high level of cleanness and of sanitaries must be secured. Separate vestiary /with showers, handwashing devices and adequate valves for drink water/ for man and women are obligatory. For the drink water system see under water supply 5.o.2.5.

Dirt pits are to be avoided by making the fundations at such a hight above the flore, that no pits are necessery. For the washing of factory flore a suitable system of underground canalization is necessery.

4.o.3. Environement problems

The main problem, the wast water treatment is sicussed at the water supply 5.o.2.6. The other problems are probably not so urgent as to be soved at the designing of the factory, however it is not useless to mention them.

Solid wast disposal - There are two common ways for this: inceneratiðn for combustible materials and sanitary landfill for noncombustible materials.

Pulp drier emission - The exhaust gases from the pulp drier containing pulp dust, molasses dust, fly ash causes the great part of air polution of the beet sugar factory.

Dusts - Sugar dust represents not only losses of sugar, but an airpolution too. Lime dust can cause air polution problemes and make necessery the use of a "dust pick-up" system.

Boiler flue gas - A well constructed and handled gas or oil fired boiler presents normaly no emission problems. The main problemes are caused by coal fireing like: Fly ash what can be controlled within acceptable limits by mechanical multicyclon collectors or by electrostatic colectors. Smoke is unburned carbon and can be very often controlled in certain limits by adequate burning chamber construction for a given type of coal and by careful operation.

4.o.4. The necessery minimum techniq and equipment

The equipment for sugar handling, pulp drying and dry pulp handling ought to be constructed properly as to minimize the fire- and explosion risks. However the necessery system and equipment for fire fighting must be at disposal evry moment. The minimum techniq and equipment needed:

Hydrant pipe-line covering the whole factory site /beet end, sugar end, pulp drying, dried pulp storage, sugar storage, auxiliary shops, lubricant and fuel storage etc./

Portable fire extinguishers ought to stand ready for use at all places mentioned above.

Gazmasks for CO_2-, SO_2-, and chlorin gases

Emergency lighting and low-voltage circuit for transportable lighting devices is inevitable /indispensable/.

Safety footpathes and safety clothes and safety glows for eventual handling of loaded circuits are necessery.

Azbestos clothes and waterproof clothes are necessery.

Boilers, pressure vessels and other equpments are to be fitted with the necessery safety devices presribed by the normes /standards/.

5.0. POWER, WATER, GAS /CO_2, SO_2/ SUPPLY

5.0.1. Heat and electric power

5.0.1.1. Generalities

The manufacturing of sugar, processing cane or beet, and of different by products requires a very large amount of heat. The method of transmission of the necessery heat by means of steam generated in the boilers is the only but very suitable one. The sugar industry has developed a high efficiency system of power economy producing electric energy at low cost by exp panding the high pressure boiler steam in steamturbines and u-sing the exhaust steam from the turbines to heat the multiple effect evaporator and for other process units.

5.0.1.2. Steam boilers

From the afforesaid follows that only up-to date high ef-ficient and economic boilers are used in the sugar industry with the following characteristics:

Water tube boiler ie. the heat is applied to the outside of the tubes.

Vertical water tubes with good natural circulation.

The furnace is built as a radiation chamber tubed on all sides.

The steam produced must be clean and dry /superheated/

The steam superheting system ought to be suitable for a complete drainage.

High thermal efficiency hence economisersm and air hea-ters are indispensable.

It must be safe in operation reguarding design and const ruction, quality of material and workmanship, and suitable for sudden changes in load.

It ought to be easy to maintain, to clean to lay by and to handle /reliable control instrumentation/

In cane sugar factories very oft bagasse is used as fuel, if so the steam boiler ie. the furnace ought to be specialy de-signed with large radiation chamber and a suitable spreader sto-cker for the appropriate feeding of bagasse.

A possibility of additional use of other fuels beside bagasse is indispensable for the begining of season or emergency cases.

The operating pressure of the boilers depends on the electric power needed which has a trend of increasing caused by constant development in every sugar factory. Though the boilers used in sugar factories are considered as "low pressure boilers" /below 650 psig, 45 kp/cm²/ it is recomanded not to choos a too low presure, as to have the possibility to produce more electric energy than needed at the first stage /450-600 psig is recomanded/. The exhaust stem pressure is usualy about 45-65 psig and the turbine backpressure according to this.

The steam consumption given in tons of steam per 100 tons of cane or beet processed vraies in wide limits which are similar both for cane and beet, 450 - 600 t/100t. As concerning the unit-capcities the former practice to have a set of several small shop-assembled boilers /so called packaged boilers/ is not economic. But it is not recomanded to have only one boiler suited for the whole consumption. Two or three units are recomanded with somewhat higher capacity eventualy with a possibility for forced steam generation by using additional fuel as oil or natural gas, in case of the braek down of one boiler or respecting future enlargement of the factory.

The type of fuel to be used is very important for the designer as to assure a high thermal efficiency of steam generating. By the economic considerations in most cases the price of fuel /including transporting costs/ is prevailing.

Auxiliary equipment of boiler houses:

Boiler fans - Tall stacks are not installed at present days. The necessery draft ie. air supply for the combustion is obtained by draft fans which remove the combustion gasse and discharge them to a short stack. Forced draft fans are also necessery to supply air for combustion though the grate.

Boiler accessories - Superheaters are indispensable not only for a better heat economy, but to reduce at a minimum the erosion of the turbine blades which can be very strong in case of wet steam. - Economisers are to be fitted with soot blows. - Boiler valves ought to be selected carefully for the sake of reliability and easy maintenance. - Central automatic control can improve the boilre efficiency, the economy of labor /one man operation/, the avarage operation rate and deminish the boiler outages. Among others the most important functions to be controlled are: water level in the boiler, boiler steam pressure, combustion control, temperature before and after superheating, quantity of the steam produced, feed water level in the sore receivers, sugar control in condensate etc.

Boiler feed-water equipment - In order to maintain the internal boiler surface clean and free of deposits or corrosion, the quality of boiler-water and feed-water is to be controlled and maintained at a prescribed level. Instruction for this ought to give the manufacturer of the boiler. The higher the working pressure of the boiler the higher are the requirement on the feed water quality. There are special prescriptions in every country for the pressure vessels, where among others the minimum storing volume for feed water, and the minimum capacity of feed water pumps /two types are to be installed with electric and with steam drive/ are given. For a "low pressure boiler" the condensate from the first effec evaporator body and some additional condensate of an other effect /which ought to be proofed on contamination by sugar/ can assure enough feedwater of the desired quality. However a stand by unit, equipment for feed water prparation by filtering and softening of row water is indispansable for emergency cases and for the beginning of procesing.

5.o.1.3. Electric power generation

The electric power consumption per ton of cane or beet processed is in constant increase as mentioned affore. This trend must be taken in account by disigning the power plant. Because of the utilization of exhaust steam in processing a noncondensing turbine-generator is used in the sugarindustry for the electric power generation. A modern sugar factory power plant uses inlet steam of 400-600 psig /28-42 kp/cm^2/ superheated and gives an exhaust stem of 45-65 psig /3-4,2 kp/cm^2/. Sometimes is practiced to drive some large horsepower units with separate directly coupled steamturbines /cane mills, compressors/.

As a sugar factory needs electric power in the period of maintenance a stand by usage of purchased power is necessery. This possibility is used, utilized also during the operating period in the event of power plant failures for supplying the critical devices as emergency lighting, boiler plant an water supplying system. Usualy it is economical to size this stand-by source of purchased electric energy to cover only about 25% of the total consumption of the factory.

5.0.1.4. Electric power distribution.

By designing the power distribuiton system the folowing points of view are to be taken in consideration:

Maximum service reliability

Maximum safety in handling

Low first costs and operating costs

The modern solution for power distribuiton is the load center distribution system by which the electric power is generated at high primary voltage, and is distributed at this in feeders at load center unit substations where the voltage is steped down to the necessery value suited for the motors and other devices. For the high primary voltage values of 4100 V or 6300V are common, and 480V or 380V are standard values for the secondary voltage. Sugar factories usually have a radial distribution system very suitable because of the simplicity, low first cost an low maintenance cost.

Auxiliary equipment for power distribution:

Grounding - Both system-grounding end equipment-grounding are indispensable to be properly carried out and maintened for the safety of personal and property. Lighting arrester system is to be mentioned here though not as integral part of the power distribution system but as a very important safety system.

System of overcurrent protection - Relays, direc acting trips on circuit breakers, and fuses are used for this protection. Relays as the most accurate, reliable types are indispensable for the generator, standby incomming line and similar. Direct acting trips are satisfactory for most low votage systems. Fuses have a serious disadvantage as they can cause a single-phase condition damaging motors an othe 3-phase devices.

5.o.2. Water supply

5.o.2.1. Generalities

Very large quantities of water are used in sugar factories for different purposes /1ooo-15oo% by weight of beets processed or 7oo-1ooo% by the weight of cane processed/, the quality of the water depending on the purpose used for. The water supply and the wast water treatment is therefor a very important problem which ought to be taken in consideration by the choice of the location for a sugar factory. However in the last twenty years the consumption of "fresh water" /row water/ was reduced to a minimum /to about 1oo% by the weight of beet processed/ by means of recuperation and clarification, or cooling of wast water for reuse. But it requires large equipment and space ie. very high investment costs, and this method is in many cases a "must" of environement protection. At the building of a new factory in some cases the use of large quantities of water can be economically atractive solution and temporary a possible one, but the above "must" is to be taken in consideration for the near future.

5.o.2.2. Row water

River water or flume water is always impure and contaminated, but it is still suitable /in some cases after mechanical settling/ for the largest consumers as: fluming, washing, extraction fresh water, cooling and condenser cooling water. The row water pumping station is located near the water source /usualy river/ together with the settling basen /if necessery/. Stand by pump unit and emergency current supply are indispensable here. The fresh water is pumped to a large tank located on the highest point of the factory /usually over the condenser tower/, as to supply the different cunsumers by gravity.

The main characteristics of the row water to be determined are:

Water level of the river all over the year.

Temperature of the river water during the processing season.

Hardness of the water.

The quality and quyntity of suspended materials.

5.0.2.3. Filtered water

For consumers like: boiler feed water preparation, cooling of the turbo-generator, cooling of pumps and compressors, working water for water ring vacuum pumps and compressors, cooling of hydraulic couplings, cooling of the massecuites mechanically filtered water /usually by sand filters/ is needed. The filtered water once used for cooling especially cooling of turbines can be reused for some other purposes.

5.0.2.4. Hot water

Condensates from the steam chests of all heating and evaporating devices are recuperated and carefully controlled on purity /contamination by sugar/. The high quality condensate from exhaust steam is sent directly to the boiler feed water tanks. Some additional quantity of other condensate is needed to cover the need of the boilers. The other condensates are gethered, successivly expanded and used for different purposes in the factory as: washing of the sugar in centrifugas, desweetening of filter cakes, melting of sugar, lime slaking, extraction /or imbibition/ etc. The quantity of condensates obtained in processing is more than enough to cover all needs in the factory and the rest is passed to the chanel as not suitable for sanitary use like showers.

5.0.2.5. Drink water

Drink water is indispensable inaboundant quantity and satisfactory quality. Normaly it is used only for human needs as: drinking, washing showering, laboratory, hygienics. Therefor it must be regularly controlled on microbiological and mechanical contamination. The drinkwater conduit can't be conected with other tube lines. For the case of emergency it can be temporary conected by mens of only one insert pice tube, which is to be removed as soon as not necessery.

5.0.2.6. Wast water treatment

Wast water treatment is a grave problem of many sugar factories all over the world and the first one of environement protection problems to be solved urgently. It is out of the scope of this paper to describe in details the methods of biological purification of wast waters, but some main problems ought to be quoted. The sugar factory wast waters do not contain any direct poisonous material, but the sugar and other orbanic matters contained are biologicaly decomposed by microorganisms and a large amount of oxigen is consumed by this. If the wast water is discharged in to a river the oxigen content of its water will be reduced to such a minimum that the life for most animals and plants will become impossible. If the river is not charged biologicaly it can have a capacity to accept some quantity of biologicaly contaminated wast waters without serious danger for the anizals and plants living in it. But the rivers are going to be charged rapidly more and more with the developing industrialization and every country must take care and take adequate measures to protect them.

The first condition for an efficient solution of wast water treatment is to design sauch a water economy as to reduce the water consumption and wast water output to an economic minimum. It is carried out by recuperating, clarifying and/or cooling of the greatest part of wast waters and by permanent reuse of the clarified water or cooled water. The reduced quantities of wast water after the above treatments can be stored in large "pounds" or "lagoons" and used for irrigation between two campaignes. Sometimes the soil of the pound is capable to drink in the whole quantity of the stored wast water in this time. But it can happen that the only possibility to avoide the contamination of water suplying source /river/ is a more or less expensive biological treatment of the wast water befor passing it in to the river.

The location of wast water "pounds" ought to be determined by taking in consideration the main cours of atmospheric motions as to avoid the spreading of very unpleasent stink toward the neighbouring habitations.

5.0.5. CO_2-gas supply

CO_2-gas is used in sugar factories to neutralise the CaO added to the juice in form of lime milk at the juice purification. Beet sugar factories consume a large quantity of lime though they produce allways the own lime in lime kilns at the factory site. In that case CO_2gas is obtained as a by product of lime burning in sufficient quantity and quality. In the cane sugar factories very oft only small quantities of lime are used, and no CO_2-gas. In this case lime is purchased in form of quicklime. At the refining of row sugar by carbonation method CO_2-gas is needed for the neutralisation of purchased lime. In this case the boiler flue gases /combustion gases/ are to be used for the carbonation. Because of the low concentration of CO_2 in them, a special construction of the carbonation device is necessery for the successfull use of this gases.

SO_2gas supply

SO_2-gas is used for the acidification of diffusion water /fresh water/ at processing beet, at the sulphitation method of cane juice purification and for thick juice sulphitation both at processing beet and cane. It can be purchased as liquid SO_2 in many countries, what is the most convinient and most suitable way for beet sugar factories, where an occasional shortage of SO_2-gas will not break down the processing, though it can cause some inconveniences. But a cane sugar factory especially with sulphitation method for the juice purification, must have an absolute reliable and safe supply of SO_2-gas. Therefor most of the cane sugar factories /if not all/ produce the SO_2-gas for themselfs at the factory site by burning sulphure in special "sulphure furnaces" as described by the section 3.2.2.2.7.

6.o. THERMOTECHNICAL SCHEME OF THE SUGAR HEAT ECONOMY

6.o.1. Generalities

The profitableness of a sugar factory depends decisively on the heat economy ie. fuel consumption /except bagasse is used as fuel/. The basic principles of the sugar heat economy are: the multiple effect evaporation and the production of power by expandign the high pressure boiler steam in the turbine.

At the multiple effect evaporator the vapour evaporated from the juice in one effect /body/ is used for the evaporation of further quantities of vater in the following effect. Generaly as many kg of water can be evaporated from the juice by one kg of exhaust steam feeded in the first body as the number of effect is. In practice it is dimished by the vapour bleeded off for juice heating etc.

Utilizing the exhaust steam for the evaporation the power in a sugar factory can be generated using about half of the fuel used in a condensing turbine used for power production, as the power generation is charged only with the additional fuel over that required for processing steam generation.

6.o.2. Heat economy

Supposing boiler steam pressure of 28 kp/cm^2 /4oo psig/ and temperature of 4oo^{0}C /752^{0}F/ and a turbine back pressure of 2,5-3 kp/cm^2 /35-5o psig/, as it is in common practice, the steam consumption of a beet sugar factory producing only white sugar, with a good thermic lay out and good working can be 42-45 tons by loo tons of beet processed /without special thermoeconomic devices like thermocompression/. Similar low steam consumptions can be achived by a can sugar factory producing "plantation white sugar", with a good thermic design and good work. On the other hand utilizing bagasse as fuel loo t of cane /with 14% fibre-content/ gives about 28,5 t bagasse /with 48% moiture/ which can produce about 62 t of the boiler steam quoted above, ie. there is a surplus of bagasse. However designing a cane sugar factory one must take care to find a good heat economy as there will be more and more possibilities for a moreprofitable use of bagasse than for fuel.

About 85% of the boiler steam production must cover the consumption for power generation. The power consumptionof a modern high-mechanized cane sugar factory is about 3,o KWh by loo kg cane processed and it has an increasing trend. The specific consumption of the turbo-generator is about 11-12 kp/KWh of the steam described affore.

The proposed conception of the heat economy by designing a new cane sugar factory is the following:

To utilize the bagasse as fuel, with the possibility of later modification of the boilers for the use of other fuels /gas, oil or coal depending on local conditions./

Boiler capacity ought to be abundant for emergency cases and further enlargements.

Working pressure of the turbine and its capacity to choose somewhat higher than needed at first time in order to facilitate future developments and enlargements.

To choose a simplier scheme of steam, vapour and condensate distribution easier to conduct /quadruple effect evaporator evantualy with an additional last body for alternate cleaning, evaporator bodies without forced circulation by pumps, heating of boiling pans with exhaust steam/ still if it requires somewhat higher steam consumption , which can be reduced when the personal will be trained enough for a more precise work, utilizing the possible surplus of steam and electric power for other purposes.

6.o.3. Flow sheet of steam, vapour and condensate

Such abundant quantities of steam consumption are quoted in the Flow sheet of steam, vapour and condensate /for a direct white can sugar factory/ presented. The distribution and the quantities are similar for a beet sugar factory however as fuel is purchased /oil, gas or coal/ the fuel consumption ought to be reduced as far as possible at the primary design and building of the factory.

Fresh, superheated steam of 28kp/cm^2 and 390°C is generated in the boilers 52t/100t cane processed/. One part of it about 38 t is expanded inthe turbine generating about 3000 KWh of electric power. The difference 14 t of steam is throtled to the pressure of the exhaust steam and passed to it. The obtained mixed steam is cooled down by adition af water, condensate, and used for heating the first effect of the multiple-effect, and for other consumers /heating of the boiling pans, of some juice heaters, steaming the sugar at centrifuging/.

The vapour generated by evaporation ie. thickening of the juice in the first effect is passed in to the heating chamber of the second effect as to evaporate further quantities of water ie. vapour which is passed in to the heating chamber of the third effect and so on. Some quantities of vapour are taken away from each effect for other consumers, usualy juice heaters. Teh vapour evaporated in the last effect is of low value and is sent to the condenser.

The condensates from each effect /from boiling pans and juice heaters also/ are recuperated separatly and after successive expnasion pased to the next effect receiver until all are gethered in the last effec receiver from wher the hot water pump furnishes it in to the hot water circuit for different services. The condensate from the first body /of exhaust steam/ can't be contaminated by entrainements therefor it is passed to the boiler feed water taks.

6.0.4. Equipment for the distribution of steam and condensates

Boiler steam main line - Serves for turbine feeding. It must be designed and built /insulated/ most carefully as to avoid or minimise pressure drops and heat losses.

Boiler steam throtling station ought to be large enough as to to throtle 30% of the steam produced if necessery. An automatic pressure controller coupled with the turbine back pressure is indispensable.

Exhaust steam cooler with automatic control is needed.

Vents, instruments /manometers and termometers/ of high class are required.

Flow-meters /indicating and recording/ for the measurment of the quantity of the steam produced are necessery for each boiler and for the exhaust steam after cooling.

Exhaust steam pipe with a minimum pressure dropp and minimum heat loss is required.

Condensate discharging system ought to secure troublefree discharging of heatign chambers when necessery raliable condens vessels are to be used as to prevent blowing through of the steam. Condensat line ought to be fitted with adequate sight glasses and sampling coks for checking all lines.

Condensate recuperation taks ought to be fitted with suitable level controllers, level transmitters with controll valves are mor reliable than mechanical condens vessel. Level glass tubes for visual controll are necessery.

Condensate pumps of special type for hot water are needed.

7.o. QUALITY CONTROL

7.o.1. Generalities

The main production goal of a sugar factory is the highest possible yield on consumption sugar or sugar output /percent sugar by weight of the cane /beet/ processed/. The quantity of sugar what enters the factory must be controlled in all phases of processing until it leaves the factory as consumption sugar and sugar in the by products, and must be accounted for periodically. During the processing there are som unavoidable losses /as sugar in bagasse or pulps, in final molasses and in filter cake/ this are the "known" losses or determined losses. But there are although "unknown" losses caused by destruction of sucrose /due to high temperature, alkalinity and microbiological activity, together with mechanic losses caused by entraninements, leakages and spillages. All this losses can not be eliminated but can and must be minimized. The next equally important duty of the analitical control is the control of the quality of final products as to secure a standard required quality of them.

7.o.2. Methods and equipments for analyzing

7.o.2.1. Sampling and averaging

The good sampling, avaraging and preservation of the samples /especially in the tropics/ is indispensable for the accurate analysis. The special sampling methods and devices to be quoted are:

a.- Bagasse sampling - The simpliest and most reliable sampler for the bagasse is a longitudinal V-shaped metal through with the width of a carrier, which when held below the delivering chute, catches the bagasse for the whole depth of the blanket and for the full width of the carrier. A suitable container for composition samples is required with a pad of adsorbent cotton soaked with 1 part of chloroforme and 6 parts of ammonia and with a piston type lid.

monia to preserve the sample.

No 3 V-shaped metal throughs

No 2 Containers with pad and piston type lid

b.- Row juice sampling

It can be done by automatic samplers, but it is recomanded to take the samples by hand and to keep them in well stoppered containers in a small refrigerator untill analizing.

No 6 well stoppered containers of 1,o-1,5 liter

No 1 Refrigerator of 5o-loo liters

c.- Sugar sampling - Row sugar is to be sampled by an automatic sampler. For white sugar or refined sugar intermittent hand sampling will serve. In evry case composite samples are analized and to preserv them galvarized iron cans with funel tops are necessery.

No 3 Containers as described.

7.o.2.2. <u>Sugar content, Polarization determination</u>

Sacharimeters /polarimeters/ with monochromatic light and International scale are used for quic routin determinations. The so obtained values called Polarisation /Pol, P/ are not quite accurate as influenced by other optically activ matters than sucrose. As a wide range of by products is analized by sacharimeter it is recomanded to have both an automatic one with automatic setting of the field and recording the reading and a classic one.

No 1 Sacharimeter with occular reading

No 1 Automatic sacharimeter

7.o.2.3. <u>Total solids, Dry matter or Brix determination</u>

For accurate determination of the solid matter in any solution the gravimetric method by drying and weighing is used.

For routin determinations instruments on the basis of specific gravity or density are used /Hydrometers i.e. floating spindles with graduation in degree Brix, Bx, i.e. percentage by weight of sucrose in pure sugar solution, Pycnometers and Westphal balances/ or the most quick and commonly used laboratory apparatus on the basis of specific light refraction the different refractometers.

No 3 Pycnometers
No 1 Westphal balance
No 1 Precision Refractometer wtih thermostate device
No 3 Hand refractometers
No 1 Vacuum oven for sugar drying
No 1 Drying oven with thermostat device 60-130°C
No 1 Infrared rapid drier

7.0.2.4. Ash content- Ash determination

Ash is the measure for the inorganic-, noncombustible matter content.

Gravimetric methods by inceneration using sulphuric acid, therefore the t erms "sulphated" or "grsvimetric" ash, are used for special high accurate determinations.

Electric-conductivity methods are rapid routin methods giving very reliable results especially when using a high-class apparatus.

No 1 Conductometer, Conductivity-Resistivity Recorder

7.0.2.5. Hydrogen Ion concentration, pH determination

It is a very important modern method for the control of microbiological activity during processing cane or beet, and for the controll of the purification unit processe /carbonation sulphitation etc./

No 1 High class pH meter

7.0.2.6. Colorimetric determinations

Color is a very important characteristic in the quality control of all sorts of commercial sugar. Therefore the color of different intermediate products /juices and liquors/ is also carefully controlled. Many different methods are still in use in the sugar industry all over the world.

Methods of visual comparison by means of different apparatus and scales /Stammer scale, Horn scale, Lovibond scale/ therefore this method can not be recomanded.

Photoelectric methods are carried out by photoelectric colorimeters giving reliable results.

No 1 Photoelectric colorimeter /for turbidity determination also/

Other laboratory equipment

No 1 Muffle furnace with temperature control 5oo-11oo°C

No 1 Calorimeter with water jacket for heat value determination.

No 1 Thermostate box of 3oo-5oo liters for microbiologic incubation.

No 1 Binocular microscope suitable for photography too

No 1 Photo-camera

No 1 Analitical balance /rapid weighing and digital reading type/

No 1 Special analitic balance /with knife edges and bearings in agate, with zero point adjustment from outside the case and single-side arches on pans. Sensitivity 1 mg.

No 1 15oo gr capacity balance with sensitivity lf 5 mg.

No 1 Double-beam trip balance of 2 kg capacity on each plate, sensitivity 1oo mg, weighing up to 2oo gr without additional weights.

No 1 Destiller for destilled water preparation

No 3 Dessicators

No 5o Glass cylinders from 5o-1ooo ccm

No 2o Glass dishes with tight fitting covers

No 5 Aluminium flat dishes

No 5 Platinum dishes

No 3o Porcelan dishes

No 2o Weighing dishes

No 3o Cover glasses

No 3o Flascs

No 3o Funnes

No 5 Sacharimeter tubes

No 2o Spindles for different Bx ranges from o-7o Bx

No 15 Thermometers from o-15o°C

No 3o Pipets

No 1o Buretes with automatic "filling"

No 5 Magnetic mixers for liquids

No 1 Set of screens for granulated sugar

7.o.3. Products and qualities to be analized

7.o.3.1. Sugar cane /sugar beet analysis

For the preparation of cane /beet cosettes/ the wet desintegration method is used /desintegrating the cane /cosettes/ by means of robust industrial type mixers/. From the obtained mixture tho following values are determined:

a.- Sugar content Pol by the sacharometer

b.- Fibre content by washing out the fibre, drying and weighing.

c.- The invert-, or reducing sugar content as at 7.o.3.2.d.

No 3 mixers /blendors/ of adequate robust type.

7.o.3.2. Analysis of the juices

a.- Juice purity /Purity quotient "q"/ is expressed in percents of sugar by weight of total solids. Refractometric Brix and polarization are determined.

b.- Settling control is carried out by means of a graduated cylinder in order to determine the quality of maddy juice.

c.- Filtrability Filtration coefficient is determined by means of "Brieghel Müller" apparatus.

No 1 "Brieghel Müller" apparatus for filtrability test.

d.- Determination of reducing sugars is very important to discover and estimate the sugar losses caused by decomposition of sucrose during processing and to determinate the "true sucrose" i.e sugar content of some products. There are two methods requiring no special equipment.

The Munson-Walker gravimetric method and

The Lane-Eynon volumetric method.

e.- Ash determination by conductometer.

f.- Aciditi and alkalinity are determined by titration.

g.- Phosphoric acid is determined by colorimetric method.

h.- Lime salts /hardness/ are determined by titration with complexon for routin work.

i-pH values of the juices are determined by precize pH meter or in the factory by indicatro-papers.

j.- For the syrups and massecuites the purity is determined commonly and the pH value.

7.o.3.3. Sugar quality and analysis

a.- Raw sugars The analysis by them, especially the polarization has a great economic importance as raw sugar is sold on sugar-content i.e. available sugar basis. The true sugar content is determined by the so called "double polarization" method. The classical single polarization value is called "direct" or "commercial" polarization, which ought to be corrigated by multiplying with the "polarizing constant" /relationsheep between polarization, pol, and true sucrose, sucrose/

Reducing sugars are determined by the Lane Eynon method.

The estimation of moisture is carried out by a standard method of drying and weighing /for instance by the Serbia's modification/, and it is very important to determine the "safety factor" /ratio between nonsucrose to the water in molasses film surrounding the crystals/ indicating the resistance of the sugar to microbiological deterioration.

Ash and color are further essential characteristics of the raw sugar.

b.- Refined sugars - A chemical analysis of the high grade refined sugar is not necessery.

c.- Consumption sugars- The commonly used consumption sugars /standard granulated/ vary in in wide ranges of quality, from the "turbinado" grade /a high-test washed raw sugar/ through the plantation white sugar /plantation granulated, direct consumption sugar, near-white sugar, off-white sugar/ to the high grade direct sugar produced in beet sugar factories, which differs sometimes very little of a high grade refined sugar. As one can see there is a confusing wide range of nomenclature what is not defined exactly until now. It is therefore very important to have the analitical characteristics of a white sugar as to estimate the true quality of it, as follows: The moisture content ought to be less than o,1o% as to avoid caking during storage. - Ash content ought to be less than o,o4%. - Invert sugar content ought to be less than o,o1%. - True sucrose more than 99,7%. - color determined by photoelectric photometer E /Extinction/ maximum tolerable 1oo. The data quoted here can serve only as orientation, but evry country can state his own standards.

7.o.3.4. Bagasse /beet pulp/ analysis

a.- Dry matter is determined by drying in a hot air oven and subsequent weighing. It must be higher than 50% for bagasse, and higher than 20% for pressed pulp.

b.- Sugarcontent,polarization is determined from the mixture prepared by the wet desintegration method quoted afore 7.o. 3.1. by the sacharimeter. It must be less than 3% for bagasse, and less than 1% for pressed pulp.

7.o.3.5. Dried pulp analysis and quality

Moisture content of the dried pulp ought to be less than 12% by weight of the pulp.

7.o.3.6. Molasses analysis and quality

The quality of the blackstrap molasses is variable depending on the cane from which is made. But the high-test molasses of cane and commonly of beet ought to have a standard quality as follows:

a.- Total solids Bx about 85% both for cane and beet.

b.- Sucrose Pol about 27% for cane high-test molasses, and about 50% for common beet molasses.

7.o3.7. Limestone and lime analysis and quality

Some forms of limestone and lime, even of the highest purity, are quite useless for the sugar factory processing, because of their physical structure. When choosing a limestone mine the burning test, carried out inoperation or in laboratory burning furnace, can be the best method to determine the suitability of the limestone for sugarfactory use. Any tendency to shrinkage, decrepitation and melting is a sign of the poor quality. When this tests and the slakability test of the quickline, have given good results only routin visual control of the particle sizing and of mechanic impurities, and routin chemical control of $CaCO_3$ content and SiO_2 content is made for every delivery.

a.- The $CaCO_3$ content is commonly determined through the burning losses.

b.- The SiO_2 content is determined by gravimetric method, weighing the insoluble dry rest after boiling in hydrocloric acid.

c.- The determination of the available CaO in quicklime is the basic control for purchased lime. It is carried out by slaking a determined quantity of the lime with sugar solution, filtering and titration with hydrocloric acid.

d.- Slakability test is carried out by determining the unslaked rest /by drying and weighing/ after a slaking period of 1o minuts.

e.- CO_2-gas - The CO_2 content is determined by a volumetric "Orsat" apparatus /gas analyzator/. By coke fired kilns it must be between 36 and 40% by the volume of the gas.

7.o.3.8. Analysis of fuels

It is very important especially if coal is used, by which large variations of the quality are possible.

a.- The determination of the heat value is carried out by a suitable calorimeter.

b.- Moisture is determined by drying and weighing.

c.- Ash is determined by burning and weighing.

7.o.3.9. Checking waste and boiler feed water for sugar

Sugar in factory wast waters in small percentages can cause large losses. All the effluent wast waters ought to be checked regulary and systematicaly as to determine /discover/ immediatly the source of sugar losses. A qualitative method using alpha naphtol is common for testing the condenser waters, boiler feed water, factory sewer outflows etc. on the presence of of sugar in traces, but it can indicate roughly the quantitative relations too. There are available automatic analizers, detectors, of sugar in wast- or boiler feed water which are useful but not indispensable. A quantitative determination can be carried out by sacharimeter but it ought to be only exceptionaly needed.

7.o.4. Microbiological control

This control is very important for the processing because of the enorme sugar losses and difficulties which can be caused by microbiologic activity, and for the sanitary condition of the consumption sugar produced and of the drink water.

8.o. FEASIBILITY STUDY

8.o.1 The main conditions to be considered

8.o.1.1. Marketing

The national sugar consumption is to be estimated at present time and in the near future.

8.o.1.2. Growing of sugar cane /beet/

The conditions for the successful growing of sugar cane /sugar beet/ are to be studied carefuly as follows:

a.- Calculating the largeness of the suitable surface areas for cane growing by an adequate cropsequence.

b.- Studying the climatic-, wether- and soil suitability.

c. - Estimating the probable aield of sugar cane and sugar pro hectar.

d. Estimating the possible growing technology: modern, large scale mechanized production or/and small scale, extensive individual production.

8.o.1.3. Location of the factory

Micro- and macro-location ought to be studied carefuly, taking in consideration several factors as:

a.- The factory must be located in the center of growing area.

b.- It ought to be as near as possible to an energetic source: fuel /coal, oil,gas/, electric power for emergency cases and for the non processing period.

c. - The suitable water supply and wast water disposal ought to be secured.

d.- A large near sugar consumption center is very advantageous.

e. - It oight not to disturbe the neighbouring residential areas.

8.o.1.4. Purchassing auxiliary materials

The possibilitiespurchassing fuel, lime stone, coke, sulphure, paper bags for the sugar and so on are to be estimated.

8.o.1.5. Transporting problems

Transporting and trafic conditions /roads, railway system/ ought to be estimated in the growing area and for longer relations. Transporting costs for the transporting of auxiliary materials and of sugar ought to be studied.

The regular, troublfree transporting of the cane /beet/ is very essential for the successful operation and good utilization of the procesing capacity. Therefore it must be studied in details /can the producer, grower manage the transporting by himself or/and the sugar factory ought to angage his own transporting units or of someone else etc./

The transporting within the factory site ought to be studied also to determine the necessery number of unloading devices, of tractors with self unloading tracks for solid wasts. The number of passenger cars and busses oght to be determined.

8.o.1.6. Power and water supply

Power and water supply and wast water disposal ought to be studied in details and the necessery allowences of the othorities ough to be obtained.

8.o.1.7. Necessery personel

The necessery number of personel /staff/ ought to be determined /engineers, technicians, specialized workers, skilled and manual labourers, clarks etc/ and the possibilities for getting them and/or traineng them ought o be estimated.

8.o.2. <u>Procedure of elaboration lf the feasibility study</u>

8.o.2.1. Estimation of the suitabilities

A thorough and detailed analysis of the affore mentioned indispensable suitabilities is to be carried out, for the successful establishment of a sugar factory or sugar industry.

8.o.2.2. Production goals

The most suitable production goals ought to be determined taking in consideration the following:

8.o.2.2.1. Final products

The assortiment of the final products /sugar/ ought to be the simpliest possible as a period of some years /3-5 years/ is necessery for the labour staff to get the necessery practice for a more precise and more complicated operation. It is supposed that the newly established sugar industry ought to cover /secure/ the national sugar consumption at the first time. If so a marketable white sugar of somewhat variable quality which can meet the domestic requirements could be the most suitable and most economic final product, as it can be produced by using a simple and cheap method for juice purification /sulphitation/ and a direct boiling scheme i.e. without remelting the produced final sugar for further purification and crystallization. However, the future development of the sugarfactory is to be estimated /production of a quantity of refined sugar, of cube sugar etc/, as to take it in account by designing.

8.o.2.2.2. The use of by-products

a.-Molasses can be used for alcohol production, can be desugarized by the Steffen process /blackstrap molasses from cane are not suitable for desugarizing/ and can be used as animal food. At the first time the most convenient solution is to sel the molasses if possible. Anyway the utilization of the molasses ought to be strictly determined as it can't be treated as a wast because of its value and because of the environment problems and troubles it can cause.

b.- Bagasse is commonly used as fuel for the boilers, but usualy there is a surplus quantity of it which ought to be used for other purposes /briqueting for domestic consumption as fuel/ or it must be burned as wast. However, depending on the local conditions bagasse can have a more economic utilisation /paper production, wall board production/.

c.- Beet pulp is a very valuyble cattle food in fresh state and dried. By wet siloing 50% of its food value is lost. So drying of the whole quantity of extracted and pressed pulp is the most, if not only, suitable solution. If the utilization of the pulp is not secured it can cause hard environmental problems and break-downs in the procesing of the beets.

8.o.2.3. Processing capacity and season

The suitable processing capacity and the duration of the processing season ought to be estimated as folows:

8.o.2.3.1. The suitable capacity

The suitable capacity is not always the most economic one. As an aconomic minimum capacity can be taken 1500-2000 metric tons of cane or beet dayly prosessing. Larger capacities are more profitable, therefore an enlargement of the new factory in the ear future is inevitable and ought to be taken in account by designing the factory. The initial optimal capacity depends on many factors the most important being:

a.- Possibility of storage of the row material - By processing sugar cane there is no possibility for a long term storage of it. By processing sugar beet there is a possibility for long term storage in cold climates, but in hot climatic conditions there is not.

b.- Transporting methods and capacities - If the cane /beet/ is transported by animal drown carts the processing capacity is limited beyond the economic minimum. Therefore the transporting of the cane /beet/ must be partly or entirely mechanized.

c.- Possibility of storage fo some intermediate products. - Thick juice storage and partially row sugar storage is practiced in many cases at present day. It can be utilized very economically by a future enlargement of the factory, enlarging only the beet end of the factory.

d.- The available trained, specialized staff is an essential question be determining the factory capacity.

8.o.2.3.2. The optimal duration of the processing season /campaign/ depends on local conditions mentioned above and some other. Anyhow it is of esential influence on the profitableness i.e. capital service, so it must be estimated very carefuly.

8.o.2.4. Purchassing preliminary offerts

Preliminary effert of some well-known contractors with adequate references ought to be purchassed for a turn-key delivery of a complete factory, with specified unit prices, as to estimate the up-to-date prices and other conditions of delivery.

8.o.2.5. Investment costs

The investment- or first costs ought to be estimated taking the following main items in consideration:

a.- Preliminary preparation and designing costs

b.- Investment costs for the building objects /processing halls, bureaus, laboratory, sanitarys, shops, store houses, roads, railway, canalization, water supply, wast water disposal/.

c.- Investment costs for the machines and equipments.

d.- Investment costs for transporting of the equipment.

e.- Investment costs of mounting /and insulating/ the equipment, pipe-lines, electric distribuition system, automation circuits etc./Separatly specified for each group/

f.- Other different investment costs /custom duties, asurances for transporting and mounting, training of the personal, take over and other controls by the authorities etc/

8.o.2.6. Production costs and profitableness

The production costs and the profitableness ought to be estimated on the basis of the following main items:

a.- Sugar cane /beet/ price fco factory

b.- Fuel price - " -

c.- Lime stone and coke price - " -

d.- Other auxiliary material prices

e.- Amortisement rates of the buildings and equipments. For the buildings an amortisement term /perio/ of 50 years is common, and for the machines and equipment 1.-15 years depending on the type of the unit and on the load in operation.

f.- Annual instalments of the investment credits.

g.- Working capital costs /The annual interests and annual installments if there are/

h.- Maintenance costs

i.- Vages

j.- Taxes, assurances

k.-Other different costs

8.o.3. Financial problems

8.o.3.1. Crediting the initial costs

The necessery financial means of the investment costs ought to be secured /obtained/ by crediting. Usually long term credits on 2o-25 years are common and necessery for the establishment of a sugar factory. The other conditions are out of the scope of this paper.

8.o.3.2. The necessery working capital

The necessery working capital by establishing a new sugar factory ought to be secured also by crediting. The rate of turn of capital, the service of the capital is very low in the sugar industry 1-1,5 yearly depending on the processing capacity, duration of the processing season and other local conditions.

8.o.4. Elaboration of the tender

8.o.4.1. Generalities

The main features /characteristics/ of the factory to be errected ought to be determined and some details are to be described as closly as necessery to avoid misunderstandings by the treatment of the offers, but in such a way as not to deminish the responsability of the general contractor, designers and equipment manufacturers in any way.

8.o.4.2. Completness of the delivery

"Turn-key" delivery which secures complete quaranty and responsability of the general contractor /for the completness of the factory, for the quality of the machines and equipments and for the technologycal efficiency of the methods and equipment/ is to be required.

8.o.4.3. Production goals

Production goals: capacities, assortiments /auality of the final products and by products/ ought to be determined.

8.o.4.4. Unit processes and equipments

The wanted methods, unit operations ought to be stated in general /continuous or batch method, the type of the diffuser, the method of purification as sulphitation or carbonation etc/, with the specification of the most important equipment and of the wanted stand by units. It must be stated very carefuly as notto deminish the responsability of the general contractor.

8.o.4.5. Technological guaranties

The required technological guaranties ought to be stated as specified in the section "Final take over-guaranty proof" lo.o.2.

4.o.4.6. Technical documentation

The required technical and technologycal documentation ought to be stated as to secure the completness of it and to avoid misunderstandings. All the documentation ought to be delivered in two coppies with the corrections made during errection.

For all building objects: Static calculations and building planes /designes/.

For the machines and equipments: asembly drowings, guidelines for handling /operation/ and maintenance, spare parts specification with adequate schemes, lubrification plane are to be required.

For the pipe-lines complete mounting drowings with the specification of the valves and other accessories.

For the electric power distribution system: complete mounting drowings and one line /one pol/ schemes.

For the automation circuits: complete mounting drowings and guidelines for handling and maintenance are to be required.

For the pressure vessels: complete assambly drowings, static calculation, certificates for the material used, for the welding electrodes used and for the welders.

For the technology: guidelines for operation, emergency cases and the parameters /normal values/ to be controled.

8.o.4.7. Terms

The wanted term of setting in operation /eventually of the designing, delivery of the documentation, delivery of the machines and equipments, readiness of the building objects for the mounting of the equipments, end of mounting etc/

8.o.4.8. Duties of the general contractor

Conditions and duties of the general contractor concerning setting in operation of the factory and the training /instruction/ of the special staff of the investor.

8.o.4.9. Mechanical guaranties

A term /duration/ of the mechanical guaranties of two subsequent processing seasons is usual.

8.o.4.1o. Standards /Norms/

Standards /norms/ and prescribtions of authorities ought to be stated which are to be respected by designing, building and mounting, and by any querel or misunderstanding.

9.o. SPECIFICATION OF MATERIALS AND SPARE PARTS

9.o.1. Building materials

9.o.1.1.Concrete

Reinforced concrete is used more and more in building in the sugar industry, but some precautions are recomanded. Just a small quantity of sugar /o,1%/ in the fressh mixed concrete can impede the setting of the mixture and to destroy the whole quantity contaminated. On the other hand after setting concrete is quite resistant to sugar, but different acids, decomposition products of the sugar, make a serious action of corrosion on concrete, therefor the surfaces of concrete, mortar and brick exposed to direct contact with sugar or sugar containing products ought to be protected by a suitable lining. The floors with ceramic plates or eventualy with asphalt; pattens, foundations walls with a suitable sheating of resins on PVC, PVD or other basis. For building frames /sceletons/ of processing halls steel profiles are the most suitable and preferable because of the plasticity and possibility of future conversion, rebuilding or reinforcement. But concrete is in many cases more resistant to atmospheric corrosion.

9.o.1.2. Steel and steel profiles

They are also in common wide use for factory or other buldings or building frames /beams, bearers, coumns, trussing doors, windows etc./, having many advantages mentioned affore vapour and humidity constantly present by processing do not cause deformation of them but can cause serious demages by corrosin if they are not properly protected.

9.o.1.3. Wood

Wood is to be replaced by concrete or steel evriwher it is possible becauuse of the deformations caused by humiditi, firehazard properties higienics etz.

9.o.1.4 Refractory materials.

They are widely used in the sugar factories for linings of boiler-fire-chambers, furnaces of pulp- or bagasse dryers, of lime kilns etc. At the last the refractory lining is exposed not only to high thermic load, but toa high mechaniz load too /pressure and friction caused by the filling ie. limestone and coke/. There are many types of materiallike chamotte, magnezit-chromit, silica etc. Refractory bricks of standard form and purpose-made bricks, profilated bricks are necessery, and refractory mortar with stamping mass also.

9.o.2. Materials for building processing equipment

9.o.2.1. Steel is the most common material used for machine and equipment building in the sugar industry in form of rolled profiles and plates, and of corse tubes.

9.o.2.2. Cast iron/grey and steel cast/ has also very wide use in the sugar industry.

9.o.2.3. Brass is very often used for smaller parts like: slives, bearing linings, smaller valves, bushes. But it is in some cases replaced by steel or stainless steel. Heating tubes, evaporating tubes are now days made mostly of steel, impellers of centrifugal pumps of steel cast.

9.o.2.4. Stainless steel is used more and more, but it is still very expensive as to be used for the construction of a whol equipment or similar wide use. Evaporating tubes of stainless steel are sometimes used but one can't say that it is an economical solution. The equipments for extraction /both can or beet/ are exposed to the highest action of corrosion and it is necessery at some parts of them are made of stainless steel and the other parts in contact with sugar ougt to be protected by a suitable lining of stainless steel plate or a suitable resin coat. For some special purposes like: tubes, vents and instruments for SO_2-gas supply, slives for CO_2-gs compressors and sfahts for other pumps, different screens, elements of automation transmitters and control-valves stainless steel must be used.

9.o.2.5. Packing materials gaskets have wide use in the sugar industry for different purposes. The required quality depends on the working condition. The most common materials are: sabestos felts, azbestos cords, graphited cotton cords, rubber felts and cors, teflon cords etc.

9.o.3. <u>Spare parts</u>

It is not easy to make a good selection choice of spare parts, because the investment cost for this purpose must be limited, but it is not possible to forsee the possible failures during the work of the machines. However it is possible to anumerate the most common parts usualy taken as spare parts. As concerning the stand-by units of single units, machines they ought to be choosed very carefully. Except some emergency cases like boiler fedwater pumps and similar it is not possible have a 100% reserve. For pumps and machines which ought to be cleaned periodicaly one can combine a stand-by unit for a group of two or more units, like: filters, juice heaters, beet slicing machine, cane knives, eventualy last evaporator body in a cane sugar factory.

Machines with the most common spare parts:

Pumps - spare impellers /rotors/ for every pump and spare shaft for thos without stand-by unit are necessery.

Waterring compressors and vacuum pumps - one common shaft with impeller is enough for each type.

Belt conveyors some rolls and belts as common reserve for severel unit of the same type is enough.

Knives for cane "knives" /or beet slicers/.

Some rolls for cane mill-tandems.

Filter clothes of synthetic for each filter one set.

Evaporator - heating tubes 25% of the quantity built in.

Juice heaters - heating tubes 40% of the quantity built in.

Tube cleaning blades and bruches ten set of each.

pH-meters - six sets for each one.

Vacuum pans - heating tubes 10% of the quantity built in.

Centrifuge - one driving set for each type.

Centrifuge - one basket for each .ype.

Centrifuge - one or twoo set of fine perforated screen for each unit.

Centrifuge - one set commonfor each type, of backing screen.

Centrifuge - one set common for each type of intermediate woven screen.

Centrifuge - One common set of automatic control an programing devices for each type.

Centrifuge - One common set of washing sprays for each type.

boiler - Some grate bars as common spare for all boilers.

boiler - One shaft with impeller for the primary air fan as common spare for all boilers.

boiler - Some water-level control glasses as common spare.

boiler - A small quantity of all types of fire-proof tubes for eventual repair.

boiler - Some sets of special welding electrodes for repair.

boiler - A small quantity of refractory materials.

V-belts - some pieces /enough for the larges set/ of every type.

Belts for revolution-variators one piece /or set/ for every unit.

Belts of other type some pieces of evry type.

Chains for bucket elevators - one set for evry unit.

Ewart chains one set for every unit.

Wires for cranes and lifts the longest piece of every type

Screens - One piece or some segments for every type.

Tubes and flanges - A small quantity of every dimension.

Vents and valves - Some pieces of all sizes except the largest sizes.

Thermometers - some pieces of the most important type.

Manometers some pieces of the most important type.

Sight glasses /with proof-certificate/ some pieces of every type.

Level glass-tubes like affore.

Gasket rings - some pieces of every type.

Roller bearings - Some pieces of those difficult to obtain.

Guanrd rings - Some pieces of each type.

Automatic controllers - One set of the most important types.

Parts for the a utomatic control devices.

Ceramic hydrociclons - one or twoo pieces of every type.

Recorder diagram-papers - the required quantity for twoo seasons /campaignes/.

Electromotors only some pieces for the most critical drives.

Electric switches one piece of the important type.

Ampermeters - only some pieces, one for each important type.

Votmeters - like affore.

Overcurrent protection - relays and directacting trips some pieces for each important type, fuses some pieces of every type.

Electric bulbs, signaling lamps for the automatic devices and the control panels some sets for not easy to purchase types.

9.o.4. Machines and tools for the maintenance shops.

9.o.4.1. Machine shop

No 1 Universal lathe 2.000 mm.
No 1 Universal lathe 3.000 mm
No 1 Universal lathe 6,000 mm ∅ 72o mm
No 1 Universal milling machine 6oo mm with spec. accessories.
No 1 Slide grinder
No 1 Universal shapin machine 6oo mm
No 1 Automatic circular saw grinding machine.
No 1 Pillar drilling machine ∅ 4o mm
No 1 Pillar drilling machine ∅ 32 mm
No 3 Bench drilling machine ∅ 15 mm
No 3 Universal electric hand grinder
No 1 Abrasive hand cutting off machine
No 1 Electric hand grinder with right angle spindl
No 1 Plate-bending machine for 8 mm plates 2ooo mm
No 1 Plate shearing machine for 6 mm plates 2ooo mm
No 1 Hand operated lever and cutting machine for 8 mm plates
No 1 Hydraulic sawing machine
No 1 Common type sawing macnhine
No 1 Electric hand drilling machine 1o mm
No 2 Hand drilling machine 1o mm
No 3 Transformer welding set
No 3 Gas welding se
No 2 Acetylene generator set
No 1o Oxigen cylinders
No 1o Acetylene gas cylinders
No 1 Smith's forge
No 1 Spring hammer of 75 kg

No 1 Set of smith's tools
No 1oSet of mechanical tools
No 1 Plate bending machine for 1mm plates 1ooo mm
No 1 Set of tin smith'x tools
No 2 Set of insulator'tools
No 1 set of vulcanizer'tools
No 1 set of plumbers tools
No 1o Chain pulley block o,5 - 1o t
No 2 Hydraulic lever of 3o t
No 2 Hydraulic lever of 2o t
No 1 Lifting winch of 15 t with hand or electric drive.
No 3 Rack type jack of 2 - 5 t
No 2 Evaporator tube cleaner with pneumatic drive
No 2 Heating tube rool-in machine, mandrell machine
No 1 Portable compressor for air pressure of 6 kp/cm^2, with a reciver of 5oo l.

9.o.4.2. Electric shop

No 2 Universal Amper-Volt-ohm meter
No 1 Megaohm meter for 5oo-15ooV
No 2 Phase-meter
No 1 Wheatstone-bridge
No 3 Mapermeter pliers
No 1 Electric tasting set
No 1 Drying chamber for electromotors
No 1 Graounding-rsistance measuring instrument
No 1 Small transformer welding set
No 1 Cable fault detector /tracer/
No 4 Sets of standard electric maintenance tools
No 1 Hand car
No 1 Bench drilling machine ø 15 mm
No 1 Electric hand grinding machine

9.o.4.3. Automation shop

No 1 Precise lathe 8oo-1ooo mm
No 1 Sensitive bench drilling machine ø 1o mm
No 1 Fine bench drilling machine ø 5 mm

No 1 Fine bench grinding machine

No 1 Miliampermeter 6o mA

No 1 Checking /verification/ manometer o-25 kp/cm^2 ϕ 3oomm

No 1 Checking /verification/ manometer o-5o kp/cm^2 ϕ 3oomm

No 1 Quick testing instrument for conductivity simulating 1oo-Ohms- lo-MOhms, portable type.

No 1 Portable pressure testing and simulating instrument

No 1 Fixed pressure testing instrument with liquid column

No 1 Tension and current testing instrument

No 1 Manometer checking device

No 1 Thermometer checking device

No 1 Checkin /verification/ thermometer o-15o°C

9.o.4.4. Building and joinery shop

No 1 Concrete mixer 5oo-looo l

No 2 Concreting vibrator

No 1 Air feed stoper for drilling concrete

No 4 Set of brick layer's tools

No 2 Set of carpenters tools

No 1 Universal planer

No 1 Bench saw /band saw/

No 1 Set of joiner's tools

No 1 Set of stand-pipes for temporary scafolds.

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