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SYRIAN ARAB REPUBLIC

Technical report: Maintenance and operation of instruments and control systems in sugar plants*

(Trouble shooting and analysis of problems related to low production, inefficiencies in operation of plant and process equipment and failures therein)

Prepared for the Government of the Syrian Arab Republic by the United Nations Industrial Development Organization, acting as executing agency for the United Nations Development Programme

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TABLE OF CONTENTS

ABSTRACT

An assignment was given by United Nations Industrial Development Organizations, Vienna under DP/SYR/86/009/11-06 as an expert in operation and maintenance of Instrument Control System in the Sugar Industries under General Organizations for Sugar (GOFS) at HOMS, in Syrian Arab Republic to undertake the studies related to low productivity and efficiencies with higher fuel consumptin in general and related problems on operation and maintenances of Instrument Controls Systems in particular.

The duration for these studies at their major trouble stricken three units at Al-GAB, TAL-SALHAB and HOMS Plants were for ten working days and for two days at Damascus Sugar Plant to study the problems in their yeast producing plant. Besides the above, general discussions on major technical points and their releated problems were held with technical personnel of General Organizations for Sugar at HOMS Office.

The major three plants of the Organization are suffering with chronic basic problems with inefficient operation with high energy consumption. Similarly, Instruments and Controls Systems, where introduced, are not working properly.

The main objective was first to identify the process related problems and reasons for the high energy consumption. Second part is related to Instrument and Controls Systems reasons for their poor and unreliable operation and non-availability in production.

While the attached report will give in details of the observations and analysis of fact findings, the recommendation can be made to take urgent action in the following points to overcome the basic problems :

1. *Proper designed Water Treatment facilities to be introduced immediately at HOMS Sugar Plant, Al-GAB plant and TAL-SALHAB plant.*
2. *Boiler operation system should be revitalized and controls parameters should be strictly followed including periodic systematic checking and inspection of Boiler burners, tube wall thicknesses at radiating and convection zones.*
3. *Large scale deposits of scaling in heat exchanger tubes are the main contributory factors for high steam consumption. This is also affecting steam generation due to scalings in convection and radiation zones.*

4. Pneumatic Instrumentation system has been considered in some units without considering the incorporation of an Air Dryer unit, causing total malfunctioning of instruments due to high degree of moisture laden air in the system. Similarly, no consideration has been given to adopt Electronic Control Systems to avoid huge measurement and control lag in a Sugar Industry where Primary measuring elements, control areas and final control elements are beyond the distance limits of pneumatic systems.

Inadequate Instrumentation for the measurement of non-electrical energy in the individual process areas are the main factor for non-acknowledgement of actual energy input. This has further aggravated for not having controls of vital parameters for efficient uses of energies by way of temperature controls and level control in heat exchangers, differential pressure monitoring for demisters in Evaporator units and blow back systems and non-existence of on-line measurement and controls for viscosity, specific gravity or percent concentration and pH/ORP systems for Process Controls to achieve optimization and quality improvements.

New design concept must be immediately adopted for proper Instrumentation and Controls, not with a package offer from any supplier but on the basis of process concept and experiences. This can be undertaken during Sugar campaigning time and in a phase-wise manner.

5. Pressure Reducing Stations with Desuperheater temperature control system must be made effective and to be used only in emergency and not in continuous operation. The operation of the pressure reducing station in a plant, where the power Turbines are back pressure type, is a crime and a loss of energy equivalent to power generation through reducing stations.

Suggestion can be made to synchronize the power Turbines with the national grid with all "fault-protections" included to meet a steam-power balance on co-generation concept. This will be beneficial in the concept of having a Condensing cum Back Pressure concept of power generation, where the grid will serve as a huge condenser and steam-power balance can be achieved in the plant. This is also beneficial for plant in particular and national grid in general where the excess power can be available from the plant and earning thereby by the Sugar plants.

This concept should be implemented instead of losing energy by operating a Reducing Station.

6. High Sulphur content of Furnace oil with improper atomization of steam "differential" is causing the excessive burner tip errosion and flame propagation is badly affected, impinging the flame on the convection zone tubes directly.

It was advised to check the burner tips frequently and adjust the steam/oil "differential" at optimum with 1.4 kg/cm2g to 1.6 kg/cm2g and not at 3.5 kg/cm2g as found in TAL-SALHAB Plant which is too high and 0.9 kg/cm2g as found at HOMS which is too low.

Steam header distribution was found improper at AL-GAB Plant. Off-takes from headers are irrational and no control is existing to maintain the individual header pressures, causing evacuation in the header and falling of pressure of steam at the large consuming ends. Ring main steam header is recommended.

7. There are no vibration monitoring instruments or Turbine supervisory monitoring instruments for axial displacement, expansion and eccentricity monitoring along with bearing temperature monitoring instruments in any of the power Turbines in the units under study. Excessive vibrations in operation was noticed endangering both machine and safety of personnel. In cases, automatic back pressure control for Turbines are not working or not provided. This is a serious drawback and failure of Turbine blades at back pressure stages are predominant due to heavy fluctuations of process steam at Back pressure level.

Recommendations can be made to introduce the minimum monitoring instruments for Turbine for vibrations at different areas, axial displacement monitors and bearing temperature systems with preset alarm and extra set values for trip to safeguard the machine and costly damage. Bentley-Nevada or Dymac system can be introduced.

8. Return condensates are directly taken into Boiler feed system without treatment, and, in cases, without even "Deaeration". This is a serious mal-operation for Boilers at operating pressures of 30-32 kg/cm2g and temperature of 380°C with high capacities. It was noticed that the colloidal suspended solids along with steam have accumulated at the last stage of Turbine blading and 2-3 MM deposits of sluge like material was found at Back pressure outlet of the turbine.

The effect of such deposits are dangerous and thus, it is recommended to return all condensate to a condensate recovery tank with all streams for monitoring and automatic diversion to bad condensate tank or to sewer through continuous on-line conductivity monitoring system. Good and acceptable condensate must be processed through Ion Exchange units after filtration and, then this water must be used for Boiler through Deaerators.

9. There are no instruments for acknowledging the feed water quality to Boilers. It was observed from the Laboratory analysis that the feed water contains various impurities at an unaccepted high level. The impurities like chloride at 24.0% Phosphate at 24.0% and Sulfur at 25.3% with Sodium Ion 36.0% and Silica containment at 0.5% can never be recommended for use in steam generation at the operating pressure level of the plant.

Similarly, no instruments are existing for continuous monitoring of CO2 in the flue gas and temperatures at various places for monitoring fluid temperatures and flue path temperatures. No soot blower is provided for TAL-SALHAB Package Boiler superheater elements, causing several failures of the tubes in operation due to high Sulfur deposition along with Venadium metal deposits on the tubes.

It is thus recommended to instal a soot blower system at TAL-SALHAB Boiler in line with the system provided at the new Package Boiler unit at HOMS Plant. It can also be recommended to blend the oil with light diesel oil to bring down the Venadium metal content level in furnace oil. Flue gas at stack must be maintained above 180°C to avoid low temperature corrosion at chimney. Present operating level of the flue gas at 130°C is *at a dangerously low level for the type of high Sulfur content (7.0% -9.0%) of furnace oil. Tne stack is made of Mild Steel which will endanger for a high rate of corrosion.*

To increase the flue gas temperature at exit it is suggested to increase the feed water inlet temperature to economizer through higher working pressure of Deaerator, which would help to maintain a higher temperature at stack above dew point and minimize corrosion rate at stack. The temperature at stack must be continuously monitored through recorder trend.

10. Poor quality of Lime Kiln gas at 26%-30% using coke, is due to non-existence of air blower batch charging of coke and limestone and working of kiln under suction. By use of Bituminous Bee-hive coke with good porosity and continuously proportioned blending of coke and limestone to obtain proper homogeniousity and with air blower for cooling of downcomer calcined lime and self pre-heating the air for combustion will give higher gas concentration between 38%-40%. The core loss at present is too high at 50% which is due to above shortcomings. Poor gas concentration uses more CO_2 in Carbonation process thus overloads the system. It is also suggested to use recycling of juice between first and second Carbonation for better productivity and efficiency.

It is recommended to instal a continuous proportioning feeder for limestone and coke for proper blending before being charged to kiln. Air blower should be installed immediately with proper design and capacity. Air flow should be monitored. Similarly, air back pressure should be monitored to anticipate any channelling or lump formation inside the kiln. Burning zone temperature, cooling zone temp. and continuous monitoring of CO_2 gas concentration for exit gas must be installed.

Wet Gas scrubbing and washing should be eliminated by use of dry filtering through Bag Filters. It was observed that thick mud deposition on the Gas Compressor valve head assembly associated with high rate of corrosin and this is due to wet scrubbing and washing of the gas. The life expectancy for valve assembly with higher efficient operation can be assured with dry filtering and this has been adopted in many parts of the world for Lime kiln operation. This also helps to avoid use of Alloy Steel Metallurgy of Compressors at much higher cost. The dry dust from Bag Filters can be used at Hydrator to improve upon the titre of

Milk of Lime, thus, a saving too of lime. It was also observed that the gas outlet temperature is too high at 220°C and there is trace of CO at 3% in the gas which indicates that incomplete combustion is taking place and the system is not getting air quenched, which justifies for use of air blower at bottom.

11. *Inadequate knowledge in Instruments and Controls associated with non-existence of qualified and well experienced Instrumentation and Control Engineer in the establishment has brought the poor performances of instruments whatever is existing. Most of the instruments are not functioning due to poor quality of instrument air and worst repair, maintenance and upkeeping of them. No action has been taken throughout the years to revamp with latest development of measurements and Control systems which could help for an efficient and productive operation and would also assess the performances of the equipments and their predictive overall and repair.*

Recommendations can be made to recruit qualified and experienced Instrumentation Engineers who can undertake Process Control requirements studies and introduce gradually the best effective systems for monitoring, operating and trend display of Process parameters and should have good Analytical aptitude for diagnosis of Process/Instruments faults. If the trained personnel are not available in the organization, it is recommended to take external helps to impart training for selective candidates in running plant, along with theoretical classes. Such external expert can render assistance in designing and System Engineering of instruments for revamping and modernization along with the selective plant Instrument personnel. This would serve as an on-job training too.

It is also suggested that before implementing the recommendations, frequent technical discussions must be conducted with the Consultant, Technical Managements, both from Design & Engineering group and also plant operating personnel so that all can get the exposure for the new system.

This study could have been more appropriate during campaigning time of Sugar so that all relevant recommendations could have been identified fully. The visit and study during running of the plant would have been more useful.

1. *General Process of Beet-Sugar producing plant with major processing activities.*

1.1 *In the direct manufacture of Sugar there are few or no chemical changes that require energy. Almost all the steps in the manufacturing sequences involve physical changes or unit operations. These consume energy in the form of power for crushing, pumping and centrifugation including preparation of Milk of Lime by Calcination of limestone and heat required for solution, evaporation and drying. The steady improvements in the Technology of the equipments and concept of Instrumentation and Controls systems have now made it possible to make various units' operations function efficiently and contributed for gradual reduction of energy requirements to reasonable amounts.*

1.2 *The Sugar Beet is widely cultivated in the Syrian Arab Republic. Sugar Beet differs from the ordinary Table Beet, in that, it is much larger and not red in colour. Sugar Beets are cultivated in this country because of soil condition favourable and for their Sugar value. The Beets containing from 13% to 17% Sucrose and 0.8% Ash enter the Factory, by way of flumes, small canals filled with warm water, which not only transport them but also wash them. The manufacture thus can be divided into following sequences :*

The Beets are rewashed, weighed and sliced into long narrow strips called Cosettes.

These are dropped into a specially designed continuous counter current diffusers. The Sugar is extracted counter currently with water at 75°C-80°C. The resulting raw juice is a blue-black 10-12% Sucrose solution with a small amount of invert sugar and 2-3% ash. The pulp remaining contains 0.1 to 0.3% Sugar. This pulp is dewatered in process and dried in a Rotary Drier and sold as a cattle feed. The change in the Beet Sugar Industry to automatic counter current continuous diffusers eliminates the sweet water handling costs and reduces the labour cost.

The juice then is given a rough screening to remove foreign materials.

Milk of Lime is added until the concentration is equivalent to about 2-3%. The lime aids in the precipitation of undesirable impurities. Any Calcium Saccharate is decomposed in Carbonators by passing $CO2$ gas from the Lime Kiln through the juice for 10-15 minutes and pH value is monitored. The foaming that occurs at this stage is reduced by addinn anti-foaming agents.

The sludge produced by the lime is equal to 4-5% of the weight of Beets charged. This is removed by thickening and filtering on Oliver Filters.

Lime is added again in the second Carbonation stage until the concentration is equivalent to 0•5% and the juice is again carbonated, this time hot. It is better, at this stage, to have re-circulation between first and second carbonator after press for better yield but not practised in any of the plants under study.

The resulting filtrate contains a large concentration of Calcium Ions which are removed by Sulfur Dioxide. The Sulfonation process is not practised in any of the plants under observation. Sulfonation process greatly helps, not only to remove Calcium ions but serves the bleach of the solution of its pale yellow colour. This SO2 should be available at its Nascent state and not through the captured Sulfur in calcined lime, where fuel oil is used for calcination. This concept is wrong for bleaching purposes. Calcium Sulfite precipitation must be removed by pressure filters with the help of on-line specific-Ion Analysers.

The purified juice is concentrated from 10-12% Sugar to about 60% Sugar in multiple effect evaporators. The resulting thick juice is grained in vacuum pans, centrifuged, washed and dried in Granulators, screened and packed.

The juice from the first vacuum pan is given further treatment to recover more Sugar crystals, but this is not pure enough and sent back to the process for further purifications.

The syrup remaining after the crystallization, called Beet Molasses, is processed for yeast product either in the Complex units or sent to other units for processing. Some of the units are producing industrial alcohol for the country.

2. *Observations and analysis of various problems at AL-GAB Sugar Plant.*

2.1 *High steam consumption for power Turbines and Processing units.*

2.1.1 *Two oil fired Boilers run continuously during campaigning. One Boiler with Economizer, Air Preheater and Superheater having fully automatic combustion controls system rendering the best efficient operation with steam-fuel ratio at 13:1 while the other operating Boiler without any Economizer and no combustion control instruments and drum level control system, working in the common header with a poor efficiency, giving steam-fuel ratio at 8.5:1. Accordingly, the automatic efficient Boiler is reactive in the system and takes the entire load fluctuations while the second manual Boiler doesn't take load fluctuation and it works in negative direction to maintain the header pressure equalization at the cost of reactive Boiler. There are possibilities for carry over of moisture droplets with the steam in case of sudden demand of steam for the process. This is due to drum level swelling effect as no level controller is existing in the manual Boiler. There is no superheater temperature controller too in this Boiler. This endangers a Thermal shock in the superheater coils and droplets also may cause joint leakages in steam pipelines. Steam with droplets may cause cavitation at the nozzle valves of the Power Turbine, causing premature failure of seat and plug due to errosion.*

2.1.2 *Pressure Reducing valve between high and low pressure header is continuously in operation with manual control desuperheater temperature. There is no measurement of steam flow through reducing station.*

The operation of pressure reducing valve is necessary to meet the steam requirement but the root causes for higher steam consumptions were never analysed. The scaling of heat exchanger tubes are the basic reason for higher steam consumption. Non-existence of level controllers and temperature controllers in heat exchangers has aggravated further. Consuming end steam flow measurements are not known through flow meters and arbritrary operational procedures are conducted. Thus the steam consumption has gone in processing units. Due to operation of pressure reducing station, higher back pressure of the power Turbine resulted *in higher steam consumption for generating same power.Thus inefficiency through loss of energy.*

2.1.3 *Suspected partial blockages of heat exchanger tubes with high rate of scaling, both internally and externally due to non-existence of Instruments and Controls to fix parameter. This is also due to bad quality of steam with high rate of salts and solids. There are no conductivity monitors for acknowledging the tube leakages.*

2.1.4 *Wastages of steam in Evaporator calendrias are prominent as there is no control for condensate level and no temperature control system to regulate the incoming steam i.e. heat input. Flash Evaporator should be provided with a level controller for high recovery. The Demisters in Evaporator bodies are not provided with the acknowledgement of differential pressure across them and no system is available to blow back at regular intervals for cleaning of depositions. The partial or full blockages of Demisters would affect the boiling point. Blow back provision would greatly help in achieving the saturation pressure and temperature in the bodies for boiling with judicious heat input and maximum vapour recoveries would be achieved in subsequent bodies. This system also holds good for vacuum pans.*

Diffusers are not insulated and accordingly desired operating temperature at 80°C not available. This is a loss of energy and performances of diffusers at low temperature operation at 50°C is incorrect. Flash Evaporator better steam recovery through level controller would help more steam availabilities.

2.1.5 *Steam headers are wrongly designed and there are no rationality in sizing them. The off-takes from headers are more in total sizes by 100% than the inlet line sizes. Further heavy demand units are not isolated with properly designed header with pressure controllers. This would help in gradual withdrawal of steam from the header without sudden evacuation. Header concept should be re-grouped with ring main concept and pressure controllers must be introduced at consuming ends for gradual withdrawal of steam and judicious use of steam. The pressure control system would also help to maintain desired process pressure in case of a change in upstream pressure. Flow meters with pressure-temperature correction must be introduced at major consuming ends.*

The steam distribution network should be designed to maintain pressure drop at the furthest consuming end at 0.2 kg/cm2g, keeping all consuming end valves full open for meeting the demand in operation.

2.1.6 Inadequate or no instruments for operation and energy conservation in this unit is a major deficiency. All necessary continuous monitoring and controlling instruments along with utilities measurements at process units with mass flow measurement system should be introduced. On line process stream analysers and controls should be introduced for process operation and continuous monitoring with alarms for conductivity of condensate returns should be provided.

2.1.7 Immediate arrangement should be made for a full capacity Water Treatment plant for producing high quality of water for steam generation. The plant should be equipped with on-line continuous monitors with recording and alarm for conductivity, hardness, total dissolved solids, pH and silica content.

Similarly cooling water for process should be improved for quality to avoid large scale depositions of Calcium Silicate and other salts.

All process condensate returns should be collected first in a flash tank and the flash vapour can be recovered for hot water requirements in process. The condensate thereafter should be stored in a hot well. The incomign to hot well tank must be controlled with conductivity monitoring and automatic diversion arrangement to sewer may be made in case of bad quality. The condensate then should process through Water Treatment unit and Deaerator before being taken for fed water in boilers.

2.1.8 No protective instruments and supervisory instruments are equipped with power generating Turbines. Vibration monitors, axial displacement monitors, bearing temperature monitors and expansion/eccentricity monitors are not provided to acknowledge the abnormal conditions in running and also to predict/anticipate a problem prior to a major breakdown.

There is no flow measurement for steam along with pressure temperature correction for the steam turbines. This flow measuring recorder cannot only help in assessing steam consumption but the pattern of flow recorder can give information about the performance of the Governor and nozzle valves and also for any abnormality in excessive steam leakages in case of erroded or damaged bladings or labyrinth.

The Back pressure control system should be of Electro-Hydraulic type and Back presure should be recorded along with inlet steam pressure recorder.

2.2 High Fuel consumption in Lime Kiln operation.

2.2.1 Lime Kilns are being operated with Gas concentration of 26-30% CO_2 along with 4-5% CO. High grade limestone and coke should give 38-40% CO_2 with O_2 content at 1.5%. No CO should be available at exit gas.

The poor gas quality is due to

a) No Air Blower is equipped with the kiln.

b) Improper feeding of coke and limestone in batch without proper mixing, resulting high unburnt and damage of kiln lining due to localised heat.

c) Anthracite coke with low porosity, high volatile matter and low ignition point.

d) No Instrumentation for operation.

2.2.2 Due to non-existent of Air Blower, two major operational performances are affected :

Bottom Air to the kiln by air blower cools the downcoming calcined limestone, while air gets preheated itself when it travels upwards. This preheated air then serves as combustion air in the burning zone and helps to oxidise fully all C and residual CO into CO_2, thereby helps to provide higher concentration of CO_2, according to theoretical formula.

$$CaCO_3 + C + O_2 = CaO + 2\ CO_2$$

Proper burning at burning zone with the help of hot combustion air, coke consumption can be reduced. CO at reducing zone would help the combustion as a secondary fuel with air. Accordingly, ratio of coke and limestone can be reduced.

Due to air quenching of downcomer calcined lime, high discharge temperature will be avoided and unburnt at 50% (as informed) will be reduced to 10-15% max. due to proper calcination at burning zone itself.

Air Air Blower with proper design capacity should be installed.

2.2.3 *Batch feeding of coke and limestone is not only affecting the kiln operation but also damaging the kiln lining. Coke and limestone are not being fed as a homogeneous mixture but they are totally segregated, resulting channelling, hot spot and improper calcination. Hot spot is damaging the lining while channelling and improper calcination is contributing for high unburnt and poor gas concentration.*

A continuous proportioning feeder with master-slave concept should be installed, whereby coke and limetone will mix together properly before being fed to Lime Kiln. Limestone control can be master and coke should be set as slave control through a ratio-setter. This mode of operation would help in reduction of valuable imported fuel (coke) and due to continuous operation, production will be increased. The costly downtime for relining will be minimized.

2.2.4 *Coke quality should be specified as Bituminous Bee-hive Metallurgical coke having porosity at 60-65% and ignition point at 850°C to 900°C. This will have better burning without channelling and would give higher gas concentration than Anthracite coke being used now.*

2.2.5 *There are no measuring or controlling instruments for Lime Kiln operation.*

Temperature measurement at the burning zone, around the kiln shell at 90° apert should be used for monitoring temperatures' equilibrium and acknowledgement of channelling, hot spot or shifting of zone. Similarly top gas temperature should be acknoledged which will be an indirect guidance for shifting of burning zone upward.

The withdrawal of calcined lime should be with "Time base" through timer and the timer setting should be adjusted properly to avoid underdraw or overdraw, where top gas temperature would be a guidance.

Continuous measurement of CO_2 gas concentration leaving lime kiln must be provided along with oxygen content monitor. The Oxygen monitor would be the guidance for bottom air flow control.

A back pressure monitor for air would help to acknowledge any lump formation inside the kiln and predictive action in operation can be taken.

It is suggested to keep the kiln top under a little pressure, say 5-6 MM W.C. through a pressure controller. The control valve can be mounted on the exhaust to atmosphere. This slight pressurization would prevent infiltration of atmospheric air through the mechanical clearances of the feeder cone at the top, thus avoiding dilution of the kiln gas by atmospheric air. At present this is under suction.

2.2.6 *Higher concentration of the gas would help to reduce gas consumptions in Carbonation process. Accordingly this would help in saving coke in making CO2 gas. The yield also would be better in Carbonation process due to better titre of Milk of Lime and good quality of gas.*

2.2.7 *Basic concept of Instrumentation is NIL and awareness of plant operation through Instrumentation has started with introduction of one Boiler fully equipped with combustion control systems, Superheater temperature control system and drum level control system but except this there is nothing for process control purpose. Even the pressure indicators and temperature gauzes are not calibrated and poorly maintained.*

The plant must be revamped fully with process controls and Analytical on-line monitors. The high speed rotating equipments must have supervisory and protective instruments.

3. *Observations and Analysis of various problems at TAL-SALHAB Sugar Plant.*

3.1 *Boiler and Power plant including Water Treatment Plant.*

3.1.1 *There is no facility for Water Softening/Treatment plant at TAL-SALHAB unit except a cation unit. This is totally inadequate to polish water at the desired value for feed water quality to generate steam at 32-34 Bar. Accordingly, due to poor quality of boiler feed water without any treatment and without any monitoring for hardness, solids in suspension and silica content, dissolved oxygen and pH monitoring has resulted for high rate of scaling in the Boiler tubes including superheater tubes and all heat exchangers which are using steam. Similarly, external scalings are in excessive where cooling waters are used for heat exchanger.*

It was observed that one one side, there is no water treatment facility to improve upon Boiler feed quality and, to aggravate further, all the Process Return condensate are being taken directly in the Boiler Deaerator without any monitoring of contamination.

Bad quality of water and thereby steam has caused large scale depositons and caused several Boiler Superheater tube failures including the recent one. On inspection of the rupture tube it was evident that internal scaling caused localized heating of the tubes. This has further aggravated by less steam generation and operators intend to increase the firing rate to sustain generation due to lack of Analytical approaches and lack of Instrumentation to acknowledge the problems.

Fine depositions of Calcium salts were noticed in the inlet steam entry pipe of the Power Turbines. Similar depositions, but much more was noticed at exhaust outlet. The Turbines were under maintenance and blading scales have been cleaned. Hence could not be assessed about the seriousness.

A thick sludge type deposit was found at exhaust of the Turbine, which is caused by the solids in juice vapour carry over and other colloidal solids came directly to Deaerator as Process Condensate.

An immediate mecsure is thus suggested for a proper Water Treatment Plant with Anion, Cation, Degasser and Mixed Bed Unit to polish the water to the acceptable limit as Boiler feed water. The boiler operating pressure at 32 Bar and at temperature of 380°C calls for polished feed water. Condensate recovery system should be as suggested for AL-GAB under 2.1.7.

3.1.2 *There are 3 Boilers including one Service Boiler originally meant for start up only and two other for regular oil fired Package type Boilers with capacity of 35 MT/HR at 32 Bar and 380°C at superheater outlet. The Boilers are to operate at balanced draught and they have individual mild steel stacks without any lining. There is no air preheater but have Economizer Banks and have 2-element superheater coils at radiant zone with provision of desuperheater by using saturated steam from drum. There are retractable soot blowers for Economizer Banks but no soot blower provision at superheater zone and for convection zone tubes. All the 3 Boilers run during campaigning.*

Original specification of Furnace oil was of Bunker 'C' grade, having Sulfur 3-5% and metal content less than 50 ppm. Presently, the Boilers are being operated with oil having 7-9% Sulfur and metal (Vanadium) content more than 75 ppm.

During the observation and as the Boilers were under annual shut down for inspection, the detrimental effect of high Sulfur and metal content in furnace oil could be thoroughly assessed. Riser and downcomer tubes were found with high corrosion due to Sulphuric Acid mist formation in cold condition. It was reported that the failures of superheater tubes, since 1985 is very frequent. On an inspection of the ruptured tubes visually it could be confirmed that the rupture was caused by high Sulphide stress and metal (Vanadium) deposition. This was confirmed also by Plant personnel through deposition metallurgy analysis. Several other ruptured elements were also inspected and all of them have similar reasons. In one case, the rupture of the tube was due to high alkalinity of water.

On inspection of burner tips, it was found that high errosion through the tips made the holes oblong and thus flame propagation gets affected and impinges on one direction with blunt ends. This type of flame propagation hurts the radiant zone and localized heat on superheater elements could not be ruled out.

The steam-oil differential in operation is kept too high as found in the Log Book of operation. The differential value at 3.5 kg/cm2g is too high as against normal 1.4 to 1.6 kg/cm2g. This high differential along with silica particles with silica particles with oil at burner tips caused this errosion. There is no inspection of the burners and it was found that operating personnel are not aware for such deformation of burner tips in operation which can disturb the flame propagation and can cause injuries of the Boilers.

Soot Blower at superheater could help to clean the depositions at regular intervals by acknowledging the differential temperatures of Boiler outlet gas and superheater outlet gas. Non existence of soot blower at this critical point has caused such failures. This must be pointed out that similar Package Boiler installed at HOMS Sugar Company is provided with proper soot blowers arrangements at superheater zone.

Boilers are being operated at a flue gas temperature of 130°C. This is dangerous for last bank of the Economizer where cold end corrosion would take place. This is also dangerous for Mild Steel stack which is suspected for the corrosion internally and advised to check. This high Sulfur furnace oil must be operated through a flue gas exit temp. at 180°C-190°C, much above dew point as a safe guard for downstream equipments and stack. During inspection, heavy attack of Sulfurous corrosion at the last bank of Economizer was noticed. It is thus suggested that the Economizer inlet water temperature should be raised by operating the Deaerator at high pressure so that feed water to Economizer can attain a temperature of 160-165°C as against present temperature of 100°C-110°C. This would prevent the Economizer last bank cold end corrosion and operation at higher inlet temp. in feed water would help to raise the exit flue gas temp. above dew point and the stack would be saved from Sulphurous corrosion. The Mild Steel stack should be checked for the thickness throughout the length and any defect should be repaired immediately before it collapses in running condition which would be dangerous.

Suggestions have been made to explore the possibilities of blending the furnace oil with at least 10% light diesel oil in burning. This would reduce the metal (Vanadium) content in oil and also would help in operating the boiler with less excess air. The blending may be done in fuel preparation area. Proper strainer for furnace oil should be used to eliminate dirt and sand particles. It is also advisable to raise the suction point of the oil pump from the tank. This would help to avoid carryover of sludge from the oil tank and would help in avoiding errosion of oil pump. Oil preheaters are suspected to consume heavy steam due to scaling. Descaling should be done and a temperature controller should be provided along with a pressure control at return oil line to maintain constant pressure at burner nozzle.

Good Instrumentation and Controls are provided for the Boilers but are suspected unreliable and out of control due to heavy carryover of moisture and rust alongwith Instrument air. There is no Instrument Air Dryer and entire air header is of Mild Steel. While air dryer should be installed immediately to protect the reliability of Controls and Instruments in the plant after complete flushing, a gradual change over of air header by galvanized iron pipe with a time bound programme is recommended.

3.1.3 There are two Turbo-Alternators, each of 5.25 MW capacity and of Back Pressure type are installed in the plant. There is also existing a parallel loop of pressure reducing cum desuperheating station (FRDS) to obtain low pressure process steam at 2.5 kg/cm2g at 185°C in emergency. The Power Turbine exhaust is connected with this loop of PRDS.

It was calculated that the plant requires only 4 MW of power. Accordingly, when 3 Boilers are in operation with a generation of 100-105 MT/HR, nearly 65 MT/HR of steam is being taken through the Reducing Station. If the plant could arrange for synchronize with National Power Grid with all protections to save guard the machine, approx 6 MW more power could be produced on co-generation concept and all the steam demand can be met without operation of pressure Reducing Station. The National Grid will get an extra 6 MW power.

It is also sure that the plant steam requirements have increased substantially, in the tune of 45 MT/HR to 50 MT/HR. A plant of this size with power requirement of 4 MW should not use more than 40-45 MT/HR. The increase of steam gradually is due to scaling of tubes in the heat exchangers and as described fully for AL-GAB plant observation under 2.1.3 and 2.1.4. It is thus suggested that after installation of Water Treatment plant and after proper descaling of the heat exchangers and coolers, both internally and externally, the plant must account for steam generation and consumption properly. It will reveal that pressure reducing station doesn't require to operate. This is a major factor for obtaining efficiency.

The Power Turbines are not at all equipped with any supervisory instruments and safety monitors. The inadequacies are the same as mentioned in 2.1.8 - paragraph one.

It is to mention here that while purchasing such high speed power Turbines, no proper scrutinization was made for equipment, metallurgy or associated Instrumentation. It was supplied as a Package unit and no respect was given by the supplier for proper Instrumentation to acknowledge either the efficiency and performances or to monitor and supervise the health of the equipment in normal running. Accordingly, no predictive maintenance is carried out except, only, the breakdown maintenance.

3.2 Lime Kiln

The calcined lime is prepared at this unit with high Sulfur oil firing system. CO_2 gas concentration is low at 26-28% with 5% Carbon Monoxide and 3% Oxygen. Outlet CO_2 gas temperature is maintained at 220°C. Carbon monoxide at 5% indicates that the sizing of limestone is improper. Bottom air for cooling is provided but Primary Air at Burner is inadequate. Top temperature of gas is too high and should not be more than 150°C. Sizing of stone should be smaller than in coke burning system. Without Desulferization oil firing system in the kiln for calcination is not advisable as this deteriorates the lime quality.

The Analyser Recorder for CO_2 gas at outlet from kiln is not provided. Present analysis by Laboratory method at Carbonation end is misleading. The concentration at kiln exit would give the performance of kiln operation. The analysis at the consuming end would give indication of any dilution by air infiltration due to leakages between kiln exit and compressors.

Instrumentation for Burner Controls for Combustion Monitoring and zone temperatures according to temperature profile not provided. The system is manual operation without any guidances.

3.3 Instrumentation and Controls

3.3.1 The plant is equipped with semi automation system through pneumatic control loops. The basic concept of Instrumentation is lost here as the owner and supplier didn't consider the process lag and measurement lags, inherent in Sugar plant due to long distances between Primary sensing devices in the field, control room and final control element in the field. Accordingly, judicious system could have been introduced through Electronic measurement and control of process variables and final actuation of control element by pneumatic through Electro Pneumatic valve positioners or Field Converters.

3.3.2 Neither the Instrument suppliers, nor the system designers of Pneumatic Instrumentation have guided the client for quality of Instrument Air required to operate the Modular type, plug-in Pneumatic Control Systems. Accordingly, there is no Instrument Air Dryer to supply dry air for Instrumentation system. The damages occured for this shortcomings could be assessed by observing internals of Instruments and Controllers. Performance and reliabilities could not be assessed as the plant was not in opertion. Similarly, the air header is laid by black Mild Steel, which is against any good pneumatic Instrumentation practice. Galvanized iron or brass piping is only recommended.

3.3.3 No concept of °Be control, ORP control, % concentration control and viscosity control have ben adopted. Purging type level measurement has been adopted with water purging which is detrimental for process. Volumetric sealed level transmitters are recommended for such applications. The range selection and choices of instruments show that the supplier only intended to sell instruments having no knowledge in system engineering.

3.3.4 The scope of Instrumentation for better operation with efficiencies have not been explored in Evaporation, Filtration and Vacuum pan areas. These are the areas where judicious Instrumentation would also help in Energy Conservation, Control Systems, which are provided do not serve the purpose. Feed forward anticipatory controls and cascade controls cold help further in these areas for effective operation.

3.3.5 On-line Analytical Instruments for Carbonation have not been considered. Milk of Lime flow controls is an open-loop control without the anticipation of variable parameters. Similarly, CO2 gas control is not provided. Oxidation-reduction potential of the 1st Carbonation outlet should control the CO2 gas flow. Milk of Lime addition in the second Carbonation also should be through ORP loop too from outlet. This system would bring an equilibrium between first and second Carbonation stage. A recirculation between first and second Carbonation on a fixed controlled quantity would help in maintaining this balance further.

3.3.6 *Flow measurements at all major consuming ends in the process and in the utility areas should be provided. For monitoring thermal efficiencies of process and equipments, mass flow measurement through pressure and temperature corrections are recommended.*

3.3.7 *Turbines are to be provided with the minimum supervisory instruments like vibration monitors at Turbine, Gear box and Generator ends. Similarly, control oil and Lube oil pressure should be recorded and bearing temperature should be continuously monitored. There is no oil centrifuge installed for centrifuging the oil.*

Axial displacement monitor alert and danger is highly recommended for back pressure type Turbine with interlock for tripping the Turbine in danger limit.

3.3.8 *Proper training for Instrumentation Engineers are required and they should be trained in the country with experts and in running plant. The training would be with theoretical background first and then on job training. It was observed that existing Instrumentation staff is inadequately trained in the subject, both by theory and by practice.*

4. *Observations and analysis of various problems at HOMS Sugar Plant and associated Complexes.*

4.1 *Boiler and Power Plant including Water Treatment Plants.*

HOMS Sugar Complex is one of the oldest Sugar factories in the country along with an Yeast Plant, Industrial Alcohol Plant and a cotton seed oil extraction plant.

This factory, like other plants has its own steam generating and associated power generating station.

4.1.1 *The unit has a battery of oil fired Boilers, totalling six numbers of various types and capacities. Oldest three Boilers are conventional water-wall, water-tube type having each of 7.0-8.0 MT/HR at a pressure of 28.0 bar and at steam outlet temperature of 380°C. These Boilers do not have any Deaerator and efficiencies vary between 65%-68%. The fourth Boiler is also of same type except that the capacity of generation is 25.0 MT/HR while the fifth one was added to obtain a generation at 35.0 MT/HR. The sixth one is a new Package type with semi-automatic controls system, having generation capacity at 40-44 MT/HR. This Boiler* has an independent Deaerator and attains for a thermal efficiencies at 92-94%. The Boiler is equipped with soot blowers for Economizer and superheaters.

The operation of the Boilers are well within the accepted limit but the concept of flame propagation, their effects in combustion and injuries thereby in the convection and radiant zones, are not at all known to the staff members. Burner nozzle checking and procedure and adjustments of steam-oil differential is not known to the operators.

The new Boiler is provided with automatic superheater temperature control to maintain at 380°C but the old other five Boiler don't have have auto controls of temperatures and manual operation is done. Thus ther is a wide variation in steam temperature from 350°C-380°C.

4.1.2 The Power Plant has three Turbo Generators out of which two numbers are very old, single stage, back pressure type (not controlled) while the third unit with 1.5 MW and controlled back pressure at 2.5 bar at 150°C is comparatively new. The first two units are having a capacity to generate 0.640 MW each. None of the Turbines, including new one have any protection or supervisory instruments.

4.1.3 The problems of treated water quality, both for steam generation and for cooling and process water are the same like other units as mentioned in 2.1.7 and 3.1.1. The water analysis for Boiler feed shows high content of CaO upto 5%, Sodium salts upto 36.0%, SiO_2 at 0.2%, Chloride at 24.0%, Phosphate at 20% and sometimes Sulphur at as high as 25.0%. This quality of water cannot be accepted as Boiler feed water and unsuitable even in process use.

Due to above reasons, even though the process steam demand has not increased substantially due to any addition in capacities but excessive scalings in Boiler tubes and heat exchangers have resulted in high steam consumption and called for addition of boilers to meet the demand without tackling the root cause.

A full proof adequate capacity Water Treatment Plant was required first. They could also consider the installing of Deaerators for old 5 Boilers where more efficiencies could have been achieved and fuel could be saved.

Good quality of water through water treatment facility with a capacity of 60 M3/HR would be able to meet the steam demand and this good polished water can be used for filters where quantity can be reduced with the good quality and would help in subsequent process operation to use less steam viz. Evaporators. The colossal loss of energy due to exchanger tubes scaling could be avoided.

Approx. 12-15% generation of steam is affected in old 5 Boilers, operating without Deaerator. An introduction of Deaerator, high ppm of dissolved oxygen in feed water would be eliminated and corrosion of generating and superheater tubes internally would be avoided. Moreover, higher inlet temperature of Boiler feed water after Deaerator at 130-140°C would help to increase flue gas temperature after Economizers which, in turn, would give higher temperature of combustion air coming through air preheater. This will help for better combustion and avoid the cold end corrosion of air preheater. An all round benefit could be achieved by introducing Deaerators immediately.

4.1.4 Turbo Generators are in extremely bad shape. Excessive vibration was observed in operation but no precaution was taken to take stopage of this and run the standby 1.5 MW new Turboset to meet the demand of Power. This set is equipped with automatic control of Back pressure which would be further helpful. The operation practice is not at all guided with concept. The plant is running with old sets with dangerous vibration level. On enquiry, it was revealed that after the repair of damaged bladings in turbine, no dynamic balancing was carried out for the rotors. It can be concluded that no Rational Engineering practices are followed in Power Plant operation. Pressure reducing station and Desuperheater unit is fully on manual operation. We could explain the effect of such operation if there would have been supervisory trend monitoring instruments or recorders.

4.1.5 *Unlike other plants where two ranges of steam pressures are required, this plant requires a third range at 8.0 kg/cm2g for cotton seed oil extraction unit. This demand is met through the Reducing Station.*

When the new 1.5 MW Turboset was specified, it could accommodate this pressure as a pass out from the Turbine along with controlled extraction. In that case, loss of power through a Reducing Station could be avoided. The new Turbine also is not at all equipped with any instruments. Steam consumption at 15 MT/HR for each MW is too high according to the operating conditions.

It is also suggested that the termination of steam header at the consuming end should be done in a practical manner to avoid losses. Ring main distribution system should be adopted.

It is also recommended to replace the existing old Turbosets which are operating inefficiently, and a new, reputed, well designed and adequately instrumented Turbo Generator of 3.0 MW capacity with controlled extraction at 2.5 kg/cm2g and 150°C temperature and pass out (with or without control) at 8.0 kg/cm2g at temperature 180°C should be installed. This may also be specified with automatic condensing to maintain steam-power balance of the plant. The set must be specified for sequential logic control for start up and loading and should be equipped with latest Instrumentation for supervisory and protection of the Lube oil and control oil console with provision of adequate filtering and the unit must have centrifuge for oil filtration frequently. At present, due to non-existence of centrifuge and provision of filtering the oil at regular intervals, the governor's function is very sluggish.

4.1.6 *Instrumentation and Controls are not at all existing in the plant for processing Sugar, cotton seed oil or in Alcohol distillation plant. Some instruments are introduced in yeast plant and they are of pneumatic type and operative. The range selections are improper. Proper specifications with improved version for a reliable performances was not considered for the instruments in Yeast Plant.*

The Instrument air dryer system is operative and designed with proper automatic regenerative system with good quality of instrument air available for the Yeast plant controls.

The plant should now consider to introduce Instrumentation in Sugar Processing and in Alcohol Distillation units for increasing productivity and Energy Conservation with actual consideration for rationalisation.

4.1.7 The observation and analysis for high fuel consumption in kiln operation is same as mentioned in 2.2.1 to 2.2.7 for AL-GAB Sugar Plant.

5 Observation and analysis of problems at Damascus Yeast factory.

5.1 The unit, though quite old but maintained in a better way. International Dairy Federation (I.D.F.) standard has been followed for layout, fittings and metallurgy in the process and equipments.

Some observations were made which when analysed after discussion with plant people, were found advantageous if implemented for better productivity and efficiencies.

5.1.1 Sulfuric Acid is added in molasses preparation tank manually to maintain a pH value of 6.5 to 7.0. This is due to bring down the brix value at 40 from incoming molasses at 80.

5.1.2 Live direct steam at 3.5 kg/cm2g and temp. at 110°C is put in the tank.

5.1.3 The operation is a batch process.

5.1.4 After the molasses preparation the batch is then taken to mixing tank after due reaction in pipeline reactor to bring the temperature of the batch at 90°C-110°C.

5.1.5 Ammonia is added and 12 hour retention of the batch. Alcohol is added at this stage.

5.1.6 The Batch is taken to Fermentation Tank.

5.2 Analysis and Shortcomings.

5.2.1 A flow control for precise acid control in molasses preparation tank will help to maintain a precise pH limit. Sulfuric acid thus to be controlled through pH.

5.2.2 Continuous Refractometer for acknowledging Brix value at outlet of preparation tank would help in operation.

5.2.3 Direct steam injection at Saturation temperature is not proper and would consume more steam and dilution would occur. Superheated steam at this stage would be advantageous due to higher enthalpy. This would further help in consuming less steam in pipeline exchanger.

5.2.4 Continuous monitoring of CO2 at the exit of Fermentation Tank with control of air would help in judicious use of air for fermentation. This would increase yield and avoid loss of Alcohol.

5.2.4 Air Dryer unit is recommended for fermentation air.

6. Special highlights on problems affecting high energy consumption and recommendations for various measures for improvements.

6.1 RAW MATERIAL PREPARATION

6.1.1 High silica content in the Beet is due to loading by shovels. High breakages rate of the slicer blades are due to improper meshed screens. A vibrating screen with magnetic separator is suggested before the raw material is fed in the screw conveyor. Use of pressurized water at the washing machine stone box would help to eliminate Silica and other similar abbrasive particles.

6.1.2 PULP PRESSING

Modern presses have hydraulic controlled system to give effective pressure on the basis of thickness or loading in the press. Two stage pressing is advantageous and is recommended.

6.1.3 DIFFUSERS

Level control system for the juice tank by sealed volumetric level transmitter, preferably Electronic controls are recommended. The level measurement should be continuously corrected with the juice concentration measurement for actual level. The concentration monitor would help to acknowledge the operation of presses.

Proper slicing in the Diffuser is most important and this should be consistent. Irregular sizing would affect badly the draft in the Diffuser and Sugar loss can be attributed. A draft controller can be introduced for Energy saving and reduction/elimination of loss of Sugar in pulp.

6.1.4 JUICE PURIFICATION

The existing equipment, methods of operation and control of preliming, effective liming and Carbonation were found as the main restricting factors. The following points are to be checked during operation as these could not be checked and established now, due to stoppage of campaigning.

6.1.4.2 TEMPERATURE MONITORING AND CONTROL

This is to be introduced with proper range selection, specification and in considera'ion with the time lag. Derivative control system should be used.

6.1.4.3 LIME CONTROL AND CARBON-DIOXIDE FLOW CONTROL

Milk of Lime should be controlled with a flow controller on the basis of titre of Milk of Lime and also on the basis of oxidation-reduction potential (ORP) measurement of the outlet juice from first Carbonation Tower. The Primary element of both Milk of Lime flow measurement and ORP measurement should be of reliable make and must have ultrasonic clearners for continuous cleaning of solids deposition on electrodes.

Carbon Dioxide flow should be controlled on the basis of decomposition of Calcium Saccharate. On-line monitor for % Saccharometer by Refraction is recommended to introduce for controlling the CO2 gas flow.

It is to be remembered that judicious control of Milk of lime would reduce the sluge produced and thus would help to reduce the loadings in the thickener and filters. Subsequently, yield would increase in this stage of operation.

Milk of Lime flow also to be controlled again in the second Carbonation in the same way as first Carbonation. The control valves for this service should be of Vee-Notch Ball type for obtaining control characteristic with minimum pressure drop across it. Saunder's type diaphragm valve is not good for this service which was observed at TAL-SALHAB unit. Carbon Dioxide flow also to be controlled.

There should be a recirculation between first and second Carbonation stage through a flow controller at fixed determined value. The consumption of lime, formation of sludge can be reduced by this way with higher yield through controls. This is highly recommended.

6.1.4.4 SULFONATION PROCESS

This process is not practised in any of the visited plants.

The filtrate of Carbonation Process contains a large concentration of Calcium Ions which are removed in this process by *introducing Sulfur Dioxide. This process not only remove the Calcium Ions but serves the bleaching of the solution of its pale yellow colour.*

Removal of Calcium Sulfite precipitation must be removed after Sulfonation process and the brightness of the juice can be analysed through brightness tester. These parameters can be used for controlling the flow of Sulfur Dioxide.

This is highly recommended for quality of the juice.

6.1.4.5 *EVAPORATION, CENTRIFUGES AND DRYING*

The purified juice from Carbonation and Sulfonation process is concentrated from 10-12% Sugar to about 60% Sugar in multiple effect Evaporator.

This is the process where maximum energy is consumed and judicious introduction of control instruments with proper operation methods can save energy.

The Instrumentation and Controls for the body calendrias are important. The calendria condensate level must be controlled for effective heat utilization. Similarly, the steam flow i.e. heat input should be controlled by the juice outlet temperature from the calendria. Mass steam flow should be acknowledged in the first body calendria along with pressure and temperature compensation. The steam quality must be maintained for effective heat transfer and overheating of the juice at this point must be avoided. Temperature control system would help.

(In one unit, at TAL-SALHAB it was observed that the calendria tubes got excessive internal scaling due to overheating of juice and Carbon deposition).

The overheating thus forms internal scaling and heat transfer gets affected, causing more steam demand. Temperature control and steam flow trend would help in steam conservation and analytical view of any abnormality.

The Demisters of the Evaporator bodies mut be provided with differential pressure indicators for continuous monitoring and also arrangements should be made for blow back with steam, occasionally, interlocked through the differential pressure switch at pre-determined value. Major problem comes when the Demisters get partially blocked with fine chips and crystals, causing false *pressure in the bodies which affects the boiling. This also affects the vapour recoveries at the subsequent bodies resulting for a high consumption of steam and also improper concentration of the outgoing juice. The juice °Be concentration at the last body should be monitored on the basis of boiling point rise method.*

The concentrated juice is then taken into vacuum pans. It is suggested to use a flash tank before being taken into vacuum pans for graining. The flashing would help to release heat energy remaining in the juice at a faster rate helping in graining in the pans at less energy. The flash steam recovered here can be taken into Diffuser. The Demisters at Vacuum pans also should be provided with similar controls as in Evaporators.

The centrifuges must have variable speed drive. The vari-speed should be controlled on the basis of incoming juice concentration or on the basis of loading in the centrifuge. Proper range selection is very important for giving the input signal to vari-speed unit. Present system is very crude and should be modified.

Dryer Granulator unit should have proper tmp. control. It was noticed that scaling of outlet duct and char formation at the outlet is due to improper control of heat input in Dryer unit. Proper insulation may be given at the outlet spout to avoid scaling.

Fluidic Bed Dryers are widely used for Sugar drying and this concept may be adopted.

Similarly, membrane filters are used in many places for higher efficiencies and recoveries than conventional press filters. These also may be considered.

6.1.4.6 With all suggestions, recommendations and measures, as mentioned, there will be no doubt that the Sugar industries would achieve a benefit by way of high energy savings, anticipatory acknowledgements of process and equipment problems, savings in downtime and self-sufficiencies in steam and power.

Main approach should be for high consistent production and higher yield with less energy consumption.

Above recommendations are focused in the same direction.

7. CONCLUSION

From the experiences gained during observations of several Sugar plants and Yeast manufacturing plants, and, after discussions with various personnel in the plant and in the General Organization for Sugar, it can be concluded that no serious positive thought for any improvement and modernizations for the plants have been considered.

The analytical approaches for finding out the root causes for high steam consumptions and the damaging of equipments thereby due to poor quality of water, have never been assessed at any technical or operating level.

No determined effort was made to engage proper Instrumentation Consultant for Design, Engineering, specification, selection of vendors and to undertake full guaranteed responsibilities for supervision of installation, calibration and commissioning with guaranteed test run. On the contrary, these responsibilities were left to Plant/Equipment suppliers who have not provided proper instruments and controls for maximising their profitability. There were none from the organization for Sugar to execute the project with them. If there would have any, insufficient or no knowledge in the subject have restricted them to get the best.

A turn-key concept has always been adopted and no specification was made first by the client for supplier to offer. The offer of the Supplier has also not been scrutinized fully due to inadequacy of technical informations. The latest development in technologies are also not known to them. Conservative approaches also have aggravated further. Modernization should be undertaken according to the pace of time. Revamping should be done in phases which is economical.

A training programme must be undertaken under the expertise of UNIDO and experts from various branches of Engineering with adequate plant experiences and inhand working knowledge with sufficient background in Analytical approaches of process operation, trouble-shooting and maintenance of equipments and machineries including Instrumentation and Controls should be inducted for rendering training to the identified plant personnel when the plant is under campaigning i.e. during the crushing season of Beet for manufacturing Sugar. The identified personnel should be at senior level and the experts should conduct training for them only for a short period and afterwards a training programme should be made in consultation with the expert to conduct training for the middle and junior level people by the plant senior people themselves in a programmed manner.

During the study tour at various plants, it was observed that the plant people are not with adequate training and experiences and not exposed in analytical approaches both for operation and maintenance.

It is also suggested that the Instrumentation and Controls scheme should be undertaken for one plant properly during the campaigning operation through UNIDO and this scheme should be implemented under the strict vigilance/guidances under the experts assigned by the UNIDO. His responsibilities would cover till successful commissioning of the instruments including training of the personnel at site. Once this is done, it is suggested that General Organization for Sugar should undertake similar design basis for their other units.

On the basis of this report and the suggestions, the following phase-wise actions should be undertaken immediately:

1. Water Treatment facility to produce Demineralised Water with zero hardness should be undertaken immediately for the plants. Analysis of Feed water should be: Ca-0.40 ppm, Mg-NIL, Chloride-5.0 ppm, SO4-NIL, CaCO3-10 ppm, SiO2-0.02 ppm, pH-8.5-9.0.
2. No condensate from the plant should go to the Boiler feed water system without its polishing through D.M. unit.
3. Lime Kiln operation should be improved immediately with properly specified coke where coke is used as a fuel so that higher concentration of CO2 is available with high grade of lime. This would save fuel consumption and would improve the quality of Milk of Lime. The consumption

of CO_2 in Carbonation system will be reduced due to higher concentration.

Where fuel oil is used as a fuel for calcination of limestone, it is suggested that concentration of CO_2 can be improved by way of CO_2 absorption system but is expensive. The possibility of improving the gas concentration by proper sizing of limestone should be tried.

4. *Sulfonation process should be added in the process units and recycle of carbonation between first and second stage should be made.*
5. *Instrumentation and Controls scheme should be made properly to suit the Sugar plant operation, analysis of the product at various stages and also continuous monitoring of the condensates recoveries from process units to predict any problem in the heat exchanger or cooling system should be made available.*

If the suggestive methods which have been brief in this report be implemented in a programmed phase-wise manner, there is no doubt that the industry will come out from various problems for a better future.