**Opening Remarks at PSST Technical Workshop**

**“Utilizing Modern Energy Saving Techniques to Exploit By-Products and Economic Viability of Sugar Industry”**

**By**

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**Venue: on 28/5/16 at Hotel Movenpick, Karachi**

**Discussion Topics**

A: Procurement of high Sugar yield varietal cane

B: Utilizing Modern Energy Saving Techniques at Cane Preparation and Milling Station

C: Control Targets at Cane Preparation and Milling

D: Utilizing Modern Energy saving Techniques at Boiling and Pan Boiling and

Curing Station

E: Control Targets of 5 Bar and Exhaust Steam Application

F: Utilizing Modern Energy Saving Techniques at Steam Boiler Station

G: Control Targets at Steam Boiler Station

H: Sugar Cane Products and By Products  
I: Bagasse and Bagasse By-Products

J: Molasses and Molasses By Products

K: Molasses Distillation Products and By Products

L: Bio-Compost Preparation with Mud, Spent wash , Boiler Ash and Cane

Trash

M: Bio-Compost composition prepared with Mud and Distillery Spent wash

N: Future Challenges of Cane Sugar Industry

O: Fact Sheet about By Products of Cane

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**A: Procurement of High Sugar Yield Varietal Cane:**

1. SPF -234, CPF-237, CPF-246,US-633 and Thatta-10
2. High Sugar yield varities produce sugar up to 12.0 – 13 % and Molasses up to 3.5 -4.0 %
3. Controlling cut to crush time of varietal cane helps in reduction of undetermined losses

**B: Utilizing Modern Energy Saving Techniques at Cane Preparation and**

**Milling Station**

1. Auto Cane Feeding System
2. Fiberizer as Cane Preparatory Device
3. Ist Mill as Maxmill
4. Use of Lotus Roller as Top Roller for 1st, 2nd and Last Mills
5. Replacement of steam turbines with Electric Drives at Cane Preparation and Cane Milling

**C: Control Targets at Cane Preparation and Milling**

|  |  |  |
| --- | --- | --- |
| **Sr.No.** | **Description** | **Target** |
| i- | Open Cell of Prepared Cane | + 92.0 % |
| ii- | 1st Mill Extraction | + 75 % |
| iii- | Bagasse Moisture after 1st Mill | Equal or less than 55 % |
| iv- | Imbibition water Temperature | + 65 oC |
| v- | Last Mill Juice Brix | Less than 3.0 % |
| vi- | Bagasse Moisture after Last Mill | Equal or less than 50% |

**D: Utilizing Modern Energy saving Techniques at Boiling and Pan Boiling and**

**Curing Station**

1. Uses of High Quality Lime at Juice purification station
2. FFE at 1st and 2nd effect in Quintuple Evaporators
3. Continuous pan Boiling at A,B and C Massecuite stations
4. Sugar Drying with Boiling House Condensate or Heated Air with Boiler Flue Gases
5. Efficient Vapour Bleeding and heat recovery from 1st Evaporator Condensate
6. Primary Juice Heating with 1st Evaporator condensate and Last Evaporator Vapours
7. Secondary Juice heating with 2nd and 1st Vapours
8. Two step Juice Preheating with 1st Vapour and Exhaust Steam
9. Refine Pan Boiling with 1st Vapour
10. A,B and C Massecuite Boiling with 2nd Vapours
11. Liquor, Run Offs and Molasses heating, Massecuite pump heating and pan washing with 1st Vapours.

**E: Control Targets of 5 Bar and Exhaust Steam Application in Boiling House:**

|  |  |  |
| --- | --- | --- |
| **Sr.No.** | **Description** | **Target** |
| i- | Exhaust Steam application | Evaporators and Curing station |
| ii- | Cut off application of 5 Bar Steam to | Zero % |
| iii- | Exhaust Steam Utilization % Cane | Equal or less than 38 % |

**F: Utilizing Modern Energy Saving Techniques at Steam Boiler Station**

1. Application of VFD and Auto Control Systems at Boiler Station
2. Suspension Bagasse Combustion
3. Heat recovery from Flue gases before leaving to Atmosphere
4. No entry of fresh air or recycling of flue gases in combustion chamber
5. Maintain Zero hardness of Boiler Feed water

**G: Control Targets at Steam Boiler Station:**

|  |  |  |
| --- | --- | --- |
| **Sr.No.** | **Description** | **Target** |
| i- | Boiler Feed water Temperature | + 130 o C |
| ii- | Combustion and Bagasse Spreading air Temperature | + 150 o C |
| iii- | Bagasse Moisture before entering the Combustion Chamber | Less than 50 % |
| iv- | Combustion Chamber Draft Air Pressure | * 2- 4 mm of water column |
| v- | Flue Gasses Temperature leaving to Atmosphere | 130 to 150o C |
| vi- | O2 level in Flue Gases | 3 – 4 % |



**H: Sugar Cane Products and By Products**

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**I: Bagasse and Bagasse By-Products**



**J: Molasses and Molasses By Products**

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**K: Molasses Distillation Products and By Products**



**L: Bio-Compost Preparation with Mud, Spent wash , Boiler Ash and Cane Trash**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **M: Bio-Compost composition prepared with Mud and Distillery Spent wash** | | | | | | | |  |  |  |  |
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|  |  |  |  |  |  |  |  |  |  |  |  |
| Ingredient | Nitrogen | Phosphorus | Potasium | Calcium | Magnasium | Sulphate | Sodium | Chloride | Organic | Manganese | pH |
|  |  |  |  |  |  |  |  |  | Carbon |  |  |
| Mud | 1.0 - 1.5 | 1.4 - 4.0 | 0.5 - 2.0 | 3.2 - 12 | 1.0 - 2.0 | Not known | Not known | Not known | 32 - 40 | 0.01 -0.3 | 6.0 - 7.0 |
|  | ( %) | ( %) | ( %) | ( %) | ( %) |  |  |  | ( %) | ( %) |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Spent Wash | 1000 - 1200 | 400 | 1100 | 7500 - 8200 | 1500 - 2000 | 2100 - 2300 | 400 - 500 | 5800 - 7500 |  | 1500 - 2000 | 4.0 - 4.5 |
|  | ( mg/L) | ( mg/L) | ( mg/L) | ( mg/L) | ( mg/L) | ( mg/L) | ( mg/L) | ( mg/L) | - | ( mg/L) |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  | C:N |  |
| Bio-Compost | 1.27 | 1.61 | 1.42 | 4.3 - 5.0 | - | 0.1 - 0.2 | 0.5 - 0.7 | 0.01 - 0.0.02 | 15.98 | (1:10) | 7.0 - 8.0 |
| (Mud + S.W) | ( %) | ( %) | ( %) | ( %) |  | ( %) | ( %) | ( %) | ( %) | ( %) |  |
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| Source: Sarangi.et.al 2005 | | |  |  |  |  |  |  |  |  |  |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ingredient | Nitrogen | Phosphorus | Potasium | Calcium | Magnasium | Sulphate | Sodium | Chloride | Organic Carbon | Manganese | pH |
| Mud | 1.0 – 1.5  ( %) | 1.4 – 4.0  ( %) | 0.5 – 2.0  ( %) | 3.2 – 12  ( %) | 1.0– 2.0  ( %) | Not known | Not known | Not known | 32 – 40  ( %) | * 1. – 0.3   ( %) | 6.0 – 7.0  ( %) |
| Spent Wash | 1000 – 1200  ( mg/L) | 400  ( mg/L) | 1100  ( mg/L) | 7500 – 8200  ( mg/L) | 1500 – 2000  ( mg/L) | 2100 – 2300  ( mg/L) | 400 – 500  ( mg/L) | 5800 – 7500  ( mg/L) | - | 1500 – 2000  ( mg/L) | 4.0 - 4.5  ( mg/L) |
| Bio-Compost  (Mud + S.W) | 1.27  ( %) | 1.61  ( %) | 1.42  ( %) | 4.3 - 5.0  ( %) | - | 0.1 - 0.2  ( %) | 0.5 - 0.7  ( %) | 0.01 - 0.0.02  ( %) | 15.98  ( %) | C:N  (1:10)  ( %) | 7.0 - 8.0 |

**N: Future Challenges of Sugar Cane Industry**

1. Heat Recovery from Continuous Pans Vapours before Condensation
2. Process designing to produce Sugar equitable to double refined Sugar without re-melting ( may be with two stage Syrup phosphitation )
3. Utilization of free space of Factory buildings top roof area for recovery of Solar Energy( Solar plate of size 1480 x680x40 mm would generate 150 watt/9.83A under working temperature of 48+/- 2)
4. Basic research and feasibility study for exploring areas for beet plantation for sugar manufacturing with alternative fuel/bagasse saved during cane sugar manufacturing periods

**O: Fact Sheet for by Products of Sugar Cane**

( Most of literature of under given write up is derived from “ Alternative Uses of Sugarcane and its Byproducts in Agro industries” by J.M Paturau and “Compost from Sugar Mill press mud and distillery spent wash” , Sarangl *et al* 2005)

By Products of cane can be more than 150, out of which 38 end products , under normal circumstances, are of economic interest others under present technological and marketing conditions would have negligible economic interest. Brief about of more common is as below:

**Bagasse:** AS an average bagasse production remained 30% of Mill crushed cane. Normal bagasse consists of 50% moisture, 48% Fibre(including ash) and 2.0 soluble solids. The Fibre consists of 27 % cellulose, 30% pentosans, 20% lignin. The calculated Net Calorific Value(NCV) of bagasse having 50% moisture is 7588Kj/Kg, which is generally equivalent to 0.173 tons Fuel Oil( 1 : 5.78) and 0.263 Tons Bituminous Coal (1 : 3.8) . One ton of Bagasse with high pressure steam generation and power production technology can generate 450 Kwhr electricity.

**Particle Board:** It is made with bone dry bagasse and synthetic resin but it has to complete with plywood and fibre board. Due to its limited thickness of about 15 mm, Its market is limited to inner house partitions and furniture.

**Paper:** Good quality wrapping and magazine paper cane be produced with high percentage of depithed bagasse as raw material. It required fair quantity of industrial water with necessity to handle polluting effluents. So technically the production of newsprint from bagasse has proven difficult and uneconomic. It may be come feasible within next 10 years under new technology where fair percentage of waste paper is mixed with bagasse.

**Paper Pulp:** The Kraft cooking process is used for production of bagasse pulp using sodium sulphate. One tone bone dry depithed bagasse cane produce 480 kg final bleached slush pulp. Water requirement is 200 m3 per one ton pulp.

***General Note:*** The production of pulp and paper from bagasse is not advisable as main use of by products. Under normal conditions, production of particle board and electricity generation from bagasse is relatively simpler and more economical.

**Furfural ( C5H4O2)**: it is colour less, inflammable, volatile, aromatic liquor. It produced from numbers of plant material containing pentosans ( 90% xylan) . With acid hydrolysis the xylan yields xylose which subsequently losses 3 water molecule to form furfural as described in simple equation:

C5H8O4 + H2O ------C5H10O5 ------------C5H4O2 + 3H2O

In practical about 25 tons of mill-run bagasse is required to produce 1 ton of furfural and 35 tons of steam is required to produce one ton of furfural . The main market of furfural as selective solvent is for refining of lubricating oil. It yields furfuryle alcohol on hydrogenation which can produce heat stable and corrosion resistant resins.

**Methane(CH4) and Carbon dioxide (CO2)**: These are main gaseous products of the anaerobic methane fermentation of waste cellulosic material. Theoretically 1 Kg of cellulose would produce 415 litres of Methane. The bagasse fibre contains 27 % cellulose. The cellulose is easily digested by bacteria but when combined with lignin as in case of bagasse fibre(20%) is degraded with great difficulty. So use of distillery stillage digestion for production of methane and CO2 is more easier and proven and economical technology for sugar industry.

**Mud**: The precipitated impurities contained in cane juice, separated by coagulation in Clarifier and removed after bagasse pith mix through Vacuum Filter operation. Roughly it is consider as 3.0% of Milled cane by weight and contains as an average 70% moisture, fibre, ash and 2.0 - 3.0 % Sugar . On dry basis it contain about 1 % by weight of Phosphate(P2O5) and about 1% of Nitrogen. The one ton mud of carbonation-sulphitation process contains 15kg N,36 Kg P, 14 Kg K and 23 kg S (Tandon 92). It is used as fertilizer and unfortunately also as fuel in soil brick making plant. The filter mud also contains a mixture of way and fatty lipids in a ratio of 5:2 and refined wax also be extracted by appropriate treatment by solvent extraction process. Only 386 kg refined wax can be obtain from mud of 1000 tons of Milled cane.

**Molasses**: Molasses is final effluent obtained in the preparation of Sugar by repeated crystallization operations. It is residual syrup from which on crystalline Sucrose can not be obtained by simple means.

Its percentage by weight varies from 3.5 to 5.0 % Milled cane. The composition varies with fair limits, but on average it contains: Water 15 %, Sucrose 30%, Fructose 9 %, Glucose 7%, other Carbohydrates 4 %, other Reducing sugars 3 , Nitrogenous compounds 4.5 % , Non Nitrogenous acids 5 %, Ash 12 % and others 10-12 %. A very large number of products can be derived from molasses. Main is animal feed and raw material for alcoholic products.

**Rum**: Rum is a public drinking Liquor, an alcoholic distillate obtained from fermentation of cane juice, syrup or molasses. It is produced at 76OGl and diluted with water and sold to public at 33 to 40OGL. One ton of molasses would produce about 230 litres of Rum (basis 100OGL).

**Ethyle alcohol/Ethanol (C2H5OH)**: In Sugar Plants on large scale Ethanol is produced from molasses sugar fermentation and distillation , so it can be produced from cane juice or with other raw stuff having any type of sugar in it. Fair quality of 1 ton cane molasses would produce about 240 litres of ethanol (basis 100OGL). Commercial ethanol is marketed at 96OGL where anhydrous which is used as car fuel mix at 99.8OGL.

**Acetic acid (CH3COOH)**: Acetic acid is a colourless liquor of sharp acidic taste. Acetic acid is produced from ethanol through carbonylation , where Co in presence of catalyst is blown through ethanol under certain conditions to from acetic acid. Acetic acid can directly be produced from juice with anaerobic bacteria-Acetobacter. The vinegar contains 4- 9 % acetic acid. Modern submerged fermentation process requires the thorough airing of the vinegar bacteria-Acetoacter . From 100 liters of absolute alcohol some 950 liters of vinegar with 10% acidity can be produced.

**Butanol-acetone( C4H9OH –CH3COCH3)** : These are fermentation products of molasses produced through fermentation process called as ABE Fermentation(Acetone-Butanol and Ethanol) as ethanol is also produce during distillation of fermented stream. The anaerobic fermentation process produce Butanol/Acetone/Ethanol in the ratio of 65:30:5, which then separated by distillation . 500 kg molasses would produce 65 kg butanol, 30 kg of acetone and 5 kg of ethanol .Main uses of acetone is being as solvent . Butanol is used as hydraulic fluid and fuel. It is less corrosive than ethanol and release no or very small quantity of SOX or NOx during combustion as it has 4 more H atoms than ethanol.

**Citric acid**: Citric acid is usually produced in the monohydrate form (C6H8O7H2O), The crystals of which are colourless and odurless with sour taste. The fermentation process consists of a complex aerobic cycle and beet molasses has had more success as main raw material than cane molasses. The addition of methanol appears beneficial when using cane molasses. The yield of citric acid is about 65 % of sugar consumed. citric acid is an industrial organic acid ,finding increasing uses in the food and beverage industries.

**Yeast**: Yeasts are complex, protein rich, living unicellular organisms that have been selected and isolated through research, and two strains are now mainly utilized, namely, Saccharomyces cerevisiae to produce baker’s yeast and Torula utilis to produce feed yeast. Yeast production requires very clean, pollution and infection free envoirnment and sterilized equipments to avoid mixing of any wild bacteria from out source.

The formation of yeast is described by following reaction of glucose with ammonia:

C6H12O6 +NH3 --------------------------- C6H7O3NH2 +3H2O

Practically yield of yeast is not more than 54 %.( including 8% ash)

Baker yeast is produced from molasses, grains or potatoes. Feed yeast usually utilizes brewer’s or distiller’s stillage. About 4 kg of molasses would be required to produce 1 kg of active dry baker’s yeast, the same quantity of molasses is required to produce 1 kg of feed yeast. In both processes about 15 m3 fine aeration per kg of dry yeast is required.

**Stillage Treatment**: One difficulty with ethanol manufacturing is the efficient handing of high quantity waste called vinasse, slops or stillage. 13 litres of slops are produced from every litre of ethanol. Slops has high TDS(mg/l) ranging from 73,000- 100,000, low pH ranging from 3.8 - 4.4 and high Chemical Oxygen Demand (COD) (mg/L) 80,000 – 120,000 and Biological Oxygen Demand (BOD) mg/L 45,000 - 60,000.

The recently developed Swedish process of Biostil, by Alfa Laval, reduced the weight of stillage by 60 %.

The two processes are utilized to treat this highly atmospheric pollution source either by evaporation plus incineration to recuperate the potash in stillage or anaerobic digestion ,to produce bio gas and CO2 of commercial use. Bio gas production becomes sufficient to fulfill the needs of steam and power of distillery plant. The waste of stillage is called spent wash which is rich in nitrogenous and phosphorus compounds and potash. It can be used for fertilizing agent if directly mixed with irrigation water in the ratio of 1:10 - 1:50 , and can be mixed with mud to prepare Bio compost. Bio Compost is made following about 16 steps process which completed in 12 week under certain open atmospheric conditions . Mud of 30 % moisture is mixed with spent wash @ 1kg/ton of mud in 10% aqueous solution. The moisture level is maintained at 50 % with spraying and mixing spent wash on the windows( mixer bed ). The refuse mass is aerotilled to control the window temperature at 70OC after each spray ,carried out in two to three splits a week. The ratio of C:N in composted mud is monitored to maintain at 1:10. The compost is prepared in 10 -12 week. The final compost has no odour . It contains 40% organic matters . To prepare 900 Kg compost general requirement of mud is 1 ton and 2.5 to 3 tons of spent wash.