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Design for Fabrication of Effective Seed Cane Hot Water Treatment Plant for Ethiopian Sugar Estates/Projects

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Abstract: Sugarcane is prone to infection by a large number of diseases that can impact significantly on productivity. Diseases caused by systemic pathogens (those that occur within the plant tissues) can introduce into a new crop by the planting of infected seed cane. So as to avoid such disease causing systemic organisms treatment of the seedcane is mandatory. The initial treatment of the seedcane often includes the routine application of thermotherapy to eliminate fungal and bacterial pathogens as well as pests. Especially for the control of smut, RSD and Albino (Mycoplasma) hot water treatment is preferable; because most of infections are killed at a temperature slightly lower than that lethal for sugarcane. Therefore, Hot water Treatment is an effective method for the elimination of pathogenic infections that are seed piece transmissible. Uniformity of temperature, proper circulation of water, Keeping 1: 4 and avoiding heavy packing of seed materials are the main requisites for successful treatment. Keeping the above facts in to consideration a rotary circular pattern treatment tanker and an automatically controlled heating tanker has been designed at Wonji/showa. The plant is designed to use both steam and electric power independently or simultaneously as a source of heat by making simple adjustment on the heating tanker. The treatment plant incorporates three successive tankers namely; 1. Water heating tanker on which the heating, limit switch and water circulating mechanisms are installed. 2. Seed cane treatment tanker on which water circulating, temperature control and avoiding heavy dumping mechanisms are installed. 3. Fungicide dipping tanker. The three tankers have been designed to plant with chronological order of the work flow and a bulk of planting material will be successfully treated by this system.

Keywords: Treatment, Effective, Pathogenic, Transmissible, Fungicide, Designed

1. Introduction

Sugarcane is prone to infection by a large number of diseases that can impact significantly on productivity, as in [1]. This is partly due to the nature of the crop and the manner in which it is propagated, cultivated and managed. In commercial practice sugarcane is propagated vegetatively, by planting pieces of stalk, termed setts or seed cane. The tillers that emerge from the axial buds on the planted stalk pieces develop into the new crop of stalks. Diseases caused by systemic pathogens (those that occur within the plant tissues) can therefore be readily introduced into a new crop by the planting of infected seed cane.

For this reason the control of diseases is a critically important aspect of the management of sugarcane and must largely be achieved through a policy of prevention. Because there are many hazardous diseases caused by systemic pathogens that are readily spread by the planting of infected seedcane, the procurement of healthy seedcane is a prerequisite for the successful production of sugarcane.

The initial treatment of the seedcane often includes the routine application of thermotherapy, such as hot water treatment (HWT), to eliminate fungal and bacterial pathogens as well as pests. Especially for the control of smut, Ratoon Stunting Disease (RSD) and Albino (Mycoplasma) disease of vegetatively propagated crop, sugarcane; because most of infections are killed at a temperature slightly lower than that lethal for sugarcane.

The treatment time and temperature is a compromise between the need to eliminate pests and pathogens without severely impacting on the subsequent germination of the treated seedcane. The standard treatment in most sugarcane industries is 2 h at 50 ^{0}C, which has been shown to achieve a high degree of elimination of the RSD pathogen L. xyli subsp xyli, as in [2]. HWT is usually followed by a fungicide dip to prevent infection of the treated seedcane by soil-borne diseases after planting, as in [3].

An important aspect of Hot water treatment plant design includes having a relatively high volume of water to seedcane (approximately 4:1) so that the water temperature does not decline substantially when each batch of seedcane is added. Also important is the need for accurate control of the water temperature, which is usually controlled by thermostats. The water in the tank must be efficiently circulated to avoid 'hot or cold spots' and the water must be replaced regularly; otherwise it soon becomes acidic and contaminated, with adverse effects on germination, as in [4].

In subjection of germination, an experiment has been conducted to know the status of germination of seed cane, at South Africa sugar Association experiment station, on three samples viz hot water treated cane, hot air treated cane and untreated whole stalks. The result indicates that hot water treated cane germinated first in most varieties [5].

The project is designed to use both steam and electric independently or simultaneously as a source of heat. Therefore, it can be implemented at any of the sugar factories, where steam heat is available, or any of sugar projects, where electric power is available, by making simple adjustments on the heating device. "Temperature control is critical, with temperatures over 50^{0}C adversely affecting germination, and temperatures below50^{0}C (< 49.8^{0}C) reducing the effectiveness of disease control", as in [6].

The economic analysis was done by considering the impact due to reduction of sugar cane yield loss by using effective Hot water treatment. As indicated with different researchers the cane yield loss due to infection of different pathogens, especially Smut and RSD are shown bellow: Smut yield losses from 12% –75% have been reported [7, 8]. In Ethiopia it causes 19.3 to 43% in sugar yield and 30 to 43% in cane yield [9]. Estimated yield loss of the commercially available cane varieties due to RSD with artificial inoculation of the pathogen at different concentration in the three Ethiopian sugar estates shown that 17.21 to 27.76% in cane yield and 19.14 to 27.83% in sugar yield [10].

Therefore, when this design realize and lays to the ground can eliminate the disease causing organisms and save the above mentioned sugar and cane losses.

The main objective of this paper is to design of effective seed cane hot water treatment plant for fabrication.

2. Methods and Materials

2.1. Description of the Study Area

Various designs and sizes of HWT plant are used in different industries. Ethiopian sugar estates have also their own HWT plants in different styles at Wonji, Metehara and Finccha sugar Factories. Even though, the treatment plants are constructed as per the standard criterion their output is not as such effective, because the treated seed canes are not cured of RSD and smut. The main reasons of this problem are lack of proper circulation of hot water between setts, lack of uniform temperature at the upper and bottom of the treatment tank and heavy packing of setts in the cages. As confirmed practically at the existing plants, the temperature of hot water at the upper and bottom in the treatment tankers are: At Wonji/shoa treatment plant 50^{0}c and 40^{0}c, at Metehara treatment plant 50^{0}c and 45^{0}c, and at Finccha treatment plant 50^{0}c and 47^{0}c.

In response to the above problems, this design suggests: to design for fabrication an effective hot water treatment plant in the nearby workshops and distribute to the existing and other newly established sugar estates. The designed project will enable to solve the problems (lack of proper circulation of hot water, heavy dumping of setts, bulk compactness of setts in the cage, improper temperature control and lack of temperature uniformity in the treating tank) seen in the existing seed cane hot water treatment plants which are the main causes for the failure of curing the seed cane to be treated.

2.2. Methodology

A basic understanding of the plant and the operations will be achieved through first hand observations on the site. Information will be gathered from primary data sources such as, interviews and direct observation on the site, and from secondary data sources like, books, journals, websites and etc.

In the meantime, both quantitative and qualitative data types will be collected from the existing hot water treatment plants and other written documents. The quantitative data includes size of the treatment tanker, size and number of cages, size of the heating tanker, size of disinfectant and cane cooling tank, etc where as the qualitative data includes type of temperature controller (sensor), tolerances for dimensional accuracy of each parts, type of materials used to fabricate each part, assembly methods such as welding, riveting, bolt and nut, etc. Having this information on hand, the drawbacks and best technologies of each existing hot water treatment plant was identified. Finally, a solution was set for the troubles seen in the existing hot water treatment plants and best technologies were adopted and incorporated in to the new design.

2.3. The Proposed Design of the Plant

The treatment plant incorporates three successive tankers namely water heating tanker, seed cane treatment tanker and fungicide dipping tanker. The three tankers were designed to plant with chronological order of the work flow.

2.3.1. Water Heating Tanker

The heating tanker is designed to fabricate from 2mm thick of mild steel sheet in a rectangular pattern of 3m x 3m x1.5m = 13.5m^3. Either resistors or 2.996m long perforated ½ inch pipes are installed for the path of heat distribution when the heat sources are electric power and steam respectively. The numbers of pipes are 10 and each has perforation throughout the entire surface of their length for the exit of the steam. The heating tanker should be cover with asbestos and laminated sheet externally to prevent heat dissipation to the surrounding. The tanker is put on a frame of equal height with the treatment tanker and a 50^0c hot water will circulate continually from the heating tanker to the treatment tanker and back to the heating tanker with the help of gravity and centrifugal pipe respectively. Tap water drainage pipe is linked with the tanker, which is weld carefully being leakage free. Limit switches are also fitted to this tanker so as to keep 50^0c temperature constantly by switching on and off the power sources. A full assembly drawing of the heating tanker is shown on fig.1 bellow.

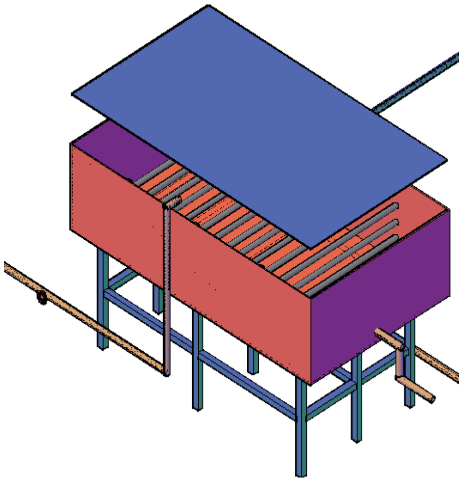

Fig. 1. *Assembly drawing of the new heating tank.*

2.3.2. Seed Cane Treatment Tanker

The main treatment tanker is designed to fabricate in circular profile with diameter 3 meters, height 1.5 meter ($10.6m^3$) and 4mm thick mild steel. The unit consists of a centrally fitted long (1.6 meter) shaft of 80mm diameter with double ball and trust bearings at the bottom and one ball bearing at the upper end. The tank accommodates six equal conical cages, supported by the sit frame attached to the shaft through the bearing house at both ends. An electrical motor is coupled with the shaft at the top of the tanker to agitate the water by rotating the cages and sustain the distribution of uniform hot water to each cane setts in each cages. Timer control switches are used to on and off the motor with an interval of 15 minutes.

The tanker has an inlet for the hot water at the top and outlet at the bottom. The inlet pipe is connected with a ½ inch circular pipe rolled around the main tanker externally possessing six nozzles facing downward at an angle of 20^0 into the tanker to spray hot water in the direction of each cage.

Two Thermostats (sensors) are also fitted to the body of the tanker, one at the upper side and the other at the lower side, to read the temperature inside the treatment tanker and transfer off and on order to the limit switch of the heating tanker when the temperature inside is above and below 50^0c respectively. Besides to this a temperature gauge is installed on the out let pipe before the pump and a manual check up with thermometer will be also carried out during treatment for additional confirmation. A full assembly drawing of the treatment tanker is shown on fig.2 bellow.

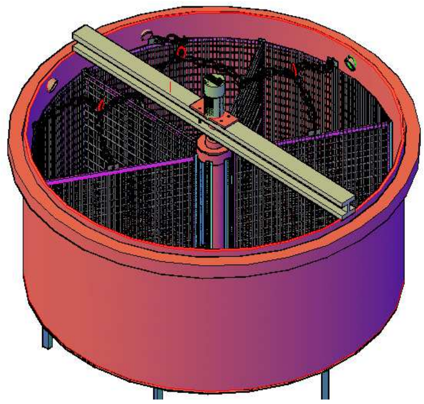

Fig. 2. *Assembly drawing of the new seed cane treating tank.*

2.3.3. Fungicide Dipping Tanker

In some instances a fungicide dip treatment is required after hot-water treatment to prevent re-infection with sugarcane smut during transport and germination. Hence, a rectangular shape of 2m x 2m x 1m = $4m^3$ fungicide dipping tanker is designed to manufacture from 2mm thick mild steel to dip the cane for 5 minutes in the fungicide. Fungicides applied through planting machines are not effective at controlling smut because a lower rate is used and the cane is not in contact with the fungicide for sufficient time for effective control of smut.

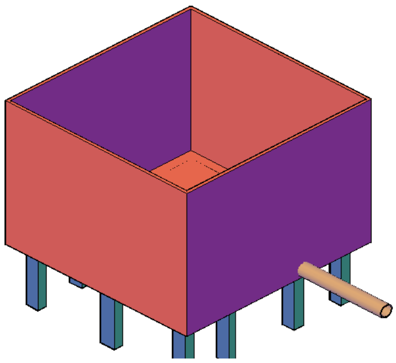

Fig. 3. *Assembly drawing of the new seed cane fungicide tanker.*

2.3.4. Seed Cane Cages

Six truncated triangular cage frames were made from L-structural steel (angle iron) and flat iron (at the top) with a curved shape from one side. On each frame round iron ø6mm were welded with an interval of 20mm in vertical pattern and 50mm apart in horizontal pattern, this helps to facilitate the removal of the water during unloading. The volume of each cage is approximately about $1m^3$ as shown on fig. 4.

The shape and size of the designed cage will avoid heavy dumping and compactness or allows loose dumping of setts during treatment, accelerates hot water circulation between each stalk, conducive to agitate the water and create uniform temperature throughout the treatment tanker. A cage placed in a cage sit frame is shown on fig.5.

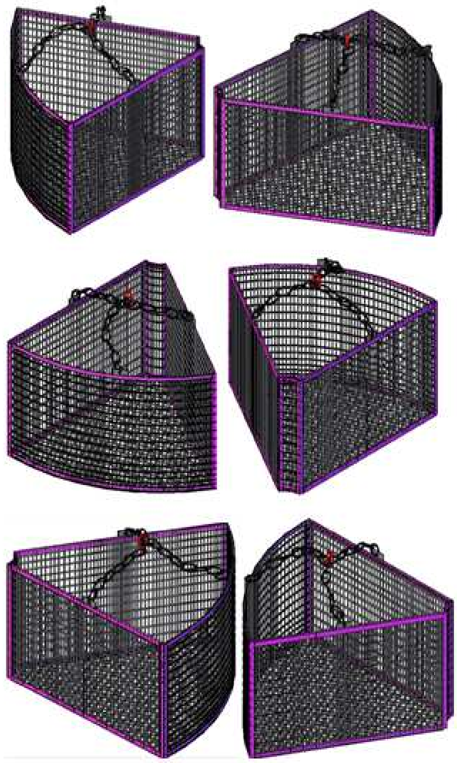

Fig. 4. Cages at different views.

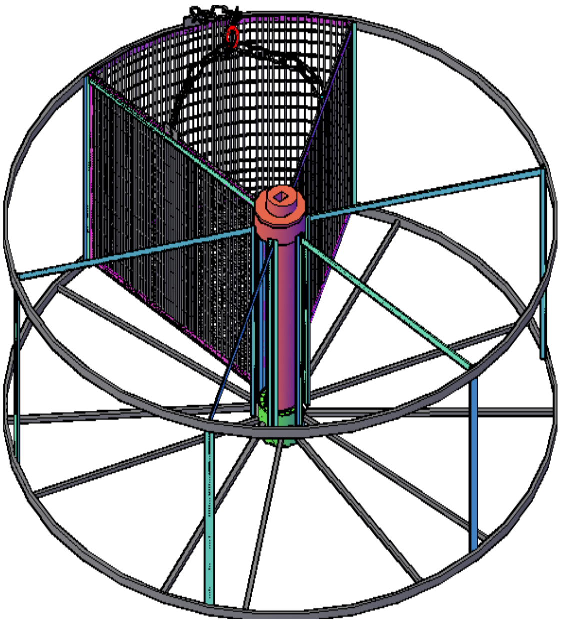

Fig. 5. A cage placed in a cage sit frame.

2.3.5. Loading and Un Loading Mechanism

An overhead gantry electrical driven crane is used to load and unload as well as to move right and left the cages containing seed cane. The gantry frame is made up of 160mm x300mm I- section structural steel and an electric driven hoist is fitted on it. This mechanism enables to accomplish the given task continuously with tireless for a long time. A full assembly drawing of the plant is shown on fig.6 bellow.

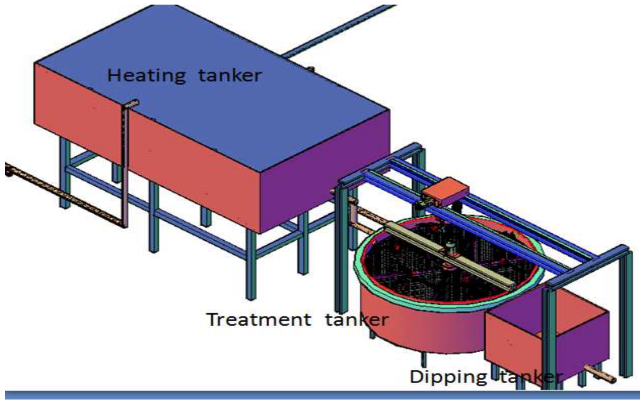

Fig. 6. Assembly drawing of the new seed cane hot water treatment plant.

3. Conclusion

This design is the result of comprehensive analysis of the existing seed cane treatment plants and detail Analysis of the critical parameters for effective hot water treatment. Even though the design is modified and somehow new, it is practical and realistic. Therefore, when this design lays on the ground and begin to serve, it will accomplish the following facts:

1. Temperature uniformity will keep by thermostats throughout the standard treatment time for 2 h at 50 ^{0}C.
2. Water to seedcane ratio (approximately 4:1) will maintain by filling water in both treatment and heating tankers.
3. The water in the tankers will circulate from heating tanker to treatment tanker and back to heating tanker by the installed circulating pipes and pumps.
4. Heavy dumping and high compactness of seedcane will resolve by the small size and shape irregularities of the cages.
5. Loading and unloading mechanism is fast and easy by using an overhead crane.

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