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Design and Analysis of Automated Scum Removal and Filtering System for Jaggary Plant

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Abstract

An automated scum removal machine is used to remove scum produced during the production of jaggery. Scum removal is done by a manual method in our country. This project aims to develop an automated scum removal machine. The Scum removal machine can be adopted in the medium and large-sized jaggery production industry. This machine makes the process simple, easy and fast. It eases human effort and no requirement for skilled workers to operate the machine. It consists of the base, stands, leads screw, horizontal arm, thrust servo motor (0.5hp), shaft collectors, pan and multilevel filtration system.The stand and lead screw is mounted on the base and the horizontal is attached to the screw through the stand. The horizontal arm carries a slow-speed AC servo motor and this AC servo motor runs the collector's through a vertical shaft. Upward and downward movement of the arm is controlled by a lead screw which is controlled by switches. A multi-level filtration system is placed under the pan. The scum that is collected in the collector is lifted by raising the arm. Hence, the pure form of juice can be obtained from the above process. There is no availability of an automated scum removal machine.

Keywords: *Scum removal, Jaggery.*

1.0 Introduction

Sugarcane is a tall perennial grass native to the warm and temperate climate of Asia. It is, however, to be found in other regions of the world including Brazil, India, Thailand, the United States of America, Mexico, Pakistan, Columbia, Australia, and Sudan, among other African countries. Brazil is the world's largest producer followed by India. Sugarcane grows as grass which has stout, jointed, fibrous stalks that are rich in sugar and measures two to six meters (six to nineteen feet) tall. All sugar cane species interbreed, and the major commercial cultivars are complex hybrids. The crop is grown on commercial farms for the production of sugar, jaggery and other sweetening compounds due to its high content of sucrose. Sugarcane is usually processed into sugar in various sugar factories in the region. These factories contract farmers to produce the cane and sell it to the factories, but due to bureaucracy and inefficiency, the process of harvesting and delivery to the factories is not appropriate hence leading to big losses to the farmers. The losses occur in the form of wastage in the farms due to harvest delays in the farms hence loss of quality and crop wastage when delivering to factories due to poor transport systems and delays before processing. The net result is that the factories can take the crop in time hence the need to look for alternative processors to avoid the losses incurred.

In earlier times, sugarcane cultivators utilized smashers controlled by bulls, however, all new smashers are power-driven. These smashers are normally set near the sugarcane fields. The cut and cleaned sugarcane is squashed and the juice separated is gathered in a giant vessel. A specific amount of the cane juice is placed into a compact vessel for boiling in a chamber. The vessel is warmed for about 60 minutes. The dried mash of the squashed sugarcane is utilized

Figure 1: Sugar can juice boiling Pan

as fuel for the chamber. During the boiling of cane juice, lime is included so that all the scum (wood particles) ascends to the highest point of the juice, which is skimmed off utilizing an automated scum removal machine. The juice is free from wood particles and is thickened. Finally, the volume of the thick cane juice is around 33% of the initial volume.

The automated scum removal machine is one of the most flexible machines, permitting the user to get rid of the scum developed throughout the jaggery production. This machine makes the removal easy, safe and economical. This machine doesn't involve any human efforts in removing the scum. This machine decreases the human risk involved. This machine helps the jaggery producers to get huge returns in a much faster time compared to the traditional technique. Jaggery is a natural, traditional sweetener made with a concentration of sugar cane juice. Jaggery making is one of the main agro-processing industries found in rural India which runs on small investments or by a group of farmers. In India, out of the 300 Mt (Megaton) of sugarcane produced 53% is processed into white sugar, 36% into Jaggery and 3% for chewing as a cane juice, and 8% as a seed cane.

2.0 Literature Review

PVK Jagannatha Rao et al. published a review article on "Technologies for Preparation of Solid and Granular Jaggery" in the Current Journal of Applied Science and Technology. (CJAST) in the year 2020. In this article, they are mainly concentrated on how to meet market demand and jaggery export and also provide high quality and hygiene jaggery within a short period of production. In this paper,they discussed the various up gradation techniques of jaggery preparation and also automation and advanced in jaggery making process. By taking into account changes to the furnace's design, the pace at which bags are consumed, and the rate at which heat is transferred from hot flue gases, they are enhancing plant efficiency. They have created and implemented 2, 3, and 4 pan methods, as well as advanced methods like vacuum pan evaporator methods and semi-automated methods like steam boiling methods. They also use fins, baffles, energy boosters, economizers, juice preheaters, and heat pump-based freeze concentration systems. [1].

In 2017, an article by Lava Chikkappaiah and colleagues titled "Preparation of plant Mucilage Clarificants and their Effect on Jaggery Processing of Sugarcane Variety of Co 86032" was published in the *International Journal of Pharmacy and Pharmaceutical Sciences*. Five plants including Aloe vera, flax seeds, fenugreek, purslane, and Malabar spinach, were tested in this study at three different concentrations of raw sugarcane juice: 0.1 per cent, 0.2 per cent, and 0.4 per cent. The processing parameters, including the amount of scum removed, the total processing time, and the yield of jaggery, were determined during manufacturing. They learn from these testing that Aloe vera at 0.4 per cent eliminated the most scum (4.07 per cent), required the least amount of processing time (72.33 minutes), and produced the most jaggery (10.92 kg). The submission [2].

Small scale automatic jaggery production (AJP) system is the result of experimental work by Ravi Hosamani and Dr Satish R. Desai. The primary goal of this project is to create an automation system that will raise production rate, and product quality, and handle labour issues in the factory. They created a recommended approach to regulate and keep track of the production processes for jaggery products. The autonomous jaggery production system's primary control panel is a microcontroller (ATMEL). Which read the sensors (LM35) to measure the physical quantity temperature of the boiling sugarcane juice to monitor the temperature to get good quality molten jaggery. The movement of the pan is controlled by DC motor and switches through the programming of the microcontroller, along with the opening of the control valve for the easy flow of molten jaggery (pug) into the cooling pit to get the required shape of jaggery to reduce the labour work [3].

3.0 Objectives

1. To remove the scum particles automatically, which are formed on the top layer of the sugarcane juice during the production of jaggery.
2. To achieve the filtration up to 50 microns by introducing a multilevel filtration system.
3. To obtain the purest form of jaggery by eliminating the mixing of chemicals which is currently following in conventional method

4.0 Jaggery Plant Construction and Working

Figure 2 shows the flow diagram of the jaggery production plant. In automatic jaggery-making plants, the juice that has been extracted from sugarcane is first collected in a settling tank that is located in the ground. In this tank, the liquid is first filtered by utilising cloth to separate the juice from the cane particles. This juice the transfer to the preheater, hear the juice get heated up to 70 degrees Celsius and then it directly falls into the boiling pan. In the boiling pan again, heat will be added through steam and hear the juice will continuously be heated up around 120 degrees to 150 degrees Celsius and also it continuously produced from particles.

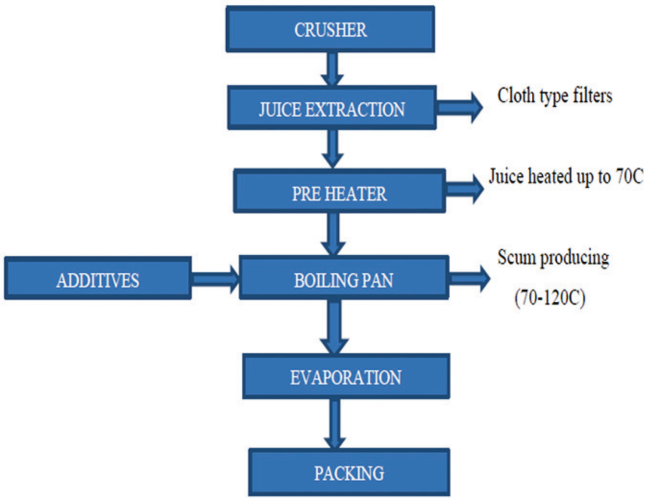

Figure 2: Flow diagram of the Jaggery production plant

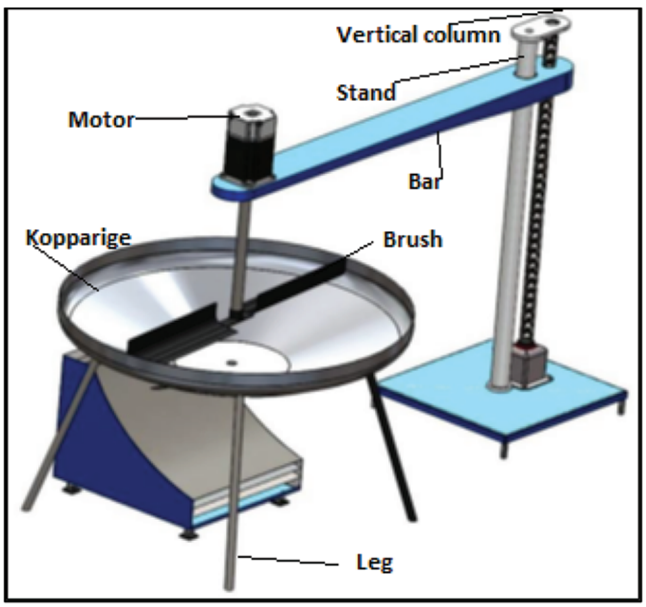

Figure 3: Isometric view of Automated Scum Removal and Filtering System

The isometric view of the automatic scum removal system in the jaggery plant is shown in Figure 3. It consists of the base, stand, lead screw, horizontal arm, thrust servo motor (0.5hp), shaft collectors, pan and multilevel filtration system. The stand and lead screw are mounted on the base and the horizontal is attached to the screw through the stand. The horizontal arm carriesa slow-speed AC servo motor and this AC servo motor runs the collector's through a vertical shaft upward and downward movement of the arm is controlled by a lead screw which is controlled by switches. The multi-level filtration system is placed under the pan and it has three various types of filters Melanin type filter (200 Microns), Finely perforated mesh (100 microns) and Fine perforated sieve (50 microns).

The scum particles will be removed in two stages and both stages are done automatically. In the first stage, the boiling pan collector mechanism is placed when juice continuously produces some particles some amount of scum particles with the removed through it further some juice will directly flow over the top of the multi filtration system.

In the second stage of the scum removal process, when juice flow over the multi-filtration system remaining the scum particles are filtered due to three various types of filters are used after Jacqueline juice will go into the next process which is evaporation and packing.

5.0 Results and Discussion

The scum removal machine has been analysed for design safety. The various load-bearing structures of the design

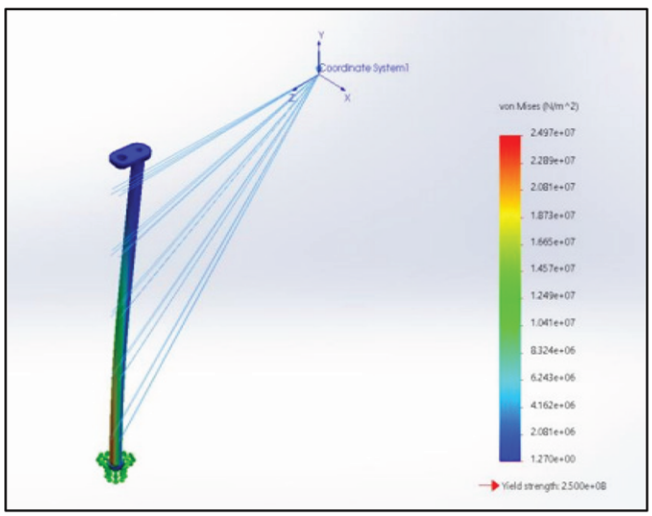

Figure 4: (a) Stress value for static load analysis of vertical column

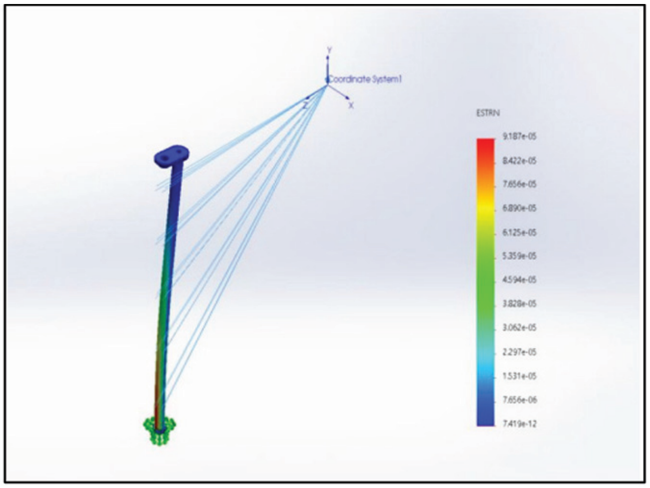

Figure 4: (b) Strain value for static load analysis of vertical column

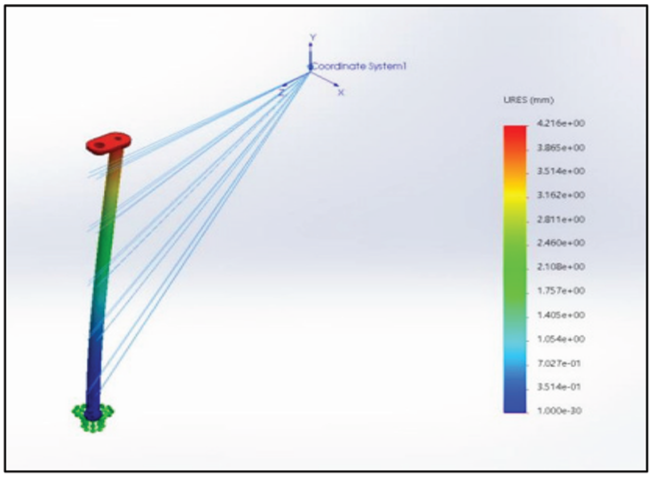

Figure 4: (c) Elongation value for static load analysis of vertical column

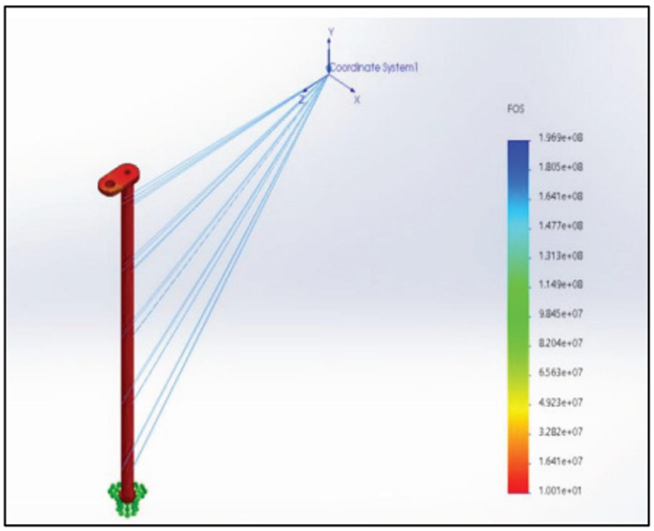

Figure 4: (d) Factor of safety value for static load analysis of vertical column

have been subjected to different loading conditions in the Ansys software. The part-wise static analysis has been performed and discussed. The stand, vertical support column and bar are to be made of ASTM A36 Steel, having a density of 7850 Kg/cubic meter. The mechanical properties of ASTM A36 Steel are obtained from the material data sheet of ASTM. The Young's modulus of the material is 200 GN/sq.m while the shear modulus is 79.3 GN/sq.m. The tensile strength of ASTM A36 steel is 0.4 GN/sq.m. The material has a yield strength of 0.25 GN/sq.m. The Poisson's ratio is 0.26.

The vertical column has a total volume of 0.008 cubic meters, thereby weighing 63.12 Kg. ASTM A36 is a ductile material, so the Von Mises theory of failure has been used for the stress analysis. The component has been designed with a factor of safety of 0.19×10^{9} as shown in Figure 4(d). The minimum and maximum stress induced in the component are 1.27N/sq.m and 24.97MN/sq.m respectively shown in Figure 4(a). The component undergoes a strain of 9.187 as shown in Figure 4(b). The maximum displacement of the vertical column is 4.216mm as shown in Figure 4(c). Since the stresses developed are lesser than the allowable stress, the design is considered safe.

The stand is made of ASTM A36. It occupies 0.0014 cubic meters, thus weighing 10.9921 Kg. The stand has been subjected to a twisting load. The minimum stress induced in the component is 13.5KN/sq.m. The maximum stress induced is 5.325 MN/sq.m as shown in Figure 5(a). The stand design requires a factor of safety of 18.52×10^{3}as shown in Figure 5(d). The material displaces by 0.6587 µm as shown in Figure 5(c), thus producing a strain of 0.1479×10^{-6}as shown in Figure 5(b). Since the stresses developed are lesser than the allowable stress, the design is considered safe.

The bar is 0.00798 cubic meters and weighs 62.6782 Kg. It has been designed to sustain bending loads. The maximum

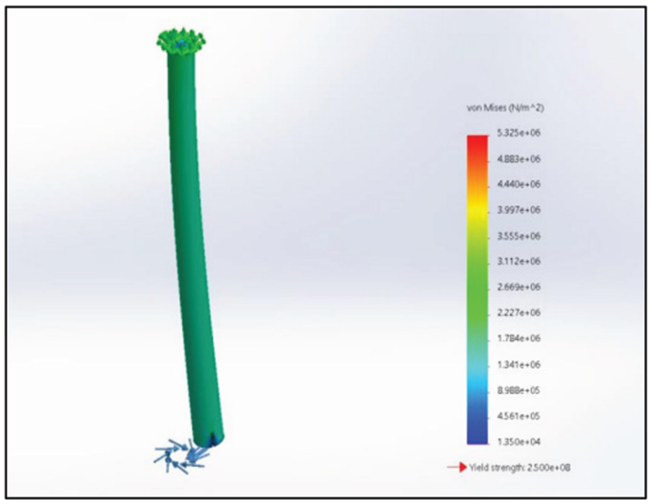

Figure 5: (a): Stress value for static load analysis of stand

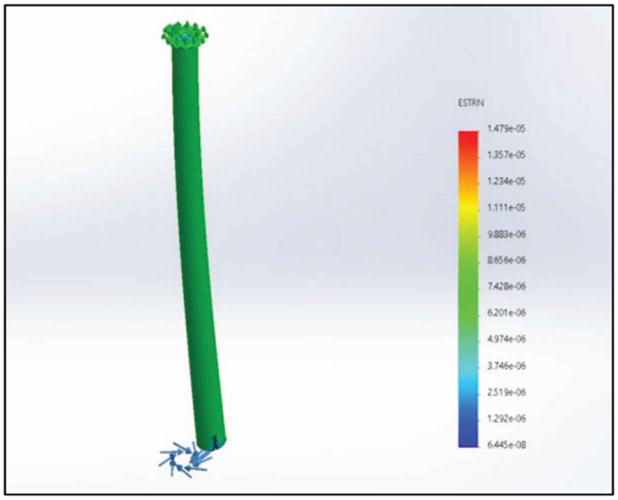

Figure 5: (b): Strain value for static load analysis of stand

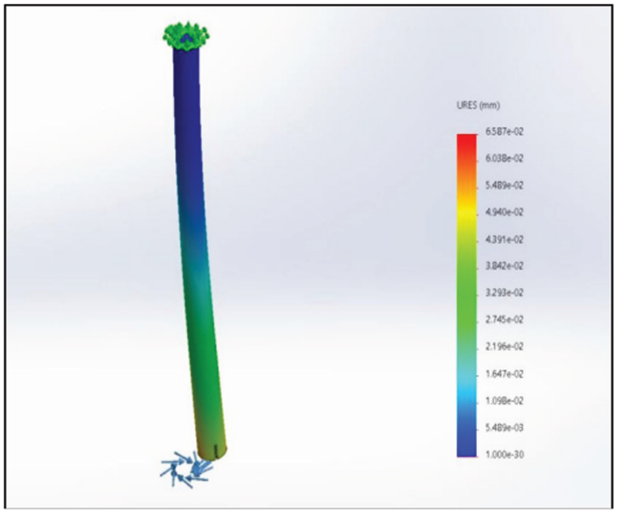

Figure 5: (c): Elongation value for static load analysis of stand

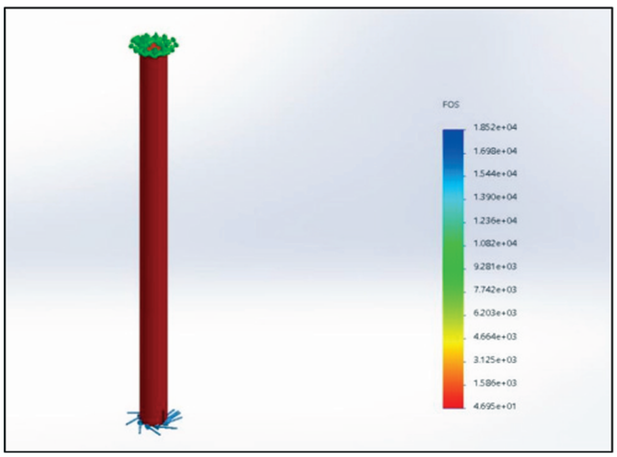

Figure 5: (d): Factor of safety value for static load analysis of stand

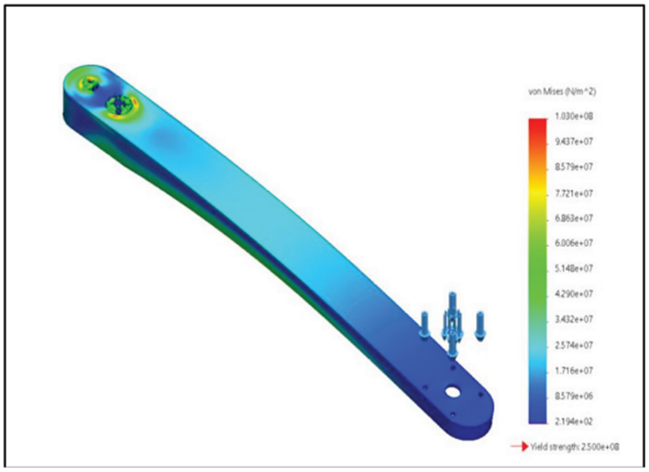

Figure 6: (a): Stress value for static load analysis of bar

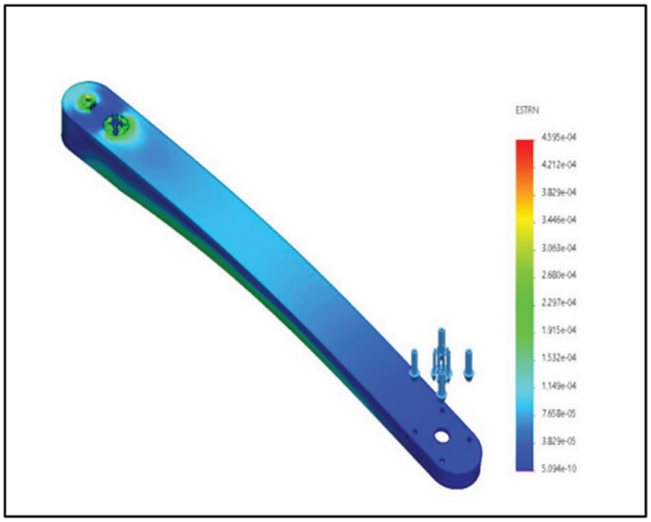

Figure 6: (b): Strain value for static load analysis of bar

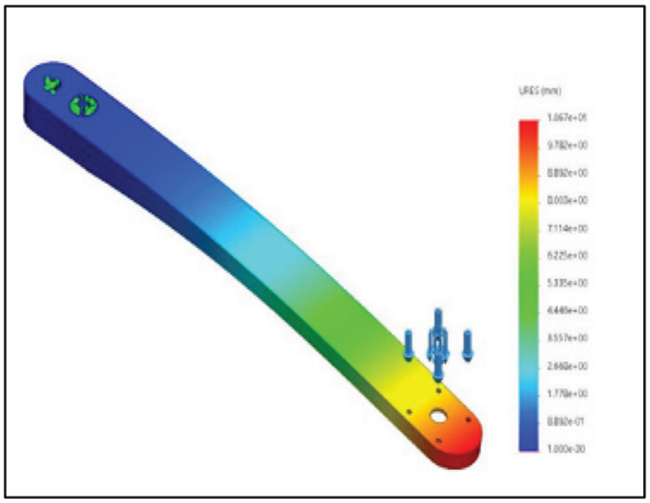

Figure 6: (c): Elongation value for static load analysis of bar

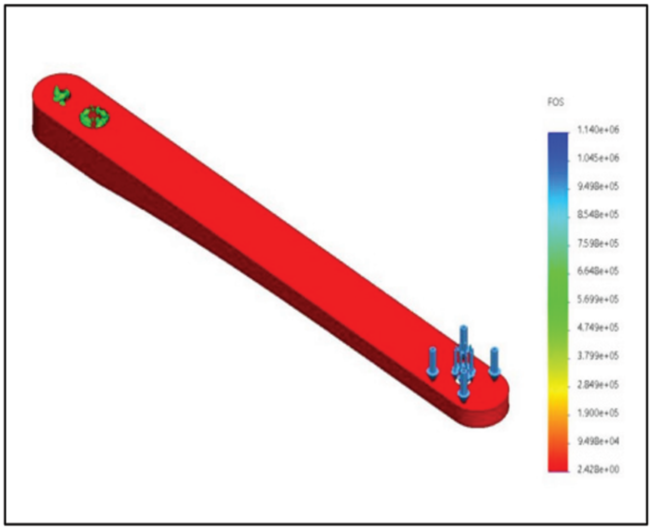

Figure 6: (d): Factor of safety value for static load analysis of bar

bending stress induced in the component is 0.103 GN/sq.m, while the minimum stress is 0.2194KN/sq.m as shown in Figure 6(a). It undergoes a strain of 45.95×10^{-3} as shown in Figure 6(b). The factor of safety to be considered in the design of the bar is 1.14×10^{6} as shown in Figure 6(d). The bar bends by 10.67 mm as shown in Figure 6(c) at the maximum stress condition.

6.0 Conclusion

1. This project is designed to ease of handling the scum particles during the production of jaggery.
2. It provides organic and hygienic and quality jaggery by increasing the rate of production, utilising very less manpower and thus using all resources efficiently.
3. The project is designed and fabricated mainly for helping the farmers at a low price.
4. By installing this machine, scum can be removed at a larger rate which results in high-quality jaggery.
5. This machine can be installed in all the jaggery plants throughout the world, where the jaggery production takes place.
6. The scum will remove ata larger rate and effectively without any human interaction with an increased production rate.
7. To the development of India, this is dedicated to hardworking Indian farmers and for their contribution towards it.

7.0 Future Scope

1. This project helps the jaggery producers to get huge returns in a much faster time compared to the traditional technique.
2. It makes the removal of scum easily, safe and economical.
3. This machine does not involve any human efforts in removing the scum during the production of Jaggery.

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