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AN ALTERNATIVE METHOD OF REMOVING SLURRY IN BIO- METHANATION PLANT USING JIB CRANE

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ABSTRACT

Slurry maintenance is the most important factor in Bio-methanation Plant. Generally, Slurry is the mixture of water and solid content i.e., Semi-solid state. The Slurry is settled down on a sludge separation bed for the separation of liquid from the solid particles. The suspended solid particles is removed by human beings. It is one of the tedious work and also causes a problem like skin rash for the labours. To overcome this problem, Jib Crane Mechanism is introduced to reduce human effort by collecting the slurry with the bucket. The Pulley and Lever operated worm gear winch Mechanism is attached with jib crane to pull in or pull out the bucket with the rope which will reduce the input required to remove the bucket. The liquid present in the slurry is being removed by Geo fabric. Due to the implementation of this equipment, the removal of a slurry is carried out without the supply of any external power source and minimizes the human efforts.

KEYWORDS: Slurry Removal, Jib Crane Mechanism, Pulley System, Hand-Operated Worm Gear Winch, Geo Fabrics**.**

Solid waste management is the most serious issue facing the modern world. The solid waste creates hazardous problem to the environment and human beings. To reduce this impact, recycling the wastes and reuse it for some other beneficial task. Biomethanation is the process of anaerobic digestion, which treats the biodegradable organic matter and produces the biogas (Patil and Deshmukh,2016). PeriyarManiammai University implemented the Biomethanation plant with the capacity of 500cu.m and produces the biogas 292 tonnes per year and 800 kg per day at maximum feed rate of 10 tonnes per day which can be utilized for cooking and generating the electricity. Municipal solid waste collecting from Thanjavur district consists of food and vegetable waste 65%, banana leaf 26%, plastics 6.8%, egg shell 0.1%, bottles 0.7% and other waste such as Cow dung and night soil can be used as the feed for the biomethanation plant.

The feed rate is mix with water in the ratio of 1:1. After production of biogas, the slurry is settled on the sludge drying bed. It separates the liquid from suspended solid particles through evaporation and gravity drainage through the sand. This process removes 90% of moisture content present in the slurry. The volume of the slurry is reduced more than half by separation of liquid. The remaining digestate contains nutrient content such as Nitrogen 2.3-4.2 kg/tonne, Phosphorous 0.2-1.5 kg/tonne and Potassium 1.3-5.2 kg/tonne can be used as a fertilizer and for vermicompost. This slurry is removed by human beings from the sludge separation bed which is more tedious. This paper demonstrates the modification of slurry removal process by collecting the slurry in the bucket and separate the liquid using Geo-fabrics. Then, the bucket is pulled out by hand operated worm gear winch machine with the wire rope. The bucket is rotated to unload the slurry with the help of Jib crane mechanism which reduces the human effort.

JIB CRANE MECHANISM

Jib crane is the combination of Gantry and tower crane, which is widely used as a most efficient material handling equipment (Gerdemeli et al.,2012). It consists of Jib or boom, mast and supporting movable hoist (Figure 1). The Jib crane is either wall mounted or floor mounted and capable of rotating 360° based on the requirements. It is considered widely for the application needs repetitive lifting and transferring the load within the fixed arc of rotation (Deepak Desai et al., 2007). There are certain parameters should be considered seriously while selecting the Jib crane. The parameters are area of rotation, hoist height, span of the boom, under boom height, power required for operation, and materials which can able to withstand the lifting weight of the load.

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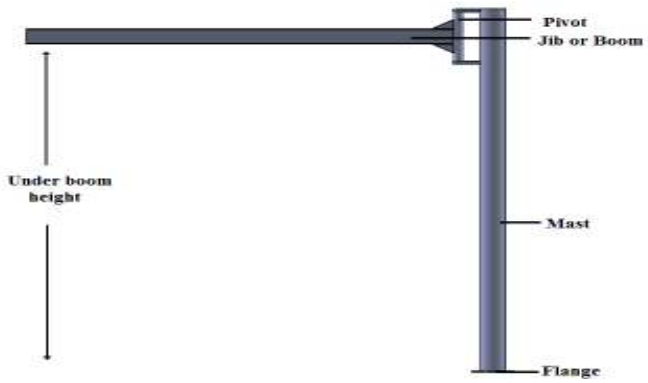

Figure 1: Jib Crane Mechanism

PULLEY AND ROPE MECHANISM

A pulley is a wheel on the shaft which is used for free movement and alters the direction of wire rope along its circumference. It is one of the necessary elements used for lifting the load with the help of the hoist (Figure 2). The pulley blocks decrease the tension force of the wire rope and driving torque. The convolution of pulley block is always correlated with high deformation, motion of the wire rope, mass vibration (Reutov et al., 2016). The wire rope consists of a number of steel wires are wound together to make the complex structure combining axial strength, rigidity and flexibility in bending.

The tolerance of wire breakage is the main reason to use steel wires which provides high strength and low ductility (Chaplin, 1995). The tension force of the wire rope is always belongs to the number of pulleys attached to the rope. If W is the weight of the load attached to the rope and P is the number of pulley block supports the rope, then the tension force or the input force of the rope is

$$T = \frac{W}{P} \quad (1.1)$$

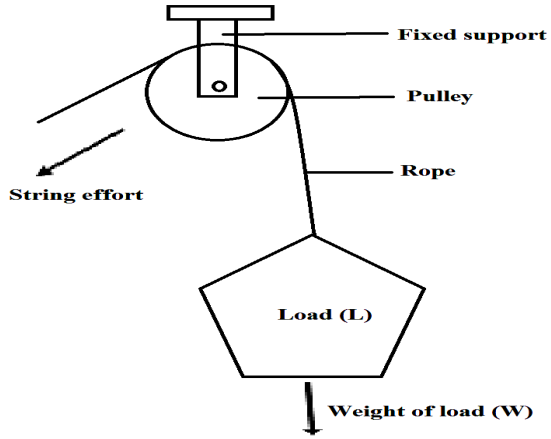

Figure 2: Pulley and rope system

Lever operated worm gear winch

To perform the load lifting and lowering with the hoist, the rope is spooled on the rope drum and reeled out of it (Reutov et al., 2016). The winch is the device which is used to pull in and pull out the load in most of the industries efficiently. The winch operates using different gear mechanisms such as spur gear, worm gear and planetary gears. The worm gear winch machine is widely used for lifting the bucket with sand in foundry (Faras and Kolhe, 2016). The worm gear winch consists of worm wheel, worm, worm shaft and spool or rope drum attached with worm wheel (Figure 3). For hand operated winch, the lever is connected with the worm shaft to rotate the gear manually. When the lever is idle the gear is protecting from rotation with the help of self-locking system.

Geo-fabrics

The Geo- fabric filter is the type of Geo textile used

to filter, reinforce, protect, or drain when it is associated with the soil. It is thick, non-oven, needle punched provides large elongation and excellent filter properties at all strains.

CONSTRUCTIONAL DETAILS

Selection of Crane

While selecting the Jib crane, there are number of parameters are taken into account such as capacity, materials and boom etc., According to the requirements (Table 1), Jib Crane is suitable for slurry removal process.

Selection of Winch Machine

The winch machine is attached with the Jib crane to pull in or pull out the bucket. The winch is to be considered which can be able to withstand the weight of the bucket. The suitable parameters can be chosen based on the requirements (Table 2).

Figure 3: Lever operated worm gear winch machine

Table 1: Details of Jib crane Requirements

S. No	Parameters	Details
1.	Capacity	2 Tons
2.	Material	Mild Steel
3.	Jib Type	Floor Mounted Jib crane
4.	Boom	I-section beam
5.	Mast	Circular Pipe
6.	Boom length	2.25m
7.	Mast Height	4 m
8.	Area of rotation	300°

Table 2: Parameters of winch Machine

S. No	Parameters	Details
1.	Winch type	Worm gear winch
2.	Operation	Lever operated
3.	Capacity	2 tons
4.	Pitch circle diameter (Wheel)	164 mm
5.	Pitch circle diameter (Worm)	34 mm
6.	Rope diameter	12 mm
7.	Rope length	30 m

ANALYSIS AND CALCULATIONS

Properties of Materials

- Density : 7.85×10^{-6}kg/mm^3
- Compressive Yield Strength : 250 MPa
- Tensile Yield Strength : 250 MPa
- Compressive Ultimate Strength : 460 MPa
- Poisson's Ratio : 0.303
- Young's Modulus : 200×10^9 Pa
- Coefficient of Thermal Expansion :1.2×10^{-5} / °c
- Specific Heat: 434 J/kg °C
- Thermal conductivity : 6.05×10^{-2}watt/mm°C

Theoretical Calculation of Maximum Deflection in I-Section Beam

The cantilever beam have one end fixed and other end is free. The slope and deflection of the fixed end must be zero. When the load acted on the free end of the beam then, the maximum deflection of the beam(Edward H. Smith, 1946) is calculated by,

$$\delta = \frac{WL^3}{3EI} \qquad (1.2)$$

Where,

δ = Maximum Deflection of beam
W = load in KN (20 kN)

L = Length of the Beam (2.25m)
E = Modulus of Elasticity (200GPa)
I = Moment of Inertia (0.00000765851 m^4)

$$\delta = \frac{(20 \times 10^3) \times (2.25^3)}{3 \times (200 \times 10^9) \times 0.00000765851}$$

δ= 0.049577m

δ= 49.57mm

Analysis of Deflection in I-Section Beam

The static analysis of I-Section beam is to ensure the safety of the Jib by applying the load on the boom and the supporting structures (Figure 4). The Load to be considered for the analysis are self-weight of the beam, operational and other environmental load acting on the boom. In the analysis, Solid works and ANSYS are the software used.The analytical result of I- section boom indicates that the maximum deflection at the end point under 20kN of load is 51.30 mm (Figure 5) by considering the factor of safety (FOS) as 1.25.

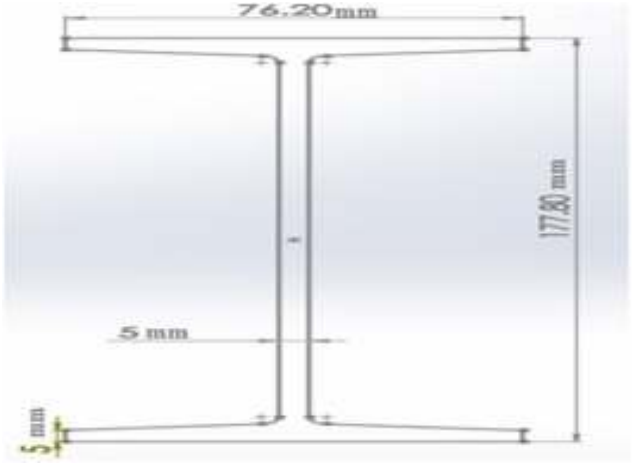

Figure 4: Dimension of I-Section Beam

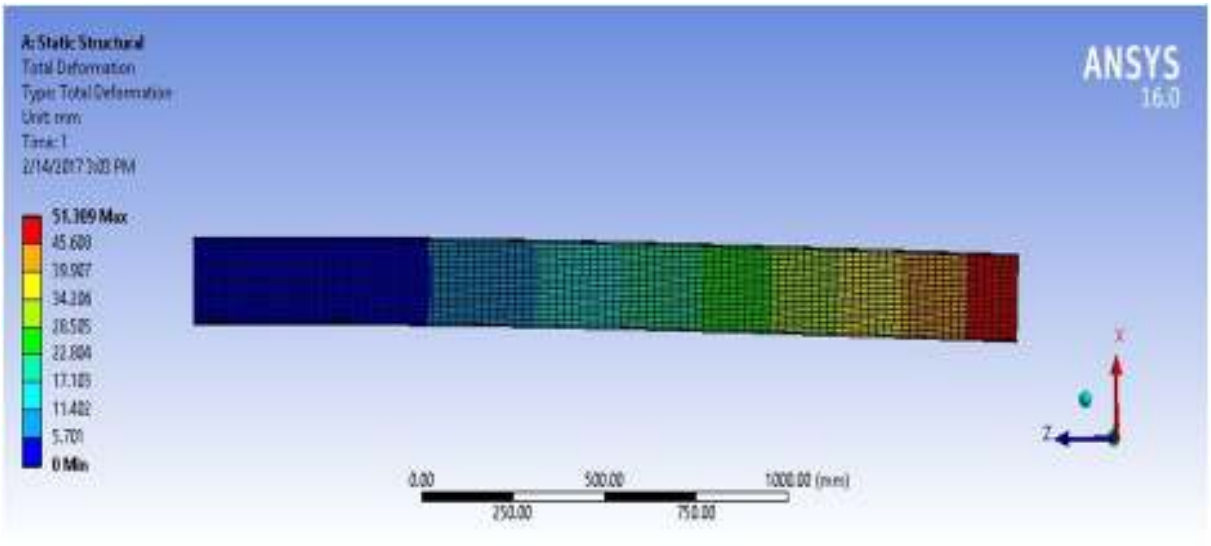

Figure 5: Static Analysis of I-section Boom load under 20kN

CONCLUSION

The Load 20 kN is applied at the free end of the boom, the maximum deflection of the I-section boom is 49.57 mm by theoretical calculation. During the analysis using ANSYS, the same load is applied on the boom. The analytical result shows that the maximum deflection of the I-section boom is occurring at 51.30mm (Figure 5) by considering the factor of safety as 1.25. From the above calculations, the result indicates that the design of crane is safe and it is suitable for lifting the load of the bucket.Thus it concluded that the way of removing the slurry is improved using the Mechanical equipment. At the same time, it reduces the human effort and makes more economical compared to the previous method of removing slurry.

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