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Design and Analysis of Floating Waste Cleaning Machine

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Abstract:
In all countries, disposal of the wastes in solid wastes in the drainage and water bodies are the major threat. There are number of machines, mechanisms and systems to clean up the solid wastes in the drainage. In this proposed project, a simple machine with bucket conveyor is designed for solid waste removal. It is designed using PTC Creo Package. The machine is fabricated and its load capacity and efficiency are calculated and stress and strain developed in the machine frame are analyzed using Autodesk Fusion 360 software. The stress and strain developed in the wheel while the wheel passing the obstacle. A load vehicle is used to carry the drainage cleaning machine.

Keywords: Loaded Vehicle, Remote control, Safety disposal

I.INTRODUCTION

Drainage is a construction for the passage of water flow in a path. As long as the function of draining system is considered to be the collection of waste water from each and every house, industries and other buildings and to transport and disposeoff the water through an outfall or outlet. Not only in recent day, till the beginning of ancient culture, drainage system is followed up. They are mostly used to carry the waste water from kitchen, bathroom and other domestic works. Nowadays, not only waste water, but also many more solid wastes are disposed in the drainage. To prevent the composition of solid wastes in drainages, Government started to build up the roadside ditches and underground drainage pipes. Impurities in drainage water can be only like empty bottles, polythene bags, papers, etc. These impurities present in drainage water can cause blockage of the drainage system. The drainage system can be cleaned time to time manually or such a system can be designed that will clean and throw out wastages and will keep the water clear. For number of years, humans used to clean the drainage. Due to insufficient oxygen in the drainage pipes and leakage of toxic gases inside the pipe causes death and severe infections. To avoid human loss, number of systems and machines are introduced to clean the drainage. But those machines are mostly static. This drainage cleaning system will clean the waste at the surface of drainage which would allow the flow of water without any solid wastes. This device can be used across roadside ditches and shallow, small underground pipes to clean up the floating substances in the flow. The drains are lifted by the conveyor which is connected to the frame. When the motor runs, the conveyor starts to rotate making the conveyor to lift up. The waste materials are carried in the conveyor and stored in storage bin.

II. LITERATURE REVIEW

Ganesh U L, et. al. [1] showed the usage of mechanical drainage cleaner to replace the manual work required for drainage cleaning system. Drainage pipes are very dirty and it is harmful to human life while it is need to clean. To overcome this problem, a semi-automatic mechanical drain water cleaner is implemented. This makes the water flow efficient due to the regular filtration of wastage.

Dr.K.Kumaresan, et. al., [2] explained manual work converted into automated system. Drainage pipe using for disposal and it may be loss for human life cleaning the blockage in the drainage.To overcome this problem, automatic sewage cleaning system is implemented. This is majorly concentrated in the clearance of gaseous substance are treated separately so the flow of water efficiently.

NDUBUISI C Daniels, et. al., [3] showed the drainage cleaner machine used to remove garbage and sewage automatically which helped to protect the environment from different kinds of environmental hazards. The drainage system cleaner has three major parts which are the propeller, the cleaner and the pan all makes up for its effective functioning.

Prof.S.D.Anap, et. al., [4] showed blockage is the major cause of the pollution and flooding in the metro cities. They have designed the drainage block detection system to avoid such problems. The system provides monitoring of drainage condition and to inform authorities of these condition using GSM.

N. Prabhushankar, et. al., [5] showed the dewatering of drainage is generally done using centrifugal pump, using centrifugal pump. Instead of slider crank mechanism, spring system with reciprocating cylinder was used which discharged the large sized drainage particles easily and there was no need of external power supply.

S. Bhattacharya, et. al., [6] described the evolution of conveyor belt material for multi-purpose. Leather, Canvas, Rubber, Balata were considered and tested for various loads and situations. The materials are analyzed with Analytic Hierarchy Process(AHP).

N. Yashaswini, et. al., [7] designed and analyzed for conveying granular materials to the height of 15 m at the rate of 10 tonnes/hr output.The explained basic design calculations for the development of the bucket elevator in 3D environment of NX software.

B. Kowalska, et. al., [8] tested the mechanical strength of PVC pipes for the water distribution. The testing included the analysis of sediment found on the inside pipe wall, with the application of a Quanta 200 FEG Scanning Electron Microscope (SEM).

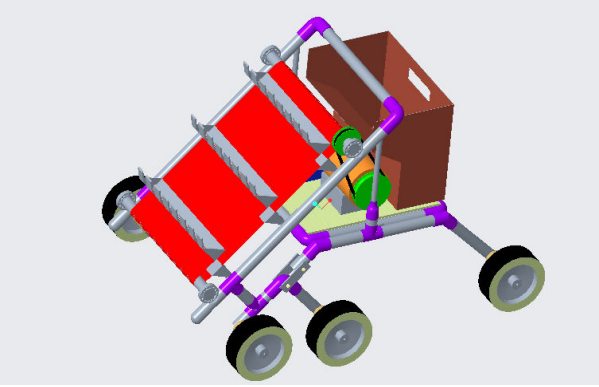
B.Babu, et. al., [9] designed the Rocker Bogie Mechanism Geosurvey Rover using PVC. The operating time, stability,

capacity to tilt, efficiency and directional control were calculated and designed.
Jignesh Rohit, et, al., [10] explained and experimented the inclined belt conveyor. The experimental aspects are analyzed and the optimum results are plotted. The effective belt pull of conveyor belt is analyzed.

III. METHODS OF OPERATION

There is a load vehicle to carry the cleaning machine. The load vehicle needs to go in slurry and rough surfacei.e, it should be an all-terrain vehicle. The best mechanism for all terrain travel is the Rocker Bogie Mechanism. The Rocker Bogie mechanism is mainly proposed for high suspension in any rough surface. This prevents the vehicle from slip. The Rocker Bogie vehicle is mainly applied for better suspension than any other mechanism or vehicle. It does not have springs and stub axles for each wheel, allowing the rover to climb over obstacles, that are up to twice the wheel's diameter in size while keeping all six wheels on the ground. It is designed to be used for slow speed of around 10 cm/s (0.1m/s), in order to minimize dynamic shocks.While facing the obstacles, the front wheels are made to force against the obstacle by rear wheels. The rotation of the front wheel lifts the vehicle up and the rear wheel pulls over the vehicle against the obstacle. This mechanism of vehicle is used by NASA for examining Mars. It is commonly called as Mars Mover or Mars Rover by NASA. The load vehicle is powered by motors The belt conveyor is used to carry the wastes from the ditches and drains. The forks in the conveyor is used to collect the wastes. The conveyor is powered by motor. When the motor runs, the conveyors start to rotate. The forks that are fixed with the conveyor also rotate with the conveyor. It collects the wastes from the surface level or float level. As the conveyor rotates, the forks get lifted up and drop the wastes into the bin that was placed behind the conveyor.

IV. CAD MODEL



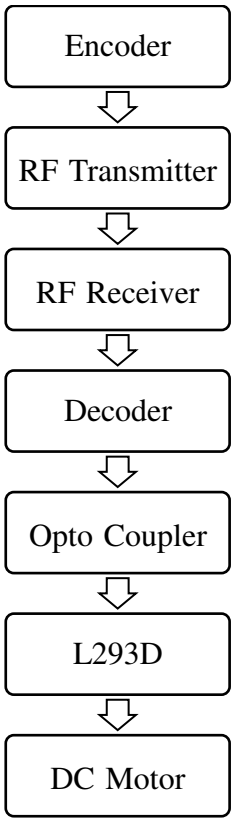
The CAD model is prepared using PTC Creo Parametric 5.0 of Creo 5.0 Package. The CAD model of the project is shown above.

V. MATERIALS

The materials used for drainage cleaner are as follows: PVC pipes for vehicle construction and frame of conveyor, bearings, Aluminium pulleys, leather belt, high density plastic sheet for bin and forks, DC motor, Robot Wheels for load vehicle, connecting wires, clamp, plastic pieces, clamps, nuts and bolts. PVC (Polyvinyl Chloride) has been chosen for the frame work becauseit is less in weight, cost and corrosion when compared to metals. It is a white, brittle solid and insoluble in alcohol. Among the two types of PVC, Rigid PVC pipes are used to construct the vehicle and conveyor frame. The yield strength is about MPa. Thermal coefficient is about $5*10^{-2}$ mm/(mm°C). It is also an electrical insulator. Aluminium pulleys are used because it has less weight and less corrosion property. Though it is quite costly than other metals such as stainless steel, MS and iron components, it can be applied. The aim of this project is to reduce much more possible weight of the machine, then only it can be easily portable. Leather belt is used for the conveyor bed. Because leather components can give more friction than any other materials with PVC pipes. DC motor of 12 V is used to run the conveyor motor. This is light load type conveyor. So, 12 V motor alone can be used to run the conveyor. DC motor of 6 V is used to run the load vehicle. For convenient torque, low speed motor (10 rpm) is used. The load vehicle is designed to carry at least 3 kg load. To achieve this load capacity, 6 DC motors with 1 kgf.cm torque is connected in each wheel. High density plastic sheet is used to design the forks and waste collector bin. To eliminate corrosion in the forks, plastic material is chosen. At the same time, cost and weight of the components can be reduced. Metal bearing of model 6005 is used for better rotary action. None of the other components can be suitable for bearing component. Clamp is used to tightly hold two components, i.e., motor and wheel.

VI. WORKING PRINCIPLE

The rocker bogie vehicle is used to carry the conveyor. The vehicle is controlled using RF remote control. The RF remote control is the wireless Radio Frequency remote control. It is most commonly used in robotics, electronic toys, automation systems, etc. There are two major parts in the RF remote control – the transmitter and the receiver. The transmitter RF TX module of 434 MHz and the receiver RF RX module of 434 MHz. The transmitter and the receiver both are connected to 9-12 V battery supply each. The L293D IC is used to control maximum two DC motors in the circuit. The working of the RF remote control is simply explained by,



When the RF remote control is activated with programmed frequency, the load vehicle moves in the desired direction. It is also used to run the conveyor. As it is difficult to manually handle the machine that is partly submerged in the ditches, the remote control must be used for handling. When the function is over, a lever with hook is used to lift the machine.

VII. DESIGN CALCULATION

ROCKER BOGIE MOTOR:

(Assume: Distance = 1 m; Time = 10 sec)

Speed, $S = \frac{\text{Distance}}{\text{Time}} = \frac{1}{10} = 0.1$ m/s

Acceleration: $S = S_0 + at$

$a = 0.01$ m/s^2

Displacement, $d = S_0 t + 1/2\ at^2 = 0.5$m

Force, $F = ma = 0.03$N

Power, $P = (F*d)/10 = 0.0015$ Nm/s

TORQUE, $T = (P*60)/(2\pi N) = 1$ Kgf.cm

CONVEYOR MOTOR:

(Preferred: Speed = 60 rpm, Torque = 38 kgf.cm)

Power, $P = 2\pi NT/60 = 2.387$ Nm/s

Angular Velocity, ω (or) $s = \pi DN/60 = 0.283$ rad/s

CONVEYOR PULLEY:

Pulley Speed: $\frac{N1}{N2} = \frac{D2}{D1}$

($N_1 = 60$ rpm, $D_1 = 90*10^{-3}$ m, $D_2 = 70*10^{-3}$ m)

$N_2 = 77.14$ rpm

Centre Distance:

$C_{max} = 2(D+d) = 0.32$ m

$C_{min} = 0.55(D+d)T = 0.033$ m

We take $C = 0.2$ m

Pulley type: A type (for small diameter)

PULLEY BELT:

Type of Belt: A type V-belt (A 34)

Length, $L = 2C + \frac{\pi}{2}(D+d) + \frac{(D-d)2}{4C} = 0.651$m

Design Power for V belt: (maximum capacity)

($d_o = 125$ mm, $F_b = 1.09$ from PSG DB)

$d_p = 65*10^{-3}$ m (Small Pulley Pitch Diameter)

$de = d_p * F_b = 70.85$ mm

$kW = [0.45\ s^{-0.09} - \frac{19.62}{de} - 0.75*10^{-4} s^2]s$

$kW = 78.25$ Nm/s

Load Rating: (for light duty L.R = 0.023)

$= \text{load rating of } V * \frac{V}{2} = 6.5*10^{-4}$ W/mm/ply

Angular Velocity of driven pulley:

ω_2 (or) $s_2 = \pi DN_2/60 = 0.283$ rad/s

BEARING: (d = 25.4mm, μ=0.61)

Selection of Bearing: 6005 Bearing (for light load)

Power = $\mu\pi dN_2/6000 = 6.16*10^{-4}$ Nm/s

Actual power of conveyor:

$P_{(a)} = 2.387 - 6.16*10^{-4} = 2.386$ Nm/s

(m = 0.075 each bearing, a = 0.0283 rad/s)

Force, $F = m*a = 0.00213$ N

Equivalent Dynamic Load:

(F_r=0.00213N,F_a=0,y= 0 for fixed, S=1.1, x=2.04)

$L_d = (xF_r + yF_a)S = 0.0472$ N

Self Load = 1.2*9.81 = 11.772 N

Load on bearing = 11.772 + (4*0.0478)=11.9632N

For each bearing = 2.9908 N

VIII. ANALYSIS

The analysis of the conveyor frame is carried out with Autodesk Fusion 360 software. The Stress, strain developed in the frame and the displacement of the frame when loading is analyzed and by using this output, safety factor of the frame is calculated theoretically and using analysis software.

STRESS ANALYSIS (Von Mises):

The maximum stress developed in the frame is 0.5861 MPa. The minimum stress developed in the frame is $4.9*10^{-6}$ MPa.

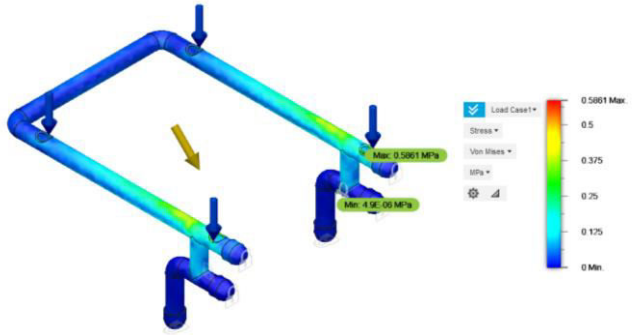


Figure.1. Stress Analysis

STRAIN ANALYSIS (Equivalent):

The maximum strain developed in the frame is $2.259*10^{-4}$and the minimum strain developed is $2.401*10^{-9}$.

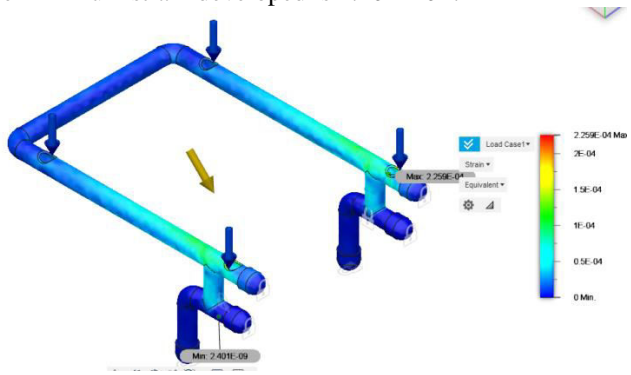


Figure.2. Strain Analysis

DISPLACEMENT (Total):

The total displacement of the frame is about 0.5872 mm.

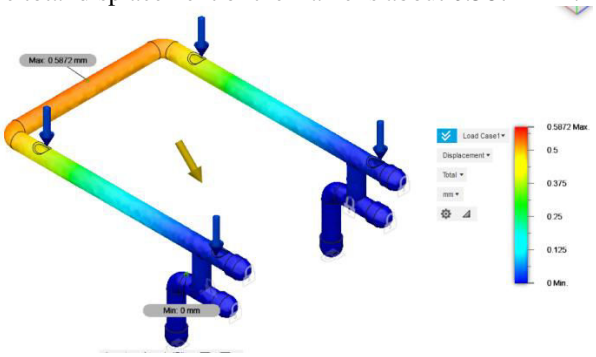


Figure.3. Displacement Diagram

REACTION FORCE (Total):

The maximum reaction force on the frame is 2.445 N.

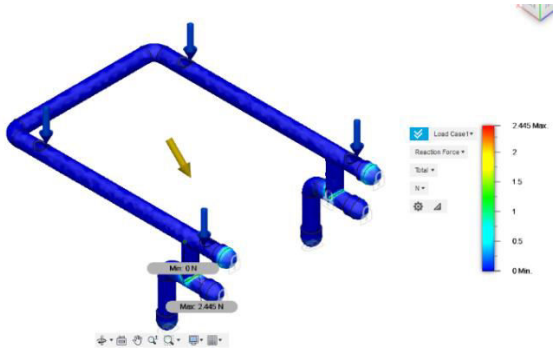


Figure.4. Reaction Force

IX. RESULT & DISCUSSION

The result shows that the material selection and the theoretical analysis is mostly similar to the analytical method. Thus, the results show that the design and analysis of the work is safe to be implemented. The project is further discussed and developed for the convenient use of this machine which is suitable for the varying size of ditches and drainage pipes across of various countries with the help of pneumatic, leadscrew and other possible simple solutions.

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