Design and Analysis of Manually Operated Floor Cleaning Machine

M. Ranjit Kumar (1)
1 M. Tech Student,
Mechanical Engineering,
Nagarjuna College of Engineering and Technology,
Bangalore, India.

N. Kapilan (2)
2Professor
Mechanical Engineering,
Nagarjuna College of Engineering and Technology,
Bangalore, India.

***Abstract* — The conventional floor cleaning machines is most widely used in airport platforms, railway platforms, hospitals, bus stands, malls and in many other commercial places. These devices need an electrical energy for its operation and not user friendly. In India, especially in summer, there is power crisis and most of the floor cleaning machine is not used effectively due to this problem, particularly in bus stands. Hence it is a need to develop low cost, user friendly floor cleaning machine. In this project, an effort has been made to develop a manually operated floor cleaning machine so that it can be an alternative for conventional floor cleaning machines. In this work, modeling and analysis of the floor cleaning machine was done using suitable commercially available software. The conventionally used materials were considered for the components of floor cleaning machine. From the finite element analysis, we observe that the stress level in the manually operated floor cleaning machine is within the safe limit.**

Keywords: Floor Cleaning Machine, Modeling, Analysis, and Stress.

I. INTRODUCTION

Effective cleaning and sanitizing helps and protect the health of the human beings directly and indirectly. Also, cleaning and sanitizing prevents the pest infestations by reducing residues that can attract and support bees, pests etc. It also improves the shelf life of the floor, walls etc due to regular cleaning and maintenance. In recent years, most of the people prefer to use trains or buses for commuting and hence these places are littered with biscuits covers, cold drink bottles etc. Hence, it is necessary to clean the bus stands and railways stations at regular interval.

There is no one single cleaning method that is suitable for all locations and occasions and effective cleaning depends upon type of cleaning device, cleaning technique and also the equipment should be user friendly. Cleaning work can be physically demanding and a need has been identified to developed methods for systematic ergonomics evaluation of new products. In recent years, floor cleaning robots are getting more popular for busy and aging populations due to lack of workers. However in India, unemployment is more and hence there is a need to develop less labour oriented cleaning machine. Hence, the present work is aimed to design, development and evaluation of a manually operated floor cleaning machine.

Liu et al [1] carried out a technical analysis of residential floor cleaning robots based on US granted patents. They observed that the macroscopic analysis of patents and patent bibliometrics or patent maps, is useful tools to make an overview for designated technical topics and they observed that the Samsung is the top one patentee in cleaning robot after macroscopic of view. Imaekhai Lawrence et al [2] evaluation has shown how the use of multiple assessment techniques can provide a comprehensive appraisal of the design, usability and musculoskeletal loading upon the operator. They suggested that the trials with a larger number of subjects would certainly strengthen the conclusions. Abhishek Chakra borty et al [3] reported that the most significant cause of road dust to the total suspended particulate burden is vehicle traveling on paved and unpaved' surfaces. Consequently data directly relating dust to road accidents are rare, but in a study if dust is the cause of 10% of these accidents casualties then the cost could amount to as much as 0.02% of GDP in some developing countries and total about $800 million annually.

In recent years, conventional floor cleaning machines are most widely used in airports, railway stations, malls, hospitals and in many commercial places, as cleaning is one of the important parameter for the sanitation and government regulations. For maintaining such places, cleaning the floor is the major task which is necessary. There are conventional floor cleaning machines available to perform floor cleaning operations in above said places. Generally a conventional floor cleaning machines requires electrical energy for its operation. In India, especially in summer there is power crisis, in majority of places. Hence cleaning the floor using the conventional floor cleaning machines is difficult without electricity. In this project an effort has been made to develop a manually operated floor cleaning machine so that it can be an alternative for conventional floor cleaning machines during power crisis.

A manually operated floor cleaning is developed with major list of objectives, one; to achieve simultaneous dry and wet cleaning in a single run, secondly to make the machine cost effective and thirdly to reduce the maintenance cost of the manually operated floor cleaning machine as far as possible.

In recent years, finite element method is most widely used to analyze the mechanical component design [4-7] and hence we have used it in the present work.

II. MATERIALS AND METHODOLOGY

In this work, three dimensional (3-D) modeling and analyses was carried out using ANSYS software. The Ansys tool was used to find the deflection and stresses on frame and beam (stick) for dry mopping and wet mopping respectively. The model was checked for the effects of self-weight (dead load) and for the combination of dead load and live load.

The maximum deflection and stresses were checked, and maintained within the allowable limits for the material of construction and span/deflection ratios.

For manual operation, pedal operated body is selected as the rider machine, to which dry cleaner (sweeper) attachment is made to the front wheel of the body. A frame is constructed for dry cleaning purpose, one side i.e. front side of the frame is made of MS shaft, to which brushes are winded and the shaft rotates by driven mechanism thereby pushing the dust into the dust chamber attached to the frame. For wet cleaning, wet mops are attached at the rear end of the body, which operates by sliding mechanism on the floor when the body moves, disinfectant liquid is spread just before the mops from a plastic tank during wet cleaning operation. This floor cleaning machine is specifically designed to clean the floors which are plane and smooth, such as tiles, mosaic and cemented smooth surfaces.

III. RESULTS AND DISCUSSION

1.1 General Assembly

A concept of low-cost user friendly floor cleaning was developed and 3-D was developed using ANSYS tool and is shown in Figure 1.

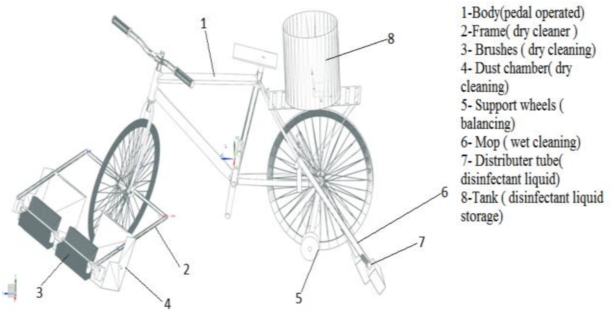

Figure 1 – Three Dimensional Model

1.2 Assumptions made for FEA model

The following assumptions are made in the finite element analysis (FEA)

1) Material is assumed to be homogeneous, isotropic and obeys Hooke's law
2) It is assumed that all material are ductile in nature and Von-Mises stress theory is used for comparing induced stress to allowable stress values.
3) We are considering 25% extra for dead loads to take care of fasteners, welds which are not modeled
4) Only structural parts are considered for modeling. Other components are modeled as lumped masses at their cg locations or forces at their acting points.
5) The structure beams, which are bolted, are considered as fixed beams.

1.3 Material properties

The properties of the materials used for this work is shown in the Table. 1. We have selected mild steel and aluminum alloy for this work as these materials are cheap and commonly used.

Table 1 Material Properties

Material	Yield strength	Allowable stress
MS IS 2062 Gr.B	250 N/mm^2	165 N/mm^2
Al alloy IS 63401	135 N/mm^2	90.45N/mm^2

1.4 Meshed 3D model of floor cleaning machine

The 3D model was developed and then it was meshed using the Ansys tool. Finite element model is made using beam elements (Beam 188), shell element (shell 63) and mass element (mass 21) & MPC 184 element (Multi point constraints 184). Figure 2 shows the model of the floor cleaning machine.

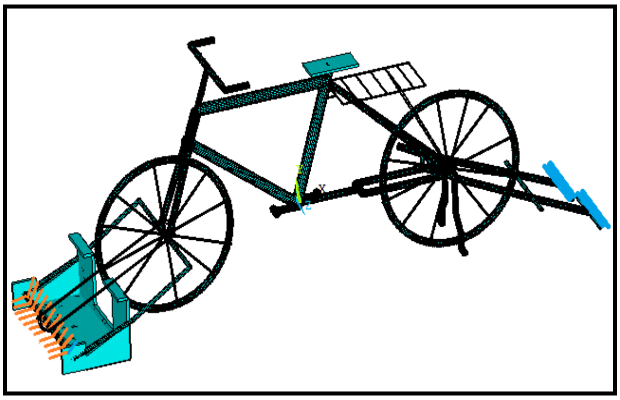

Figure 2: Load Case 1 (Boundary condition applied to the model)

1.5 FE Analysis on model for different loads conditions

(1) For Load Case 1

Dead load is the self weight of the structure which is acting on it. Load Case 1 is the dead load applied on the machine. Figure 3 shows the dead load acting on the model at the specified points. The required boundary conditions are applied on the model and then the model was checked for maximum deflections and maximum stresses using the software.

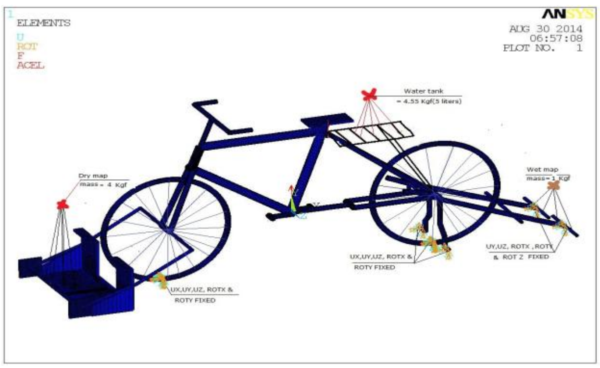

Figure 3: Load Case 1 (Boundary condition applied to the model)

(a) Maximum Deflection for Load Case 1

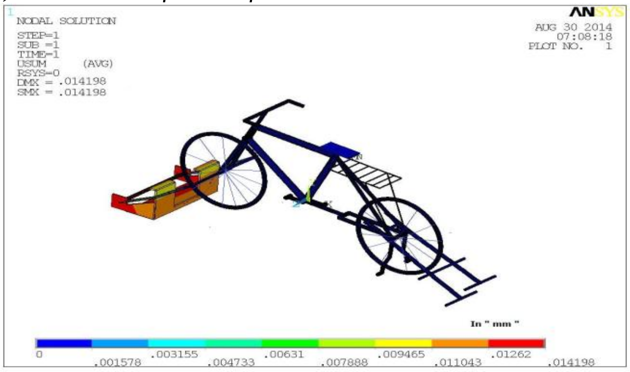

Figure 4: Load Case 1 (Maximum deflection)

The figure 4 shows the maximum and minimum deflection of the frames and beams under load case 1. From the deflection contour, maximum deflection and minimum deflection were evaluated, red color and blue color in the deflection counter indicates maximum and minimum deflection respectively under load case1. From the deflection counter, it is found that induced maximum deflection on the frame and beam are less than the allowable deflection of material of construction. Also, the value of the deflection was very small and is negligible.

(b) Maximum von-mises stresses for Load Case 1

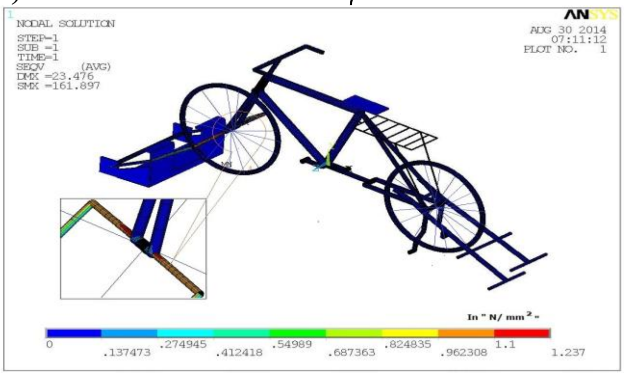

Figure 5: Load Case 1 (Von-Mises stresses)

The figure 5 shows the maximum and minimum stresses on the frames and beams under load case 1. From the stress contour, Maximum Von-Mises stress and minimum Von-Mises stresses were evaluated, Von-Mises stress was chosen for better results. The maximum and minimum stresses are indicated by the red color and blue color stresses respectively under load case1. From the stress contour, it is found that induced maximum Von-Mises stresses on the frame and beam are less than the allowable Von-Mises stress of material of construction and hence the design was safe.

(2) For Load Case 2

Load Case 2 is the total load acting on the model which includes dead load and live load. Dead load is self weight of the structure and Live load is the weight of the person riding the structure. Figure 6 shows the total load acting on the model at the specified points. The required boundary conditions are applied on the model and the model was checked for maximum deflections and maximum stresses using the software.

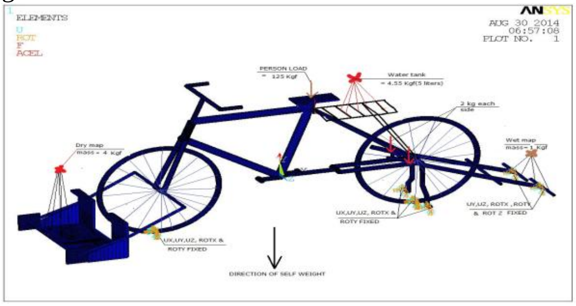

Figure 6: Load Case 2 (Boundary condition applied to the model)

(a) Maximum Deflection for Load Case 2

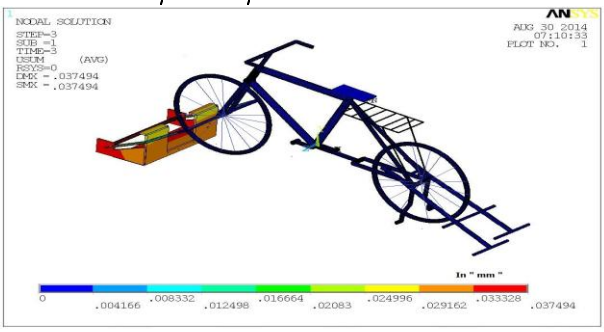

Figure 7: Load Case 2 (Maximum deflection)

The figure 7 shows the maximum and minimum deflection of the frames and beams under load case 2. From the deflection contour, maximum deflection and minimum deflection were evaluated, red color and blue color in the deflection contour indicates maximum and minimum deflection respectively under load case 2. From the deflection counter it is found that induced maximum deflection on the frame and beam are less than the allowable deflection of material of construction. Also, the value of the deflection was very small and is negligible.

(b) Maximum von-mises stresses for Load Case 2

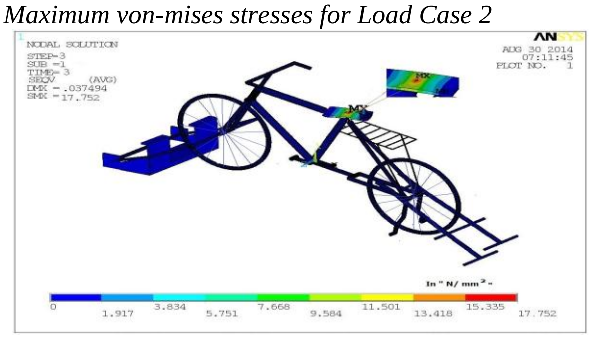

Figure 8: Load Case 2 (Von-Mises stresses)

The figure 8 shows the maximum and minimum stresses on the frames and beams under load case 2. From the stress contour, Maximum Von-Mises stress and minimum Von-Mises stresses were evaluated, Von-Mises stress was chosen for better results. The maximum and minimum stresses are indicated by red color and blue color stresses respectively under load case 2. From the stress contour, it is found that induced maximum Von-Mises stresses on the frame and beam are less than the allowable Von-Mises stress of material of construction and hence the design was safe.

IV. CONCLUSION

Manually operated floor cleaning machine is an alternative for an automated floor cleaning machines during power crisis. Body is pedal operated to achieve dry and wet cleaning simultaneously. Its 2D design was carried out in Unigrahpics tool and by using Ansys tool 3D meshed model is developed according to the required dimensions. Using Ansys tool, 3D model is checked for Deflection, Stresses.

1) Maximum defection and stresses in the frame (dry cleaner) i.e. for total load (dead load and live load), dead load is the self weight of the body and live load is the rider weight over the body. For total load, induced deflection and induced stress were found and these values are small and negligible.

2) For Maximum total load on the beam (wet mop), induced stress and induced deflection were found and these values were small and negligible.

From the above two FEA results induced stress is lesser than the allowable stress therefore design is safe.

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