International Journal on Emerging Technologies (Special Issue on ICRIET-2016) **7**(2): 371-376(2016)

ISSN No. (Print) : 0975-8364
ISSN No. (Online) : 2249-3255

"Simulation, Design and Analysis of Solar Powered Horticulture Intercultivator Equipment"

M. Rajashekar[*] and Dr. S. Mohankumar**
**Research Scholar, Mech. Engg. Dept., MCE, Hassan VTU, Belgaum INDIA*
***Prof. Malnad College of Engineering, Hassan, VTU, Belgaum, INDIA*

(Corresponding author: M. Rajashekar)
(Received 28 September, 2016 Accepted 29 October, 2016)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Horticulture plays a vital role in Indian economy, provides livelihood support to about two-thirds of country's population directly. Solar energy is one of the easiest and most affordable forms of renewable energy for farmers to adopt into their operation. According to the time-consuming, laborious, high-costing traditional design methods for the Intercultivator, this paper studied the main components of a solar powered Intercultivator and obtained its performance parameters after analysis and simulation work on the basis of the modern design methods and tools, including the three-dimensional modelling techniques, finite element method and the virtual prototyping. In the light of the structural characteristics and the actual working conditions of the selected Intercultivator, its three-dimensional solid model and finite element model were established at the beginning, the static analysis, and motion simulation were all done subsequently using CATIA 3D modelling tool and ANSYS Work bench analysis software. The designed Intercultivator tool is fabricated and tested for its working having field efficiency about 86% and weeding capacity was 0.028 ha/hr. It is a best solution of labor problem in the Horticulture farming because a lot of labor is required for removing the unwanted plant/grass from the farm field.

Key word: Intercultivator, CATIA 3D design, virtual prototyping, solar energy, simulation, finite element analysis, Horticulture

I. INTRODUCTION

Manual labour has been an integral part of rural agricultural systems in India for hundreds of years and is still continuing. Due to shortage of electricity and the immediate use of farm equipments, solar energy is effectively used. Neglected and improper weeding reduce the crop yield which varies from 45 to 65 % and in lot of cases whole crop yield may fail.
Intercultivating is the process used to remove unwanted plants to protect the regular crop in respect to soil nutrition's and wetness. Hence the crops may give high yield and more profit to farmer.
Intercultivator Functions are:

- To interculture the soil.
- Remove the unwanted plants in the field.
- To increase Aeration of the soil for higher yields.
- To Preserve moisture content by mulching the soil.
- To sow seeds when it is provided with sowing attachments.
- To avoid surface evaporation
- To encourage rapid infiltration of rain water into the soil.

Farm machine is design is not so easy. Due to invent of innovative CAE tools which consumes less MLT as compared to conventional/ traditional design methods.

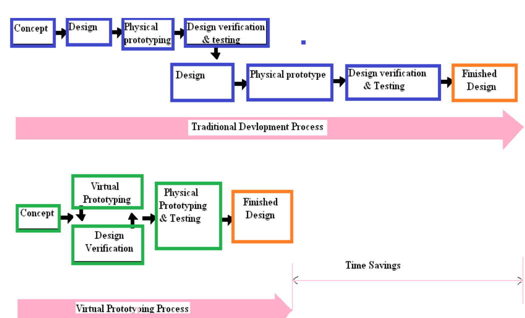


Fig. 1. Traditional and Virtual Design Process.

Structural design calculates the effects of static/steady loadings conditions by neglecting inertia and damping factors, which are dynamic/time varying loads.

A various virtual design tools are Solid Edge, Solid Works, CATIA, Auto CAD, PRO-E Creo, etc., which have different functions used for specific applications. Many CAD tools includes kinematic simulation and structural analysis along with 2D sketches and three dimensional models of the assembled parts /equipments.

Parminder Kamboj [8] elaborates CAD software facilitates future expansion of geometry model by providing flexible options to modify the existing design.

Kaveh Mollazade [5] discusses analysis tool that can be adopted to predict deflection and induced stress distributions on the surface of intercultivator during tillage operations is very much essential for the design engineers and Farm machine manufacturers in producing sustainable machines.

CAD design software tools Mohan Kumar [10]. At present, foreign farm machinery companies have started to use CAD modern technology, while problems such as not precise enough, long design cycle still exist in domestic agricultural machinery companies.

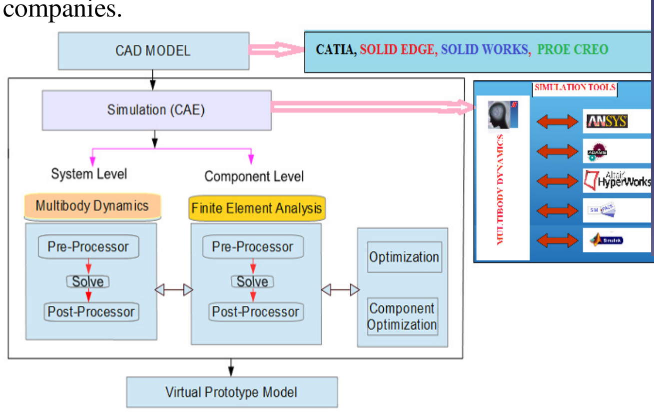


Fig. 2. Simulation and Analysis based design Process.

Ebrahimi [9] ellobrates how zero-till planter opener set was designed and kinematic simulation tested by CATIA tool. Later it is imported in ADAMS software and the behaviour of various parts were investigated in four different conditions. Mohammad Shekofteh explains the soil cutting FEA considering the effect of forward speed, rotary speed and soil moisture content on rate of stress applied to the soil.

II. MATERIALS AND METHODS

Intercultivator is a tool which is used for un wanted plant removal in wide row spacing crops. Intercultivator blades are used to achieve advantages of better weed control and more efficient inversion and trash mixing.

Blades are the main critical parts of rotary Intercultivator, engaged with the soil for weeding operation. These blades interact with soil in different ways than normal ploughs which are subjected to impact and high friction that ultimately creates the unbalancing force on the Intercultivator resulting in wearing of the blades. The design optimization and manufacturing errors can be minimized by the proper design analysis of the components. Especially, the blades have to be reliable in the field performance against the operating forces. Prediction of stress distributions among the blades is important for the designers and manufacturers to optimize the power requirement. Under these circumstances, an engineering analysis of blades used in a Intercultivator was carried out using CAD software and structural stability of blades were analysed using ANSYS software in order to determine the energy requirement and cutting force.

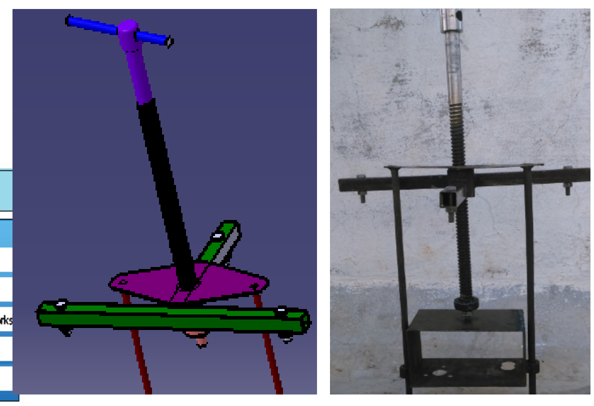


Fig. 3. New Modified Feeding Mechanism.

Table 1: Base Fame Material Properties.

1	Modulus of Elasticity	209 GPa
2	Compressive Strength	2.5e+8Pa
3	Mass Density	7855 kg m^{-3}
4	Co-efficient of Thermal Expansion	1.21e-5 C^{-1}

Table 2: Intercultivator Tool Material Properties.

1	Tool Material	High carbon steel
2	Modulus of Elasticity	1.95e + 11Pa
3	Compressive Strength	2.95e+8Pa
4	Mass Density	7860 kg/ m^3
5	Poisson's ratio	0.27

Table 3: Soil Properties.

Sl.No.	Type of Soil	Soil Resistance Mpa	Soil moisture %
1	Sand Soil	0.215	3.52
2	Loamy Soil	0.346	5.83

Table 4: **Soil Mechanical Characteristics.**

Sl.No.	Properties	Values
1	Density	2000Kg/m3
2	Young Modulus	4.106N/mm2
3	Poisson ratio	0.3
4	Plastic Flow	160e3 N/mm2

To estimate the soil forces that will be acting on the actuation system, a single tine soil dynamics model developed by Godwin and Odogherty [7] was used.

Energy Design Parameters:

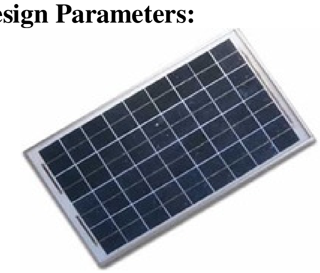


Fig. 4. Solar Plate 40 Watt.

Fig. 5. D.C Motor 12V. **Fig. 6.** Battery 12.8V 7.5Ah.

The electronic circuit designed helps the battery to run the D.C. motor in turn mechanical rotation of Intercultivator bades.

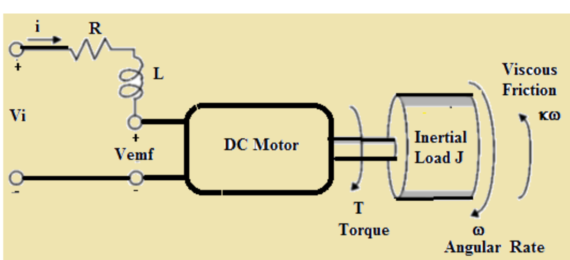


Fig. 7. Energy Model.

The torque of electric motor **T** is given by a product of the armature current, **i,** and torque constant **K**;

$$T = K * i \qquad (1)$$

The back electromotive force V_b, is a function of angular velocity

$$V_b = K^* \omega = K^* d\theta/dt \qquad (2)$$

Power consumed by motor=40 w, Rotational Speed N = 100 rpm, rotor inertia J is assumed to be 0.01 and input voltage Vi=12 volts

Using the following equation=]n we will calculate the value of K ,

$\omega_m = V_t/K = 2\pi N/60$ then We get K= 1.146 and ω=10.47 rad/sec

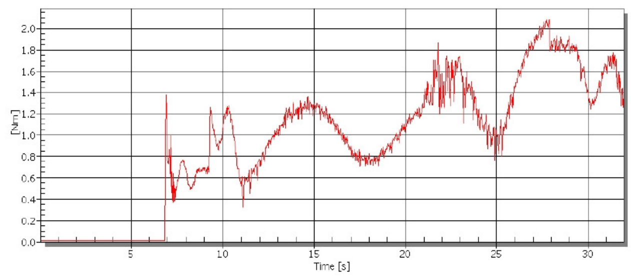


Fig. 8. Torque- Speed Characteristics.

.Solar battery 12.8v, 7.0 Amp can power a 20 watt for a theoretical maximum of 5-6 hours. The 30 Watt solar panel will be able to fully charge the battery in about 3-4 hours, which means it should be capable of charging the battery fully on a regular basis. I can select a slightly greater solar panel such as the 40 W.

Power consumption by Intercultivator motor:

Drive Motor Voltage (V): 12v
Expected current draw (I): 1.1 amps
% of Time Motor used (T): 100
Total Power consumption by motor: (V * I) *T= 13.2 watts

From the above data we can see that it takes Solar Powered Intercultivator, work around 5-6 hours.

Working Mechanism: The intercultural blades tap power from the geared Direct Current powered motor with 100rpm. The rotating blades continuously remove the unwanted plants and the Intercultivator is propelled forward with help of manually. Depth of intercultivating is adjusted by means of the screw and nut mechanism with the help of the screw rod.

Design Considerations: When soil-acting mechanical weed-control implements are used, the soil is subjected to cutting or shear forces which cause it to fail and disintegrate. The parameters which influence a soil's resistance to this failure are its cohesion and internal friction, by the angle of internal friction .$R_{ma} = cA_s + W \tan\alpha$ ....(3)

Where: R_{max} = Shear force
A_s = C/s area of soil sheared
W = Normal loading on the soil

The angle of soil attack is around 15-16° is ideal to lift and separate the unwanted plants from the soil.

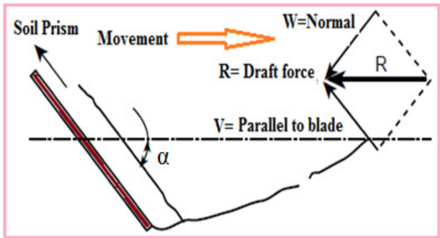


Fig. 9. Forces acting on Blade.

a) This Equipment will target small scale vegetable farms, which means that the work rate will be lower compared to larger, bulkier machinery targeting large scale production.
b) An effective weeding mechanism should be able to uproot, bury and cut weeds at the same time.
c) The working diameter of the weeding mechanism should be as small as possible to operate within the crop row.
d) The weeding mechanism should not be required to work at a depth more than 20-30 mm because early growth stage weeds have not penetrated deeply into the soil.
e) The average draft power availability in sustained working from male agricultural worker is consider as 60Watts while for a women it is consider as 48Watts. Development of equipment which allows different categories of tasks: Removal of weeds, aeration of the root zone, creating soil mulch, spray the Pesticides or liquid fertilizers on the vegetables, fruits, seeds, washing /cleaning and also part of that energy is stored in the form of battery which may be further utilized by using other attachments.

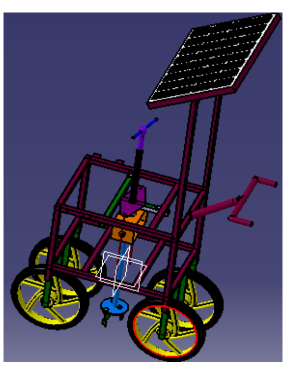
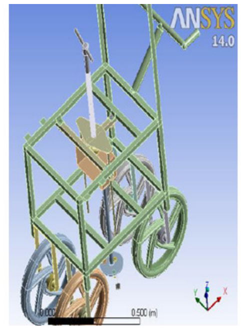


Fig.10: CATIA Model **Fig.11.** Fabricated .Model.

Analysis of Base Frame: The 3D model of rotary Intercultivator blades were designed in CATIA tool . Then it is exported as tool.igs file to the analysis software Ansys work bench.



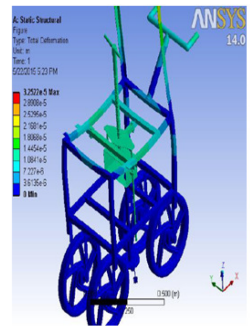
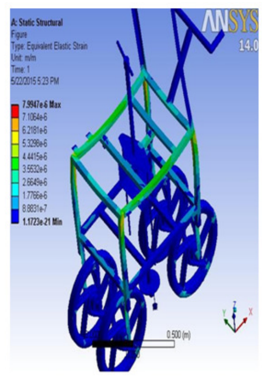


Fig. 12. Imported Ansys Model. **Fig. 13.** Total Deformation.



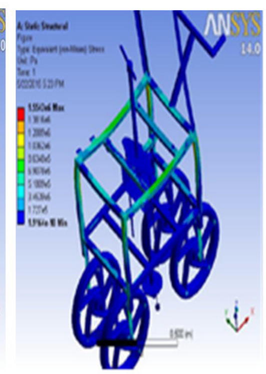


Fig. 14. Equivalent Elastic Strain. **Fig. 15.** Equivalent Stress.

The stress variation in the interface area of the blade was indicated from colours varying from blue to red respectively in a contour plot were shown in Figure 16.

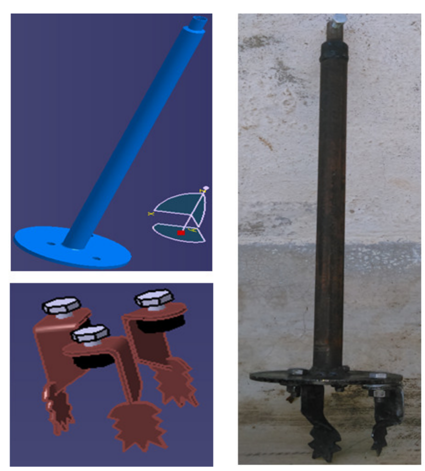


Fig. 16. Intercultivator Tool CAD Model and Fabricated Tool.

It was seen that, the extreme values of principal stresses for base frame were found to be 1.55e6Pa from 1.9e-10Pa respectively with a total deformation of 3.25e-3 cm. The induced stress values were less then design yield strength of the material.

Analysis of Intercultivator Tool: The Intercultivator tool is designed by considering various methods used in Intercultivator process earlier. the tools are mounted on a disk of diameter 5 inch . there are three tools and placed in a portion such that it covers the area of 178 mm diameter and also covers the inside area of the disk. The tools are attached with the nut bolt so that it can be changed easily in case of breaking the tool**.** The feeding mechanism is used to feed the tool up and down. It consist of a screw rod inserted into a threaded hole and the movement of the screw rod gives the movement to the tool. The motor housing is also attached in the feeding mechanism and the screw rod is connected through the motor housing by using bearings which provided a free movement to the end of the screw rod while moving up and down.

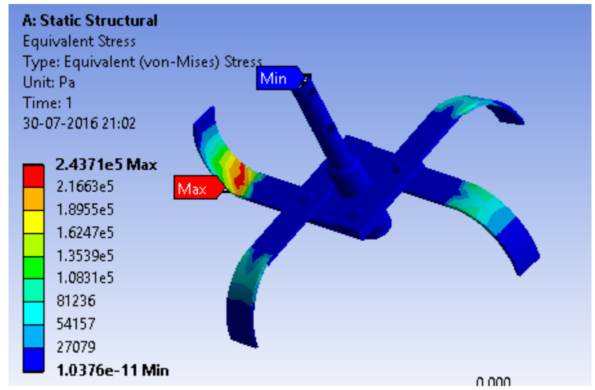


Fig. 19. Von-Misses Stress Modified Blade.

It was observed that, extreme values of principal stresses for Intercultivator were found to be 1.085e9Pa and 0.42e3Pa and a total deformation of 6.38mm. The induced stress values were very less than the yield strength of the material. Hence, the modified blades are important for an effective Intercultivator.

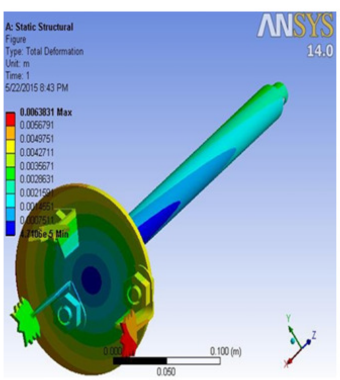


Fig. 16. Total Deformation

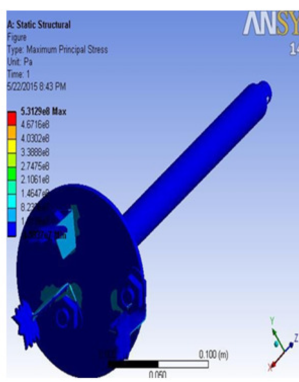


Fig. 17. Maximum Principal Stress.

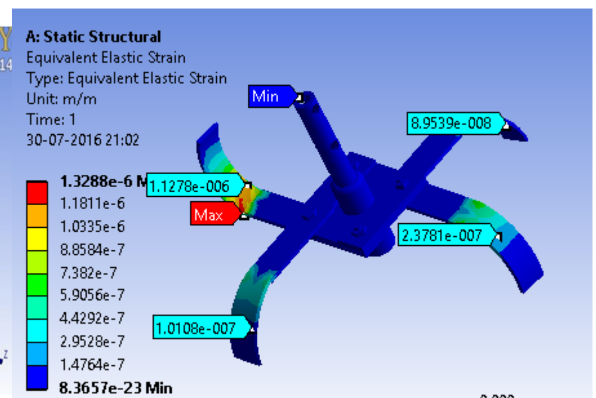


Fig. 20. Equivalent Strain Modified Blade.

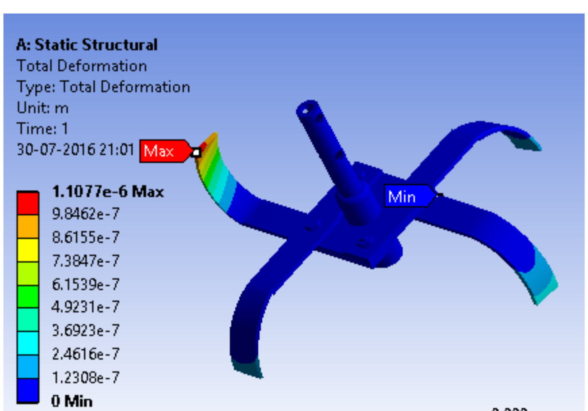


Fig. 18. Total Deformation Modified Blade.

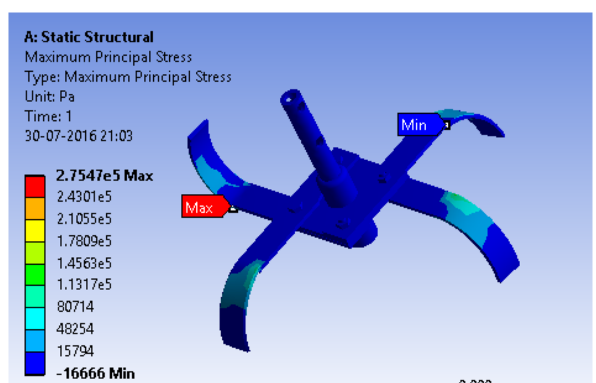


Fig. 21. Equivalent Strain Modified Blade.

CONCLUSIONS

The CAE tool for design of rotary Intercultivator blades on the basis of FEA was carried out using CATIA and Ansys work bench. Hence, the blades designed and selected for the study could be adopted for the development of an effective sustainable Intercultivator. A solar powered Intercultivator was designed, fabricated at college workshop and tested on a test field. The main components of the Intercultivator were: a 40W solar panel, D.C. motor, three sets of Intercultivating blades, main frame and ground wheels. The overall width, length and height of the machine are: 0.609m *X 0* .457m and 0.85 m respectively. Field efficiency was found to be 86% and weeding capacity was 0.028 ha/hr. The cost of fabricated the model was estimated at about Rs 15,000/-. If we go for mass production, it would cost less thus making it sustainable for poor farmers.

The machine designed here utilizes the solar energy in place of conventional fuel. In villages peoples are facing fuel shortage and also unavailability of required power supply. Deeper working depth and a slow travel speed can achieve good weed control. Therefore, it is very important to consider these two factors to achieve good weed control effect. By reducing the drudgery and hectic work of farm operators, we can reduce the migration of rural labours to urban areas, greatly helping the national cause of arresting undesirable population movement.

REFERENCES

[1]. Gopal U Shinde, Shyam, R. and Kajale, (2011). Computer aided engineering analysis and design optimization of rotary tillage tool components, *Int. J. Agric. & Biol. Eng.,* **4** (3): 1- 6,

[2]. Wang Hongli,(2012) No-tillage planter's stubble breaking device modeling and finite element analysis of the disc, The 2nd International Conference on Computer Application and System Modeling, 65-68.

[3]. Cloutier, D. C., R. Y. V. D. Weide, A. Peruzzi, and M. L. Leblanc. (2007) Mechanical weed management. In Non-Chemical Weed Management. Upadhyaya, M. K. and R. E. Blackshaw, ed. 111-134. CAB International.

[4]. Gopal U. Shinde, J.M. Potekar, R.V. Shinde, Dr. S.R. Kajale " (2011), Design Analysis of Rotary Tillage Tool Components by CAD-tool: Rotavator" International Conference on Environmental and Agriculture Engineering IPCBEE vol.**15** Singapore.

[5]. Kaveh Mollazade, Ali Jafari and Ebrah Ebrahimi,(2010) Application of Dynamical Analysis to Choose Best Subsoiler's Shape using ANSYS, *New York Science Journal.* **3**(3): 93-100, 20.

[6]. Gurusamy, T. (1988). Effect of blade shapes on the performance of blade hoe. *Agricultural Engineering Today,* **12**(2):25-27.

[7]. TajuddinA; Job TV.(1997). Min tiller for weeding and interculture. The Hindu dated October 2: 28.

[8]. Parminder Kamboj, Amarjit Singh, Mahesh Kumar and Salam Din, (2012) Design and development of small scale pea depoding machine by using CAD software, *Agric.Eng. Int: CIGR Journal,* **14** (2): 40—48,

[9]. Ebrahimi, E. and Ranjbar Malekshahi, M.(2012) Dynamic analysis of opener set of planter, *J. Basic. Appl. Sci. Res.*, **2**(3):2674-2679..

[10]. Rajashekar M, V K Heblikar S.Mohan Kumar,(2014)" Simulation and Analysis of Low Cost Weeder", *International Journal of Research in Engineering and Technology* Volume: **03** Special Issue: 03, p 543-549

[11]. Dr. S. Mohan Kumar (2008) "Virtual Prototyping Technology - An Aided Design for Product development" International conference on Total Engineering, Analysis and Manufacturing Technologies at TEAMTECH -2008, 22-24 September 2008, at IISC, Bangalore.

[12]. Rajashekar M, Ashok, Anita," Multibody Dynamic Analysis Of Mechanism For Health Exercise Vibrator" *IJRET: International Journal of Research in Engineering and Technology* Volume: **03** Special Issue: 03, p 550-553 May-2014.