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CPR (Cardio-Pulmonary Resuscitation) Machine For Medical Assistance

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Abstract: Various research publications and technical documentation are reviewed to conclude information and the best possible methods/techniques for making an effective CPR Machine. Different human trials were also studied along with their outcomes to understand the efficiency of CPR Machines. Biological terminologies and information related to Cardiac Arrest were also taken into account in our study.

Keywords: CPR, Cardio Pulmonary Resuscitation, Cardiac Arrest, human body, Force, Chest

1. INTRODUCTION

The term "CPR" usually refers to "Cardio Pulmonary Resuscitation," which involves putting compressive force outside the chest area of the human body, whether by hand (manually) or by machine(automatically), to immediately restore breathing and blood circulation of the body affected by Cardiac Arrest. Cardiac arrest happens to a body while sleeping or awake due to sudden heart failure, which dampens the proper pumping of blood, resulting in loss of blood flow. The anatomy of the "Heart" also came under review. Our "Cardiac Machine" project strongly focuses on UN SDG #3, "Good Health and Well-Being."

2. BACKGROUND STUDY

Initially, we started reviewing CPR provided to human bodies by Trained CPR Providers and Non-Professional Adults. The study showed a stark contrast in results, with CPR provided by untrained adults being less effective due to lesser force exertion along with wrong arm angle. It was also understood as per AHA Standard, a chest displacement of 1.5-2 inches would be necessary. [1], [2]

The scatter plots of force Exerted vs. Subject Weight helped us determine the patterns showing the difference in CPR providers' efficiency and varying subject weight. It also helped deduce that only 9% of Non-Professional Adults can exert more force excessively than their body weight. The cost of automatic CPR Machines is a significant concern that needs to be addressed in our findings. We will be using a camshaft mechanism along with a belt-driven chain for our CPR Machine. [3]

In contrast, we studied literature about Piston-Based Chest Compression CPR device, which also has its own merits and deficiencies. We have also learned the scope of applications for CPR machines such as in Helicopters or Ambulances. Diversity was observed while studying possible electromechanical actuators or sensors that reflect design can be more innovative than current ones. The other components required for CPR Systems, such as GUI Monitoring Interface, were also understood and the possible software used. Both Open and Closed-Loop mechanisms for CPR Machines were briefly reviewed. The purpose of using a load cell and potentiometer pre-and post-design was also understood. [4]

Various medical studies exhibit amplitude of blood pressure attaining normality by chest compression devices and better psychological outcomes when there is cardiac arrest for an extended interval. [5] A case study which was conducted in Australia to assess the effectiveness of CPR Machines in ambulances operating in urban, rural or mixed setting had findings which indicated that there is a need for sufficient training of medical workers, house members and other staff to provide CPR effectively through both machines or manually specifically in rural area settings. [6]

CPR machines can sustain the rate of compression and distance, which is reciprocal of compression barriers accurately. However, the importance of manual CPR still overweighs the importance of CPR given by various machines. [7]
According to American Heart Association, the chest should be compressed at the rate of 100CPM by the CPR Provider and should be sustained until the victim regains normality. [8]

CPR Machines were also tested on animal subjects, including pigs, which showed the machine's mechanical impedance change on prolonged compressions. The behavior of the thorax area was also studied in findings. The effectiveness of CPR Systems on Out Hospital Patients was studied through a wide variety of data reported by various medical and statistics-related agencies. The findings conclude that demand for CPR Machines outside of the hospital vicinity increases each year due to various factors. [9]

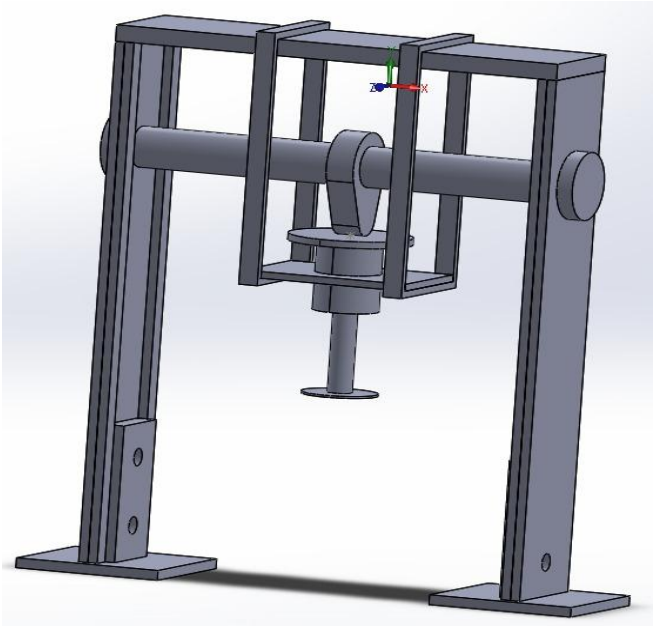
3. METHODOLOGY

Our project work was done in the following manner:

A) Proposal of the project keeping in mind shared goals of group members and their relation with relevant SDG's
B) Creation of Gantt Chart to properly implement our working direction for this project
C) Market survey for our project accessories and materials afterward purchasing the relevant stuff
D) Research Paper Started from this stage.
E) Design building in both university workshop and working spaces at home
F) As a team, we used conflict resolution to resolve any design building error or misunderstanding between members related to design.
G) Designs available on the internet examined and further decided with which one to go-ahead

	February 21	March 21	April 21	May-June 2021
Proposal & Design				
Research Work				
Market Survey and Purchasing				
Design Building				
Presentation & Finalization				

Table 1



I. CAD DESIGN

Fig 1: CAD Model

The camshaft mechanism is used in this project. A high torque speed motor drives the shaft. The shaft in the camshaft is made of PVC pipe. Both motor shaft and camshaft are connected with the help of an aluminum circular block placed inside the PVC pipe. The 4.5mm shaft of motor is placed easily inside the circular block, and the headless screw is used to ensure the motor position is made fixed.

The follower is designed concerning the motion of the cam. The follower is pushed by the camshaft when driven by the motor, the follower compresses the chest at 2 inches, and it comes back up with the help of spring.

Extensions are also provided so that CPR could be placed correctly according to body type.

The switch is used to vary the speed for the adult and child victims. An Arduino runs the whole system to control motor speed.

In fabrication, except for the follower, the whole project is done through laser cut with a thickness of 6mm per part. The whole project is 285*400 mm.

II. RESULTS

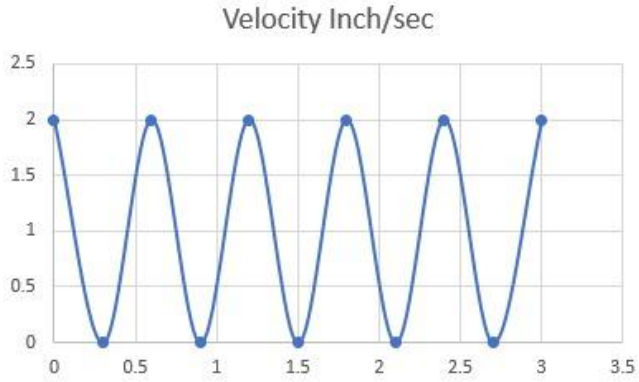


Fig 2: Motion Analysis

The graph is showing the compression of the model. CPR requires 120 compressions per minute, which is shown from this graph that this model is following the compression per minute ratio accurately.

Stress Analysis is done on the follower part of the CPR.
Stress Analysis is done according to both adults and children.
Adult force is 10.3N.
Child force is 3.2N

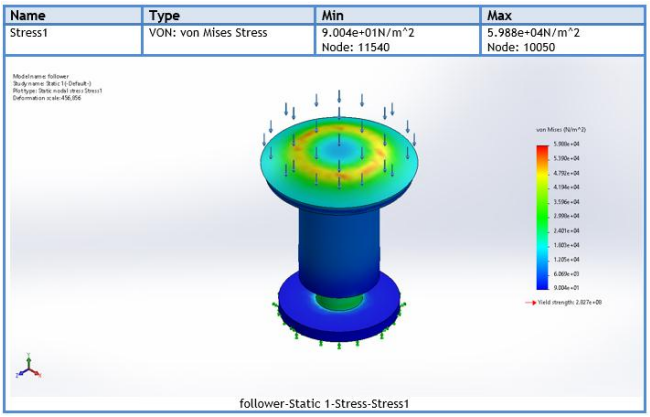


Fig 3: Stress Graph of Moving Piston for Adult

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00mm Node: 1	2.145e-05mm Node: 406

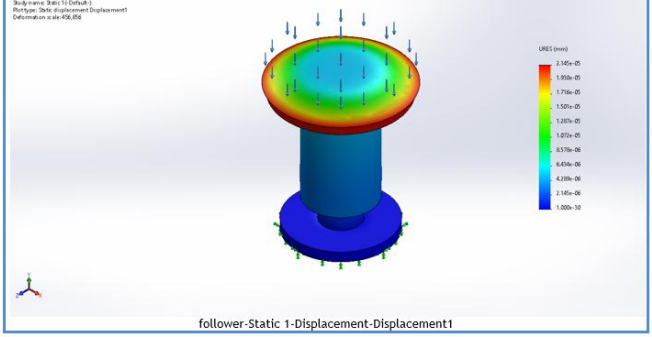


Fig 4: Displacement Graph of Moving Piston Adult

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	4.483e-10 Element: 2077	2.050e-07 Element: 7233

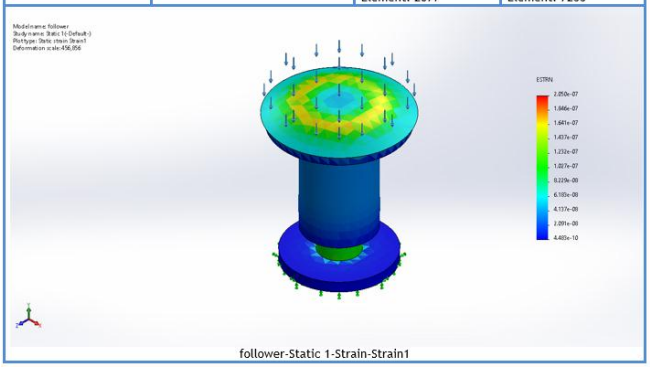


Fig 5: Strain Graph of Moving Piston Adult

Name	Type	Min	Max
Factor of Safety1	Automatic	4.721e+03 Node: 10050	3.140e+06 Node: 11540

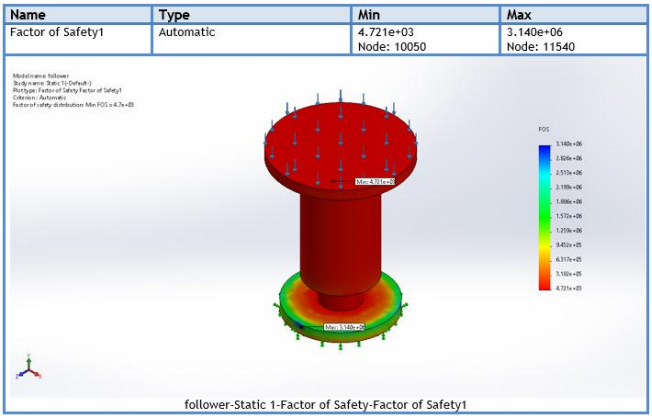


Fig 6: Factor of Safety Graph of Moving Piston Adult

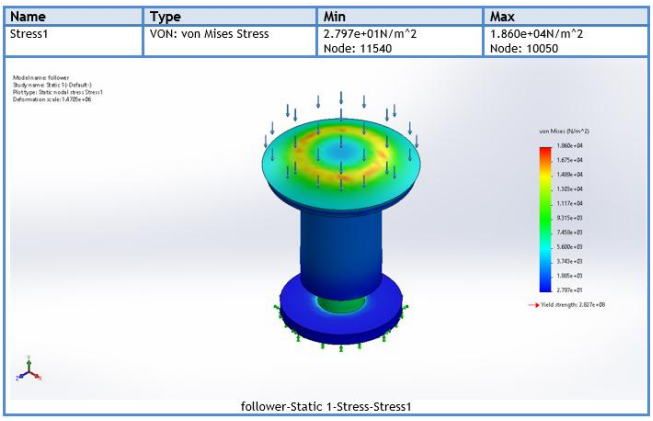


Fig 7: Stress Graph of Moving Piston for Child

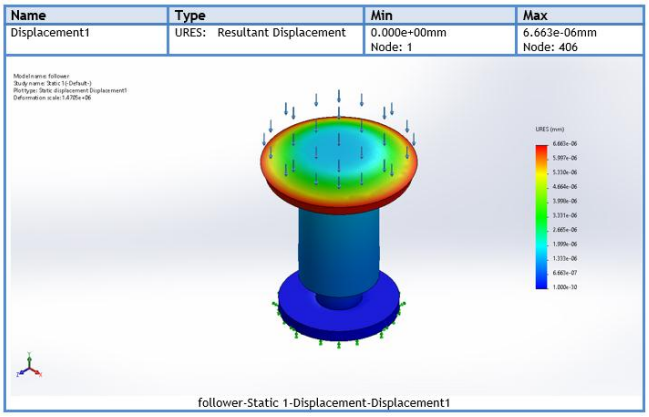


Fig 8: Displacement Graph of Moving Piston for Child

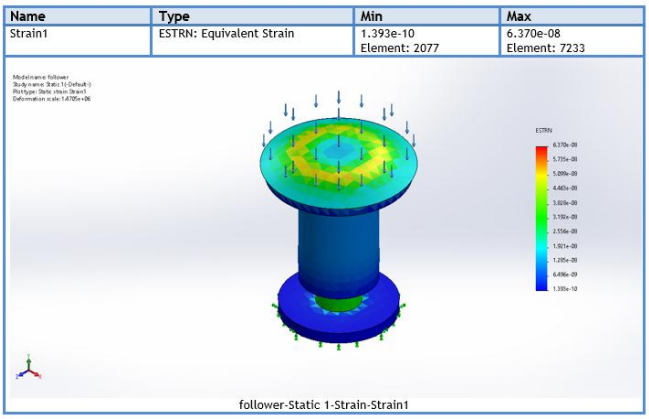


Fig 9: Strain Graph of Moving Piston for Child

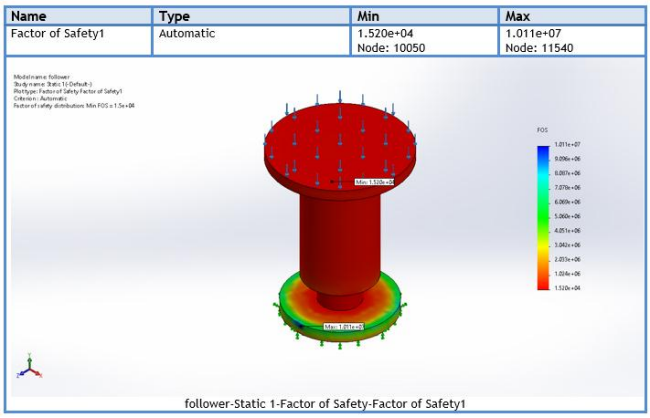


Fig 10: Factor of Safety Graph of Moving Piston for Child

The Following graphs shown the stress analysis on Adult and Child Force required for CPR.

4. CONCLUSION

Profile of Cam and Follower Mechanism should be chosen based on the size and working capacity of CPR Machine and its application. There is a need for more data from medical records and restrictive research material to maintain equilibrium compression force for patients' varying body types and ages. CPR Experts should also be surveyed about their experiences while working. Besides our project, we also studied different research studies carried out on victims manually and by machines. It is recommended to go for manual CPR in those studies compared to waiting for a few minutes for machine CPR to arrive. Our project mainly targets Sustainable Development Goal # 3, which is health and well-being, but it also targets other SDG indirectly. Motor RPM of CPR Machine should be regulated as per the requirement of patient or victim Different type of materials was incorporated in our project like acrylic, metal, wood, etc. as the need arises.

5. REFERENCE

[1] L. A. Geddes, M. K. Boland, P. R. Taleyarkhan, and J. Vitter, "Chest compression force of trained and untrained CPR rescuers," *Cardiovasc. Eng.*, 2007, doi: 10.1007/s10558-007-9029-5.

[2] I. Amin and A. Saeed, "5.10 Wireless Technologies in Energy Management," in *Comprehensive Energy Systems*, Elsevier, 2018, pp. 389–422.

[3] P. A. Jennings *et al.*, "An automated CPR device compared with standard chest compressions for out-of-hospital resuscitation," *BMC Emerg. Med.*, 2012, doi: 10.1186/1471-227X-12-8.

[4] H. Shirzadfar, "Heart beat rate monitoring using optical sensors," *Int. J. Biosens. Bioelectron.*, 2018, doi: 10.15406/ijbsbe.2018.04.00097.

[5] P. A. Kahn, S. S. Dhruva, T. G. Rhee, and J. S. Ross, "Use of Mechanical Cardiopulmonary Resuscitation Devices for Out-of-Hospital Cardiac Arrest, 2010-2016," *JAMA Netw. Open*, 2019, doi: 10.1001/jamanetworkopen.2019.13298.

[6] C. Remino, M. Baronio, N. Pellegrini, F. Aggogeri, and R. Adamini, "Automatic and manual devices for cardiopulmonary resuscitation: A review," *Adv. Mech. Eng.*, 2018, doi: 10.1177/1687814017748749.

[7] D. Y. Lee, S. M. Kang, and S. W. Choi, "Utility of CPR Machine Power and Change in Right Atrial Pressure for Estimating CPR Quality," *Sci. Rep.*, 2019, doi: 10.1038/s41598-019-45749-0.

[8] P. S. Sebastian *et al.*, “Closed-loop machine-controlled CPR system optimises haemodynamics during prolonged CPR,” *Resusc. Plus*, 2020, doi: 10.1016/j.resplu.2020.100021.
[9] M. James Clerk, *A treatise on electricity and magnetism*. 2010.