International Journal of Engineering, Science and Mathematics
Vol. 7 Issue4, April 2018(special issue NCIME)
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijesm.co.in, Email: ijesmj@gmail.com Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

DESIGN AND ANALYSIS OF ROCKER BOGIE SUSPENSION FOR VOLCANO EXPLORATION AND EVALUATED THE PERFORMANCE USING PROTOTYPE

Indhusekaran.N ,Abinesh.R ,Chandramouli.M,Dhinesh Kumar.R ,Dhivagar.V

[1] Head of the Department, [2]UG Scholars, Department of Mechanical Engineering,
TRP Engineering College, Trichy

Abstract— Earth holds many systems, Volcano is the important one, which act as door to the internal workings of the planet. There are many active volcanoes in the world which cause devastating destruction to lives, homes, and infrastructure on the act of eruption. During, the eruptive phenomena the volcanologist has to work close to the vents it is more hazardous to their life .so, it can be replaced by robots. The terrain of the volcano is the main challenge to the robot. It can be successfully overcome by implementing rocker bogie suspension system on the rover. We developed a conceptual design along with dimensions considering actual working, using solid works software .The rover is also analyzed for the temperature stability and structural stability with the selected material using ANSYS software and the outcomes are studied. The conceptual model is operated in real-time using the prototype. It is operated using motor drivers, Arduino controller and arm actions are manipulated. The proposed system is also compared with the existing system.

Key words: Volcanologist, Rocker bogie suspension, Solidworks , ANSYS, Prototype, Arduino controller

I. INTRODUCTION

Volcanoes are a key part of the Earth system, and open a window into the inner workings of the planet. More than a dozen volcanoes are usually erupting on Earth at any given time. Some of these eruptions are devastating, killing people, damaging homes and infrastructure, altering landscapes, and even disrupting climate. There are many development in volcanic study, over the erupted area is important, it is achieved by appointing experts, which is very hazardous to their life so robots can be replaced here. Mobility robot enforced with suitable devices is preferable one.

Volcanic terrain is one of the worst outdoor environments that can be found for a robot: rocks, steep slopes, very fine ash sand, this can be avoided by providing rocker bogie suspension design. NASA and Jet Propulsion Laboratory have jointly developed a suspension system called the rocker-bogie Suspension system. It is basically a suspension arrangement used in mechanical robotic vehicles used specifically for space exploration.

NEED AND MOTIVATION FOR THE SELECTION OF THE PROJECT

Since most volcanoes are not actively erupting when they are being climbed, most people that fall into them die from the impact and/or tumble of the fall. Some die from the toxic fumes, and some die from dehydration.

Whether inside a crater or not, people who die due to volcanic processes near an active vent usually die of fumes or heat or chunks of rock (lava bombs) falling on their heads, rather than from touching the lava. The famous volcanologist couple, Katia and Maurice Krafft were killed in a pyroclastic flow, the same sort of event that took out Pompeii. Pyroclastic flows and lahars (mudflows) are the deadliest volcanic hazards because they travel quickly and can reach 10s of kilometers from the erupting vent.

Fig : Volcanologist collecting sample

Boiling mud and toxic fumaroles are also a serious hazard, even when a volcano isn't actively erupting. There are so many easy ways to die before making it into an actively erupting volcanic vent!

To avoid these kind of accidents the considerable development in the robotic study to put their hand to uplift the hazards faced by the volcanologists.

METHODOLOGY

Scientists use a range of different methods to learn more about volcanoes. A volcanologist may start by conducting fieldwork, collecting rocks and samples, and then move into the lab to undertake detailed analysis. The combination of data from all this research will be combined to form a detailed picture of the volcano being studied.

Fieldwork methods can include:

- Surveying
- Collecting Rock Samples
- Drilling Core Samples
- Seismic Monitoring
- Gas Monitoring
- Ground Deformation Monitoring.

These techniques can reinforced in a mobile robotic platform which provided with Rocker Bogie suspension is used for the exploration purposes.

OBJECTIVE OF THE PROJECT

A major aim of this project is to minimize the risk to volcanologists and technicians involved in work close to volcanic vents during eruptive phenomena. It should be noted that observations and measurement of the variables relating to volcanic activity are of greatest interest during paroxismal phases of eruptions, which unfortunately are also the periods of greatest risk to humans.

Volcanologists have identified that a volcano exploration robot should be able to carry out a number of key operations, the most important being the ability to:

- Approach an active volcanic vent
- Collect samples of volcanic eruption products
- Collect other physical and chemical data
- Survey close to vent openings

Volcanic gas is quickly contaminated by the atmosphere and is thus empirically worthless to collect for analysis far from the eruptive vent. As this environment is extremely dangerous for humans this is a task suitable for a robust rover robot which can collect more reliable samples and data, close to their volcanic source.

Sites of interest include lava flows, ash and spatter cones and large ground fractures; in general these surfaces are very rough and disconnected and occur close to, or inside, volcanic craters. The ground often has a steep gradient and unstable surface due to loose rocks and sliding materials, therefore the robot needs a sophisticated assembly to move safely and surely. To pursue these needs rocker bogie suspension holds the great deal.

II. PREVIOUS ROBOTIC PROJECTS ON VOLCANOES

Dante II is a multi-legged frame walking robot designed by NASA and Carnegie Mellon University to investigate live volcanoes and test robotic technology (Bares & Wettergreen,1999). The robot is a frame-walker with eight pantographic legs arranged in two groups of four, on inner and outer frames. A tension-controlled tether was connected to Dante II, to maintain stability and to allow rappelling on steep slopes. In 1994 Dante II underwent a trial exploration of Mount Spurr volcano in Alaska. For more than five days the robot explored alone in the volcano crater using a combination of supervised autonomous control, and tele-operated, control. The robot travelled one-quarter of its 165-m descent autonomously, relying only on on-board sensors and computers to plan and execute its motion. The terrain was very rough including crossing 1-m boulders on ash-covered slopes, navigating areas of deep snow, ditches and rubble. The robot measured the gas composition of several large fumaroles vents. However while climbing out of the crater, Dante II lost stability and fell on its side thus ending its mission. The Dante II/Mt. Spurr expedition was considered a success because of the amount of data and experience that was accumulated. This trial gave NASA valuable experience in determining what improvement considerations would be needed for future robotic missions. There are instead several examples of robot that have been designed for planetary exploration and that have been tested on volcanic sites (Guccione et al., 2000). In fact there are many similarities between volcanic terrain and many planetary sites.

It is important to observe that not one of these robots has been totally developed in an EC country. An important example that can be cited is the Marsokhod Planetary Rover. The Marsokhod rover is an all terrain vehicle developed by the Mobile Vehicle Engineering Institute (VNIITransmash) in Russia for 502 planetary exploration(Kemurdjian et al., 1992). The chassis (100cm wide, 150cm long, 35kg unloaded mass) consists of three pairs of independently driven titanium wheels joined together by a three degree of freedom passively articulated frame. This design enables the rover to conform passively to very rugged terrain. The amplifiers, motors and batteries are mounted inside the wheels to provide a very low centre-of-gravity. The robot can travel at speeds up to 12 cm/sec and can traverse obstacles up to 30 cm high and slopes up to 45°. The duration of operation with batteries is approximately 6 hours. The Marsokhod robot, originally designed for Mars exploration, has been extensively tested in volcanic environments such as in Kamchatka, Russia (1993), Amboy crater in California (1994) and Kilauea Volcano in Hawaii (1995). Kilauea Volcano was selected primarily for its great diversity of geological features similar to those expected on Mars and the Moon.

As an example of flying vehicles tested on volcanic environments, a Yamaha RMAX helicopter has been involved in a project for the surveillance of the Mt. Usu Volcano in the Hokkaido region of Japan. For this purpose a special version of the unmanned helicopter RMAX has been developed. Due to the large distances of operation an autonomous flight system has been developed and the cruise autonomy of the helicopter increased to 4km. In April 2000 the helicopter, equipped with four CCD cameras, was successful in performing several surveillance missions observing the hazards caused by volcanic sediment and debris flow (Yamaha, 2000).

A Robot for Volcano Exploration is the name of a project funded by the European Commission, whose activities started in 2000. The main purpose of the ROBOVOLC project has been the development and trial of an automatic robotic system to explore and perform measurements in a volcanic environment.

III. CALCULATIONS

DIAMETER OF THE WHEEL

$V = \pi DN / 60$

Assumed velocity will be 1m/s i.e. 1000 mm/s

Therefore,

$1000 = \pi DN / 60$

DN =19098.5

Table : Dia of wheel

D(mm)	N(rpm)
50	382
100	191
150	127.3
200	95.5
250	76.4
300	**63.66**

So the selected D-N combination is-

D=30cm D- Diameter in mm

N=64rpm N-Speed in rpm

BOGIE AND FRAME CALCULATION

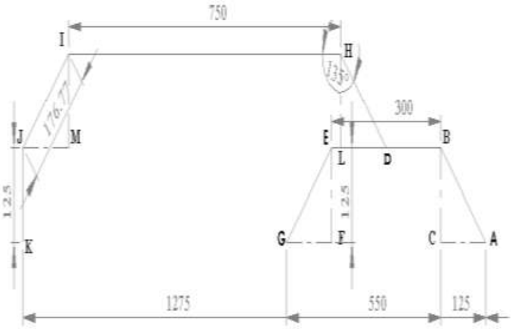


Fig : Line diagram

Bogie Length=550mm

Total length of the vehicle=1275mm

Let as assume θ =45◦

In triangle BAC,

Angle BCA =90◦

Angle ABC =Angle BAC=45◦

Therefore,

AC =BC

AC^2+BC^2 $=AB^2$ ………….(1) (Pythagoras theorem)

AB^2 $=2(BC)^2$

$=2(125)^2$

=31250

Therefore,

AB =176.77mm

Now due to symmetry,

Triangle GEF,

EF=GF =125mm

BD =150mm

Length of the bogie= BD+DE+AC+FG

=2(BD)+2(AC)=2(125)+2(150)

AG =550mm

In triangle GDH,

angle HLD =90◦

DL^2+HL^2 $=DH^2$ …………… (Pythagoras theorem)

$2(DL)^2$ $=DH^2$

DH^2 $=2(125)^2$

DH =176.77mm

Now, due to symmetry,

International Journal of Engineering, Science and Mathematics
Vol. 7 Issue4, April 2018(special issue NCIME)
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijesm.co.in, Email: ijesmj@gmail.com Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

IM=JM=125mm

JK =IK-IM

=250-125

=125mm

Therefore,

JK =125mm

HEIGHT CALCULATION

Height =IM+JK

=125+125

IK =250mm

Net height

=IK+ Wheel Radius

=250+150

=400mm

WHEEL BASE CALCULATION

WHEEL BASE CALCULATION

tan α =AB/BC

=600/1575

tan α=.381

α =20.854

Width of the stair is 1575mm, so the maximum length of the rover can be 1575mm.

To deduce the wheel base ,

= total length – (radius of the front wheel +radius of the rear wheel)

=1575-(150+150)

=1575-300

=1275mm

IV. DESIGN MODELS

SKETCH DIMENSIONS

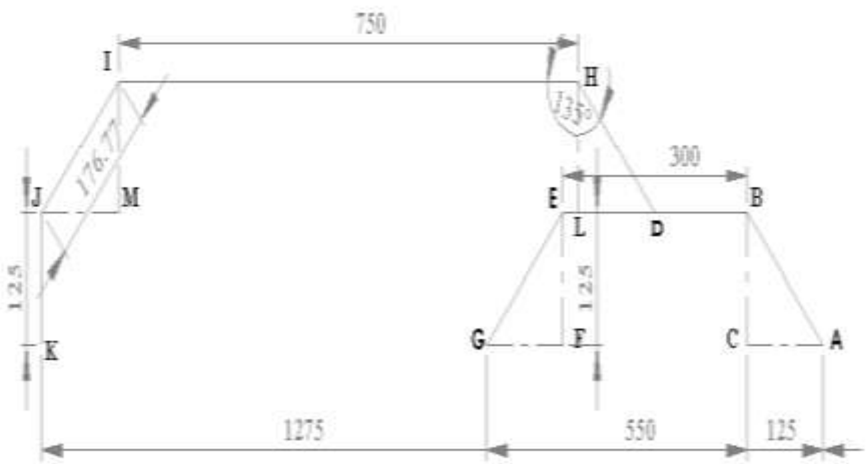


Fig : Line diagram

SECTIONAL VIEW OF ROVER PLATFORM

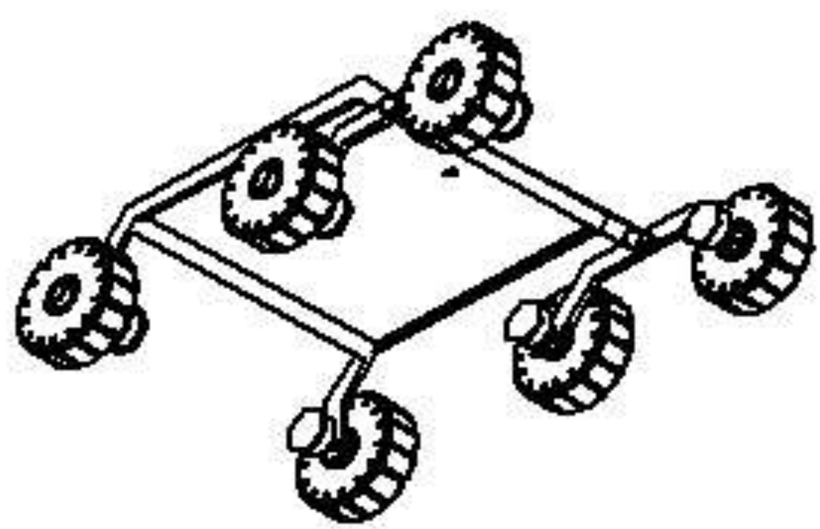
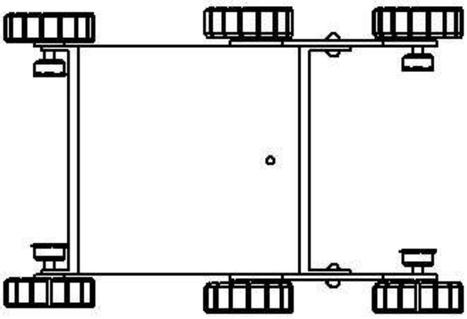


Fig (a): Isometric view



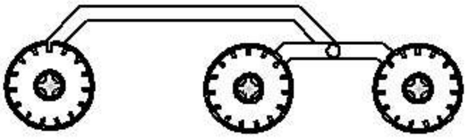


Fig (b): Top view and front view

3D VIEW

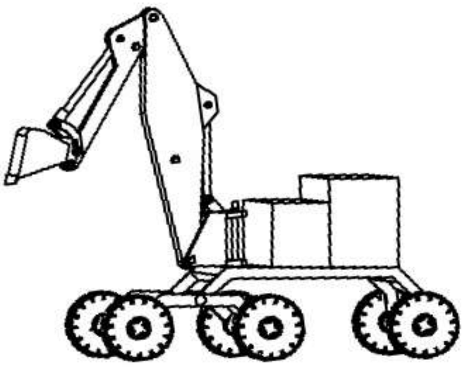


Fig (a): 3D view 1

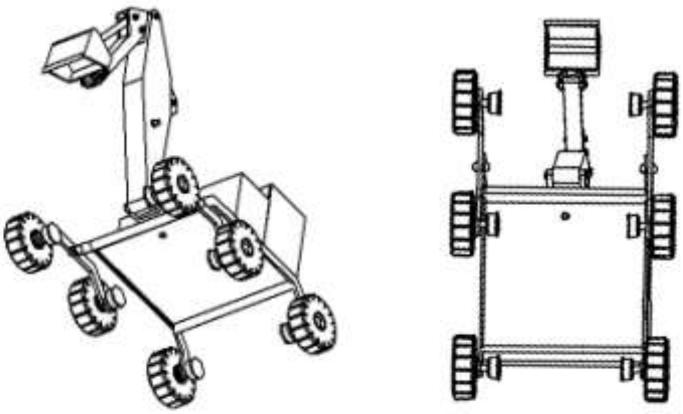


Fig (b): 3D view 2

MODEL

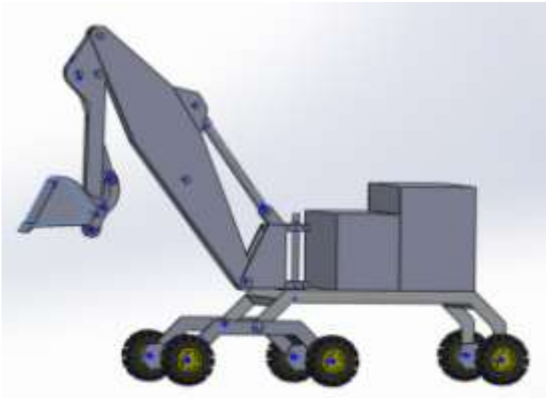


Fig (a): Model View 1

Fig 6.4(b): Model view 2

International Journal of Engineering, Science and Mathematics
Vol. 7 Issue4, April 2018(special issue NCIME)
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijesm.co.in, Email: ijesmj@gmail.com Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

The above models are created using the Solid works software based on the dimensions which are calculated for the basic mechanism requirements .

V. ANALYSIS REPORT

STATIC STRUCTURAL

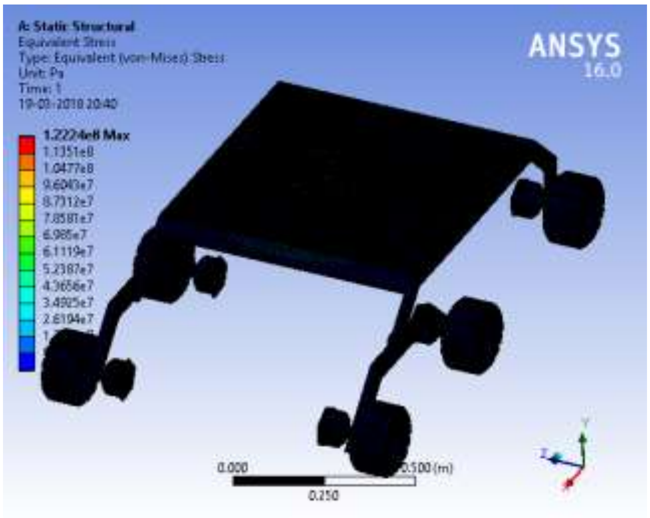


Fig : Analyzed image

In this we put a possible load on the frame model and analysed for the static structural stability of the rover platform. The load of about 500 pascal acts on the base of the platform under the high temperature environment of about 100^{o}c and the corresponding stress acts on the structure is calculated using ANSYS software as follows,

Table : Definition

Definition	
Physics Type	Structural
Analysis Type	Static Structural
Solver Target	Mechanical APDL
Options	

Environment Temperature	100. °C
Generate Input Only	No

Table : Loads

Object Name	Pressure
State	Fully Defined
Scope	
Scoping Method	Geometry Selection
Geometry	1 Face
Definition	
Type	Pressure
Define By	Normal To
Magnitude	500. Pa (ramped)

International Journal of Engineering, Science and Mathematics
Vol. 7 Issue4, April 2018(special issue NCIME)
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijesm.co.in, Email: ijesmj@gmail.com Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

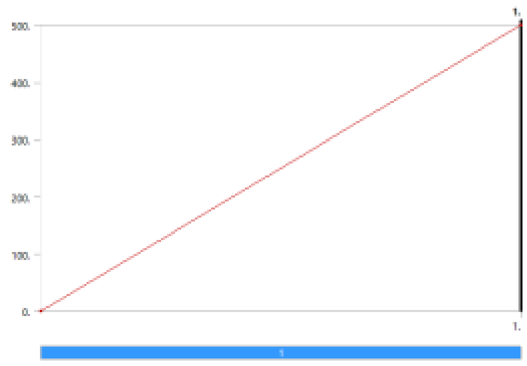


Fig : Load pressure distribution

Table : Processing

Object Name	Solution (A6)
State	Solved
Adaptive Mesh Refinement	
Max Refinement Loops	1.
Refinement Depth	2.
Information	
Status	Done
Post Processing	
Calculate Beam Section Results	No

Table : Output

Time [s]	Minimum [Pa]	Maximum [Pa]
1.	4.3522	1.2224e+008

The output stress value 122Mpa which is under the endurance limit of the considered material SS304 of 205Mpa so it is safety to use under the high temperature environment.

VI. MATERIALS AND COMPONENTS REQUIRED FOR PROTOYTPE

AUTOMATION

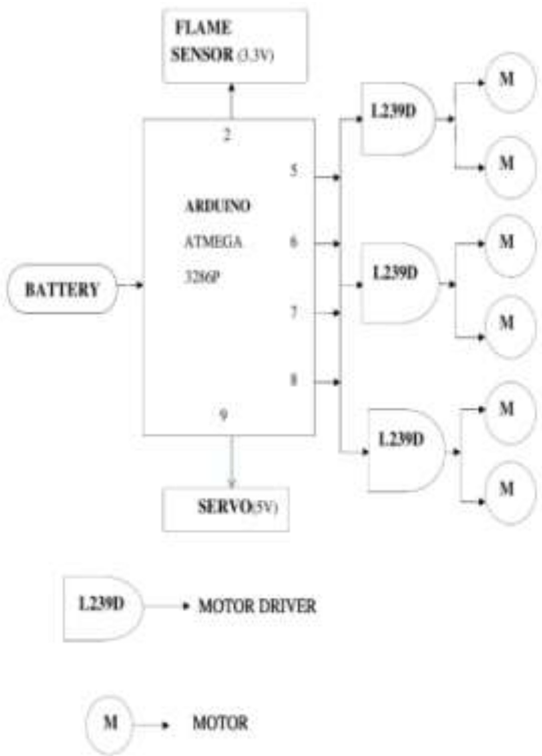


Fig : Block diagram for automation part in prototype

For the automation work we use the micro controller and motor drive which is operated via Dc Battery .The specification and details of the components are discussed below.

Components	**Particulate**	**Required QTY**
Motor drive	L293D	3
Arduino board	Arduino UNO	1
Motor	12v DC,45 rpm	6
Sensor	Flame sensor (3×1.5×.5)cm	1
Wheel	Rubber,10cm Dia	6
Frame	Aluminium sheet (2×4×.04)m	1
Wires	Copper	3m
Bearings	Ball bearing 20mm	2
Battery	12v DC, 7 Amps,2.25kg	1

International Journal of Engineering, Science and Mathematics
Vol. 7 Issue4, April 2018(special issue NCIME)
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijesm.co.in, Email: ijesmj@gmail.com Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

VII. PROTOTYPE OF THE PROJECT

Fig : Prototype at working

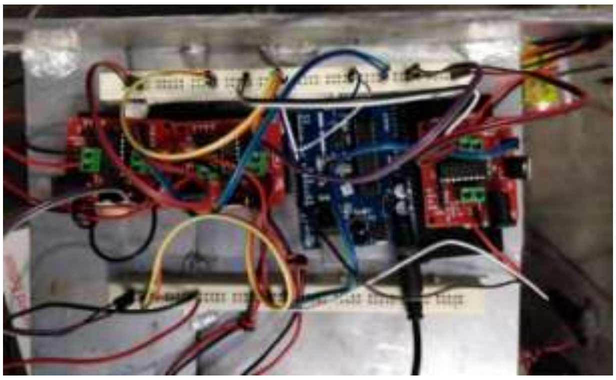


Fig : Automation connections over the project

International Journal of Engineering, Science and Mathematics
Vol. 7 Issue4, April 2018(special issue NCIME)
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijesm.co.in, Email: ijesmj@gmail.com Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

OBSERVATION

When, we operate the prototype has some faults then we undergo certain corrective actions then it performed successfully. It is programmed in such a way that, when the flame is detected the vehicle stop moving, actuate a manipulator arm and then it start moving. The increase of weight, cause the trouble for climbing the obstacle. In the rough surfaces the prototype performed very well but in the smooth surface it did not hold good. The electronic connections are checked perfectly in order to avoid damages to the components. Thus, we successfully operated our prototype.

VIII. CONCLUSION

This project will enable us to improve knowledge of volcanic activities especially during dangerous active phases. In this way the safety of volcanologists employed in collecting such a kind of measurement will considerably improve.

Historically many scientists studying eruptions from unsafe places suffered serious injuries. In the last decade alone, due to both unpredictable timing and to the magnitude of volcanic phenomena, several volcanologists have died surveying eruptions.

The improvement in the working conditions for volcanologists that are directly involved in monitoring of dangerous eruptive activity will enhance systematic study of these phenomena for which until now data are not yet available.

Another, important aspects to be considered concerns the improvement in the anticipatory capability of the volcanic activity by way of continuous updating during eruptive phenomena also when they become very dangerous for volcanologists.

This could improve volcanic risk assessment contributing to an integrated risk management system for obtaining an almost real-time early warning, useful to civil protection authorities to inform and protect citizen from dangerous volcanic eruption consequences. This will lead to huge savings in potential losses caused by damage to buildings, land ,equipment ,livestock and injury to humans.

By doing this project we successfully done our conceptual design and analyzed the model for its basic stability and operating even though the performance of the rover evaluated using the miniature prototype which is automated using aurdino controller.

From this project work,

- The vehicle's climb over capability can be increases up to head start of 90◦(previous project only climb over 35◦).
- Concept design of robot is successfully done using solid works sotware.
- Static and thermal(heat)analysis can be done using Ansys software is successfully studied.
- Fabrication and automation of this project will be done by simple operation condition.

IX. FUTURE SCOPE

- With some developments like attaching arms to the rover it can be made useful for the Bomb Diffusing Squad such that it can be able to cut the wires for diffusing the bomb.
- By the development of a bigger model it can be used for transporting man and material through terrain or obstacle containing regions like stairs.
- We could develop it into a wheel chair too.
- It can be send in valleys, jungles or such places where humans may face some danger.

REFERENCES

[1] Hong-an Yang, Luis Carlos Velasco Rojas*, Changkai Xia, Qiang Guo, School of Mechanical Engineering, North western Polytechnic University, Xi'an, China, Dynamic Rocker-Bogie: A Stability Enhancement for High- Speed Traversal- Vol. 3, No. 3, September 2014, pp. 212~220 ISSN: 2089-4856.

[2] IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 3 Ver. III (May. - Jun. 2015), PP 64-67

[3] R.E. Moore, Interval analysis (Englewood Cliffs, NJ: Prentice-Hall, 1966). (8)

[4] Brooks Thomas; Graham Gold; Nick Sertic; DARK ROVER ROCKER-BOGIE OPTIMIZATION DESIGN, The University of British Columbia, Project Number 1076 January 18, 2011.

[5] AnInternational Journal, Vol.30Issue:3,pp.231242, https://doi. Robotic Fire Extinguishing Vehicle with Rocker Bogie Suspension System. ISSN: 2454-132X Impact factor: 4.295 *(Volume3, Issue3)*Available online at www.ijariit.com

[6] "A Robotic System for Volcano Exploration" G. Muscato, D. Caltabiano, S. Guccione, D. Longo, M. Coltelli, A. Cristaldi, E. Pecora, V. Sacco, P. Sim, G.S. Virk, P. Briole, A. Semerano, T. White, (2003) "ROBOVOLC: a robot for volcano exploration result of first test campaign", Industrial Robotorg/10.1108/014399103104742

[7] Journal of volcanology and geothermal research 1265-320-(2016)CarolynE.Parcheta[a]catherieA.Pavlov[b]nicholaswiltsie[a]kalind C.Carpenter[a]jeremynash[a]aaronparness[a]karl L.Mitchell, "A robotic approach to mapping post-eruptive volcanic fissure conduits.

[8] Journal of geophysical research, VOL.109, B03202, doi:10.1029/2003JB002573,2004 "Numerical modeling of lava flow cooling applied to the 1997 Okmok eruption: Approach And Analysis" M. R. Patrick, J. Dehn and K. Dean.

[9] Geo science 2017, 7, 118; doi:10.3390/geosciences 7040118 "Thermal activity monitoring of an active volcano using Land sat 8/OLI-TIRS sensor images" Md. Bodruddoza Mia, Yasuhiro Fujimitsu and Jun Nishijima.

[10] Estier, T.,crausaz, y.,merminod,lauria, m.,piguet,r. and siegwart,r. "an innovation space rover with extended climbing abilities"proceedings of space and robotics 2000,Albuquerque usa ,February 27-march 2,2000.

[11] Mishkin, a. h., Morrison, j. c., nguyen, t. t., stone, h. w., cooper, b.k. and Wilcox , b.h"experiences with operations and autonomy of the mars , pathfinder microover" ieee aerospace conference, vol.2,1998,pp.337-351.

[12] Terada, a.;sudo, y.thermal activity within the wetern slope geothermal zone of aso volcano , japan: development of a new thermal area. Geothermics 2012,42,56-64.

[13] Li, y.; shi, t.; yang, y.;wu,b.;wang,l.;shi, c.;guo,j.;ji,c.;wen,h.satellite-based investigation and evaluation of the observational environment of metrological stations in anhui Province, china. pure appl.geophys,2015,172,1735-1749.

[14] Chottiner.j. e., 1992," simultation of a six- wheeled martain rover called the rocker bogie" M.s, thesis, the Ohio state university, Columbus,ohio.