Rocker-Bogie with Pick & Place Arm

[#1]Swapnil Tambe, [#2]Shubham Shinde,[#3]Yogesh Punde ,[#4]Vishwaraj Suryawanshi
[#5]Prof.V.H.Shinde

[1]tambeswapnil86@gmail.com
[2]shubhamshinde220@gmail.com
[3]yogesh.punde123@gmail.com
[4]raje.vishwa@gmail.com
[5] vinayak.shinde@dyptc.edu.in

[#1234]Student, Department of Mechanical Engineering,
[#5]Asst.Prof., Department of Mechanical Engineering,

D.Y.Patil College of Engineering, Talegaon Dabhade(Ambi),
Pune, Maharashtra, India

ABSTRACT

The rocker-bogie suspension mechanism it's currently NASA's favored design for wheeled mobile robots, mainly because it has robust capabilities to deal with obstacles and because it uniformly distributes the payload over its 6 wheels at all times. Even though it has many advantages when dealing with obstacles, there is one major shortcoming which is its low average speed of operation, making the rocker-bogie system not suitable for situations where high-speed traversal over hard-flat surfaces is needed to cover large areas in short periods of time, mainly due to stability problems. Our propose is to increase the stability of the rocker-bogie system by expanding its support polygon, making it more stable and adaptable while moving at high speed, but keeping its original robustness against obstacles.

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1. INTRODUCTION

The place, where the value of gravity remain lower than earth's own gravitational coefficient, at that place the existing suspension system fails to fulfil desired results as the amount and mode of shock absorbing changes. To counter anti-gravity impact, 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 . The proposed suspension system is currently the most favored design for every space exploration company indulge in the business of space research. The motive of this research initiation is to understand mechanical design and its advantages of Rocker-bogie suspension system in order to find suitability to implement it in conventional loading vehicles to enhance their efficiency and also to cut down the maintenance related expenses of conventional suspension systems.

II. OBECTIVES

1. To foster teamwork
2. To evoke the spirit of competition To develop problem solving skills
3. To use mathematics to develop the design
4. To apply theories and principles of Kinematics (ToM) and power transmission to hands on application
5. To develop oral presentation and technical writing/reporting skills

Different operation consist of

- Turning
- External & internal screw threading
- Sheet metal cutting
- Sheet Metal Bending
- Drilling
- Welding (Arc)
- Fitting

III.METHODOLOGY

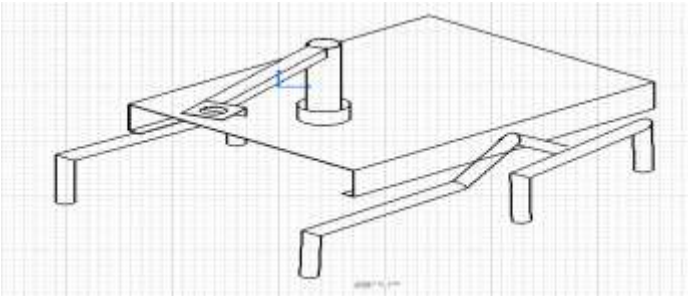
The methodology for this project is similar to the fabrication analysis process. In this project we are fabricating AGR and other experimental attachments. The methodologies of these attachments are explained in few sub- headings.

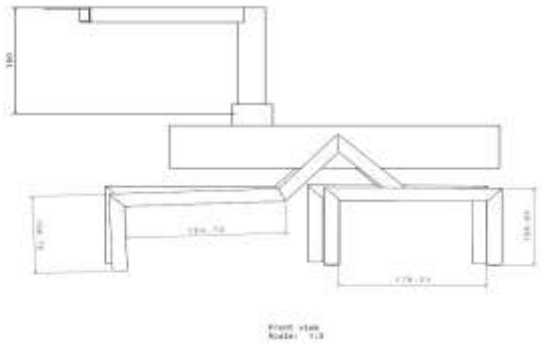
The methodology is explained in four parts. System parts are given with their specification and dimension. Modeling will have a simple layout type diagram in thesis. In this diagram the parts are explained by their major

dimensions only. Working has just functional details in paragraphs. The delayed or incomplete portion of fabrication is not explained.

3.1 Geometry of Rocker Bogie:

As per the research it is find that the rocker bogie system reduces the motion by half compared to other suspension systems because each of the bogie's six wheels has an independent mechanism for motion. Every wheel also has thick cleats which provides grip for climbing in soft sand and scrambling over rocks with ease. In order to overcome vertical obstacle faces, the front wheels are forced against the obstacle by the centre and rear wheels which generate maximum required torque. The rotation of the front wheel then lifts the front of the vehicle up and over the obstacle and obstacle overtaken. Those wheels which remain in the middle, is then pressed against the obstacle by the rear wheels and pulled against the obstacle by the front till the time it is lifted up and over. At last, the rear wheel is pulled over the obstacle by the front two wheels due to applying pull force. During each wheel's traversal of the obstacle, forward progress of the vehicle is slowed or completely halted which finally maintain vehicles centre of gravity. The above said methodology is being practically proved by implementing it on six wheel drive with the use of differential system in AGR system in order to gain maximum advantage by rocker bogie system.





IV. WORKING OF SYSTEM

Working Procedure:

- ✓ Set the initial positions of the Gripper
- ✓ Connect the android phone with the control circuit.
- ✓ Then as per commands set on control-panel AGR will actuate.
- ✓ Press down key.
- ✓ The AGR arm will move vertically down.
- ✓ Press up/stop key.
- ✓ The arm will move vertically upwards.
- ✓ Press forward key.
- ✓ The AGR will move in the forward direction.
- ✓ Press reverse key.
- ✓ Then the AGR will move in the reverse direction.
- ✓ Press left/right keys.
- ✓ The AGR will move in either left side or right side.
- ✓ By these commands one can move the AGR in the required direction and position.
- ✓ Then press the Pick command.
- ✓ AGR shall start gripping the object.
- ✓ To release or place the object, press the release key.
- ✓ AGR will release the grippers.
- ✓ Two more commands as clockwise and anticlockwise are there to move the arm in either of the directions respectively.
- ✓ One can have downward inclined or upward inclined movement of AGR arm with Pick & Place arm for inclined places by simultaneous command of either up and clockwise or down and clockwise keys, and vice versa.
- ✓ To stop any operation or command given press 'STOP' button. On Control Panel in Android App.
- ✓ One needs to use stop key after every key given, if no other command is to be given after that.
- ✓ At the end of operation switch off the battery/supply switch

V. DESIGN OF SYSTEM

1. Static equilibrium: In this analysis the designer is trying to determine the overall forces and moments that the design will undergo. The analysis is usually done with rigid members of model of structure and is the simplest analysis to perform.
2. Deformation: This analysis is concerned with how much the structure will move when operating under the design loads. This analysis is usually done with flexible members.
3. Stress: In this analysis the designers wants a very detailed picture of where and at what level the stresses are in the design. This analysis usually done with continuum members.
4. Frequency: This analysis is concerned with determining the natural frequencies and made shape of a structure. This analysis can be done with either flexible members of a structure. This analysis can be done with either flexible members or continuum members but now the mass of the members is included in the analysis.

5.1 Considerations and Alternatives:

During the mechanical design designers must always consider the following factor:

- Manufacture ability (production cost and ease assemble of the ("AGR Mobile Operated).
- Ease of Installation.

- Ease of modification is re-configurations to adopt the “AGR Mobile” to specific task.
- Ease of Adjustment & Calibration.
- Ease of maintenance, including maintenance intervals, materials and labor cost.
- Ease of diagnosis and repair in the event of a failure in one of the “AGR Mobile” sub systems.
- Accessibility of spare replacement parts (Standard or ordinarily available Components).

value of SSF. The factor of two in the computation "TW over 2h" makes SSF equal to the lateral acceleration in g's (g-force) at which rollover begins in the most simplified rollover analysis of a vehicle represented by a rigid body without suspension movement or tire deflections.

5.2 Description of Different Parts of AGR:

5.2.1 Chassis

A chassis (pronounced TCHA-see or CHA-see) is the physical frame or structure of an automobile, an airplane, or other multi-component device. The automotive chassis is tasked with holding all the components together while driving, and transferring vertical and lateral loads, caused by accelerations, on the chassis through the suspension and wheels.

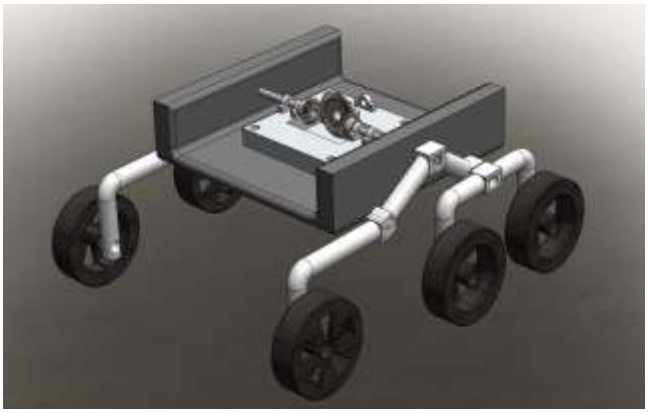


Fig.5.1 Chassis

The above figure shows the basic structure of the chassis used in the AGRs. It is provided with six wheels and with the help of which the AGR can move on a given path. The load of the whole assembly is carried by the chassis.

5.2.2 Wheels:

A wheel is a circular device that is capable of rotating on its axis, facilitating movement or transportation while supporting a load (mass), or performing labor in machines. Common examples are found in transport applications. A wheel, together with an axle overcomes friction by facilitating motion by rolling. In order for wheels to rotate, a moment needs to be applied to the wheel about its axis, either by way of gravity, or by application of another external force.

Fig.5.2 Wheels

5.2.3 ARM:

An arm is a AGR manipulator, usually programmable, with similar functions to a human arm. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated AGR) or translational (linear) displacement. The links of the manipulator can be considered to form a kinematic chain. The business end of the kinematic chain of the manipulator is called the end effectors and it is analogous to the human hand. The end effectors can be designed to perform any desired task such as welding, gripping, spinning etc., depending on the application. For example AGR arms in automotive assembly lines perform a variety of tasks such as welding and parts rotation and placement during assembly.

Fig. 5.3 Arm

5.2.4 Pneumatic Cylinder:

6. Pneumatic cylinder(s) (sometimes known as air cylinders) are mechanical devices which use the power of compressed gas to produce a force in a reciprocating linear motion.
7. Like hydraulic cylinders, something forces a piston to move in the desired direction. The piston is a disc or cylinder, and the piston rod transfers the force it develops to the object to be moved. Engineers sometimes prefer to use pneumatics because they are quieter, cleaner, and do not require large amounts of space for fluid storage.
8. Because the operating fluid is a gas, leakage from a pneumatic cylinder will not drip out and contaminate the surroundings, making pneumatics more desirable where cleanliness is a requirement.

Fig. 5.4 Pneumatic Cylinder

5.2.5 D.C. motors:

Motors are devices that convert electrical energy into mechanical energy. The D.C. motors that we have been dealing with here convert electrical energy into rotational energy. That rotational energy is then used to lift things, propel things, turn things, etc... When we supply the specified voltage to a motor, it rotates the output shaft at some speed. This rotational speed or angular velocity, ω is typically measured in radians/second {rad/s}, revolutions/second {rps}, or revolutions/minute {rpm}.

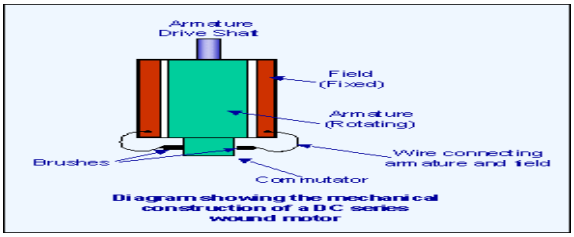


Fig.5.5 DC Motor

The above diagram shows the actual mechanical construction of the DC series motor.
Mechanically all DC motors have two main parts:

1. The armature
2. The field poles

The mechanical power developed by motor results from the interaction between the magnetic fields created by the armature and the field poles. A motor is made up of many individual parts as follows:

1. Commutator
2. Armature Drive Shaft
3. Brushes

5.2.6 Torque Speed Characteristics of D.C. Motor:

The quantitative measure of the tendency of a force to cause or change rotational motion is called torque.

The rate of rotation around an axis usually expressed in radians or revolutions per second or per minute is called speed.

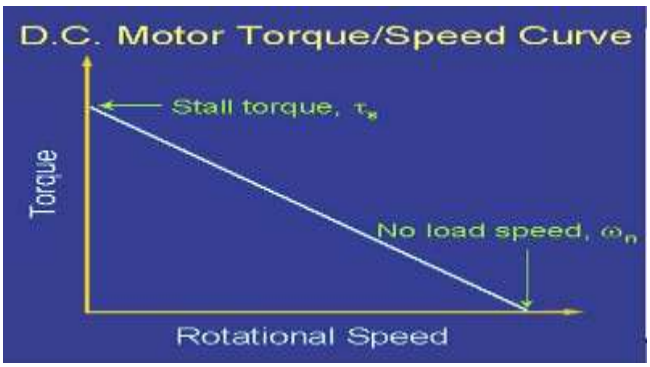


Fig.5.6 Torque / Speed Curve Of A Typical D.C.

5.2.7 MOTOR:

The graph above shows a torque/speed curve of a typical D.C. motor. Note that torque is inversely proportional to the speed of the output shaft.

- The stall torque, τ_s, represents the point on the graph at which the torque is a maximum, but the shaft is not rotating.
- The no load speed, ω_n, is the maximum output speed of the motor (when no torque is applied to the output shaft).
- DC motors are connected to motor driver IC. 12 volts, 100 rpm DC motors are used which move the wheels.
- A DC motor is a mechanically commutated electric motor powered from direct current (DC). In DC motor, operation is based on simple electromagnetism. A current-carrying conductor generates a magnetic field; when this is then placed in an external magnetic field, it will experience a force proportional to the current in the conductor, and to the strength of the external magnetic field. Opposite (North and South) polarities of magnet attract, while like polarities (North and North, South and South) repel. The internal configuration of a DC motor is designed to harness the magnetic interaction between a current-carrying conductor and an external magnetic field to generate rotational motion.

Fig. 5.7 D.C. Motor

5.2.8 Selection of Dc Motors For Different Parts of AGR:

a. <u>Wheels</u>:

The criteria for selection of motors for wheels are the speed of the wheels and the weight of the assembly which the wheels are going to carry.
We have selected motors of 60 r.p.m. because the speed of the AGR during the performance of the tasks should be less

for getting balanced rocker and bogie movements with required torque.

b. Horizontal leadscrew**:**

The horizontal lead screw is used to pick up and place the object with the help of jaw connected to the screw. Motor selected for this screw is of 15 rpm.

c. Column:

The column is fixed to the chassis with the help of a bush. Now, this column is used for the movement of the arm of AGR Arm in 360 degrees. A stylus is fixed to the column as an element of a limit switch. In our application the rotational movement of the arm should not be fast to maintain the accuracy. Thus a 15 rpm motor is selected for the rotational movement of the arm.

5.2.9 Microcontroller:

A microcontroller is a small, low-cost computer-on-a-chip which usually includes:

- An 8 or 16 bit microprocessor(CPU)
- A small amount of RAM
- Programmable ROM and/or flash memory
- Parallel and/or serial I/O
- Timers and signal generators
- Analog to Digital (A/D) and /or Digital to Analog (D/A) conversion

It is often used to run dedicated code that controls one or more tasks in the operation of a device or a system. They are also called as embedded controllers, because the microcontroller and the support circuits are often built into, or embedded in, the device they control.

Microcontrollers usually must have low power requirements since many devices that they control are battery operated.

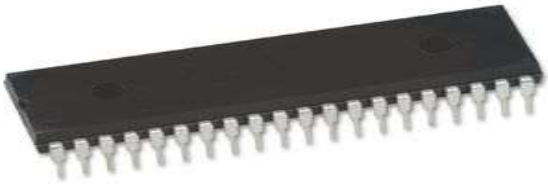


Fig. 5.8 Microcontroller

5.2.10 Differential gear arrangement:

Fig. 5.9 Differential

We have used 40 mm O.D. and 16 no. of teeth of 90° of alignment bevel gears to make a differential gear set for balancing of chassis position to equilibrium state along with providing extra support to rockers at their un even movements.

Fig. 5.10 Project parts a look

Applications and advantages:

Material Handling System:

Automobile industries, manufacturing industries, packaging industries

Relieve human workers from hazardous operations:

There are many applications like spray painting, arc welding, spot welding, chemical processing, atomic power plants, etc., where the work environment is highly hazardous to human health.

To compensate for shortage of human workers:

In many developed countries, there is shortage of human workers. In such cases, the use of robots always complements the human worker.

Flexible Manufacturing System (FMS):

In today's state of art, global manufacturing system, flexibility of products in batches are required. Robotic systems can be programmed accordingly without any change over time.eg. – TATA MOTORS, FORD, etc.

Prototype Research:

Robots are used in prototype systems where testing of the actual systems is not possible, eg.- Simulation is done with prototype product before going in for CIM (Computer Integrated Manufacturing)

VI. FUTURE SCOPE

1. Sensors:

Sensors can be fixed below the arm and on the chassis for accurate positioning of the arm. This means that when the two sensors sense each other, then the rotating arm will stop and it will pick or place the object depending upon the program in the microcontroller. This will eliminate the time based errors and increase the accuracy.

Sensors can be placed for detecting the object also. In this the sensors can be placed on the front side of the chassis of the robot and thus object can be detected when the rays strike back to the sensors on the chassis after hitting the object.

2. Battery operated:

We can replace the electric supply wires by battery. In this a 12 volt battery can be placed on the chassis and thus the robot can move anywhere it needs to.

3. End effector:

Can mount pneumatic cylinder for actuating gun as well.

4. Servo motors:
Servo motors can be used instead of DC motors to get more accuracy. We can get more accuracy by using the servo motors because we can make angle based programming.

VII. CONCLUSION

The main aim for designing of a prototype **"**Mobile Operated Rocker Bogie Robot **"** used in various industries & research institutions & off-road works like collecting test samples, examining geographical locations & space research works was designed where human reach is very difficult due to complexities & hazardous areas.

A low Mobile AGR was attempted, but future developments can be achieved to make it more versatile with good equipments.

The project was a great experience for us. We faced lot of problems during designing of arm, Rocker & Bogie and electronics circuit, but successfully got through all of them.

6.2 Further work:

As modular research platform the rover developed by this project is designed specifically to facilitate future work. With the development in technology the rover can be used for reconnaissance purposes with the cameras installed on the rover and minimizing the size of rover. 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 a rough terrain or obstacle containing regions like stairs. We could develop it into a wheel chair too. It can be sent in valleys, jungles or such places where humans may face some danger. It can also be developed into low cost exploration rover that could be send for collecting information about the environment of some celestial bodies.

Also it can be mounted with rotating wireless camera with temperature, Gas/Smoke sensors with Buzzer alarm. Bluetooth connectivity shall be replaced with electro-magnetic wave signal based connectivity for long distances & fully independent compressor for pneumatic operations.

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