DESIGN OF A HYDRO STRUT SUSPENSION IN A TRACKED VEHICLE TO MAXIMISE RIDER COMFORT AT HIGH SPEEDS ON CROSS COUNTRY TERRAIN

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ABSTRACT

A tracked vehicle has to be designed to operate under severe conditions. When a tank is moving in a cross country terrain, it encounters different sizes of crests and troughs. It has to negotiate through all such surfaces during actual operation. However, the design has to ensure that during such movement, certain points on the body of the vehicle have acceleration levels below a specified comfort level. In case the specified comfort level is exceeded, the performance of all instruments, weapons etc. becomes erroneous.

In one of the tracked vehicle with GVW of 20 tonne, there are 6-road wheel stations on each side. A new Hydro Gas Suspension System (HGSS) is designed to keep the acceleration levels within a specified band at a predefined operational speed. The suspension should allow for a wheel travel of 100 mm in rebound and 300 mm in bump condition. Although there are 22 parameters which affect the performance characteristics of the suspension system, some of them could be fixed because of system and sub-system constraints. For a given HGSS model, ADAMS is used to predict the performance and rider comfort of the vehicle at predefined speed on a given cross country track.

The project is still under execution.

INTRODUCTION

A tracked vehicle is a cross country vehicle which has to operate on terrain which are very severe. While mobility is one of the main requirements, stability and manoeuvrability of the whole vehicle are no less important. If the load of the road impact is transmitted directly to the vehicle body (henceforth reffered to as hull), it will have adverse effect on the vehicle operation. Not only will the occupents suffer, the navigational instruements will malfunction and the body will undergo excessive fatigue.

The objective of developing and incorporating a Hydro Gas Suspension System (HGSS) in the tracked vehicle is to ensure that the body of the tracked vehicle is spared the shock loads which come on the wheel due to irregular nature of the terrain. This will enable normal navigational operation inside the cabin. At the same time it has to ensure that the general stability and steering of the vehicle is not compromised.

CONSTRUCTION AND WORKING PRINCIPLE

The HGSS has one accumulator cylinder which telescopically moves inside the actuator cylinder. The actuator cylinder is filled with oil while the accumulator cylinder is filled with gas. A damper block is part of the accumulator cylinder which has a floating piston inside it. The damper block has holes to allow pressurised oil to pass through it and move the floating piston.

In rebound condition, the gas in the accumulator cylinder is fully uncompressed and in the bump condition, the gas is fully compressed. The position of the floating piston also varies accordingly. The point A on the actuator cylinder is mounted on the hull and the point B on the accumulator cylinder is mounted on the exxtension of the axle arm.

When the road wheel moves upward, the axle arm also moves upwards and the accumulator cylinder starts moving inside the actuator cylinder. This increases the pressure of the oil. The pressurized oil will now enter the accumulator cylinder through the damper block hole (creating damping) and pushes the floating piston towards point B. This results in increase in pressure of the gas. The movement of the floating piston continues till the pressures in the oil and gas chambers become equal. Since the gas is compressed adiabetically, following the gas law $P_1V_1^r = P_2 V_2^r$ (P and V are the pressures and corresponding volumes and r=1.4), the non-linear charecterestics of the suspension system is obtained.

GENERAL LAYOUT OF HYDROSTRUT

The General Layout of the HGSS in static condition is shown below.

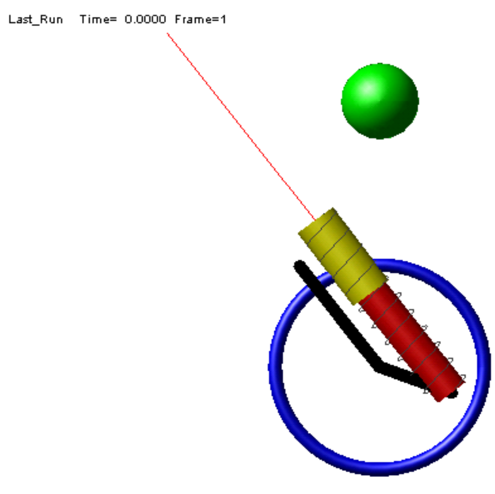

Figure 1- Layout in static condition

Co-ordinate System: The cartesian co-ordinate system is followed. X-axis is in the horizontal direction passing through the centre of the road wheel in static condition and the Y-axis is the axis in the vertical direction passing through the point very close to the sprocket on the hull.

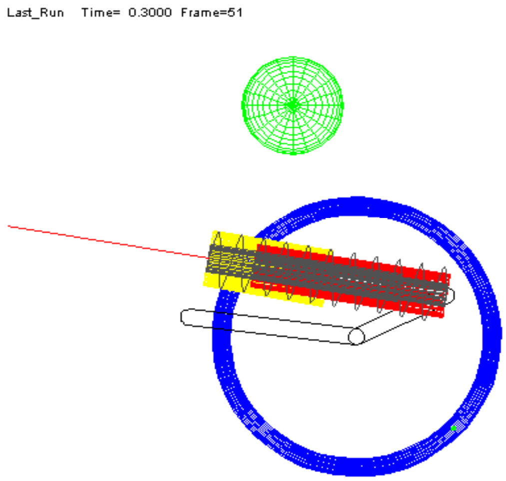

Figure 2 - Layout in bump condition

MODELING OF THE HGSS AS A COMBINATION OF A SPRING-DAMPER AND A VECTOR FORCE

On the basis of the gas laws and the configuration/dimension of the actuator cylinder and accumulator cylinder, the resulting force was obtained as a function of the stoke length.

This was used for defining a V-FORCE in ADAMS between the actuator cylinder and accumulator cylinder. The expression used for defining the same is

VFORCE = K **/** (((V_0 +***dm(.model.CYL.MAR_1,.model.PIS.MAR_1)*** -B) / V_0)**1.4)

Where K, V_0 and B are constant evaluated from the gas equation.

K = 2549.3793
V_0= 56.904134
B = 480.195

Besides this, to simulate the damping effect, a spring-damper (SPDP) element is defined between the actuator cylinder and accumulator cylinder with zero stiffness and desired damping co-efficient.

MODELING OF THE TERRAIN AS AN STEP FUNCTION

The tracked vehicle has to be operational on a track with 150 mm bumps. The distance between two consequtive bumps is to be 1000 mm.

Instead of creating the track as a 3D road surface, an alternative approach was adopted to simulate the dynamics of the suspension model. In this approach, two dummy parts were created at the point where the road wheel comes in contact with the track. One dummy part A was constrained with the road with a horizontal translation joint and the other dummy part B was constrained to the former dummy part A with a perpendicular translation joint. A vertical motion in the form of a step function was applied on part B to simulate the bump. The step function is given as:

Displacement = 150*step(time,.10,0,.14,1)*step(time,.14,1,.18,0) + ...

The wheel was resting on the dummy part B and this condition was modeled using a circle to plane contact force.

RUNNING THE SIMULATION AND RESULTS

The objective of the analysis was to determine the value of the damping co-efficient for which the value of vertical acceleration at the hull CG would be less than or equal to 2g. A design of experiments study was performed and the value of the damping co-efficient was found to be 0.3.

Based on the above results, a larger model of the whole vehicle is being created which will provide a better insite into the dynamics of the tracked vehicle.

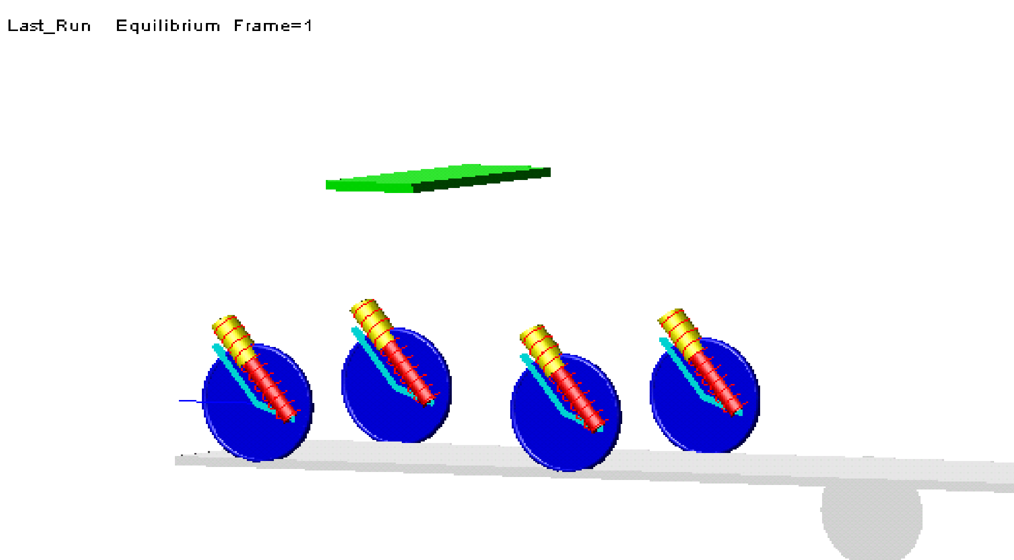

Figure-3 Assembled layout for planned analysis with bump as a 3D solid surface.

CONCLUSION

The project is still under execution for further analysis in order to obtain the full and complete performance analysis of the complete vehicle. The performance of the HGSS has been analysed in this work and the results have been found to be very near expected results. The layout of the HGSS with respect to the whole vehicle has been verified in solid modeling softwares also. The manufacturing cost of one unit of the HGSS is approximately US $ 5000. With virtual prototyping in ADAMS, the reworking costs could be reduced to a large extent.

FURTHER RESEARCH PLANNED

1. **Soil conditions:** The HGSS and also the complete vehicle has to analysed for operations on sandy and marshy conditions so that the vehicle can be made operational on universal conditions. This will require that the impact function on the road wheel be modified suitably to take into account the stiffness of the track.

2. **Offset corrugated track:** The full vehicle analysis has to be performed for operation in conditions where the parallel road wheels are offset. This will require input of different input functions on individual.

3. **Track on road wheels:** This analysis is expected to be performed only with the ADAMS /Tracked Vehicle software. The analysis will be done only when the said module is procured.

4. **Road wheels**: The wheels have been assumed to be rigid and mettalic. In the actual case, the road wheels will be made up of hard compressed rubber and will not be rigid.

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