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Variable Density Speed Hump

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Abstract: **This technical paper relates to a device that reduces the speed of any overspeeding vehicles travelling on a roadway.It is formed by at least one hollow strip of flexible material, made up of several receptacles located in the shell body. Each receptacle is impregnated with a dilatant shear-thickening fluid. The material is placed under compression during impact when the vehicle strikes it and the fluid itself acts as means for controlling the resistance to deformation of the strip. Thus, if the vehicle travels at a low speed the fluid has a low viscosity and the strip is easily deformed, whereas if the speed of the vehicle is high the viscosity of the fluid is high and as a result has great resistance to deformation, thus forming a rigid obstacle to the passage of the vehicle. Drivers must always slow down when driving over the conventional speed bumps to prevent damage to their vehicle. However, the Variable Density Speed Hump is sensitive to the speed of the vehicle.The vehicle needs to slow down only if it is overspeeding.**

Keywords: Variable Density, Speed Control, Shear Thickening, Thixotropic Fluid, Speed Hump

I. INTRODUCTION

A conventional speed bump usually consists of a concrete or asphalt hump formed in the road. They are designed to be driven over at a predetermined comfortable speed, while causing exceeding discomfort at higher speeds. Drivers must slow down when driving over these speed bumps to prevent damage to their vehicle. However, even if travelling at the posted speed limit or below, these conventional speed bumps can take a toll on a vehicle's mechanical components, such as the shock absorbers and steering system.

This paper relates to a traffic control device sensitive to the speed of a vehicle. The ideal situation is that if the vehicle travels at a very low speed, the stiffness of the obstacle reduces to facilitate the vehicles passage without any bounce or jump.However if the vehicle exceeds the advisable minimum speed the obstacle stiffness increases and the vehicle encounters a considerable jump.This speed control device will also allow emergency vehicles to traverse speed humps without having to reduce their speed which in turn will reduce their response time to emergencies.

II. PROBLEMS WITH CONVENTIONAL SPEED HUMPS

Conventional devices are known to help slow down the speed of traffic in selected areas. For example, conventional speed bumps or rumble strips are used in such places as school zones, parking lots, construction zones, hospital zones and similar areas where it is desired to control or reduce the speed of vehicles for the safety of pedestrians. A conventional speed bump usually consists of a concrete or asphalt hump formed in the road. Drivers must slow down when driving over these speed bumps to prevent damage to their vehicle. However, even if travelling at the posted speed limit or below, these conventional speed bumps can take a toll on a vehicle's mechanical components.

The conventional speed bumps are very heavy and, once in place, are typically permanent fixtures on the roadway. In order to remove a conventional speed bump, the speed bump must be broken up and the roadway repaired where the speed bump used to be. Another major problem associated with such speed bumps is that they often cause spinal damage or aggravate chronic backache due to the constant shocks suffered while traversing the speed humps.

Additional criticism of speed humps includes their effect on emergency vehicles. Response time is slowed by 3–5 seconds per hump for fire trucks and fire engines and up to 10 seconds for ambulances with patients on board. [1] Also there is an increase in traffic noise from braking and acceleration of vehicles on streets with speed humps, particularly from buses and trucks. They end up increasing noise levels where they are implemented.

Therefore, it would be advantageous to provide a traffic control device that reduces or eliminates at least some of the problems associated with conventional speed bumps. The "Variable Density Speed Hump" aims to overcome all these short comings of the conventional speed control devices

III. DESIGN AND IMPLEMENTATION

A. Speed Hump – Body and Containing Fluid

The speed hump includes an outer shell and a bottom plate. The bottom plate may include one or more fastening holes so that the device can be either permanently or temporarily mounted to a roadway or other surface such as by bolts, screws, or other conventional devices. The shell can be formed of any conventional material, such as but not limited to flexible or resilient materials including or rubber

The shell encloses one or more housings containing a compliant material such as a Non Newtonian fluid, which reversibly hardens or stiffens in response to an applied pressure and goes back to its original form when the pressure is relieved. The housings are in the form of elongated, hollow, flexible tubes having closed ends. The tubes are made up of either polymeric or rubber material. The flexible tubes are filled with a fluid and interconnected by a conduit which enables the controlled flow of the fluid in or out of the chamber

If the vehicle travels at a reduced speed, fluid is moved to the adjacent chamber and a depression of the strip occurs in the area in which the wheels pass over, forming a small obstacle to the passage of the vehicle.However , if the speed of the vehicle is high then the fluid has no time to pass into the adjacent chambers and a considerably smaller depression occurs.Hence the strip forms a step with greater height, causing the vehicle to jump, warning the driver about his excess speed.

The fluids used to fill the housings are non-Newtonian fluids .A non-Newtonian fluid is a fluid the viscosity of which varies with the pressure gradient applied. As a result, a non-Newtonian fluid does not have a defined and constant viscosity value, like a Newtonian fluid. Therefore, these fluids can be better characterized by means of other rheological properties.Hence they are characterized by properties connected to the relationship between the stress and strains under different flow conditions, such as shear or oscillating stress conditions.

A non-Newtonian fluid subjected, for example to an impact of a teaspoon makes the fluid behave in a manner that is more similar to a solid than to a liquid, however if the same teaspoon is slowly pressed on the non-Newtonian fluid its behavior seems more similar to a liquid than to a solid since its viscosity has considerably decreased. The Non Newtonian fluid acts like a fluid below a critical shear rate but above the critical shear rate, the material acts like a solid. [2]

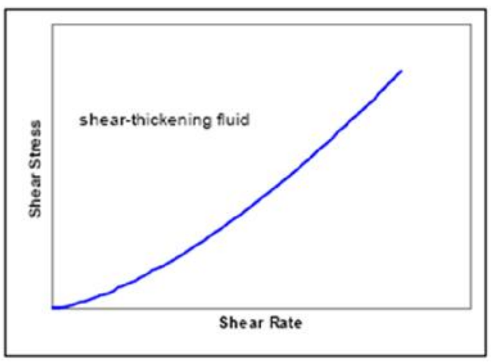

Fig. 1. A Plot Of Shear Rate vs. Shear Stress For A Shear Thickening Fluid

Non Newtonian fluids can also be formed by dissolving particulate matter in a carrier fluid. One example is formed by placing silica particles in a fluid, such as polyethylene glycol. At high shear rates, the hydrodynamic forces overcome the repulsive inter-particle forces, forming silica hydro-clusters which increase the viscosity of the fluid.

Therefore, the non-Newtonian fluid itself acts as means for controlling the resistance offered by the strip to its deformation depending on the speed of impact of the wheels of the vehicle on it. Thus, if the vehicle travels at a low speed the fluid has a low viscosity and the strip is easily deformed, whereas if the speed of the vehicle is high the viscosity of the fluid is high and as a result has great resistance to deformation, thus forming a rigid obstacle to the passage of the vehicle. Thus the speed of the vehicle is controlled due to the combined effect of non-Newtonian fluids and their flow via narrow conduits

B. Pumping System

It is required that when an emergency vehicle approaches the speed hump, the fluid should escape rapidly from the tubes of the speed hump, causing a rapid deflation of the speed hump. This will ensure that the emergency vehicle can pass over the speed hump without having to slow down, reducing the response time of the vehicles in case of an emergency.

The flow of the fluids is carried out utilizing pumps. A pump is a device that moves fluids, by mechanical action. As the various pump parts like the impeller, vane, piston begin to operate, air is pushed out of the way. The movement of air creates a partial vacuum which can be filled up by more air, or in the case of water pumps, water.

However shear sensitive liquids can behave very differently when sheared. Some require shear force to get them to the ideal viscosity for transfer. [3]

However other types of shear sensitive fluids can be temporary or irrevocably damaged by shear. Hence we utilize progressive cavity pumps to control the fluid flow within the speed hump.

Progressive cavity pumps, widely regarded as being a low shear pump, have internal contact between the pumping element and the casing. It transfers fluid by means of the progress, through the pump, of a sequence of small, fixed shape, discrete cavities, as its rotor is turned. [4]

This leads to the volumetric flow rate being proportional to the rotation rate (bi-directionally) and to low levels of shearing being applied to the pumped fluid. Hence these pumps have application in fluid metering and pumping of viscous or shear-sensitive materials. Progressive cavity pumps do not damage the fluid and ensure optimal pumping of the fluid over a short span on time.

C. Emergency Vehicle Detection System

An emergency vehicle detection system for alerting the speed hump of an approaching emergency vehicle is mounted near the hump. It is essentially a sound signal detection unit. The sound signal detection unit has at least one sound transducer for detecting sound signals and producing an electric current upon detection of a signal. The sound waves from the siren of the emergency vehicle are received by the sound signal detection unit.

A signal comparator is connected to the sound transducers for comparing the currents from the transducers to preprogrammed patterns. The sound patterns of the various emergency sirens will be stored and compared with the current conditions.

If there is matching pattern, a signal output encoder connected to the signal comparator constructs an encoded signal and transmits the encoded signal to the pump. The pump then pumps out the fluids from the hump into a reservoir. This deflates the hump, causing the emergency vehicle to pass over it without having to slow down. This reduces the response time of emergency vehicles.

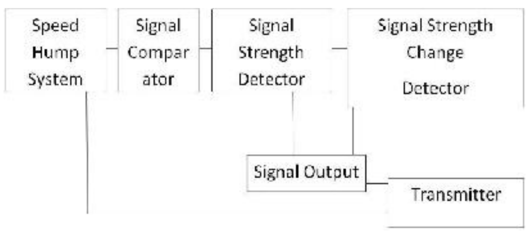

Figure: 2 Emergency Vehicle Detection System

D. Reflector Plates

Reflector plates are placed on the road leading to the speed hump. The safety reflector is a device intended for pedestrians, runners, motorized and non-motorized vehicles. It aids visibility of a person or vehicle, as it reflects light from headlights of vehicles .The reflector is manufactured in the form of a molded tile of transparent plastic. The outside surface is smooth, allowing light, such as from a car's headlights, to enter.

The rear surface of the tile takes the form of an array of angled micro-prisms or spherical beads. The light striking the rear, inside surface of the prisms or beads, does so at an angle greater than the critical angle thus it undergoes total internal reflection. [5] Due to the orientation of the other inside surfaces, any light internally reflecting is directed back out the front of the reflector in the direction it came from. This alerts the person close to the light source, in this case, the driver of the vehicle, to the presence of the speed hump.

IV. Operation of the Entire System

The speed hump can be either permanently or temporarily mounted at a desired location, such as in a street or roadway. The dilatant material in the tubes can be selected based on a desired shear rate.

The shear rate selected will correspond to a predetermined vehicle speed. When a vehicle rolls over the hump below the predetermined speed i.e. below the critical shear rate of the dilatant material, the dilatant material remains in fluid form and the weight of the vehicle compresses the shell and the tubes. This pushes the dilatant fluid out of the shell into the reservoir. When the vehicle has passed over the hump, the shell returns to its initial shape and the pump pushes the dilatant material back into the tubes which also return to their original shape. Thus, below the critical shear rate, little impact is felt by the driver.Therefore, if the vehicle is traveling under the selected speed limit which will provide a shear rate less than the critical shear rate

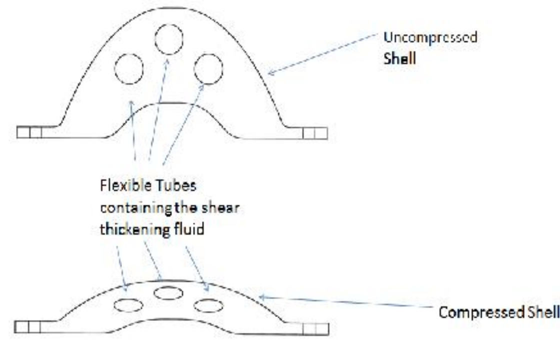

Figure: 3 The Side View Cut Section Of The System In The Uncompressed And Compressed Stages.

However, in the event a vehicle impacts the speed hump at a speed above the predetermined speed that is, providing a shear rate above the critical shear rate, the viscosity of the dilatant material increases .The dilatant material acts as a solid and the speed hump substantially retains the speed bump shape. The speed hump in this scenario acts similarly to a conventional speed bump and the driver of the vehicle exceeding the selected speed limit will experience a bump or jolt as would be felt with a conventional speed bump.

IV. Conclusion

The Variable Density Speed Hump can help in increasing the fuel efficiency of vehicles up to a large extent. Vehicles need not come to a complete halt in from of speed humps, reducing traffic congestion also.

It also does not take a toll on a vehicle's mechanical components, such as the shock absorbers and steering system if the vehicle is following the speed limit.

The setup is completely mobile and can be installed within an hour. The installation process does not require a technically skilled person.

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