IP LICENSING/ SALES PROPOSAL

A SHEAR-THICKENING FLUID BASED PACKAGING PROTECTION SYSTEM

Applicant: Chinmay Kendurkar

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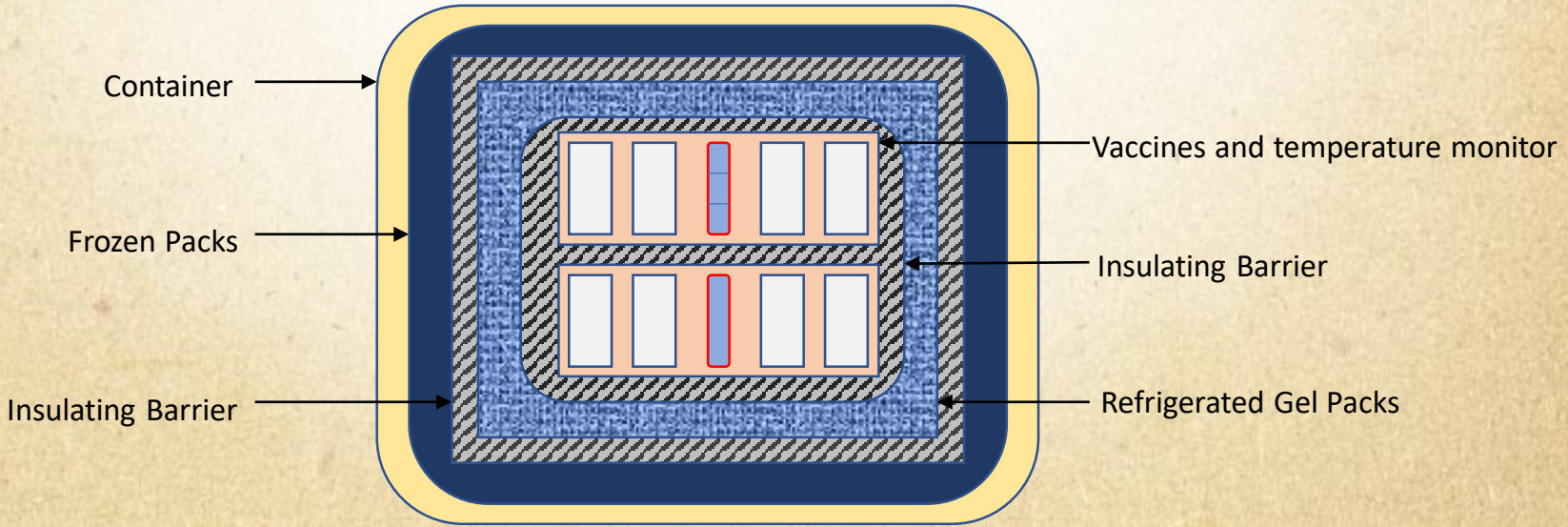
BACKGROUND

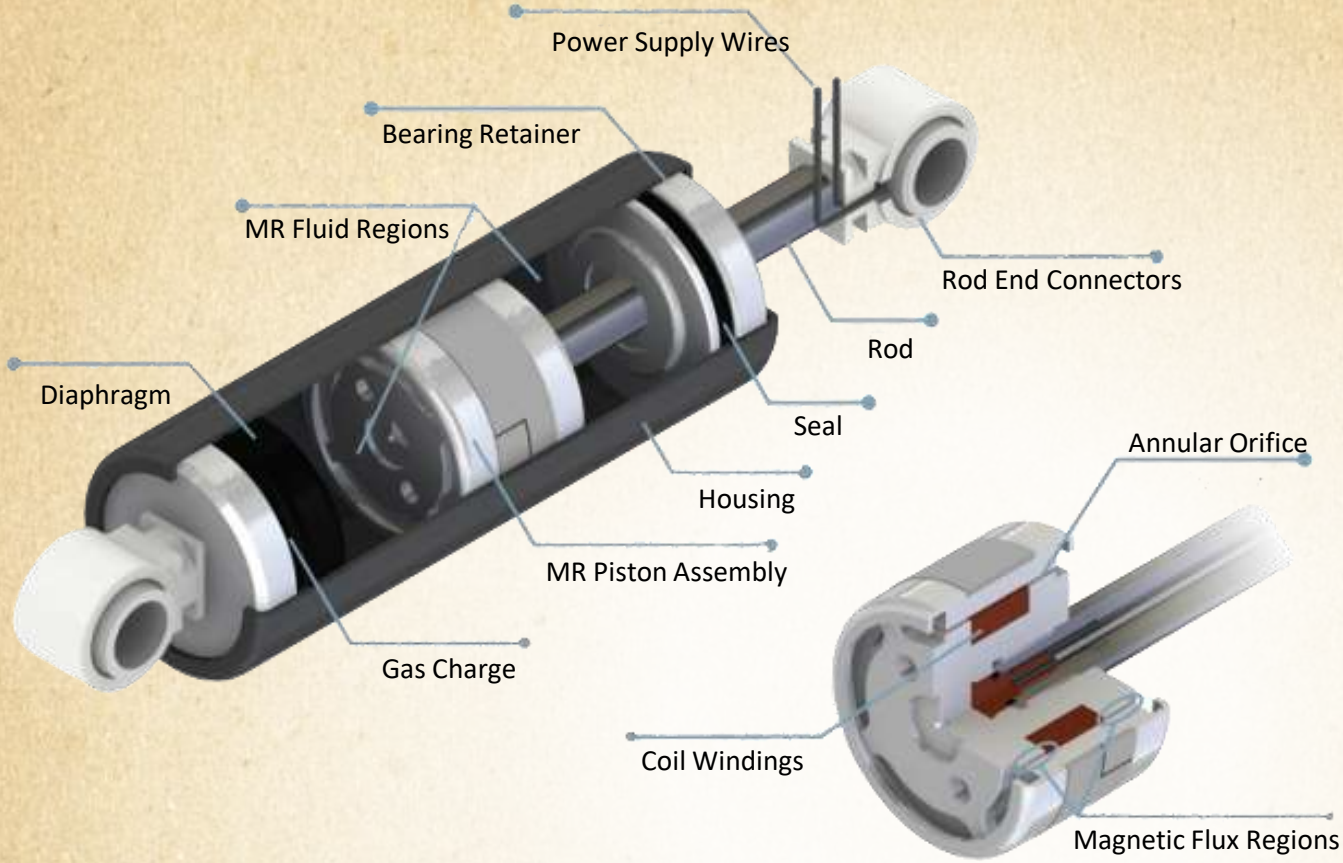
- The function of packaging materials and technique has seen its envelope grow widely in the past few years due to the complex new systems and challenges such as increased consumer demand, long distance logistics, rapid delivery models and strict cost control measures.
- Nowadays, the cargo has to be protected not only from mechanical shocks, but also temperature fluctuations, humidity, light, pressure, chemical and biological hazards.
- Various types of materials are used for packaging a single item- which not only decreases efficiency of the system, but also is heavy, prone to failure and not reusable, which significantly increases the cost and carbon footprint of the industry.
- Therefore, there is a need to simplify, and at the same time create solutions for new challenges facing the manufacturing and distribution of various types of goods.

For example, this is the current method of packing vaccine vials for transportation

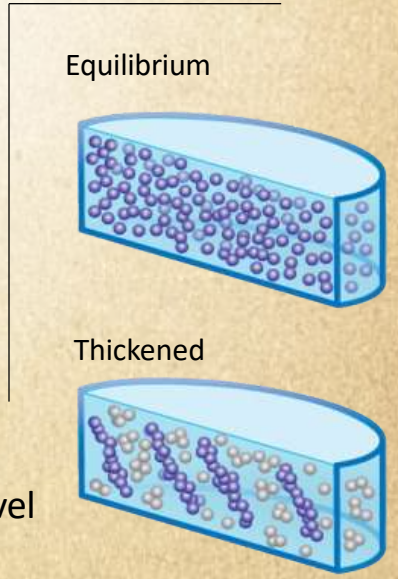


MATERIALS USED

- Shear Thickening Fluids (STF), also called dilatants, are fluids which do not have a constant viscosity but instead, the viscosity varies with shear force applied.
- In simple words, viscosity increases as the force applied on it increases i.e. the fluid becomes solid for the time force is applied and that too instantaneously (with no time lag).
- This gives the material a unique property of active impact force and vibration absorption, for which it has been studied exhaustively.
- Fluids where viscosity can be controlled by various external stimuli:
- These materials behave similarly to STF, but their viscosity can be controlled.
- Magneto Rheological (MR) Fluids- Their viscosity increases when a magnetic field is applied.
- Electro Rheological (ER) Fluids- Their viscosity increase when an electric current is applied.
- Many more such materials exist which can change properties of the fluids in response to external stimuli like temperature and pressure.



Application of MR fluid in vehicle dampers to absorb impact forces in suspension

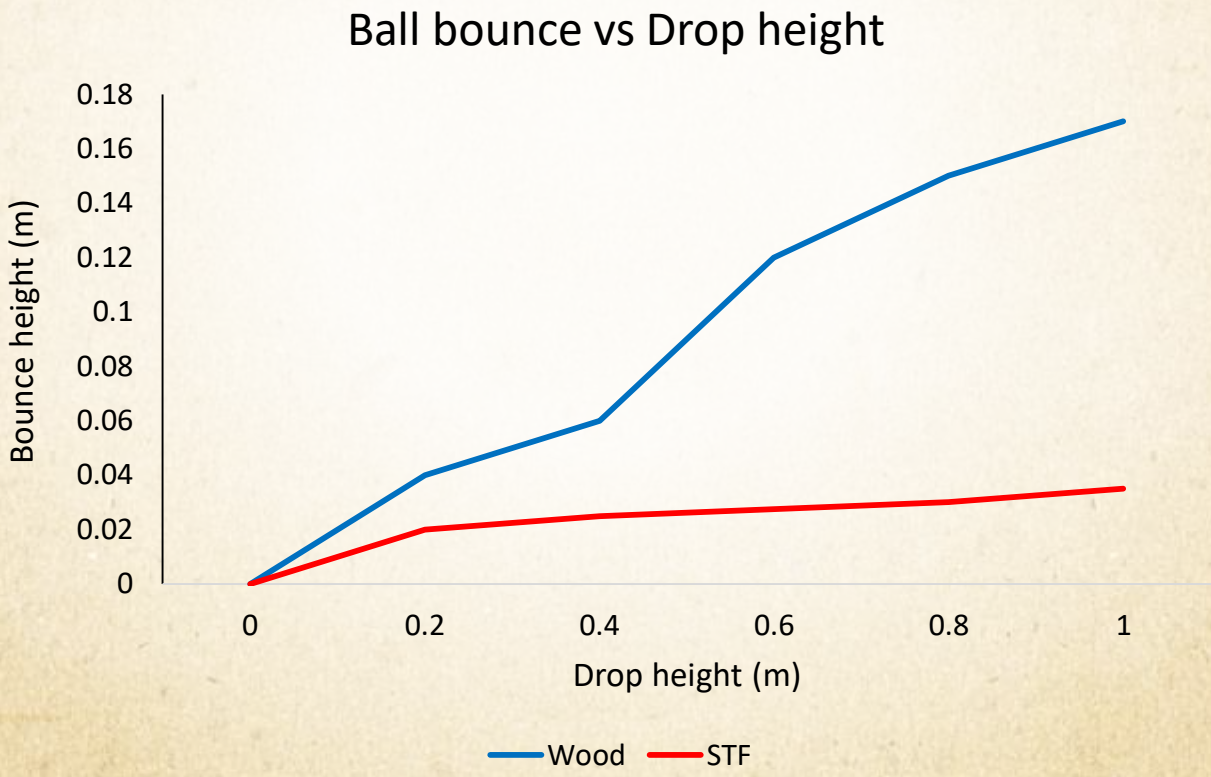


Working of Shear Thickening Fluid at a molecular level

HOW WELL DOES IT WORK?

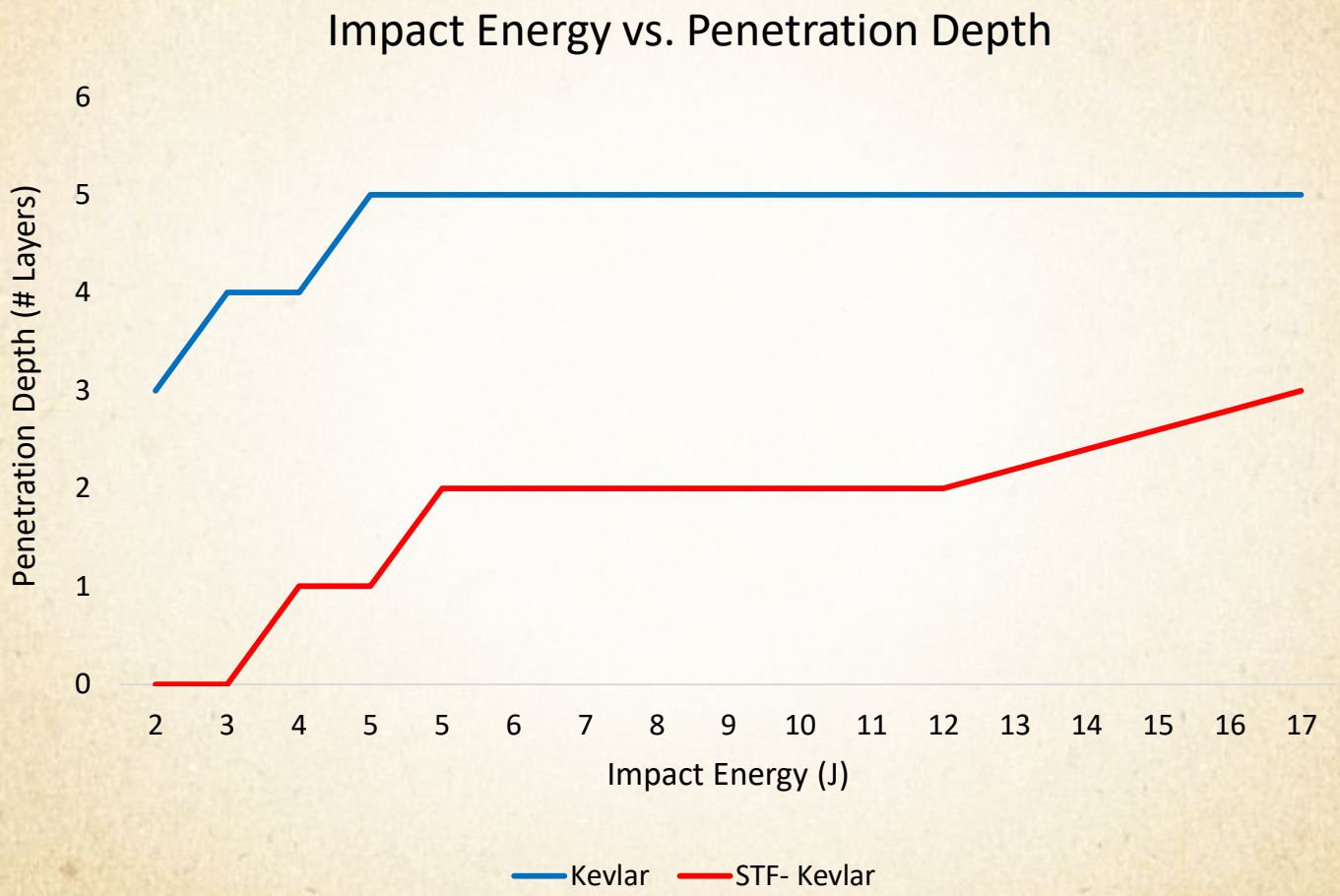
The first and simplest test consists of a ball being dropped on the test subjects and measuring the bounce height. We can calculate energy absorbed by calculating change in potential energy.

In this experiment, STF absorbs 5 times more energy than wood, which is a common packaging material.



Source: Duncan Price, ;Shear Thickening Fluid', May 2012

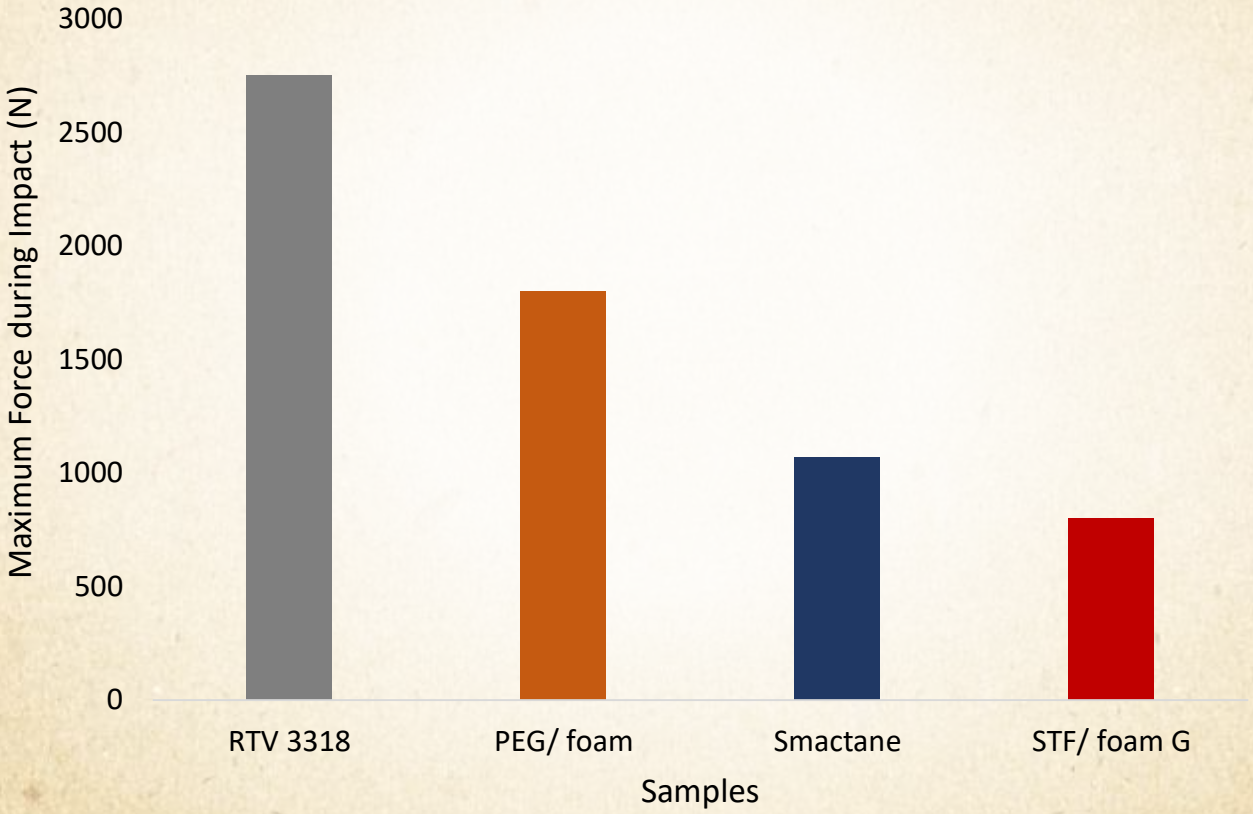
Impact Energy absorption of STF infused Kevlar as opposed to traditional Kevlar.
The depth is measured in number of layers.



Source: M.J Decker *et al*. 'Stab resistance of shear thickening fluid (STF)-treated fabrics', Oct 2006

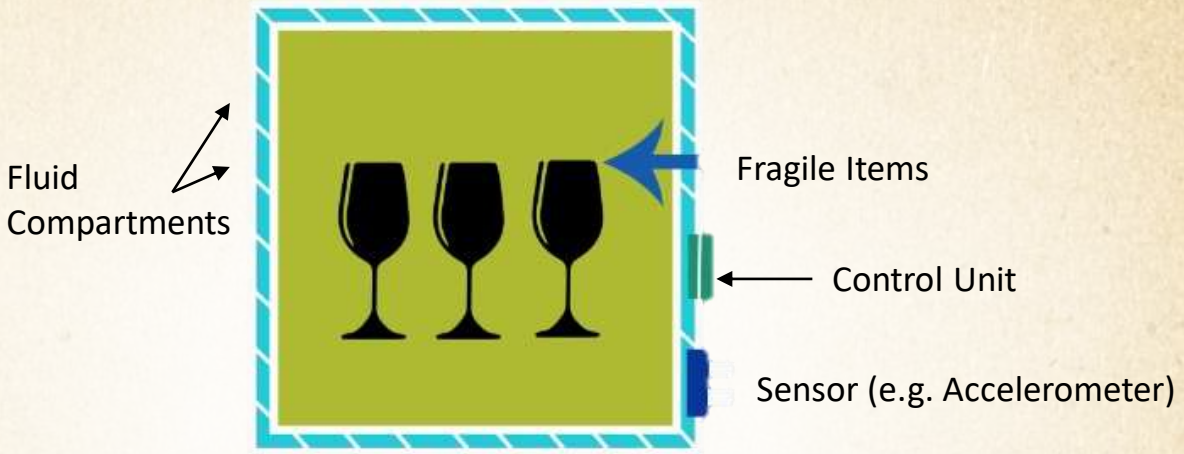
Here, the force is measured behind a specified thickness of the material.

RTV 3318: Silicone based soft polymer used as a reference
Foam: Common industrial foam used for insulation
Smactane®: Viscoelastic rubber material used for damping, specifically for space applications
STF/ foam G: Foam impregnated with STF



Source: M Soutrenon et al. 'Impact properties of shear thickening fluid impregnated foams', Feb 2014

SETUP



- Here, a sensitive cargo is put in a box which is surrounded by a removable fluid cove, which is compartmentalized.
- The sensor can be placed inside or the outside, depending on the type of sensor used, which can be ultrasonic (distance measuring), accelerometer, gyroscope, etc. or a combination of any of these.
- The control unit can be independent or combined with the sensor in a single module.
- The sensor and control unit's combined size will be extremely small.

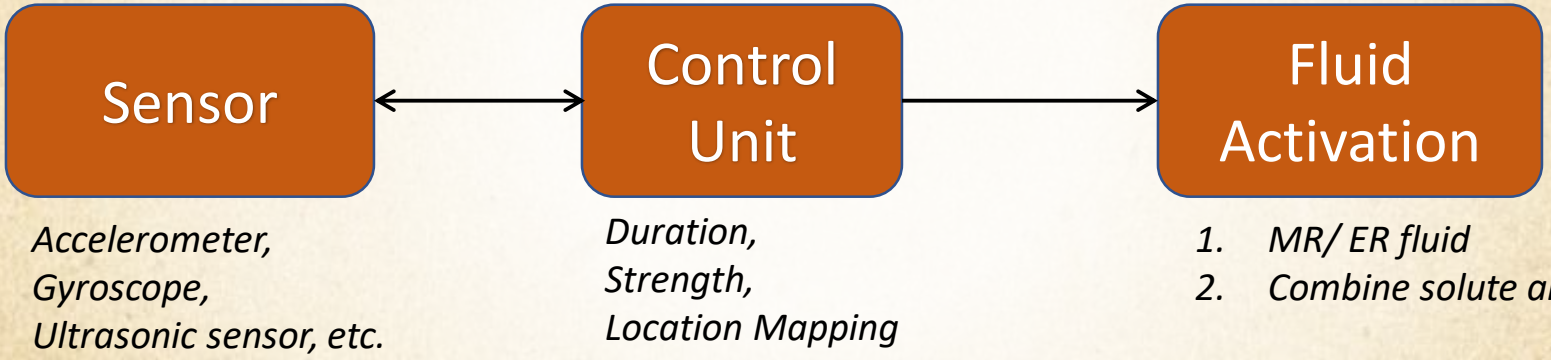
WORKING

- The STF is stored in an outer shell where it is deemed to be most effective for impact absorption in a structure.
- Static Method- The STF absorbs the impact and vibrations only due to it's inherent properties. The fluid remains stationary throughout the process. (reusable)
- **The problem** with this method is that since the STF is a suspension (particles settle down in a solvent)- so the fluid loses its property after some time and has to be agitated continuously.
- Dynamic Method 1- STF is stored as two individual packets containing solvent and solute- and get mixed just before the impact. (non-reusable)
- Here, the solvent and solute are mixed just before the impact. Sensors can be used to detect free fall, orientation and other characteristics, which also determines the location of impact, and the two packets are mixed just before the impact.

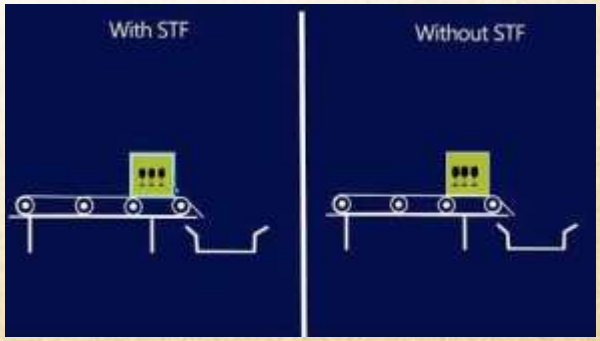



WORKING METHOD 2

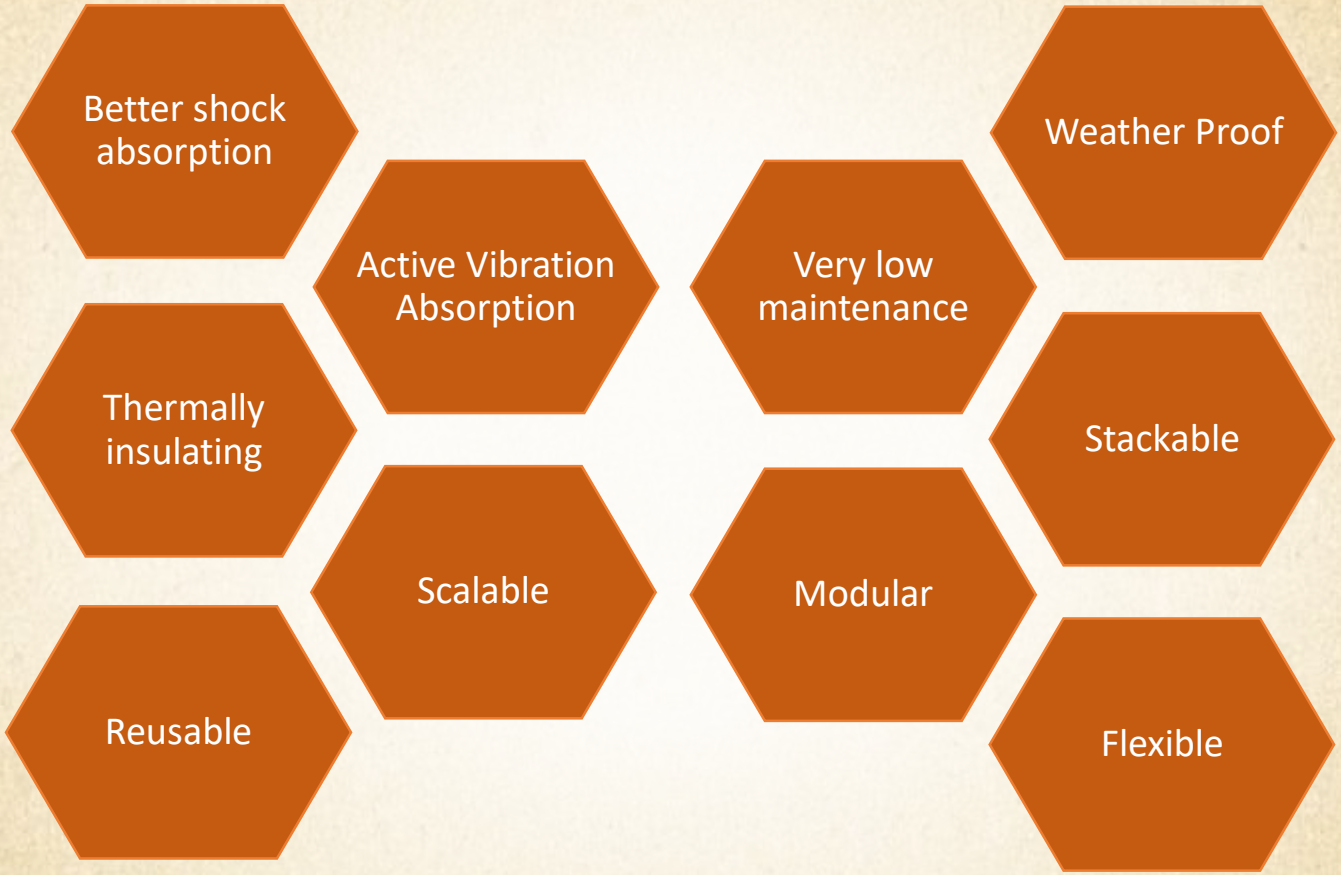
- Dynamic Method 2- The fluid remains of a desirable viscosity in normal circumstances, and a magnetic field/ electric current is applied to trigger the fluid when needed.
- It can be controlled via sensors as the previous method.
- For vibration absorption, its viscosity can be dynamically controlled according to the amplitude and frequency of the vibration so to get maximum efficacy.
- Dynamic Method 2 makes this system maintenance free, while at the same time reducing the complexity of the whole method. It ensures long life of the system, since the fluid does not degrade. (reusable)



- Video Link: https://youtu.be/vmTRHxuzDzA



BENEFITS


Better shock absorption
Active Vibration Absorption
Thermally insulating
Scalable
Reusable
Very low maintenance
Modular
Weather Proof
Stackable
Flexible

FEATURES

The properties of the fluid can be changed by modifying the constituents and varying particle size, volume fraction and concentration. Special additives can be added to -

1. *Absorb UV/IR radiation*
2. *Absorb moisture*
3. *Bacterial and fungal growth inhibitors; and much more*

- Since the formulation of the fluid can be changed according to the properties required, it provides protection against a lot of hazards-

1. Mechanical – Absorb shock, impact, compression, vibration, abrasion.
2. Climate – Add additives to absorb moisture.
3. Temperature- The fluid layer can be an excellent insulator.
4. It can contribute to seal against atmospheric gases and chemical hazards.
5. Light – Additives which can absorb UV/IR radiation.
6. Growth inhibitor additives to mitigate bacterial and fungal growth.

APPLICATIONS:

- To transport any kind of sensitive cargo or common consumer goods via drone, for example medical equipment and instruments, organ transport.
- Automobile safety (for example in bumper or crumple zones)
- Susceptible part of drones, such as landing gear to strengthen the frame and absorb forces.
- Smart prosthetics where a sensor setup on the body (e.g. smartphone) can activate the fluid.

DRONE DELIVERY:

- Drone deliveries for emergency and non-emergency medical supplies like injections, vaccination vials, first aid supply (near a major accident or natural calamity site) is going to increase exponentially in the near future.
- Zipline has completed 43000+ deliveries of medical supplies, and companies like Amazon and Uber have invested heavily in this sector.
- The type and quantity of load can be a problem- this is not a range or capacity issue, but a packaging problem- since the velocity at which the package hits the ground is considerable, and might damage supplies.
- There is a need for smarter, lighter and stronger packaging to withstand the mechanical forces generated during the flight and dropping the package.

The Inventor:

The inventor, Chinmay Kendurkar, is passionate about safety engineering, and is familiar with smart and advanced materials and their application in the industry.

He also has five other inventions in various fields of engineering, and is about to join MS program in Aerospace Engineering at Virginia Tech.

Being an ardent researcher for the most of his bachelor's degree, he has published eight research papers in various journals and believes that true innovations come from multidisciplinary engineering and using simple concepts for making our day-to-day life easier, more efficient and safe.

LinkedIn: https://www.linkedin.com/in/chinmay-kendurkar/

Expectations:

- Patent Applicant is interested in sale of IP
- Patent Applicant wishes to offer exclusive or non-exclusive Licensing Rights.

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Thank You!