iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 Issue: II Month of publication: February 2022

DOI: https://doi.org/10.22214/ijraset.2022.40237

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue II Feb 2022- Available at www.ijraset.com

Analysis of Materials Used in Hyperloop Capsule

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Abstract: Hyperloop transportation system is the advancement of railway system. It can eliminate most of the problems which occurs when we use road as a medium of transport. It uses a capsule kind of a thing which carries upto 28 passengers. The main area of research done is on the materials used to make the capsule of the hyperloop. We have compared many materials and have come out with the best material as far as our knowledge is concerned . The capsule must be made of materials which possess very good properties and which are resistant to impact forces. We have come across 3 such materials and have included another interesting material which can be made in the near future. While selecting the material we have to do a pre feasibility study which covers aspects such as budget longetivity availability etc. The four materials which we came across are steel , concrete, carbon fibre and vibranium.

I. INTRODUCTION

Elon Musk was the first to propose this transportation system, and in this paper, he outlined the project's ultra-high-speed transit system. This transportation system was designed to convey passengers between San Francisco and Los Angeles in California (USA). This technology uses a capsule that travels at a speed of 1220 kilometres per hour inside the tube, covering a distance of 561 kilometres in around 30 minutes. This ultra-high-speed transportation system, known as the Hyperloop, became so well-known that numerous governments began development in preparation for its usage.

We came across 4 such materials. The most used material used is steel because of its high strength Another material used is carbon fiber because they have less weight when compared to other materials listed further. Vibranium is also a material which we came across but it doesn't exist in real world but can be developed using intelligent engineering. Concrete is also used because rigidity and stiffness.

II. STEEL

One of the most often used low carbon steels is SAE AISI 1018. Carburized steel is the most common application. Because the majority of 1018 carbon steel is made by cold drawing, this cold rolled steel is referred to as C1018 (1018 cold rolled steel). Weldability, surface hardening quality, mechanical qualities, and machinability are all advantages of AISI C1018 steel (1018 CRS). Cold drawing improves tensile, yield, torsional, surface hardness, and wear resistance while reducing ductility.

1018 HR is an ASTM AISI SAE 1018 hot rolled steel with good toughness, strength, ductility, formability, weldability, and workability.

Applications

Round bar, flat bar, steel tubing and pipes, and other semifinished and finished items are available in AISI SAE ASTM 1018 steel.

Carburized parts such as gears, pinions, ratchets, worms, pins, chain pins, pins, machine parts, tools, and mould components are usually made of 1018 carbon steel.

A. Specification & Datasheet

The chemical composition, density, thermal expansion coefficient, thermal conductivity, yield strength, hardness, and other properties of AISI 1018 carbon steel are listed below.

B. AISI SAE 1018 Chemical Composition

ASTM AISI SAE 1018 chemical composition is presented in the following table.

	AISI SAE 1018 Chemical Composition (%)			
Steel Grade	C	Mn	P (≤)	S (≤)
1018 (UNS G10180)	0.15-0.20	0.60-0.90	0.040	0.050

C. AISI SAE 1018 Mechanical Properties

Modulus of elasticity (Young's modulus): 186 GPa (27×10^6 psi)

The following tables give AISI SAE 1018 steel mechanical properties of cold-drawn carbon steel rounds, squares, and hexagons.

Steel (UNS)	Tensile strength (Mpa)	Yield strength (Mpa)	Elongation in 50 mm, %	Reduction in area, %	Hardness (HB)	Processing, condition or treatment	Sample Diameter (mm)
AISI 1018 (G10180)	483	413	18	40	143	Cold drawn	16-22
	440	370	15	40	125	Cold drawn	20-32
	414	345	15	35	120	Cold drawn	32-51
	400	220	25	50	115	Hot rolled (steel bar)	20-32

D. Typical Heat treatment for SAE 1018 Case Hardening

1) Reheat temperature: 790 °C (1450 °F), cooling method: water or 3 percent sodium hydroxide; • Carbon temperature: 900-925 °C (1650-1700 °F), cooling method: water or caustic;
2) Temperature for carbonitriding: 790-900 °C (1450-1650 °F), cooling method: oil
3) Temper temperature: 120-205 °C (250-400 °F) to relieve stress and improve crack resistance (not mandatory).

III. CONCRETE

A. Hyperloop Concrete Structure and Tubes

Hyperloop tubes must be sturdy, stiff, resilient, and airtight. The shape and size of the tubes are currently made of concrete and steel, however an alternate tube design in concrete (ultrahigh performance steel fibre reinforced concrete) UHPFRC is also being studied. The hyperloop's structure is made up of huge concrete tubes. These tubes will mostly be erected on pylons, with some ground level and underground pieces thrown in for good measure.

B. Properties of Hyperloop Concrete

1) The tubes has condition similar to a vaccum.
2) It almost eliminates air resistance.
3) During moment, the pod levitates which in turn reduces the force of friction.
4) As it moves faster, because of straight tubes.

Grades of concrete	Modulus of Elasticity in KN/mm2
M20- M25	30
M25-M30	31
M30-M35	32
M35-M50	33-35
Grades of concrete	Tensile strength
M20- M25	2.2 N/mm2
M25-M30	2.6 N/mm2
M30-M35	2.9 N/mm2
M35-M50	3.2-3.5N/mm2
M50-M60	3.5-4.1N/mm2

C. Advantages

1) These pipes can withstand tensile stress (due to internal pressure).
2) They are economical, hence used for every type of sewers.
3) High compressive strength.

D. Disadvantage

1) Can crack, due to dry shrinkage and moisture expansion.
2) Require formwork.
3) Low tensile strength and toughness.
4) Require a bulky structure.

IV. CARBON FIBRES

A. Introduction

Carbon fibres are of five to 10 micrometres in diameter
They Are Mostly Made Of Carbon Atoms
It was first founded in 1860 by Joseph swan
It was used in light bulbs
Its chemical formula is C60

B. Properties

1) High strength to weight ratio
2) Corrosion Resistant And Chemically Stable
3) Good fatigue resistance
4) Electrically conductive in nature
5) Very rigid in nature
6) Low coefficient of thermal expansion
7) Good Thermal conductivity

Material	Grade / Type	Design / Application	Longitudinal Tensile Strength (ksi)	Longitudinal Tensile Modulus (Msi)	Shear Modulus (Msi)	Density (g/cm^3)
Carbon Fiber/Epoxy (Unidirectional)	Standard Modulus	Bending	300	15	0.6	1.55
Carbon Fiber/Epoxy (Unidirectional)	Standard Modulus	Torsion	20	2.2	4.5	1.55
Carbon Fiber/Epoxy (Unidirectional)	Intermediate Modulus	Bending	325	20	0.6	1.57
Carbon Fiber/Epoxy (Unidirectional)	High Modulus	Bending	250	30	0.6	1.59
Carbon Fiber/Epoxy (Unidirectional)	Ultra High Modulus	Bending	200	45	0.6	1.70
Steel	4130		100	30	12	7.7
Titanium	6M-4V		120	16	6.2	4.34
Aluminum	6061-T6		35	10	3.8	2.7

C. Characteristics

1) Physical strength, lightweight
2) Good vibration damping arm
3) Electromagnetic Properties Rings

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D. Application

1) Automobile, sporting goods
2) Audio equipment, robot
3) Large generators, retaining.

V. VIBRANIUM

Hyperloop Transportation Technologies has claimed that it would use a new form of sensor-embedded carbon fibre in its capsules to make them capable of transporting passengers through a practically airless tube at speeds of up to 760 mph in a manner that is safer than ever before. The new substance is known as vibranium by the business. Anyone who has even a rudimentary understanding of Marvel Comics may recognise this name.

A. Advantages

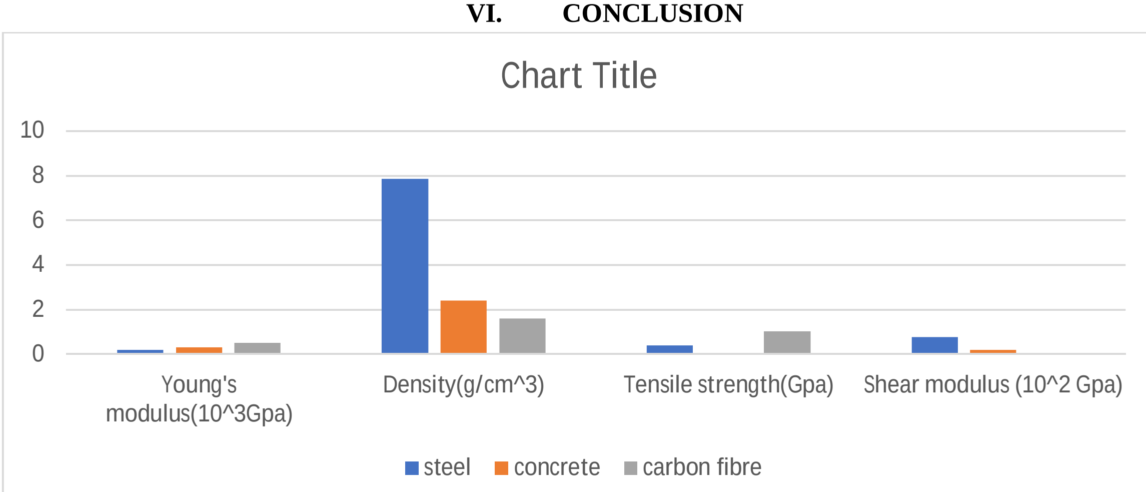
1) It is stronger than steel and 1/3 of its weight
2) It is completely vibration and sound absorbent which means that it makes no sound even during any impact with an obstacle
3) It conducts electricity
4) It has magnetic properties
5) It is wind assistant
6) It deflects kinetic energy

No natural material can have those qualities in the actual world. According to Drexel University's leading professors, sophisticated nanoparticles can be used to achieve various vibranium qualities while creating materials structures. For example, using sophisticated ceramic materials like boron carbide for lightweight armour or using fisoelectric materials that can convert vibrations into power. Some of the traits are visible in materials (with more than one element to form alloys or compounds), according to Ravichandran, a professor of chemical engineering, but not to the same extent as in vibranium. He cites visco elastic materials as an example, claiming that while they are good at absorbing sound, they aren't stiff enough to perform like vibranium. Other materials may be more impact resistant, however
So vibranium just exhibits the best properties of all materials .

B. Scope for Real World Vibranium

The greatest material we have for a real-world analogue of vibranium is probably graphene. However, some individuals are concerned about nano composite structures and designing materials that use nano particles that act like sand from a bowling ball that has been thrown out of a window. They're doing it in such a way that when energy comes in from a blast or a collision, it's distributed out over the nano particles. They can disperse the energy over a large number of atoms, ensuring that no new atom bears the entire weight and that no chemical connections or fissures are formed.

VI. CONCLUSION



From the above data we can conclude that carbon fiber has out performed in all the parameters but because of its cost we prefer steel to be used since it is more practical as it is widely available and less cost.

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