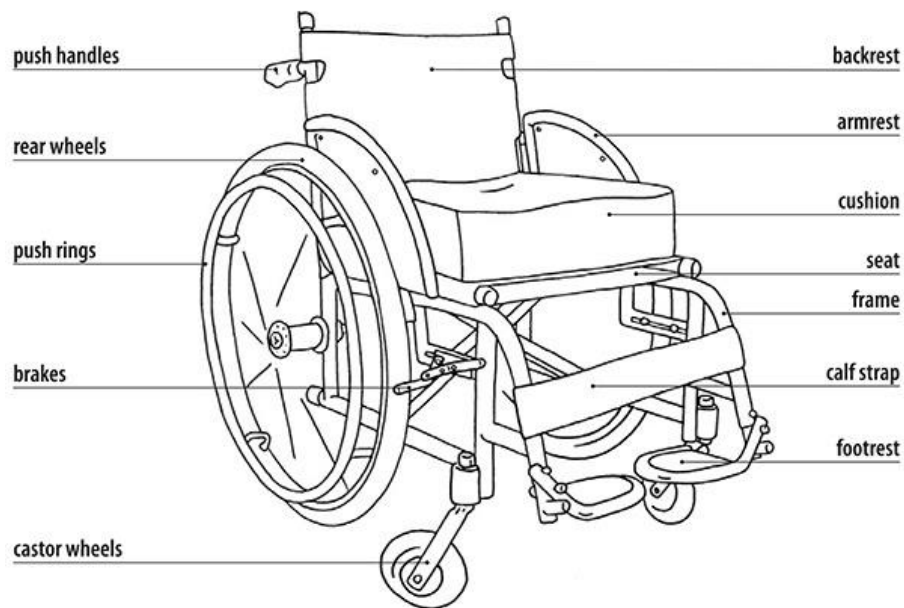
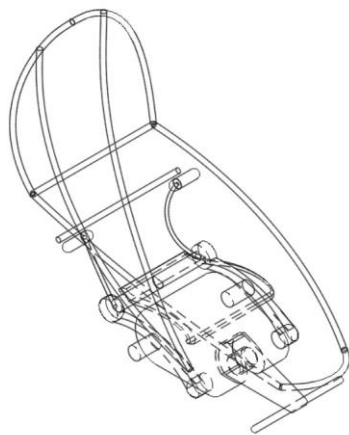


Material Selection for Wheel Chair Frame

Typical wheel Chair figure:



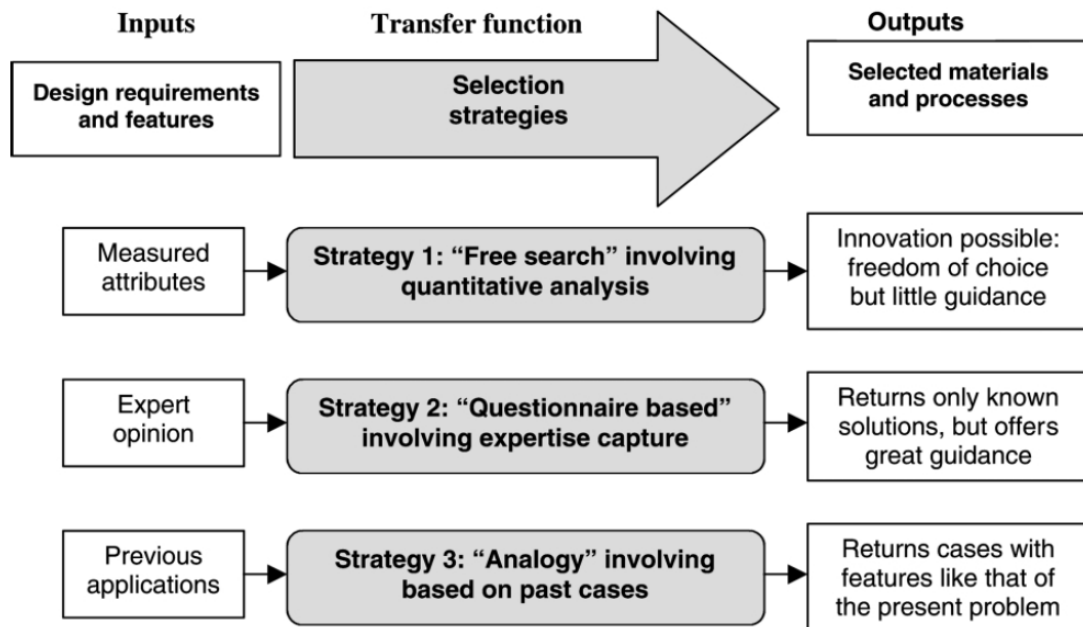
Wheel Chair Frame Modelled for Prototyping:



Wheel chair frame is main load bearing member of wheelchair. The material selection for the same has to be performed appropriately in-order to ensure strength to withstand loads acting on it. THE CES EDU PACK tool is used in shortlisting material for the frame.

SELECTION STRATEGIES

"Selection strategy act as a transfer function, converting design requirements into a listing of selected material and processes, with background information about each." Ref. M.F. Ashby et al. Materials and Design 25 (2004)

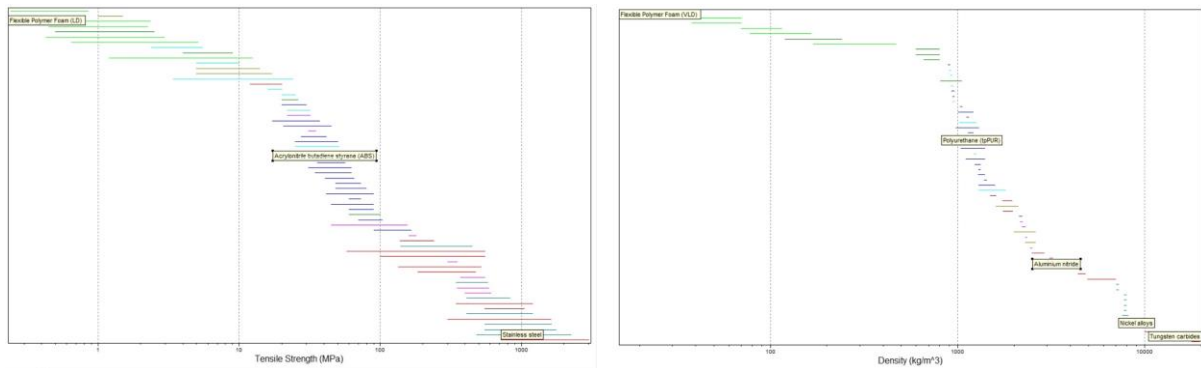


PROGRESSION OF MATERIAL SELECTION

There are several materials available in Engineering world. Design demands mostly high strength, high resistance to corrosion, low density, low cost, easy availability and flexible manufacturability.

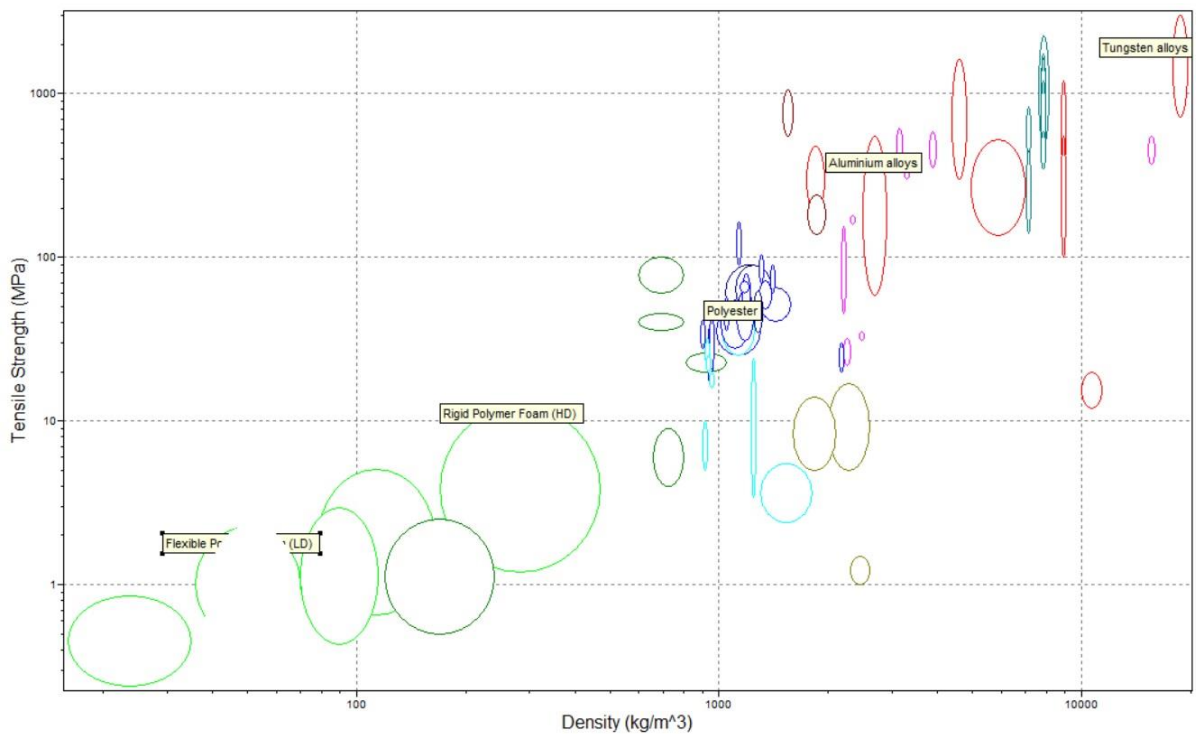


At first Density & tensile strength of materials are plotted independently



Stage I:

STRENGTH OF MATERIAL vs DENSITY



Criteria for Stage I: Material should be stronger enough and light weight. Minimum value of strength of 270 MPa executed for structural design and Density to 7750 kg/m³, so as lesser than steels weight.

Point to note that, here strength referring to Maximum tensile strength. As strength is different for different materials, like concrete its crushing strength, elastomers it's tearing strength, etc. care should be taken appropriately in choosing material.

Shortlisted Materials are:

Aluminium Alloys, Nickel alloys, Copper alloys, Molybdenum alloys, Zinc alloys, lead alloys and Cast Iron are excluded as density is greater than 7750 kg/m³ and based on polymer foams, elastomers, polymers, woods are excluded based on plastic deformation strength 270 MPa.

Materials are,

Composites

Magnesium Alloys

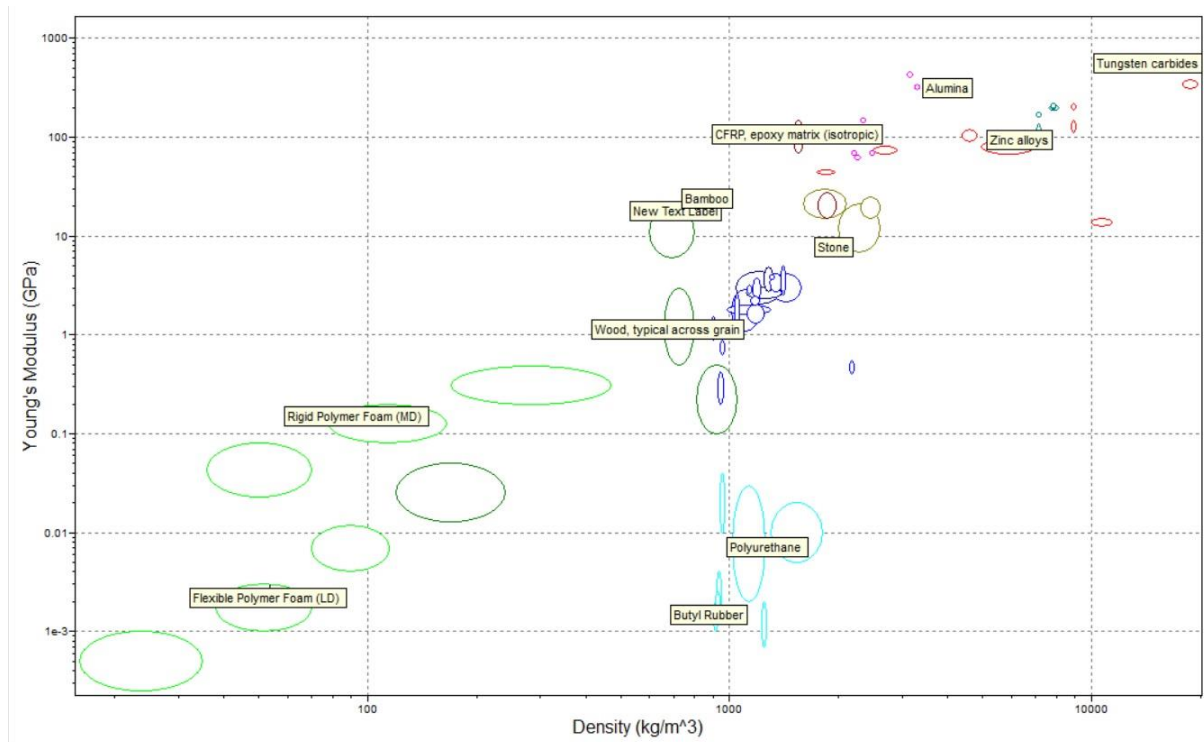
Aluminium Alloys

Ti Alloys

Ceramics

Stage 2:

YOUNG'S MODULUS vs DENSITY



Criteria for Stage 2: Young's Modulus determines the stiffness or sag ability of Material of construction. Out of shortlisted materials ascending order of materials in accordance with higher rankings are sorted.

Shortlisted Materials are:

Carbon Fibre Reinforced Polymer

Titanium Alloys

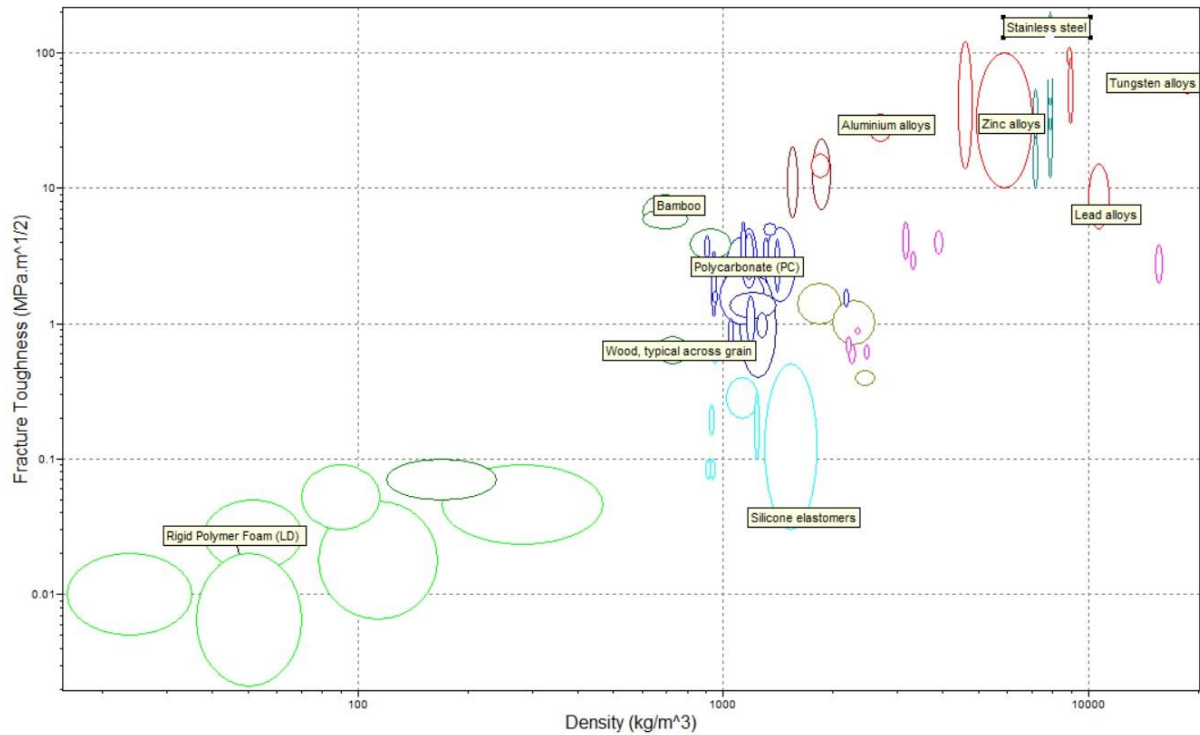
Glass Fibre Reinforced Polymer

Aluminium Alloys

Magnesium Alloys

Stage 3:

FRACTURE TOUGHNESS vs DENSITY



Criteria for Stage 3: Fracture Toughness determines the resistance of Crack propagation once crack has been initiated in the structure. Lower the value brittle is the material, with little load or damage initiation the metal will shatter immediately. On the same front, with higher value of Fracture Toughness, material will deform more & more before tearing.

Above 20 MPa m^{1/2} is the range of Engineering Materials and hence the minimum value for conventional design is kept as 20 MPa m^{1/2}. Almost all materials shortlisted satisfies this criteria as well.

Shortlisted Materials remains same.

Carbon Fibre Reinforced Polymer

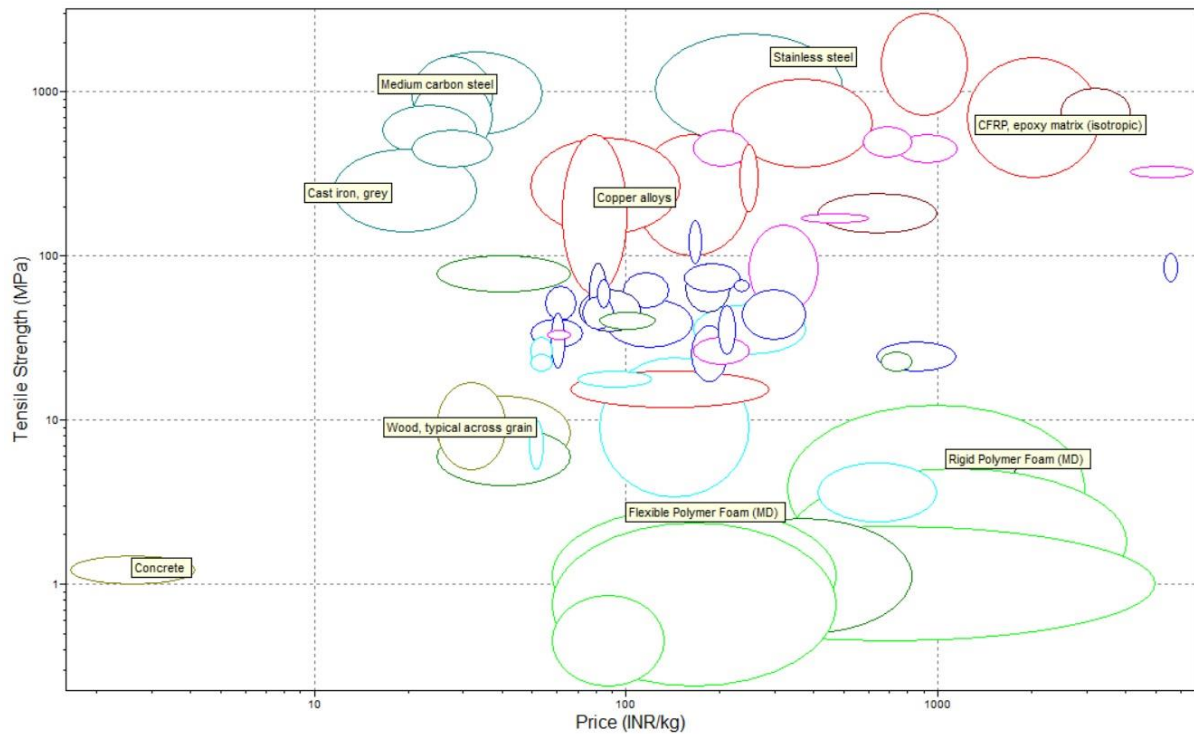
Titanium Alloys

Glass Fibre Reinforced Polymer

Aluminium Alloys

Stage 4:

STRENGTH OF MATERIAL vs COST INR



Criteria for Stage 4: Cheaper material is always preferred in the industry and cheaper material with higher strength is added advantage. Based on the priority criteria we have the shortlisted remains almost same.

Shortlisted Materials.

Carbon Fibre Reinforced Polymer

Titanium Alloys

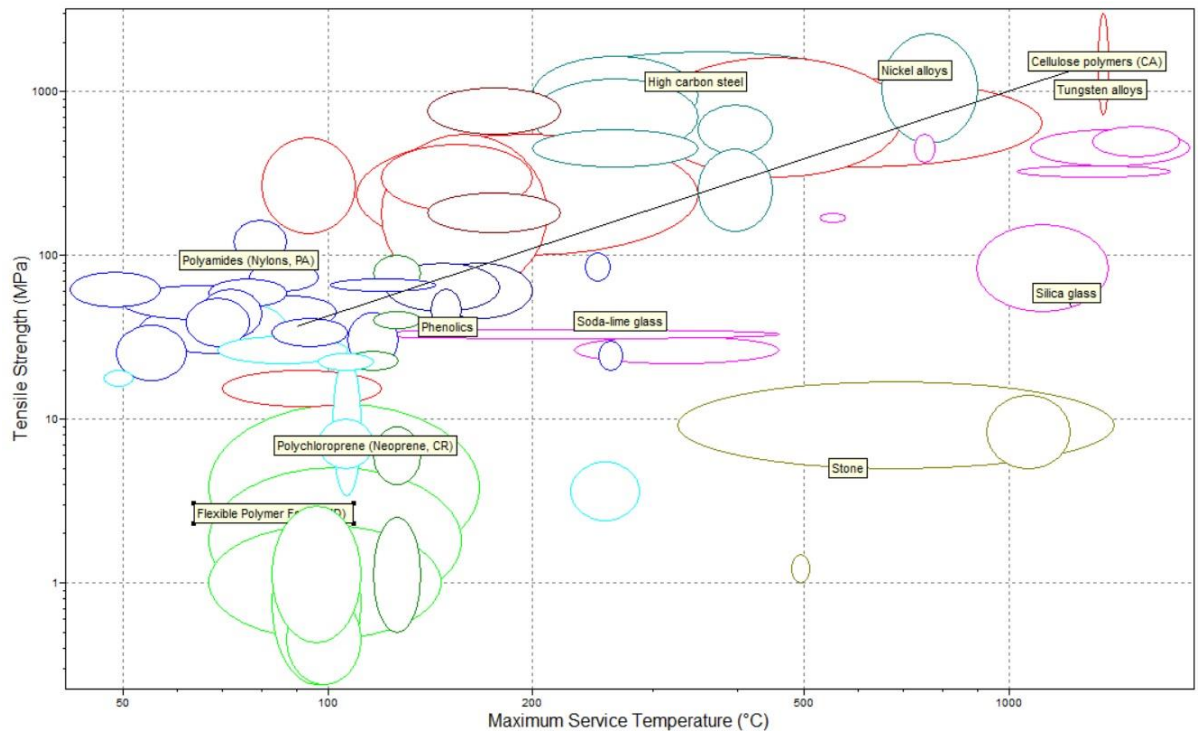
Glass Fibre Reinforced Polymer

Aluminium Alloys

Out of above lists, aluminium alloys are easily available and lower cost compared to other making process.

Stage 5:

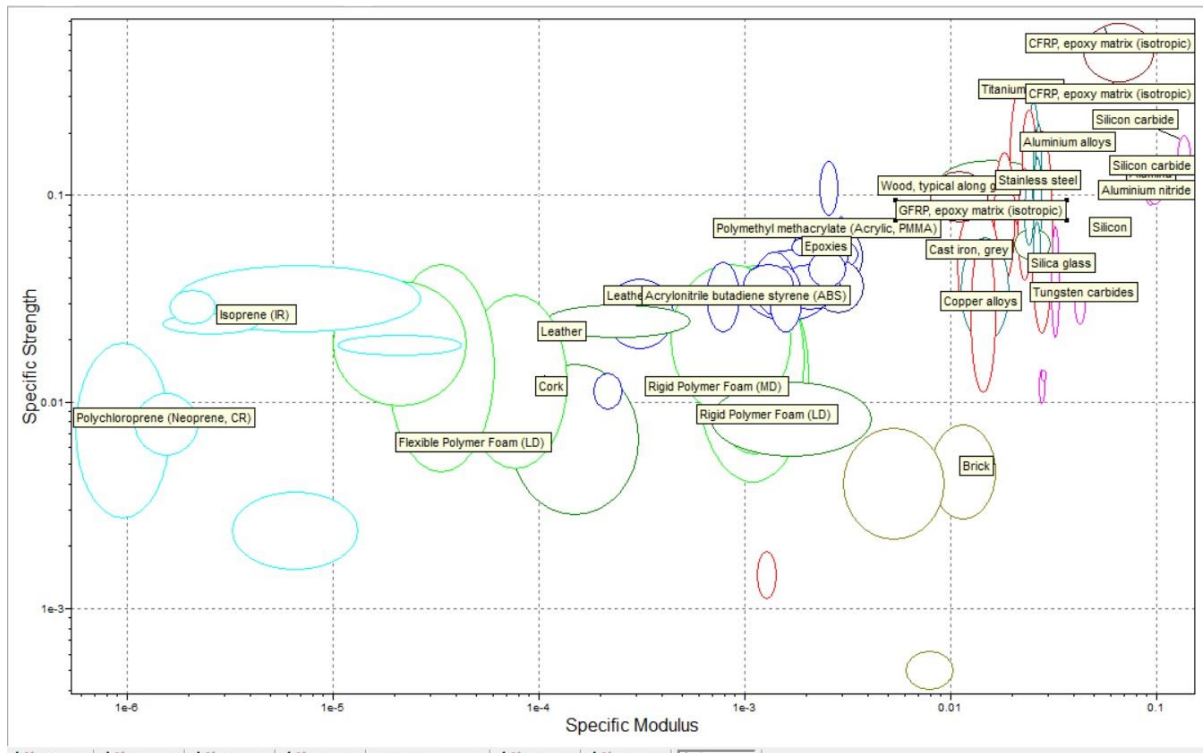
STRENGTH OF MATERIAL vs MAXIMUM SURFACE TEMPERATURE



Criteria for Stage 5: For wheel chair frame, the temperature range that will be exposed is never more than 200 degree Celsius. From the shortlisted materials, limiting the maximum temperature less than 200 degree Celsius and since it has battery will be used in the design, the proper thermal isolation should be taken care while making enclosure for electronic components. And making them water proof is also very eminent. Design of frame is made in such a way that temperature at frame should not reach above 50 degree Celsius. Aluminium alloys fits to this category as well.

Stage 6:

SPECIFIC STIFFNESS vs SPECIFIC STRENGTH OF MATERIAL



Criteria for Stage 6: The ratio of Strength of the Material to its density is the defined as specific strength of the material. This formulation is done by using advanced feature of CES tool. Similarly, the ratio of Young's modulus to it's respective density is called as Specific modulus of the material. Aluminium shares the capabilities similar to stainless steel. Less weight with more strength is most preferred. As so, aluminium alloys fits best in the lot.

From the slots of Aluminium alloys, Aluminium 6000 Series is selected as they used in automobile industry which will be optimum for designing Wheel chair frame.



Design guidelines

Aluminum alloys are light, can be strong, and are easily worked. Pure aluminum has outstanding electrical and thermal conductivity (copper is the only competition here) and is relatively cheap - though still more than twice the price of steel. It is a reactive metal - in powder form it can explode - but in bulk an oxide film (Al_2O_3) forms on its surface, protecting it from corrosion in water and acids (but not strong alkalis). Aluminum alloys are not good for sliding surfaces - they scuff - and the fatigue strength of the high-strength alloys is poor. Nearly pure aluminum (1000 series alloys) is used for small appliances and siding; high strength alloys are used in aerospace (2000 and 7000 series), and extrudable, medium strength alloys are used in the automotive and general engineering sectors (6000 series).

Technical notes

Until 1970, designations of wrought aluminum alloys were a mess; in many countries, they were simply numbered in the order of their development. The International Alloy Designation System (IADS), now widely accepted, gives each wrought alloy a 4-digit number. The first digit indicates the major alloying element or elements. Thus the series 1xxx describe unalloyed aluminum; the 2xxx series contain copper as the major alloying element, and so forth. The third and fourth digits are significant in the 1xxx series but not in the others; in 1xxx series they describe the minimum purity of the aluminum; thus 1145 has a minimum purity of 99.45%; 1200 has a minimum purity of 99.00%. In all other series, the third and fourth digits are simply serial numbers; thus 5082 and 5083 are two distinct aluminum-magnesium alloys. The second digit has a curious function: it indicates a close relationship: thus 5352 is closely related to 5052 and 5252; and 7075 and 7475 differ only slightly in composition. To these serial numbers are added a suffix indicating the state of hardening or heat treatment. The suffix F means 'as fabricated'. Suffix O means 'annealed wrought products'. The suffix H means that the material is 'cold worked'. The suffix T means that it has been 'heat treated'. No classification system for cast aluminum alloys has international acceptance. In the most widely used (the AAUS system), the first digit indicates the alloy group. In the 1xx.x group, the second two digits indicate the minimum percentage of aluminum; thus 150.x indicates a composition containing a minimum of 99.5% aluminum. The digit to the right of the decimal point indicates the product form: 0 means 'castings' and 1 means 'ingot'. In the 2xx.x to 9xx.x groups, the second two digits are simply serial numbers. The digit to the right of the decimal point again indicates product form. More information on designations and equivalent grades can be found in the Users section of the Granta Design website, www.grantadesign.com

Typical uses

Aerospace engineering; automotive engineering - pistons, clutch housings, exhaust manifolds; die cast chassis for household and electronic products; siding for buildings; foil for containers and packaging; beverage cans; electrical and thermal conductors.

Based on the above stages of selection criteria, Aluminium 6000 series has been selected for the construction of wheel chair frame. In-future, with appropriate market survey apt series of material will be shortlisted.