Introduction into GRANTA EduPack

MATERIAL SELECTION OF SPRINGS FOR JUMPING LOCOMOTION AND HIGH-PRESSURE TURBINE DISK

VYSHAK SURESHKUMAR

202090275

- Introductory learning
- Can be used by any one from schools to universities
- Basic description of around 70 widely used materials
- Limited Data of material properties

- For advanced users with over 4000 materials
- Specialized packs like Aerospace, Polymer, etc.
- Extensive data for all materials

- For aerospace application additional material property with temperature dependent data is added to the database

- All of level 1 with around 100 widely used material
  with around 110 widely used materials
- Additional numerical data, design guidelines and technical notes
- Typically used for people who are finishing their bachelor degrees

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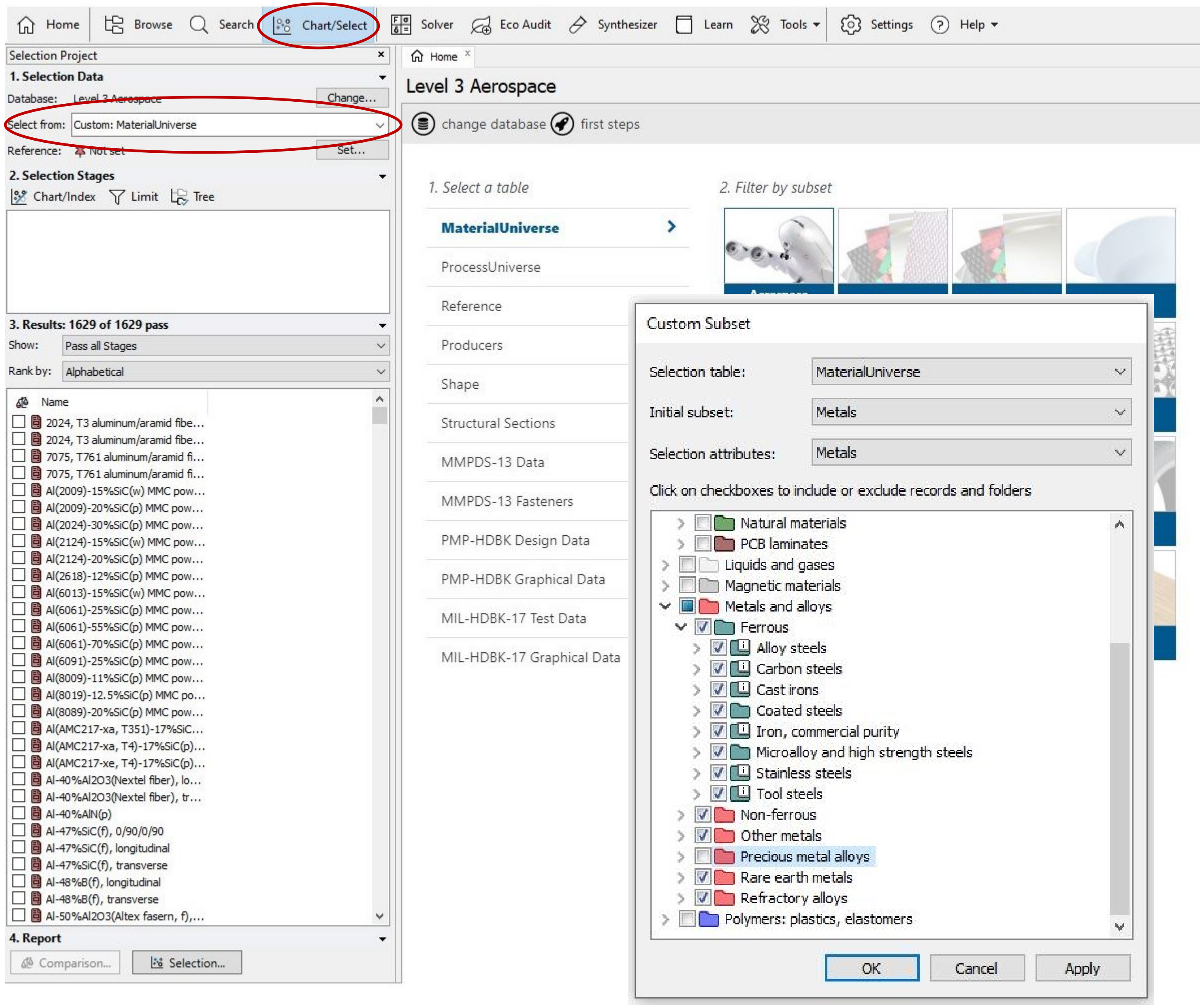

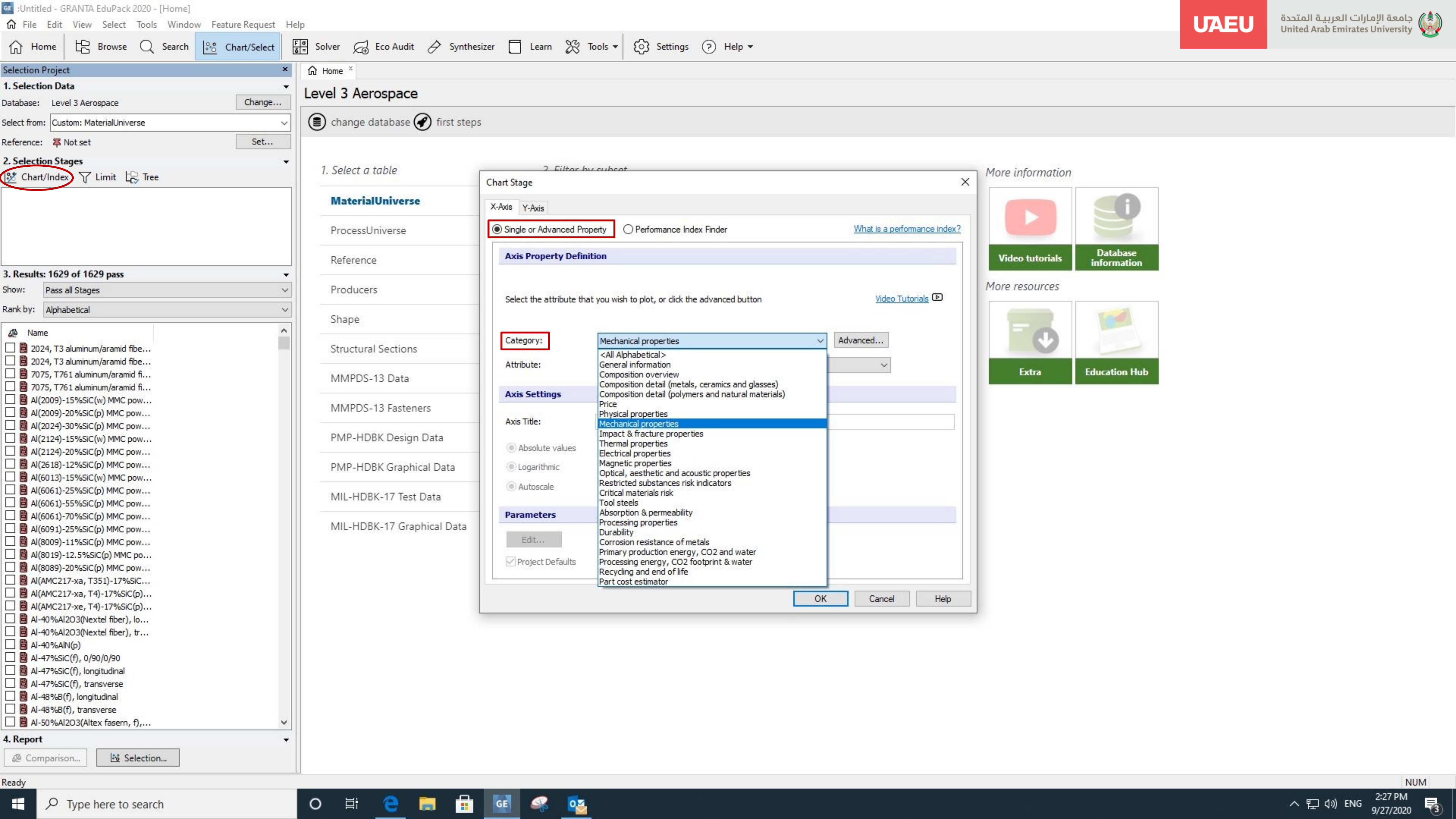
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Home Browse Search Chart/Select Solver Eco Audit Synthesizer Learn Tools Settings Help
Selection Project
1. Selection Data
Database: Level 3 Aerospace
Change...
Select from: Custom: MaterialUniverse
Reference: Not set
Set...
2. Selection Stages
Chart/Index Limit Tree
3. Results: 1629 of 1629 pass
Show: Pass all Stages
Rank by: Alphabetical
Name
2024, T3 aluminum/aramid fibe...
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4. Report
Comparison... Selection...
Home
Level 3 Aerospace
change database first steps
1. Select a table
2. Filter by subset
MaterialUniverse
ProcessUniverse
Reference
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Shape
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MMPDS-13 Data
MMPDS-13 Fasteners
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What is a performance index?
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Select the attribute that you wish to plot, or click the advanced button
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Attribute:
<All Alphabetical>
General information
Composition overview
Composition detail (metals, ceramics and glasses)
Composition detail (polymers and natural materials)
Price
Physical properties
Mechanical properties
Impact & fracture properties
Thermal properties
Electrical properties
Magnetic properties
Optical, aesthetic and acoustic properties
Restricted substances risk indicators
Critical materials risk
Tool steels
Absorption & permeability
Processing properties
Durability
Corrosion resistance of metals
Primary production energy, CO2 and water
Processing energy, CO2 footprint & water
Recycling and end of life
Part cost estimator
Axis Settings
Axis Title:
Absolute values
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Autoscale
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OK Cancel Help
More information
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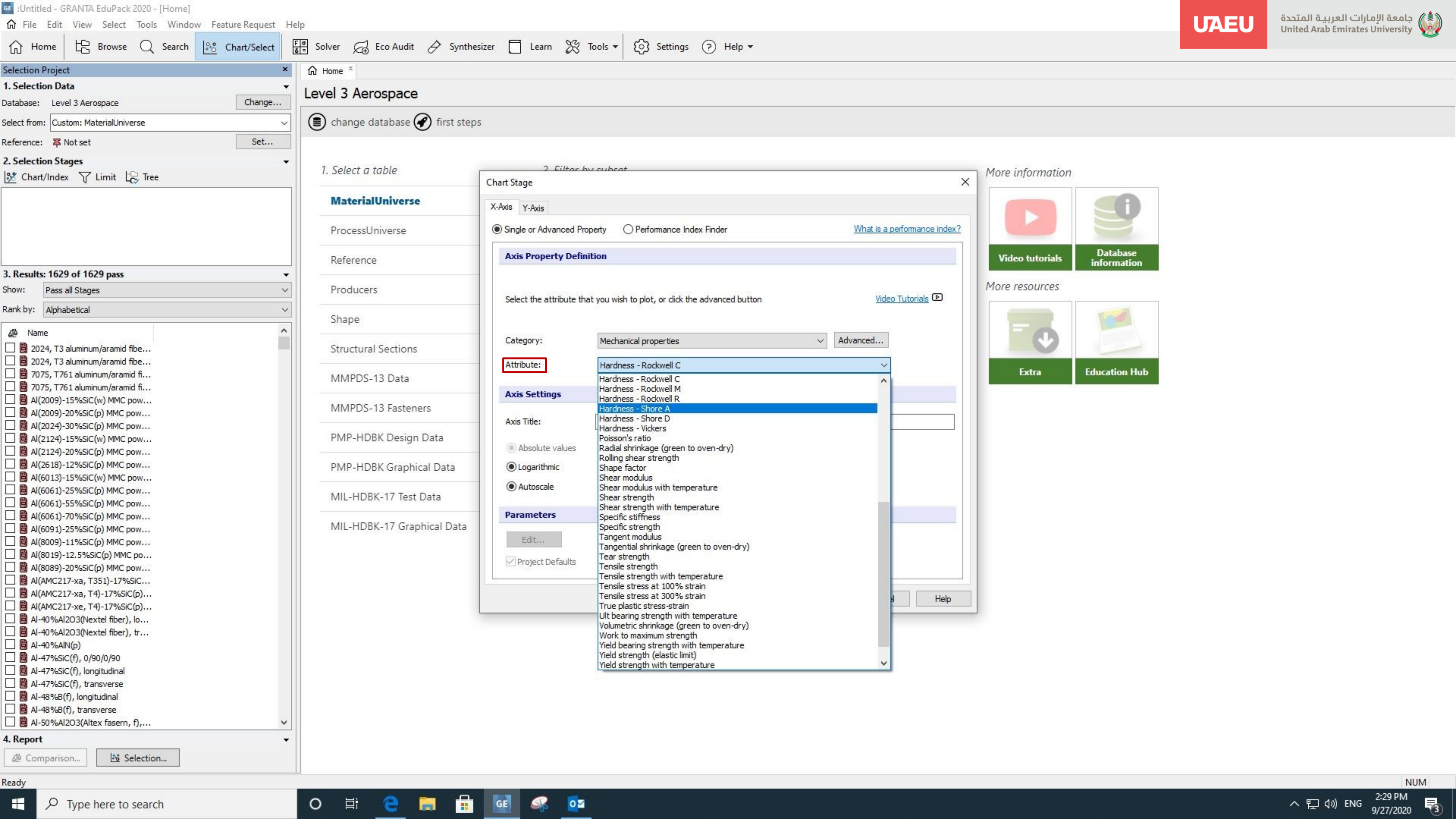

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Hardness - Rockwell C
Hardness - Rockwell M
Hardness - Rockwell R
Hardness - Shore A
Hardness - Shore D
Hardness - Vickers
Poisson's ratio
Radial shrinkage (green to oven-dry)
Rolling shear strength
Shape factor
Shear modulus
Shear modulus with temperature
Shear strength
Shear strength with temperature
Specific stiffness
Specific strength
Tangent modulus
Tangential shrinkage (green to oven-dry)
Tear strength
Tensile strength
Tensile strength with temperature
Tensile stress at 100% strain
Tensile stress at 300% strain
True plastic stress-strain
Ult bearing strength with temperature
Volumetric shrinkage (green to oven-dry)
Work to maximum strength
Yield bearing strength with temperature
Yield strength (elastic limit)
Yield strength with temperature
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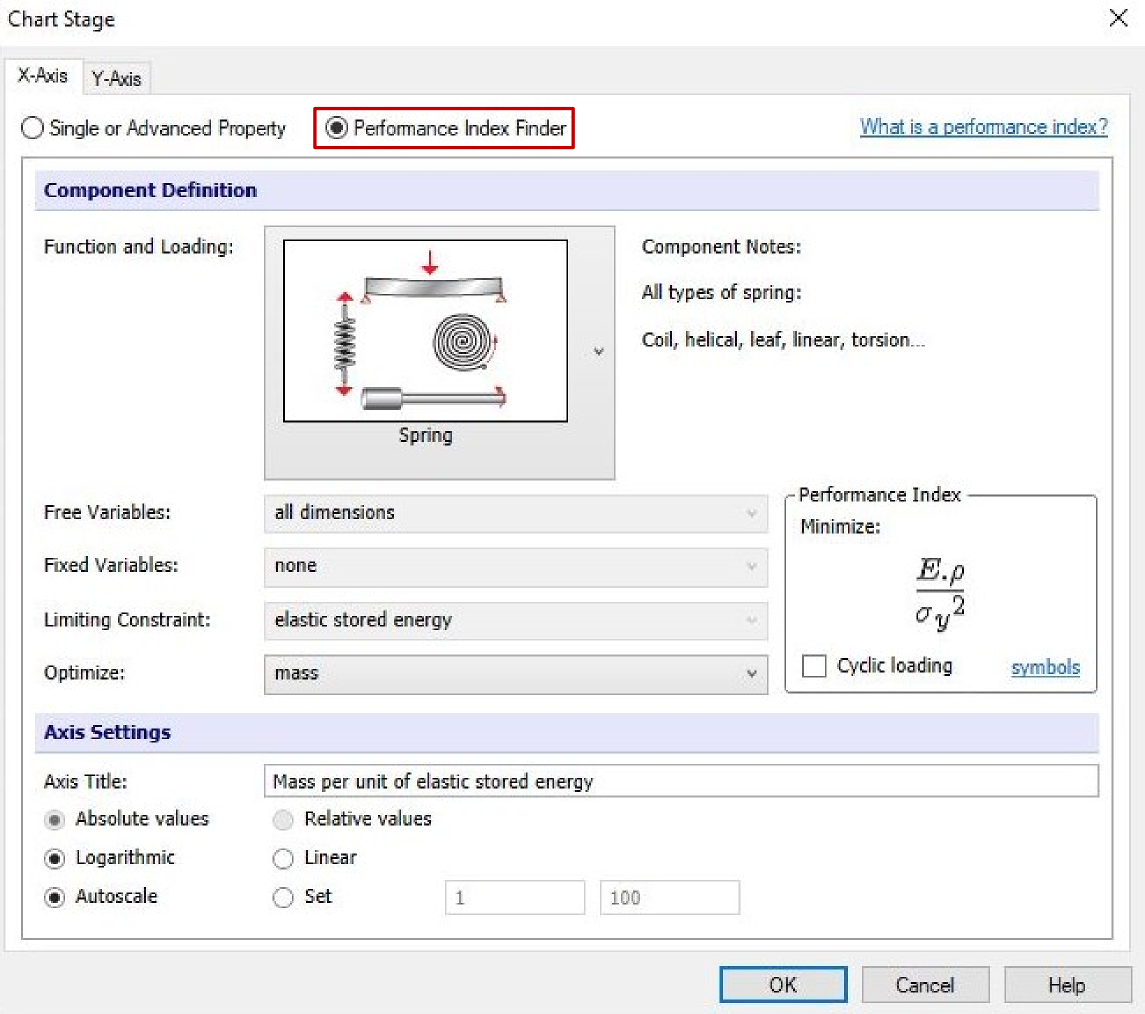
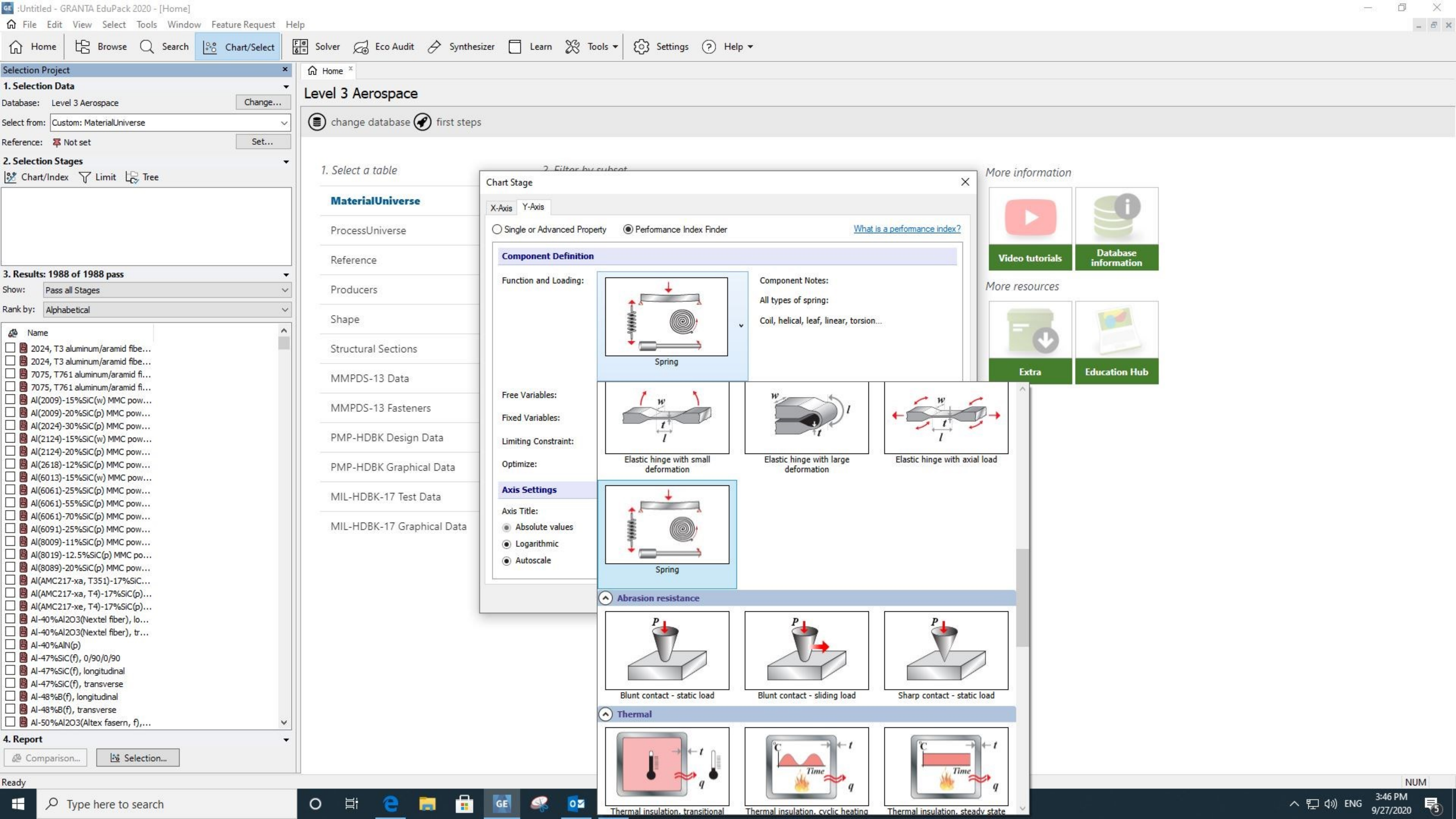


Performance Index

- Developed by Prof. Mike Ashby
- PI is the ratio of parameters of material used to optimize and maximize the performance of a component based on objective, specific function and limiting constraint of the design
- Design Factors
  - The main variable that needed to be optimized is defined as the objective (minimizing cost or mass)
  - Function is defined as load condition and basic geometry (a column in compression)
  - Limiting constraint is defined as the criteria that is to be met to avoid the failure of a component
  - The geometry parameter that can be varied with the choice of material is called free variable (thickness of a plate)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Spring
Component Notes:
All types of spring:
Coil, helical, leaf, linear, torsion...
Free Variables:
Fixed Variables:
Limiting Constraint:
Optimize:
Axis Settings
Axis Title:
Absolute values
Logarithmic
Autoscale
Elastic hinge with small deformation
Elastic hinge with large deformation
Elastic hinge with axial load
Spring
Abrasion resistance
Blunt contact - static load
Blunt contact - sliding load
Sharp contact - static load
Thermal
Thermal insulation, transitional
Thermal insulation, cyclic heating
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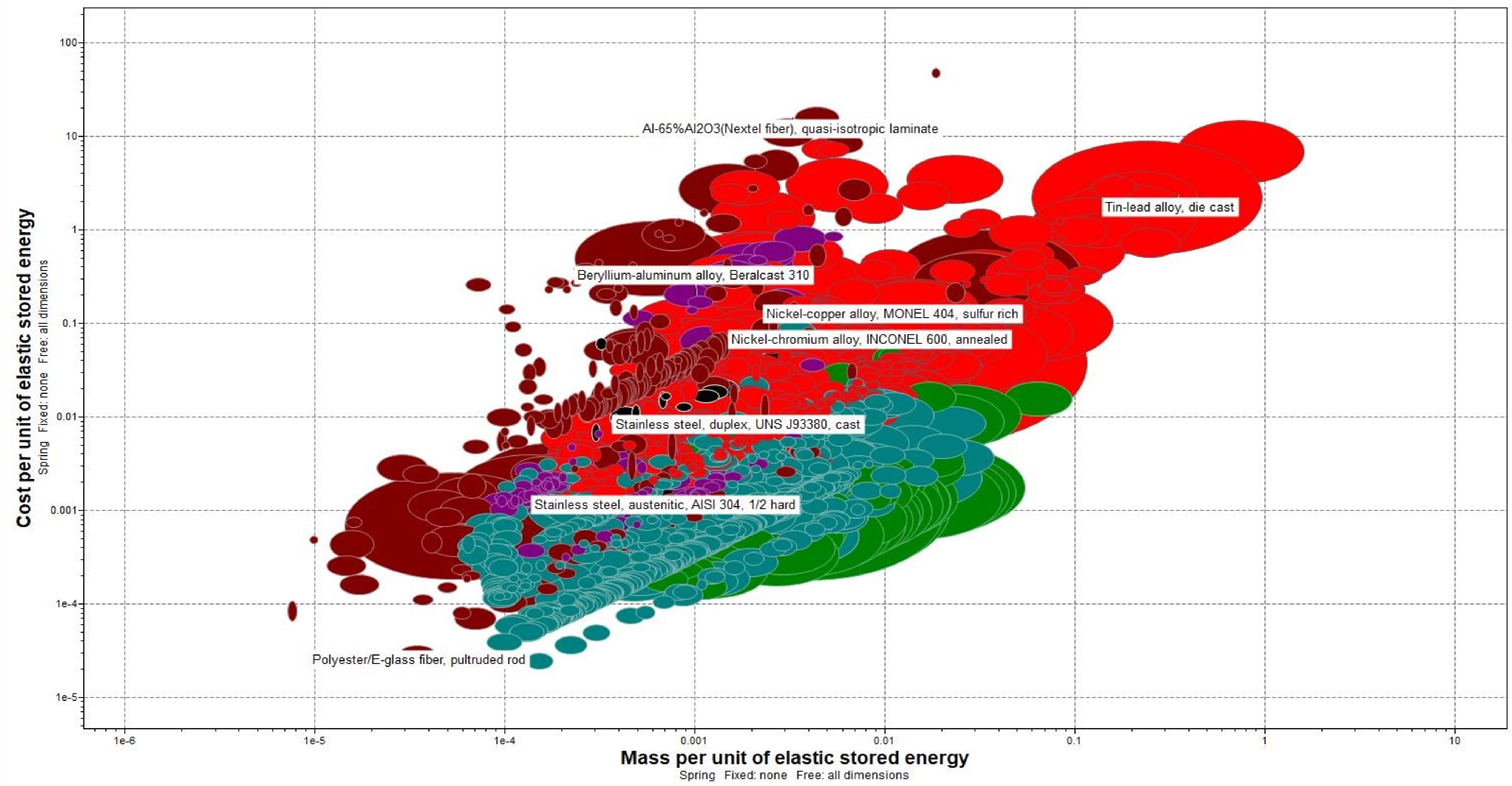
Cost per unit of elastic stored energy vs. Mass per unit of elastic stored energy



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Reference: Not set

2. Selection Stages

Chart/Index | Limit | Tree

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- [x] Stage 2: Limit

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Comparison... | Selection...

Home | Stage 1 | Stage 2

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Limit

Settings | Apply | Clear

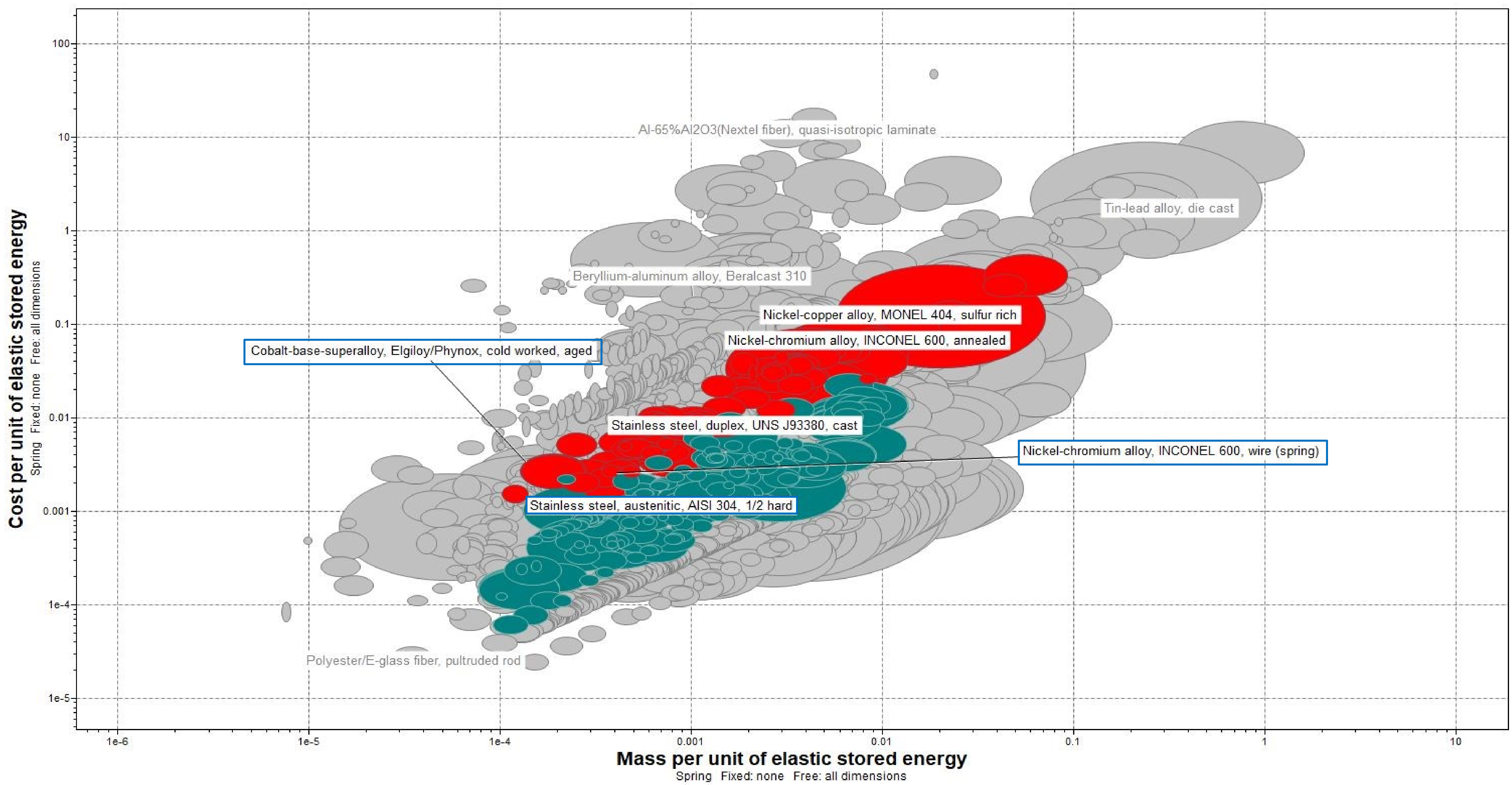
Video Tutorials

Can't find the property you are looking for?

- General information
- Composition overview
- Composition detail (metals, ceramics and glasses)
- Composition detail (polymers and natural materials)
- Price
- Physical properties
- Mechanical properties

Property	Exists	Minimum	Maximum	Unit
Young's modulus		25	32	10^6 psi
Young's modulus with temperature				10^6 psi
Specific stiffness				lbf.ft/lb
Yield strength (elastic limit)				ksi
Yield strength with temperature				ksi
Tensile strength		1300	2200	ksi
Tensile stress at 100% strain				ksi
Tensile stress at 300% strain				ksi
Tensile strength with temperature				ksi
Specific strength				lbf.ft/lb
Elongation				% strain
Elongation at yield				% strain
Tangent modulus				ksi
True plastic stress-strain				ksi
Compressive modulus				10^6 psi
Comp. Young's modulus with temperature				10^6 psi
Compressive strength				ksi
Compression strength with temperature				ksi
Compressive stress @ 25% strain				ksi
Compressive stress @ 50% strain				ksi
Flexural modulus				10^6 psi
Flexural strength (modulus of rupture)				ksi
Shear modulus				10^6 psi

Cost per unit of elastic stored energy vs. Mass per unit of elastic stored energy



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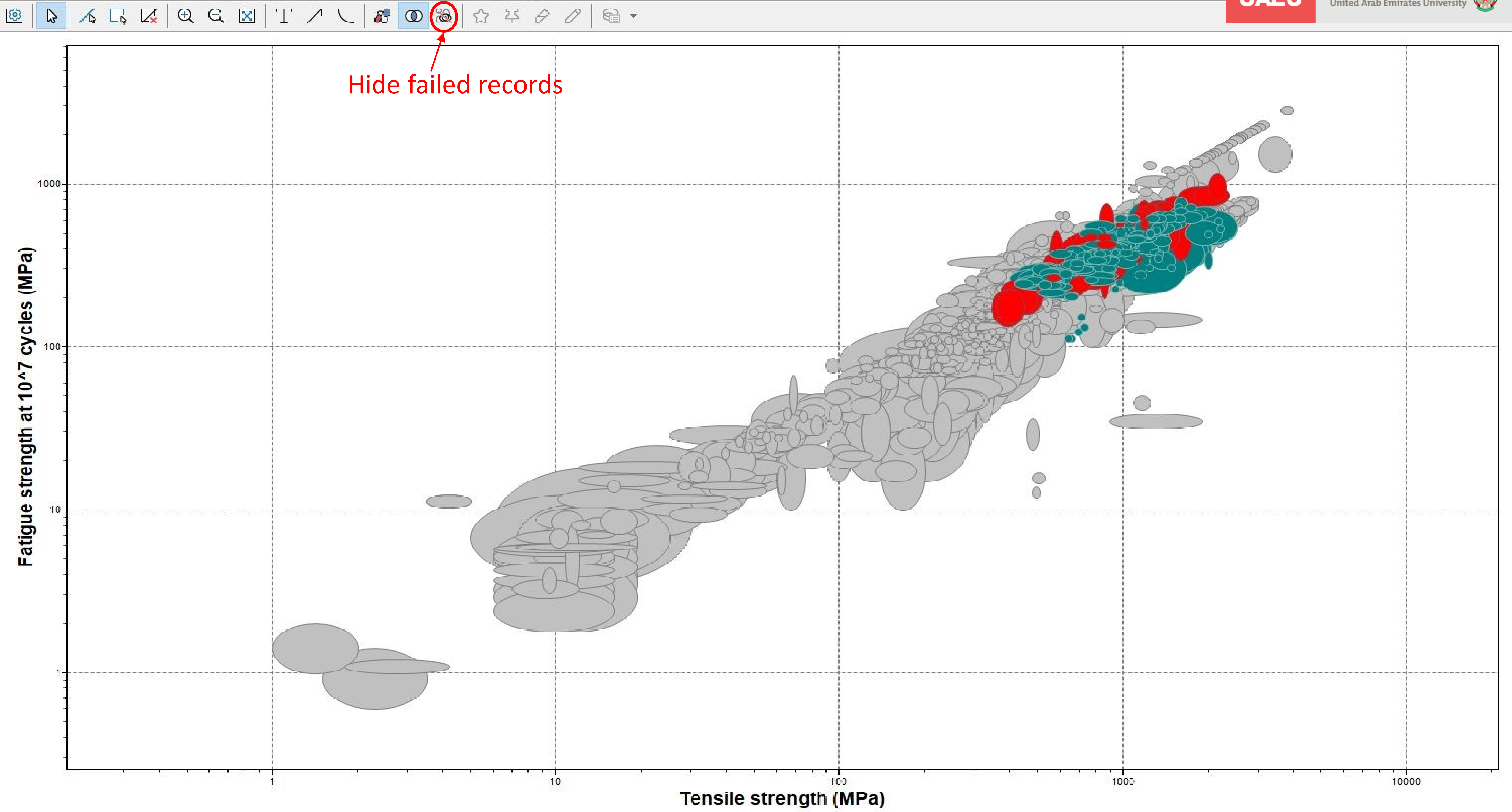
Fatigue strength at 10^7 cycles (MPa) vs. Tensile strength (MPa)



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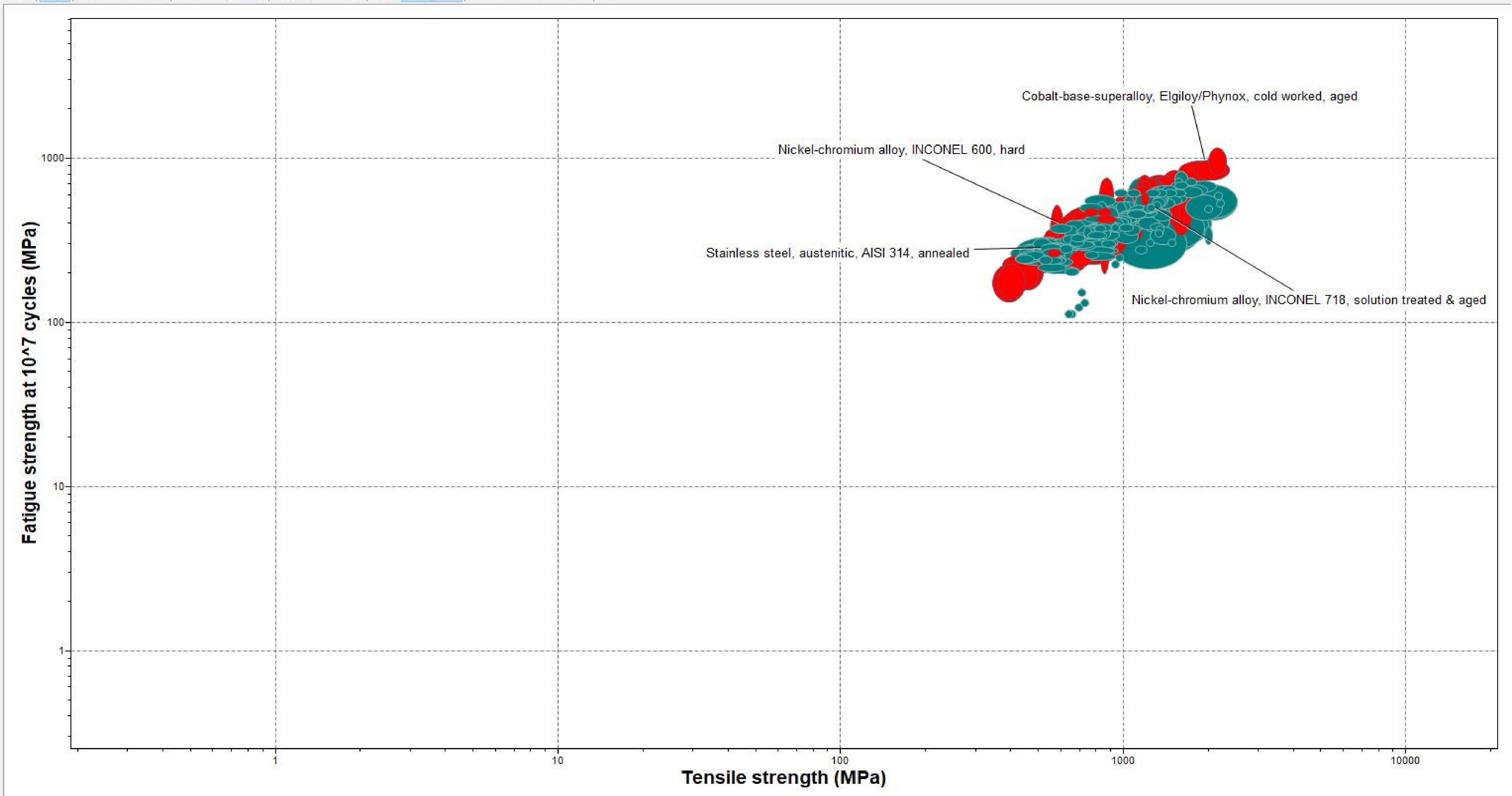

Maximum service temperature (°C) vs. Fatigue strength at 10^7 cycles (MPa)

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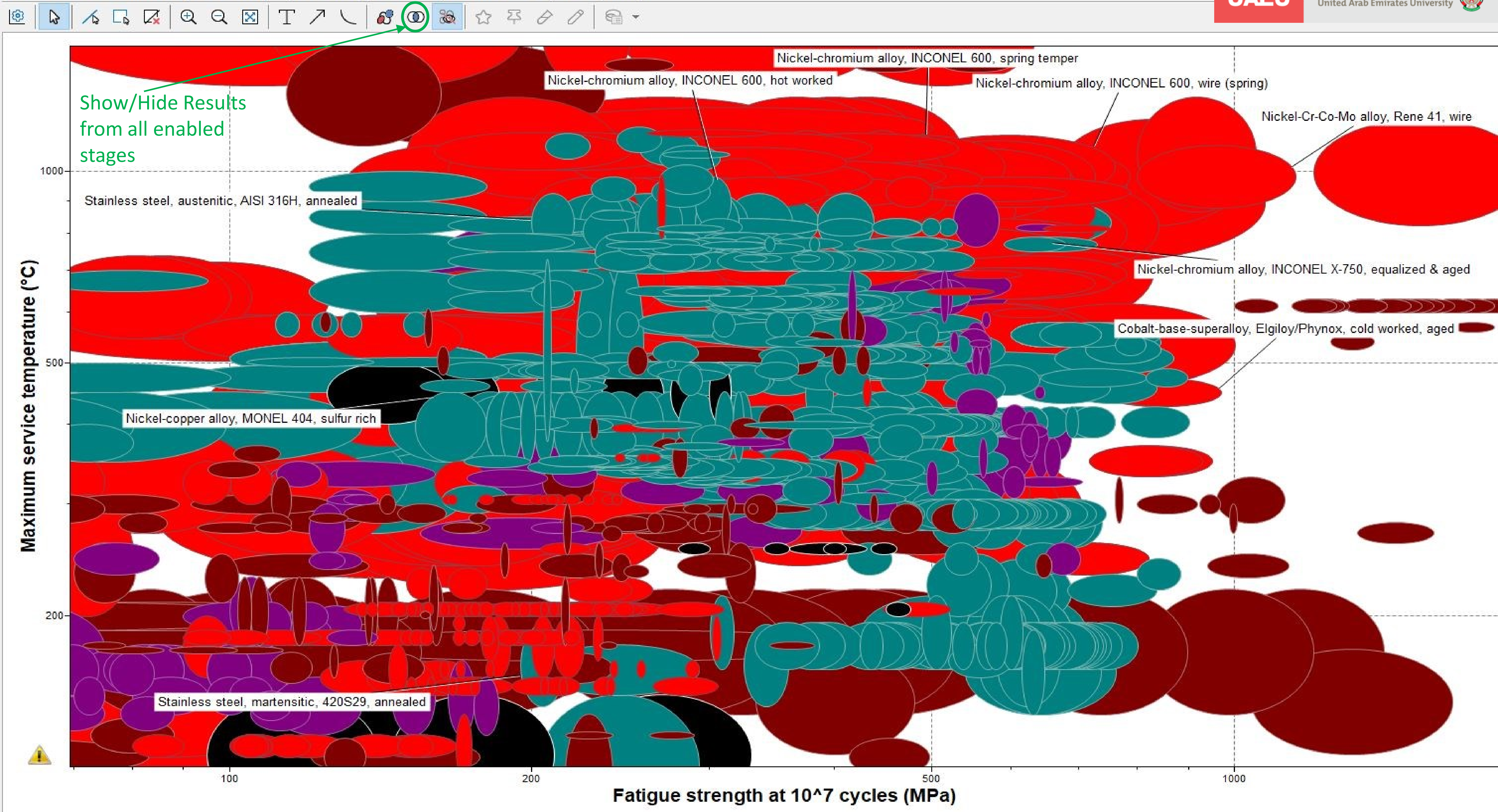

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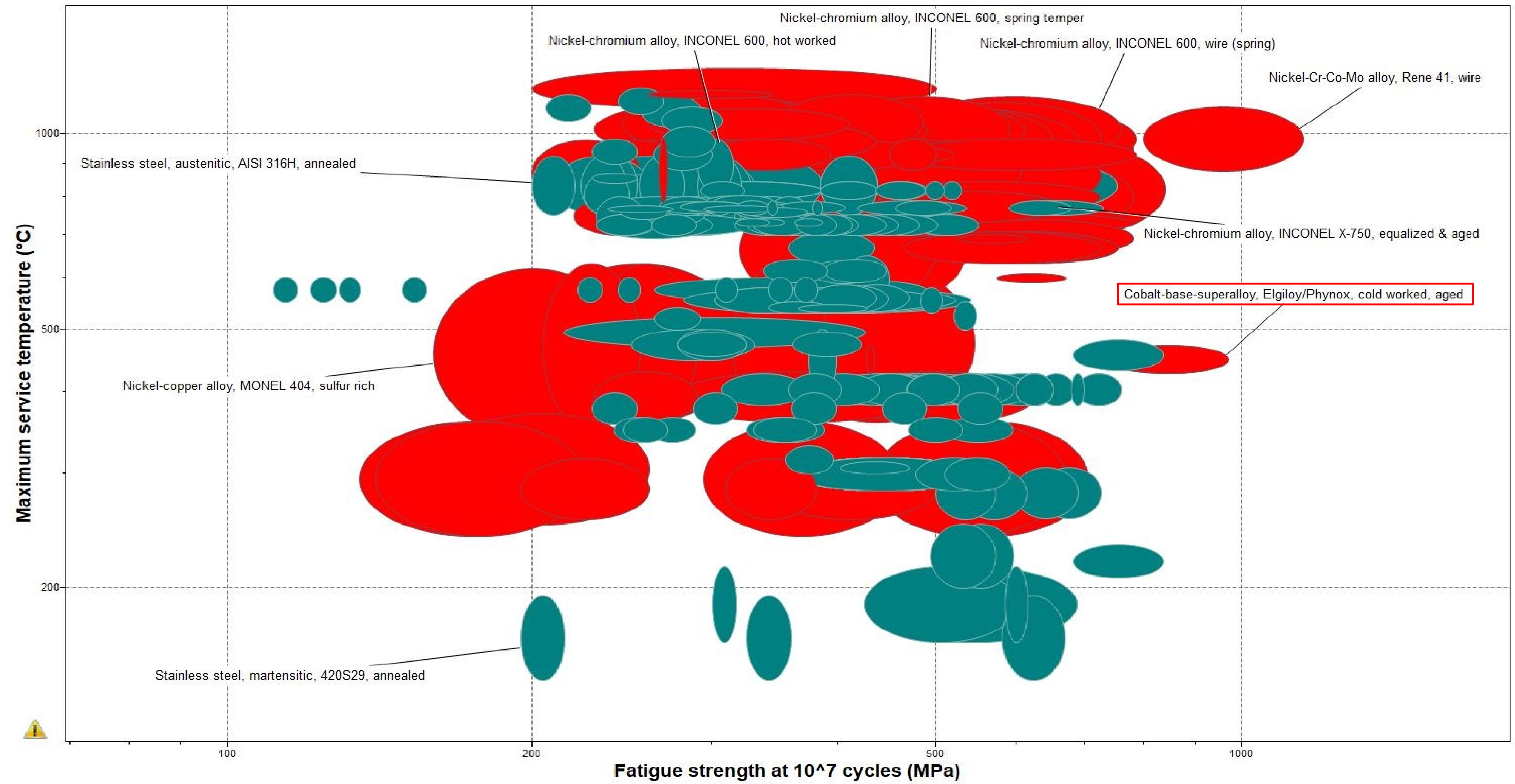
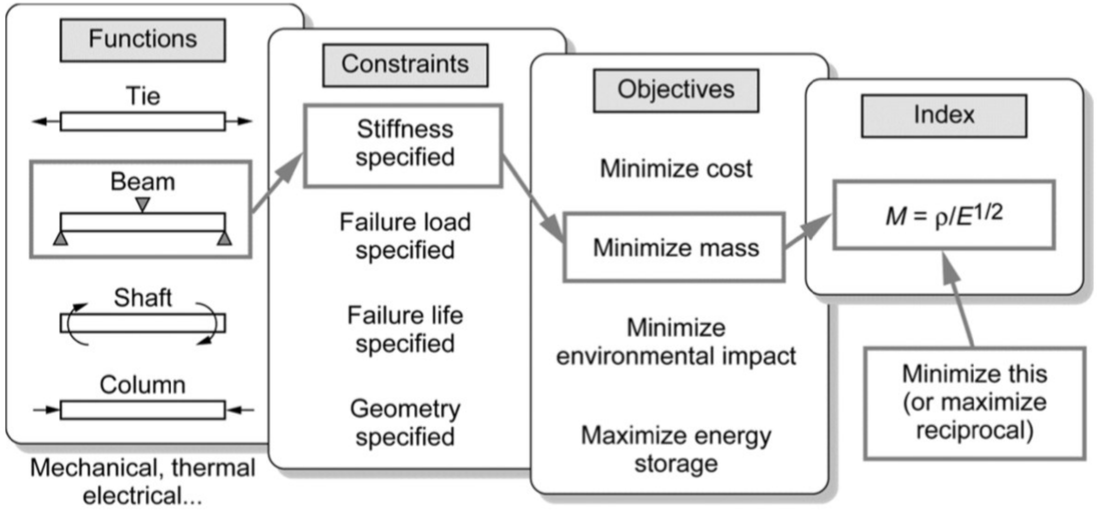


Review on Performance Indices



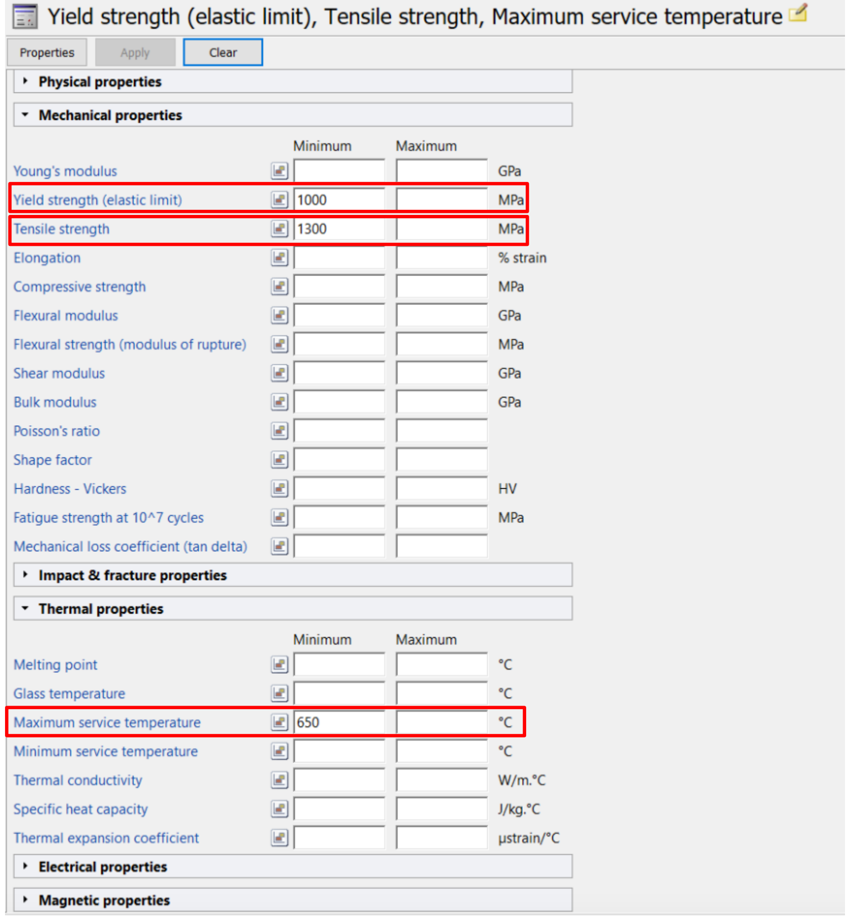
- It has been seen that there are four main design parameters involved
- It can be expressed as $P = f_1(F).f_2\,(G)\,.f_3(M)$; G = Geometry, M = properties of material and F = functional requirement
- The product $f_1(F).f_2\,(G)$ is defined as the coefficient of structural efficiency where as $f_3(M)$ is the coefficient of material efficiency
- Minimizing $f_3(M)$, the overall performance index could be maximized or minimized.

Understanding the performance index

- Focusing on High Pressure Turbine Disk of an aircraft engine
- Understand the function: Similar to a flywheel which generates KE by the rotational forces and transfer this energy to the mechanical energy which in-turn rotates the shaft
- Define the constraints: Fixed outer radius, and the material should not fracture and have enough toughness to resist the initiation of crack
- Objective: Maximize the KE per unit mass
- Free variables: Choice of materials

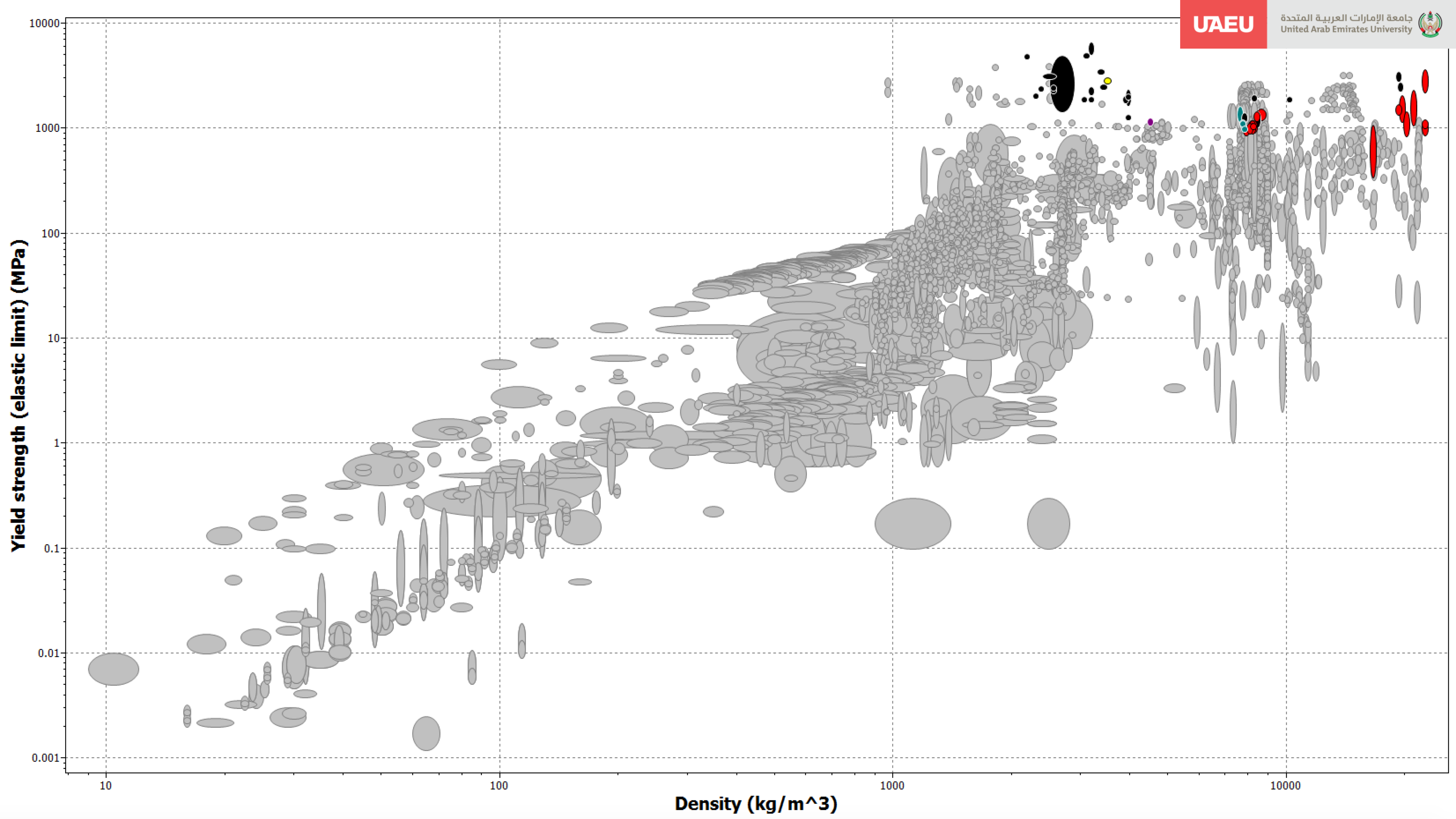
Derivation for selecting the gradient line

- Energy stored in a rotating disk is given by $U = \frac{1}{2}J\omega^2$, where ω is the angular velocity and J is the polar moment of inertia
- J can be defined as $J = \frac{\pi}{2}\rho R^4 t$, where ρ, is the material density, R is the disk radius and t is the disk thickness
- $\Rightarrow U = \frac{\pi}{4}\rho R^4 t\omega^2$
- Next, we define the mass of disk and can be expressed as, $m = \pi\rho R^2 t$
- Focusing on the objective which is to maximize the KE per unit, it can be expressed as, $\frac{U}{m} = \frac{1}{4}R^2\omega^2$
- The increase in rotational speed of the turbine disk results in the increased energy generation along with its centrifugal force and hence the max principal stress generated can be written as $\sigma_{max} = \left(\frac{3+\nu}{8}\right)\rho R^2\omega^2$, where ν, is the Poisson's ratio, $\approx \frac{1}{3}$ for solids.
- This maximum principle stress should not exceed the yield or failure strength σ_y with a safety factor, S. This will create an upper limit to the disc radius R and angular velocity ω which are the free variables
- Rearranging the equations we get; $\frac{U}{m} = \frac{1}{2}\left(\frac{\sigma_y}{\rho}\right)$
- This shows that the best material for HPT Disk are those with high values of the material index $M = \frac{\sigma_y}{\rho}$ (kJ/kg)
- Now the gradient can be calculated taking the log of each side which gives $log\sigma_y = log\rho + logM$, which is like the equation of line, $y = mx + c$and hence the gradient (slope) for this material selection will be 1



Selection of materials

- Before selecting the materials, we should know what are the primary minimal conditions that should be considered
- The operating temperature of the disk will be between 200°C – 300°Cat the bore to around 650°C at the rim
- The rotation speed will be more than 10,000rpm and hence the mechanical stress could reach around 1000MPa at the time of takeoff
- Tensile strength close to 1200-1300MPa
- Yield strength close to 1000MPa
- Highly ductile with high fracture toughness to improve the defect tolerance and prevent fracture
- High creep resistance is another property to be considered to avoid creep strain at the outer rim


UAEU
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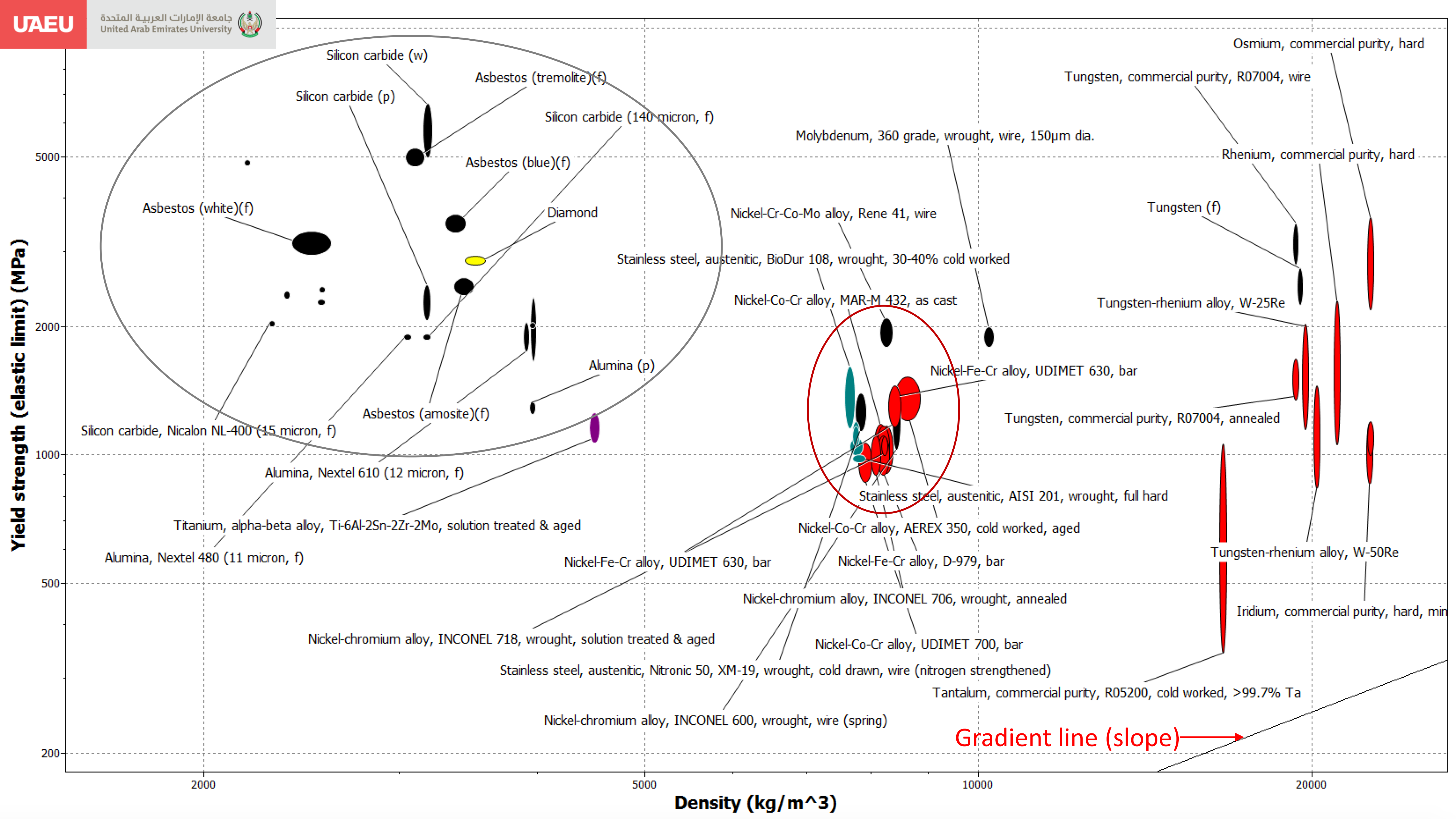
United Arab Emirates University
10000
1000
100
10
1
0.1
0.01
0.001
Yield strength (elastic limit) (MPa)
10
100
1000
10000
Density (kg/m^3)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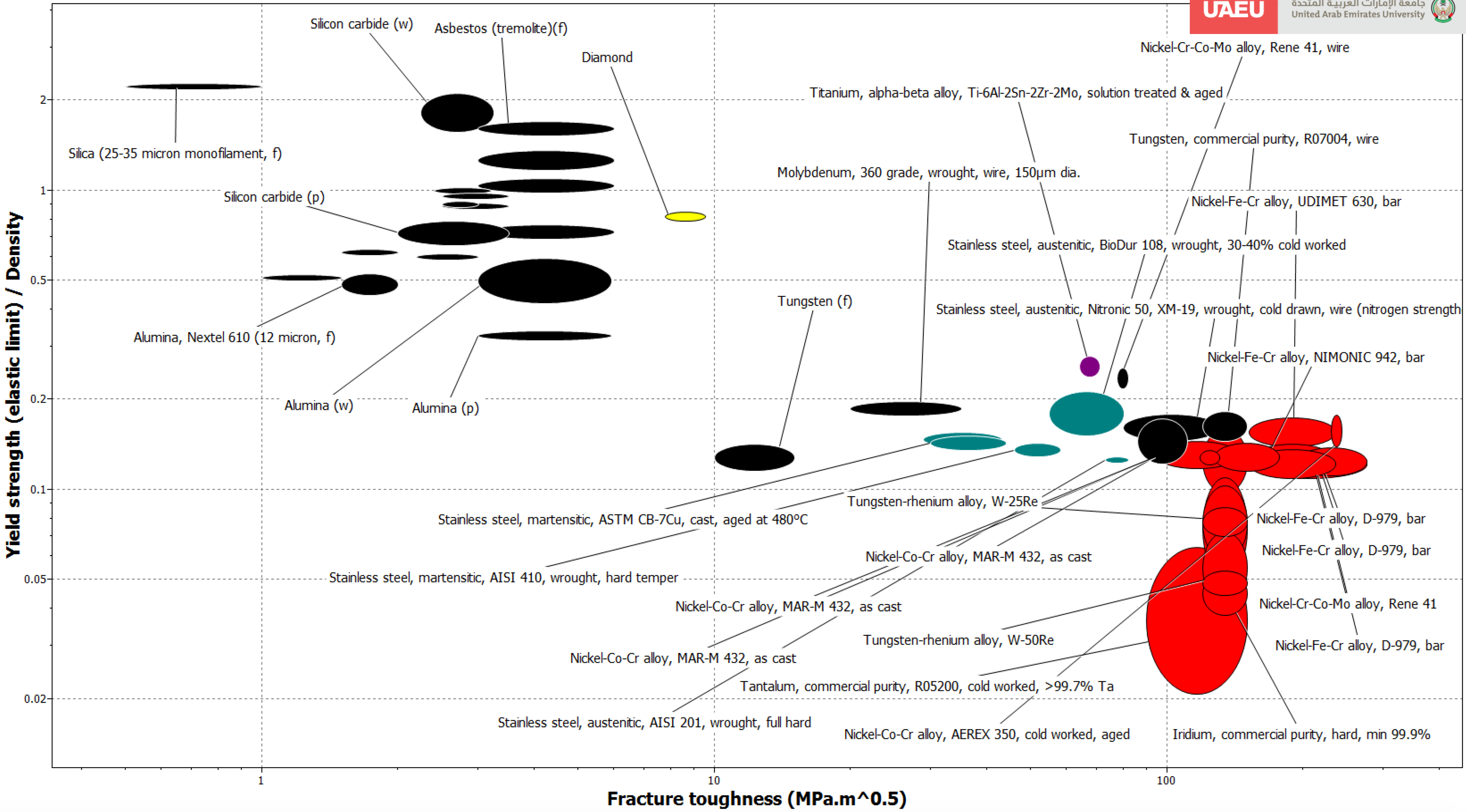
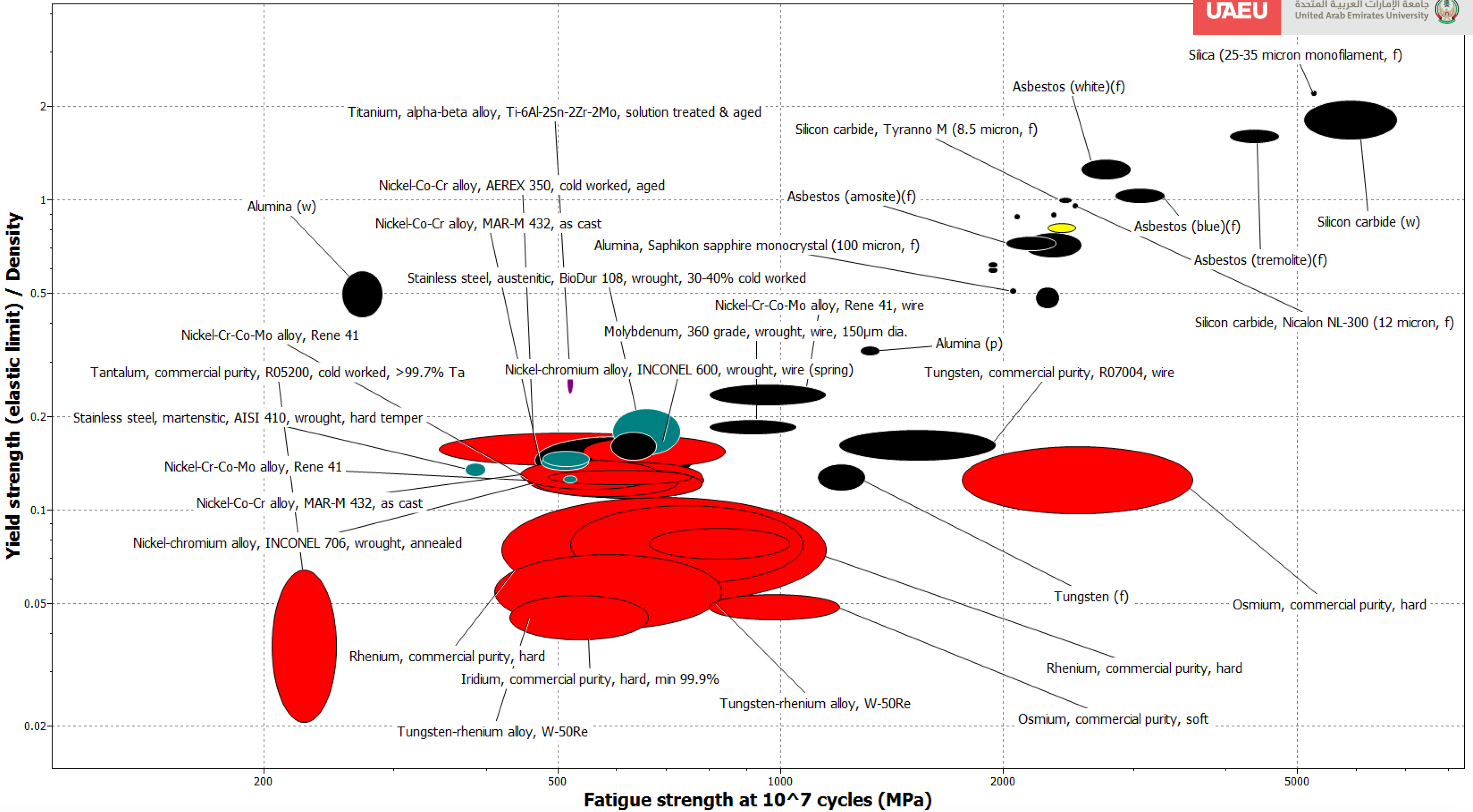
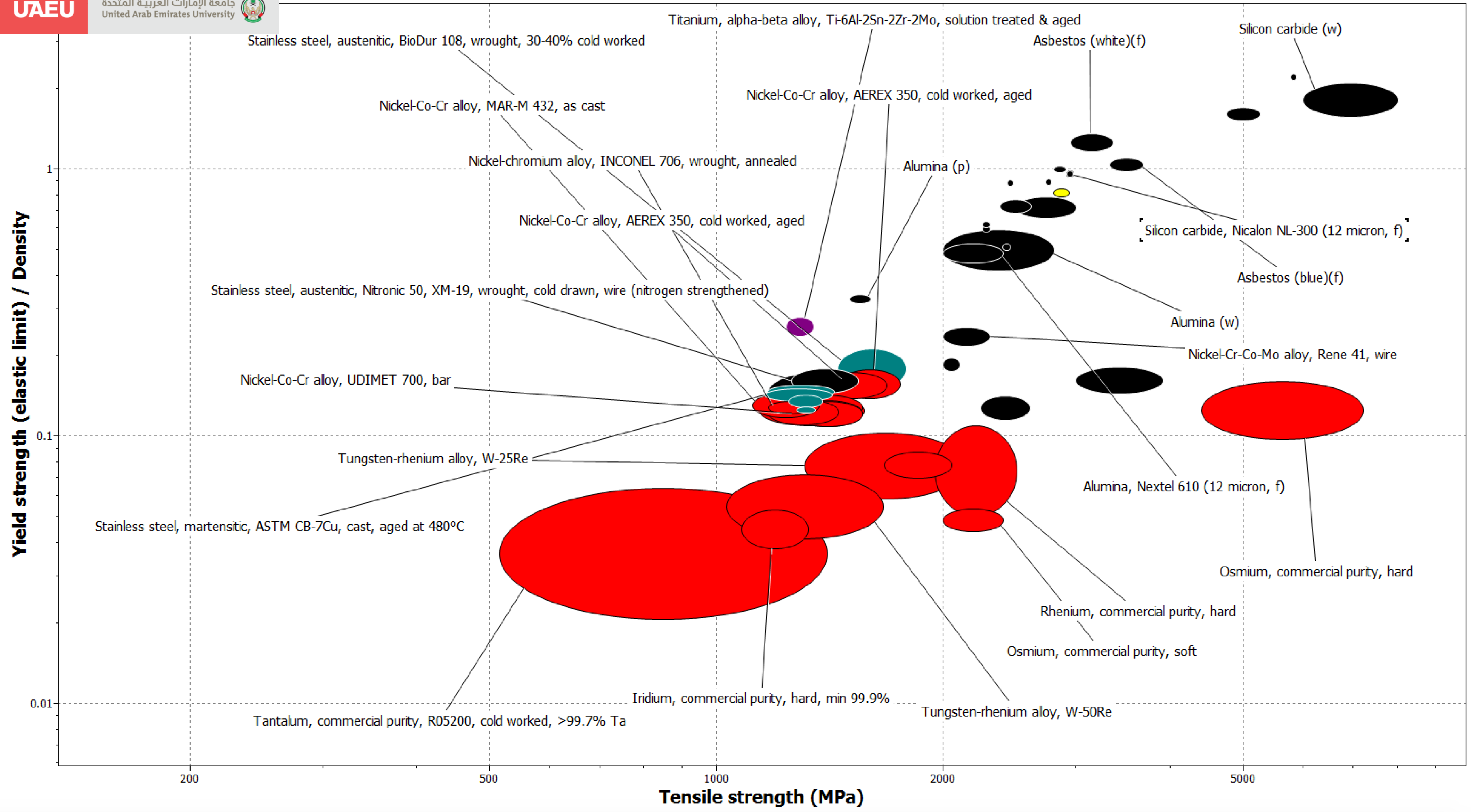
Yield strength (elastic limit) (MPa)
Density (kg/m^3)
5000
2000
1000
500
200
2000
5000
10000
20000
Silicon carbide (w)
Asbestos (tremolite)(f)
Silicon carbide (p)
Silicon carbide (140 micron, f)
Asbestos (blue)(f)
Asbestos (white)(f)
Diamond
Alumina (p)
Asbestos (amosite)(f)
Silicon carbide, Nicalon NL-400 (15 micron, f)
Alumina, Nextel 610 (12 micron, f)
Titanium, alpha-beta alloy, Ti-6Al-2Sn-2Zr-2Mo, solution treated & aged
Alumina, Nextel 480 (11 micron, f)
Molybdenum, 360 grade, wrought, wire, 150µm dia.
Nickel-Cr-Co-Mo alloy, Rene 41, wire
Stainless steel, austenitic, BioDur 108, wrought, 30-40% cold worked
Nickel-Co-Cr alloy, MAR-M 432, as cast
Nickel-Fe-Cr alloy, UDIMET 630, bar
Stainless steel, austenitic, AISI 201, wrought, full hard
Nickel-Co-Cr alloy, AEREX 350, cold worked, aged
Nickel-Fe-Cr alloy, UDIMET 630, bar
Nickel-Fe-Cr alloy, D-979, bar
Nickel-chromium alloy, INCONEL 706, wrought, annealed
Nickel-chromium alloy, INCONEL 718, wrought, solution treated & aged
Nickel-Co-Cr alloy, UDIMET 700, bar
Stainless steel, austenitic, Nitronic 50, XM-19, wrought, cold drawn, wire (nitrogen strengthened)
Nickel-chromium alloy, INCONEL 600, wrought, wire (spring)
Osmium, commercial purity, hard
Tungsten, commercial purity, R07004, wire
Rhenium, commercial purity, hard
Tungsten (f)
Tungsten-rhenium alloy, W-25Re
Tungsten, commercial purity, R07004, annealed
Tungsten-rhenium alloy, W-50Re
Iridium, commercial purity, hard, min
Tantalum, commercial purity, R05200, cold worked, >99.7% Ta
Gradient line (slope)

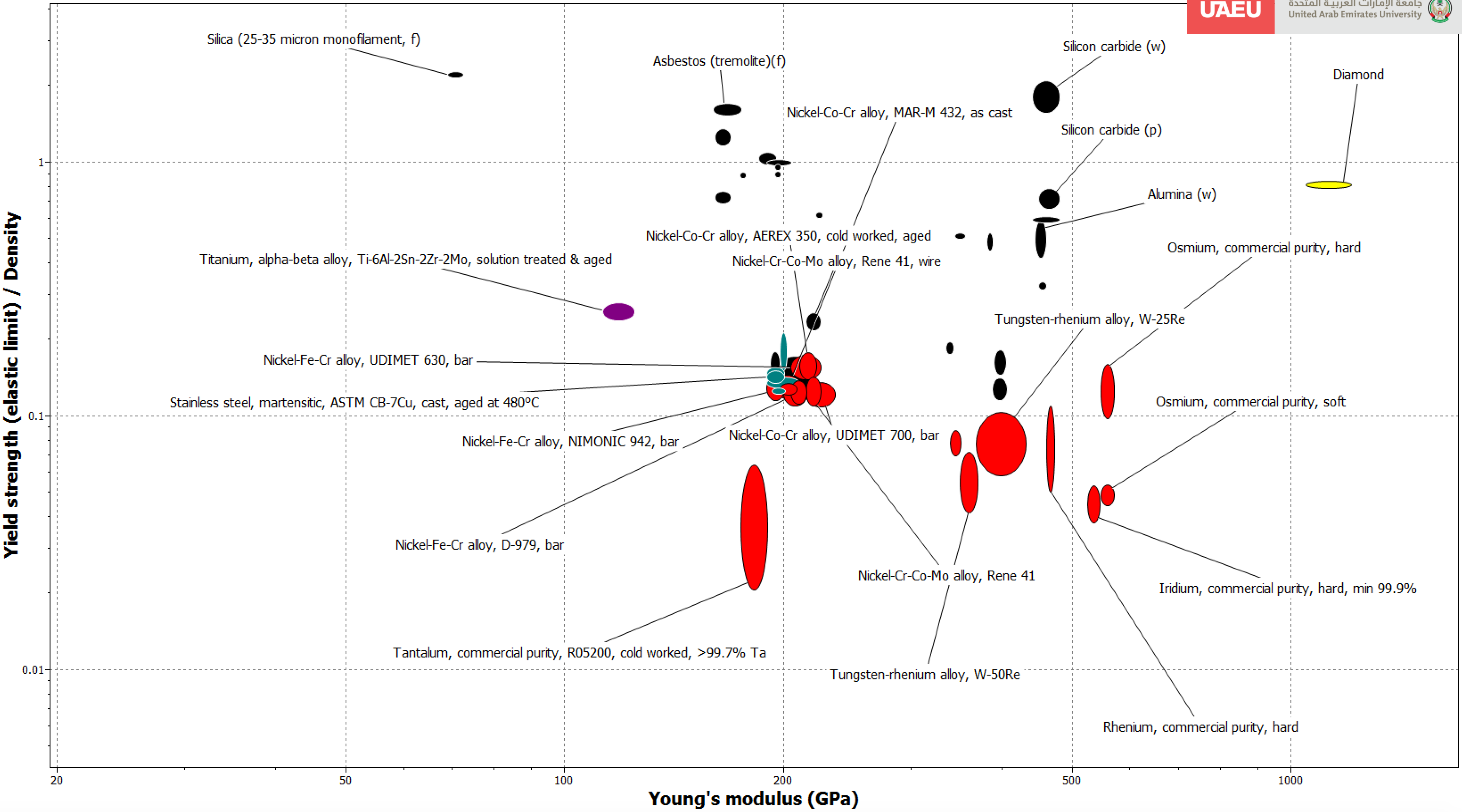


Silicon carbide (w)
Asbestos (tremolite)(f)
Diamond
Silica (25-35 micron monofilament, f)
Silicon carbide (p)
Alumina, Nextel 610 (12 micron, f)
Alumina (w)
Alumina (p)
Tungsten (f)
Molybdenum, 360 grade, wrought, wire, 150µm dia.
Titanium, alpha-beta alloy, Ti-6Al-2Sn-2Zr-2Mo, solution treated & aged
Nickel-Cr-Co-Mo alloy, Rene 41, wire
Tungsten, commercial purity, R07004, wire
Nickel-Fe-Cr alloy, UDIMET 630, bar
Stainless steel, austenitic, BioDur 108, wrought, 30-40% cold worked
Stainless steel, austenitic, Nitronic 50, XM-19, wrought, cold drawn, wire (nitrogen strength
Nickel-Fe-Cr alloy, NIMONIC 942, bar
Tungsten-rhenium alloy, W-25Re
Stainless steel, martensitic, ASTM CB-7Cu, cast, aged at 480°C
Nickel-Fe-Cr alloy, D-979, bar
Nickel-Fe-Cr alloy, D-979, bar
Nickel-Co-Cr alloy, MAR-M 432, as cast
Stainless steel, martensitic, AISI 410, wrought, hard temper
Nickel-Co-Cr alloy, MAR-M 432, as cast
Nickel-Cr-Co-Mo alloy, Rene 41
Tungsten-rhenium alloy, W-50Re
Nickel-Fe-Cr alloy, D-979, bar
Nickel-Co-Cr alloy, MAR-M 432, as cast
Tantalum, commercial purity, R05200, cold worked, >99.7% Ta
Stainless steel, austenitic, AISI 201, wrought, full hard
Nickel-Co-Cr alloy, AEREX 350, cold worked, aged
Iridium, commercial purity, hard, min 99.9%
Yield strength (elastic limit) / Density
Fracture toughness (MPa.m^0.5)
2
1
0.5
0.2
0.1
0.05
0.02
1
10
100

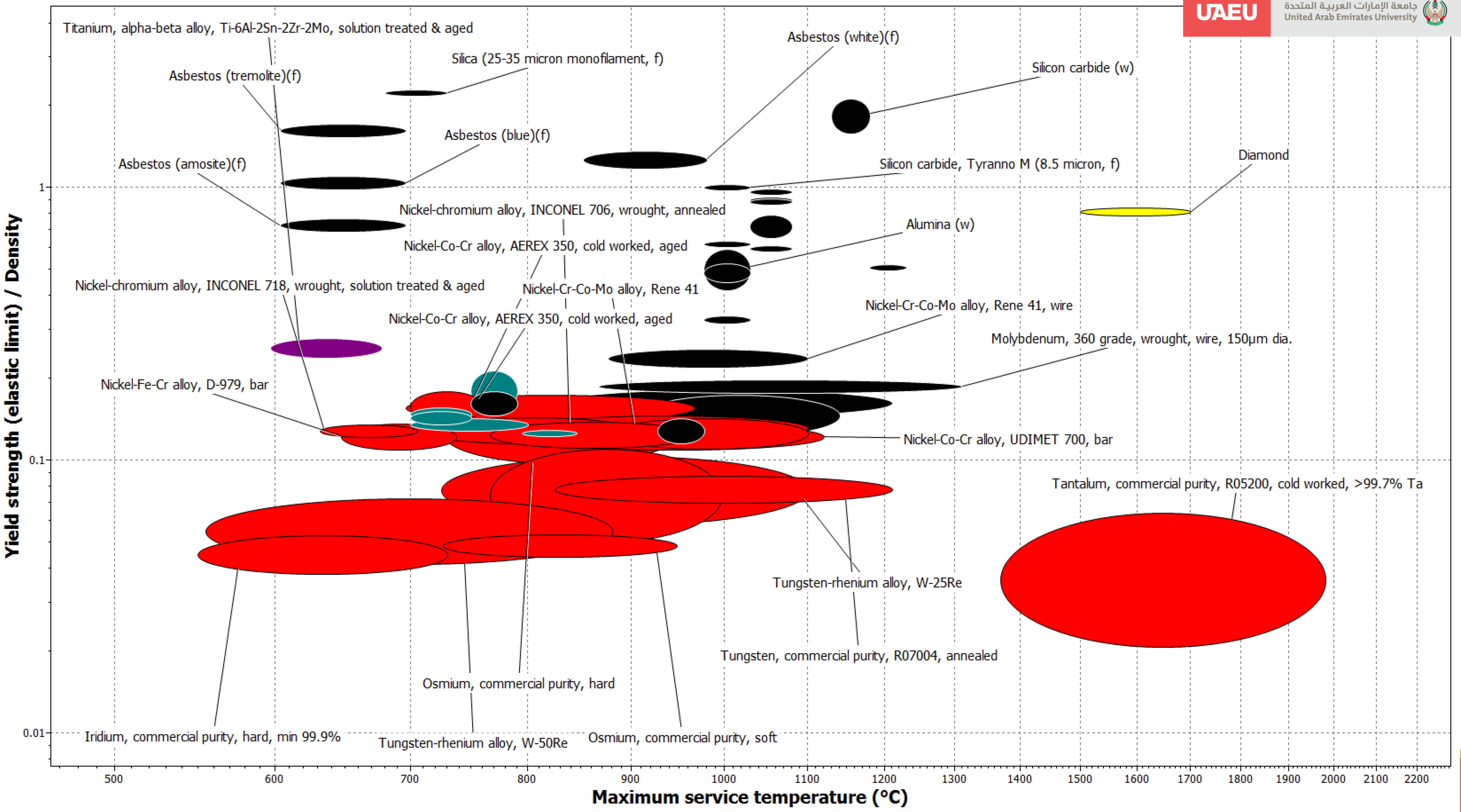

Silica (25-35 micron monofilament, f)
Asbestos (white)(f)
Titanium, alpha-beta alloy, Ti-6Al-2Sn-2Zr-2Mo, solution treated & aged
Silicon carbide, Tyranno M (8.5 micron, f)
Nickel-Co-Cr alloy, AEREX 350, cold worked, aged
Alumina (w)
Asbestos (amosite)(f)
Nickel-Co-Cr alloy, MAR-M 432, as cast
Asbestos (blue)(f)
Silicon carbide (w)
Alumina, Saphikon sapphire monocrystal (100 micron, f)
Asbestos (tremolite)(f)
Stainless steel, austenitic, BioDur 108, wrought, 30-40% cold worked
Nickel-Cr-Co-Mo alloy, Rene 41, wire
Silicon carbide, Nicalon NL-300 (12 micron, f)
Nickel-Cr-Co-Mo alloy, Rene 41
Molybdenum, 360 grade, wrought, wire, 150μm dia.
Alumina (p)
Tantalum, commercial purity, R05200, cold worked, >99.7% Ta
Nickel-chromium alloy, INCONEL 600, wrought, wire (spring)
Tungsten, commercial purity, R07004, wire
Stainless steel, martensitic, AISI 410, wrought, hard temper
Nickel-Cr-Co-Mo alloy, Rene 41
Nickel-Co-Cr alloy, MAR-M 432, as cast
Nickel-chromium alloy, INCONEL 706, wrought, annealed
Tungsten (f)
Osmium, commercial purity, hard
Rhenium, commercial purity, hard
Iridium, commercial purity, hard, min 99.9%
Rhenium, commercial purity, hard
Tungsten-rhenium alloy, W-50Re
Osmium, commercial purity, soft
Tungsten-rhenium alloy, W-50Re
Yield strength (elastic limit) / Density
2
1
0.5
0.2
0.1
0.05
0.02
200
500
1000
2000
5000
Fatigue strength at 10^7 cycles (MPa)

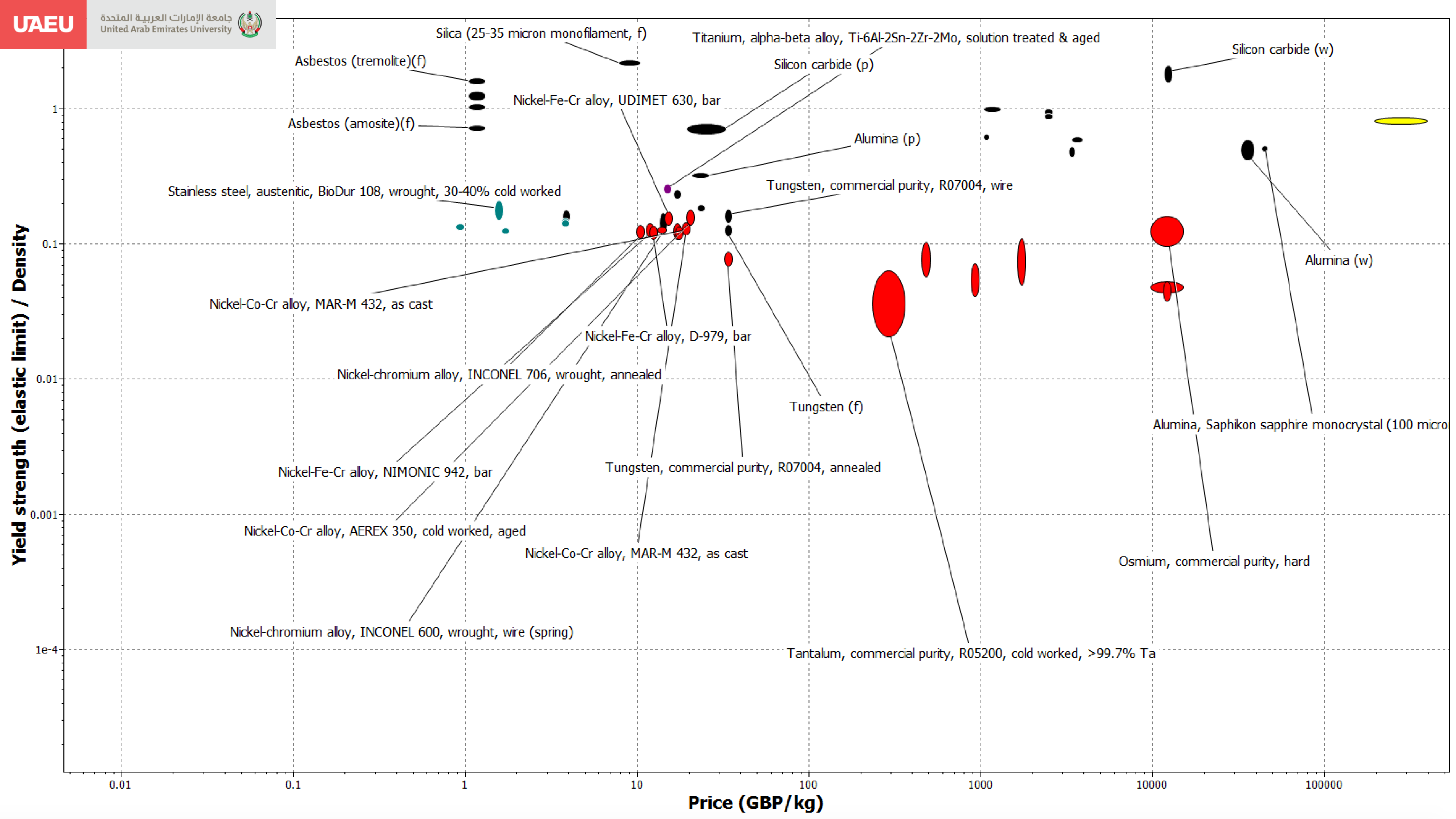


Titanium, alpha-beta alloy, Ti-6Al-2Sn-2Zr-2Mo, solution treated & aged
Stainless steel, austenitic, BioDur 108, wrought, 30-40% cold worked
Silicon carbide (w)
Asbestos (white)(f)
Nickel-Co-Cr alloy, AEREX 350, cold worked, aged
Nickel-Co-Cr alloy, MAR-M 432, as cast
Nickel-chromium alloy, INCONEL 706, wrought, annealed
Alumina (p)
Nickel-Co-Cr alloy, AEREX 350, cold worked, aged
Silicon carbide, Nicalon NL-300 (12 micron, f)
Asbestos (blue)(f)
Stainless steel, austenitic, Nitronic 50, XM-19, wrought, cold drawn, wire (nitrogen strengthened)
Alumina (w)
Nickel-Cr-Co-Mo alloy, Rene 41, wire
Nickel-Co-Cr alloy, UDIMET 700, bar
Tungsten-rhenium alloy, W-25Re
Alumina, Nextel 610 (12 micron, f)
Stainless steel, martensitic, ASTM CB-7Cu, cast, aged at 480°C
Osmium, commercial purity, hard
Rhenium, commercial purity, hard
Osmium, commercial purity, soft
Iridium, commercial purity, hard, min 99.9%
Tungsten-rhenium alloy, W-50Re
Tantalum, commercial purity, R05200, cold worked, >99.7% Ta
Yield strength (elastic limit) / Density
1
0.1
0.01
Tensile strength (MPa)
200
500
1000
2000
5000



Silica (25-35 micron monofilament, f)
Asbestos (tremolite)(f)
Silicon carbide (w)
Diamond
Nickel-Co-Cr alloy, MAR-M 432, as cast
Silicon carbide (p)
Alumina (w)
Nickel-Co-Cr alloy, AEREX 350, cold worked, aged
Osmium, commercial purity, hard
Titanium, alpha-beta alloy, Ti-6Al-2Sn-2Zr-2Mo, solution treated & aged
Nickel-Cr-Co-Mo alloy, Rene 41, wire
Tungsten-rhenium alloy, W-25Re
Nickel-Fe-Cr alloy, UDIMET 630, bar
Stainless steel, martensitic, ASTM CB-7Cu, cast, aged at 480°C
Osmium, commercial purity, soft
Nickel-Fe-Cr alloy, NIMONIC 942, bar
Nickel-Co-Cr alloy, UDIMET 700, bar
Nickel-Fe-Cr alloy, D-979, bar
Nickel-Cr-Co-Mo alloy, Rene 41
Iridium, commercial purity, hard, min 99.9%
Tantalum, commercial purity, R05200, cold worked, >99.7% Ta
Tungsten-rhenium alloy, W-50Re
Rhenium, commercial purity, hard
Yield strength (elastic limit) / Density
1
0.1
0.01
20
50
100
200
500
1000
Young's modulus (GPa)


Titanium, alpha-beta alloy, Ti-6Al-2Sn-2Zr-2Mo, solution treated & aged
Silica (25-35 micron monofilament, f)
Asbestos (white)(f)
Asbestos (tremolite)(f)
Silicon carbide (w)
Asbestos (blue)(f)
Diamond
Asbestos (amosite)(f)
Silicon carbide, Tyranno M (8.5 micron, f)
Nickel-chromium alloy, INCONEL 706, wrought, annealed
Alumina (w)
Nickel-Co-Cr alloy, AEREX 350, cold worked, aged
Nickel-chromium alloy, INCONEL 718, wrought, solution treated & aged
Nickel-Cr-Co-Mo alloy, Rene 41
Nickel-Cr-Co-Mo alloy, Rene 41, wire
Nickel-Co-Cr alloy, AEREX 350, cold worked, aged
Molybdenum, 360 grade, wrought, wire, 150μm dia.
Nickel-Fe-Cr alloy, D-979, bar
Nickel-Co-Cr alloy, UDIMET 700, bar
Tantalum, commercial purity, R05200, cold worked, >99.7% Ta
Tungsten-rhenium alloy, W-25Re
Tungsten, commercial purity, R07004, annealed
Osmium, commercial purity, hard
Iridium, commercial purity, hard, min 99.9%
Tungsten-rhenium alloy, W-50Re
Osmium, commercial purity, soft
Yield strength (elastic limit) / Density
1
0.1
0.01
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
Maximum service temperature (°C)



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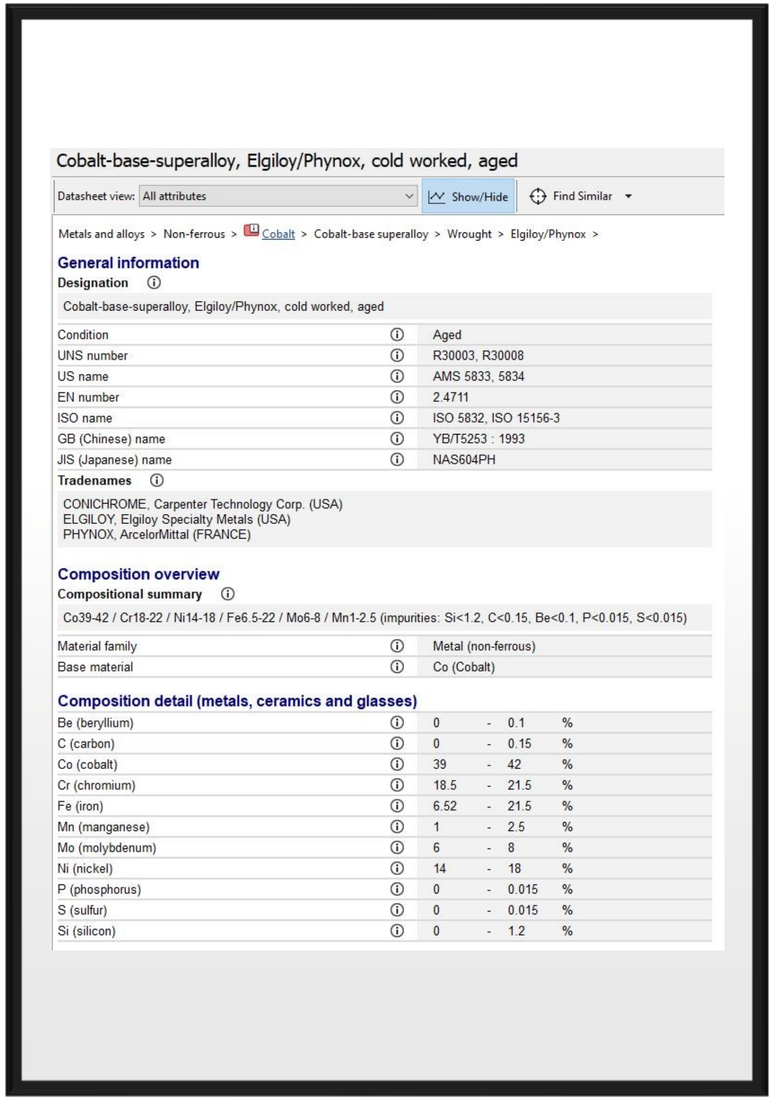
Silica (25-35 micron monofilament, f)
Titanium, alpha-beta alloy, Ti-6Al-2Sn-2Zr-2Mo, solution treated & aged
Silicon carbide (w)
Asbestos (tremolite)(f)
Silicon carbide (p)
Nickel-Fe-Cr alloy, UDIMET 630, bar
Asbestos (amosite)(f)
Alumina (p)
Stainless steel, austenitic, BioDur 108, wrought, 30-40% cold worked
Tungsten, commercial purity, R07004, wire
Alumina (w)
Nickel-Co-Cr alloy, MAR-M 432, as cast
Nickel-Fe-Cr alloy, D-979, bar
Nickel-chromium alloy, INCONEL 706, wrought, annealed
Tungsten (f)
Alumina, Saphikon sapphire monocrystal (100 micro
Nickel-Fe-Cr alloy, NIMONIC 942, bar
Tungsten, commercial purity, R07004, annealed
Nickel-Co-Cr alloy, AEREX 350, cold worked, aged
Nickel-Co-Cr alloy, MAR-M 432, as cast
Osmium, commercial purity, hard
Nickel-chromium alloy, INCONEL 600, wrought, wire (spring)
Tantalum, commercial purity, R05200, cold worked, >99.7% Ta
Yield strength (elastic limit) / Density
1
0.1
0.01
0.001
1e-4
0.01
0.1
1
10
100
1000
10000
100000
Price (GBP/kg)

Material Properties



Cobalt-base-superalloy, Elgiloy/Phynox, cold worked, aged

Datasheet view: All attributes | Show/Hide | Find Similar

Metals and alloys > Non-ferrous > Cobalt > Cobalt-base superalloy > Wrought > Elgiloy/Phynox >

General information

Designation

Cobalt-base-superalloy, Elgiloy/Phynox, cold worked, aged

Condition	Aged
UNS number	R30003, R30008
US name	AMS 5833, 5834
EN number	2.4711
ISO name	ISO 5832, ISO 15156-3
GB (Chinese) name	YB/T5253 : 1993
JIS (Japanese) name	NAS604PH

Tradenames

CONICHROME, Carpenter Technology Corp. (USA)
ELGILOY, Elgiloy Specialty Metals (USA)
PHYNOX, ArcelorMittal (FRANCE)

Composition overview

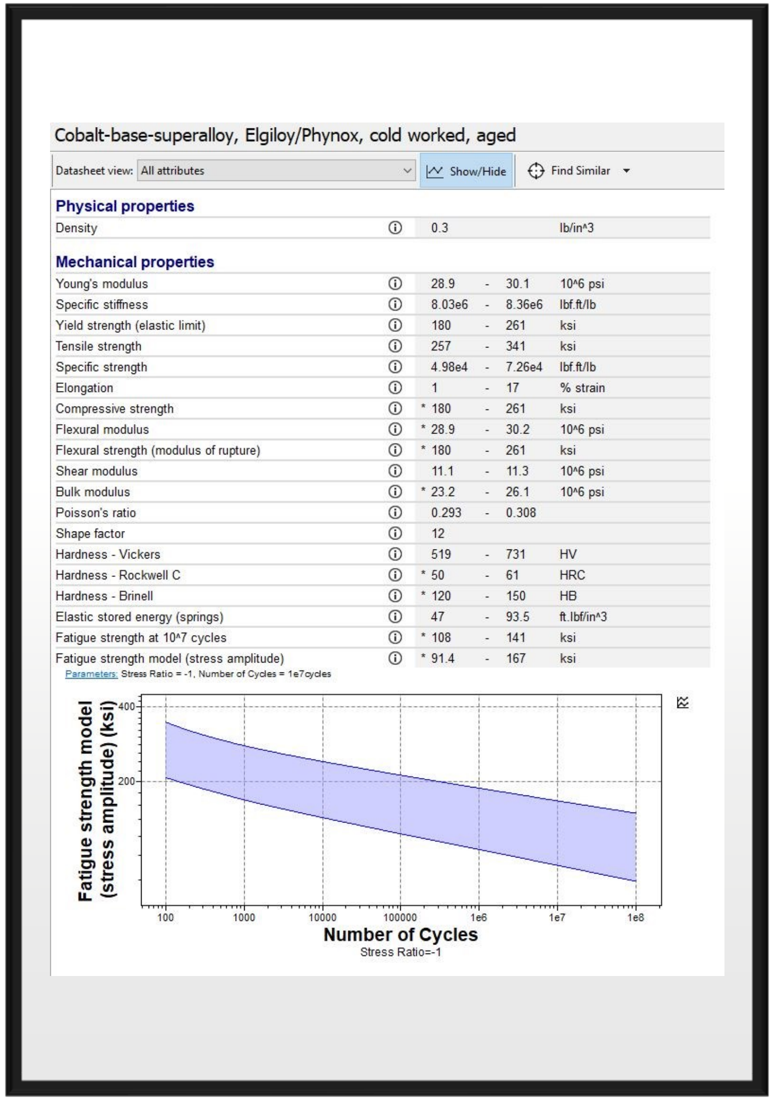
Compositional summary

Co39-42 / Cr18-22 / Ni14-18 / Fe6.5-22 / Mo6-8 / Mn1-2.5 (impurities: Si<1.2, C<0.15, Be<0.1, P<0.015, S<0.015)

Material family	Metal (non-ferrous)
Base material	Co (Cobalt)

Composition detail (metals, ceramics and glasses)

Be (beryllium)	0	-	0.1	%
C (carbon)	0	-	0.15	%
Co (cobalt)	39	-	42	%
Cr (chromium)	18.5	-	21.5	%
Fe (iron)	6.52	-	21.5	%
Mn (manganese)	1	-	2.5	%
Mo (molybdenum)	6	-	8	%
Ni (nickel)	14	-	18	%
P (phosphorus)	0	-	0.015	%
S (sulfur)	0	-	0.015	%
Si (silicon)	0	-	1.2	%



Cobalt-base-superalloy, Elgiloy/Phynox, cold worked, aged

Datasheet view: All attributes | Show/Hide | Find Similar

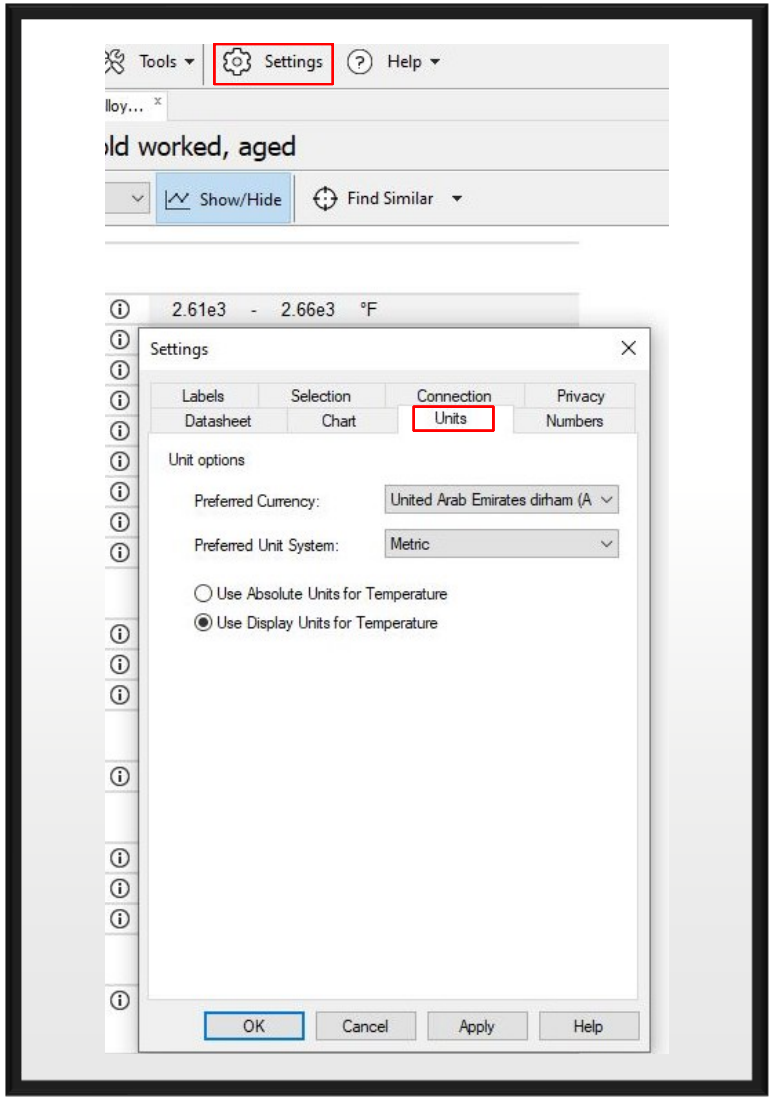
Physical properties

Density	0.3			lb/in^3

Mechanical properties

Young's modulus	28.9	-	30.1	10^6 psi
Specific stiffness	8.03e6	-	8.36e6	lbf.ft/lb
Yield strength (elastic limit)	180	-	261	ksi
Tensile strength	257	-	341	ksi
Specific strength	4.98e4	-	7.26e4	lbf.ft/lb
Elongation	1	-	17	% strain
Compressive strength	* 180	-	261	ksi
Flexural modulus	* 28.9	-	30.2	10^6 psi
Flexural strength (modulus of rupture)	* 180	-	261	ksi
Shear modulus	11.1	-	11.3	10^6 psi
Bulk modulus	* 23.2	-	26.1	10^6 psi
Poisson's ratio	0.293	-	0.308	
Shape factor	12			
Hardness - Vickers	519	-	731	HV
Hardness - Rockwell C	* 50	-	61	HRC
Hardness - Brinell	* 120	-	150	HB
Elastic stored energy (springs)	47	-	93.5	ft.lbf/in^3
Fatigue strength at 10^7 cycles	* 108	-	141	ksi
Fatigue strength model (stress amplitude)	* 91.4	-	167	ksi

Parameters: Stress Ratio = -1, Number of Cycles = 1e7cycles



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Cobalt-base-superalloy, Elgiloy/Phynox, cold worked, aged

Datasheet view: All attributes | Show/Hide | Find Similar

Thermal properties

Melting point	1.43e3	-	1.46e3	°C
Maximum service temperature	428	-	473	°C
Minimum service temperature	-194	-	-176	°C
Thermal conductivity	12.4	-	12.6	W/m.°C
Specific heat capacity	446	-	455	J/kg.°C
Thermal expansion coefficient	12.4	-	12.6	µstrain/°C
Thermal shock resistance	487	-	709	°C
Thermal distortion resistance	* 0.986	-	1.01	MW/m
Latent heat of fusion	* 352	-	426	kJ/kg

Cobalt-base-superalloy, Elgiloy/Phynox, cold worked, aged

Datasheet view: All attributes | Show/Hide | Find Similar

Durability

Water (fresh)	Excellent
Water (salt)	Excellent
Weak acids	Excellent
Strong acids	Acceptable
Weak alkalis	Excellent
Strong alkalis	Excellent
Organic solvents	Excellent
Oxidation at 500C	Excellent
UV radiation (sunlight)	Excellent
Galling resistance (adhesive wear)	Excellent
Notes	High resistance especially when self-mated.
Flammability	Non-flammable

Corrosion resistance of metals

Stress corrosion cracking	Susceptible
Notes	Rated in chloride; May be susceptible in halide, ammonia, nitrogen, acidic, caustic, carbonate environments

Design Note

Back | Forward | Copy | Print

Stress corrosion cracking

The resistance of the material to stress corrosion cracking (SCC). Crack growth is caused by the combined effects of stress and chemical attack.

Test notes

Materials are categorized qualitatively on the following four point scale:

- Highly susceptible
- Susceptible
- Slightly susceptible
- Not susceptible

Four factors are required for SCC to occur:

Cobalt-base-superalloy, Elgiloy/Phynox, cold worked, aged

Datasheet view: All attributes | Show/Hide | Find Similar

Processing energy, CO2 footprint & water

Casting energy	* 11.3	-	12.5	MJ/kg
Casting CO2	* 0.845	-	0.934	kg/kg
Casting water	* 21.3	-	32	l/kg
Roll forming, forging energy	* 11.7	-	12.9	MJ/kg
Roll forming, forging CO2	* 0.876	-	0.969	kg/kg
Roll forming, forging water	* 6.55	-	9.82	l/kg
Extrusion, foil rolling energy	* 23.1	-	25.5	MJ/kg
Extrusion, foil rolling CO2	* 1.73	-	1.91	kg/kg
Extrusion, foil rolling water	* 11.4	-	17.1	l/kg
Wire drawing energy	* 85.8	-	94.8	MJ/kg
Wire drawing CO2	* 6.43	-	7.11	kg/kg
Wire drawing water	* 32.3	-	48.5	l/kg
Metal powder forming energy	* 36.1	-	40	MJ/kg
Metal powder forming CO2	* 2.89	-	3.2	kg/kg
Metal powder forming water	* 39.5	-	59.2	l/kg
Vaporization energy	* 1.54e4	-	1.71e4	MJ/kg
Vaporization CO2	* 1.16e3	-	1.28e3	kg/kg
Vaporization water	* 6.44e3	-	9.65e3	l/kg
Coarse machining energy (per unit wt removed)	* 2.18	-	2.41	MJ/kg
Coarse machining CO2 (per unit wt removed)	* 0.164	-	0.181	kg/kg
Fine machining energy (per unit wt removed)	* 17.6	-	19.4	MJ/kg
Fine machining CO2 (per unit wt removed)	* 1.32	-	1.46	kg/kg
Grinding energy (per unit wt removed)	* 34.7	-	38.3	MJ/kg
Grinding CO2 (per unit wt removed)	* 2.6	-	2.87	kg/kg
Non-conventional machining energy (per unit wt removed)	* 154	-	171	MJ/kg
Non-conventional machining CO2 (per unit wt removed)	* 11.6	-	12.8	kg/kg

Recycling and end of life

Recycle	✓			
Embodied energy, recycling	* 33.6	-	37.2	MJ/kg
CO2 footprint, recycling	* 2.64	-	2.92	kg/kg
Recycle fraction in current supply	0.1			%
Downcycle	✓			
Combust for energy recovery	✗			
Landfill	✓			
Biodegrade	✗			

Report comparison

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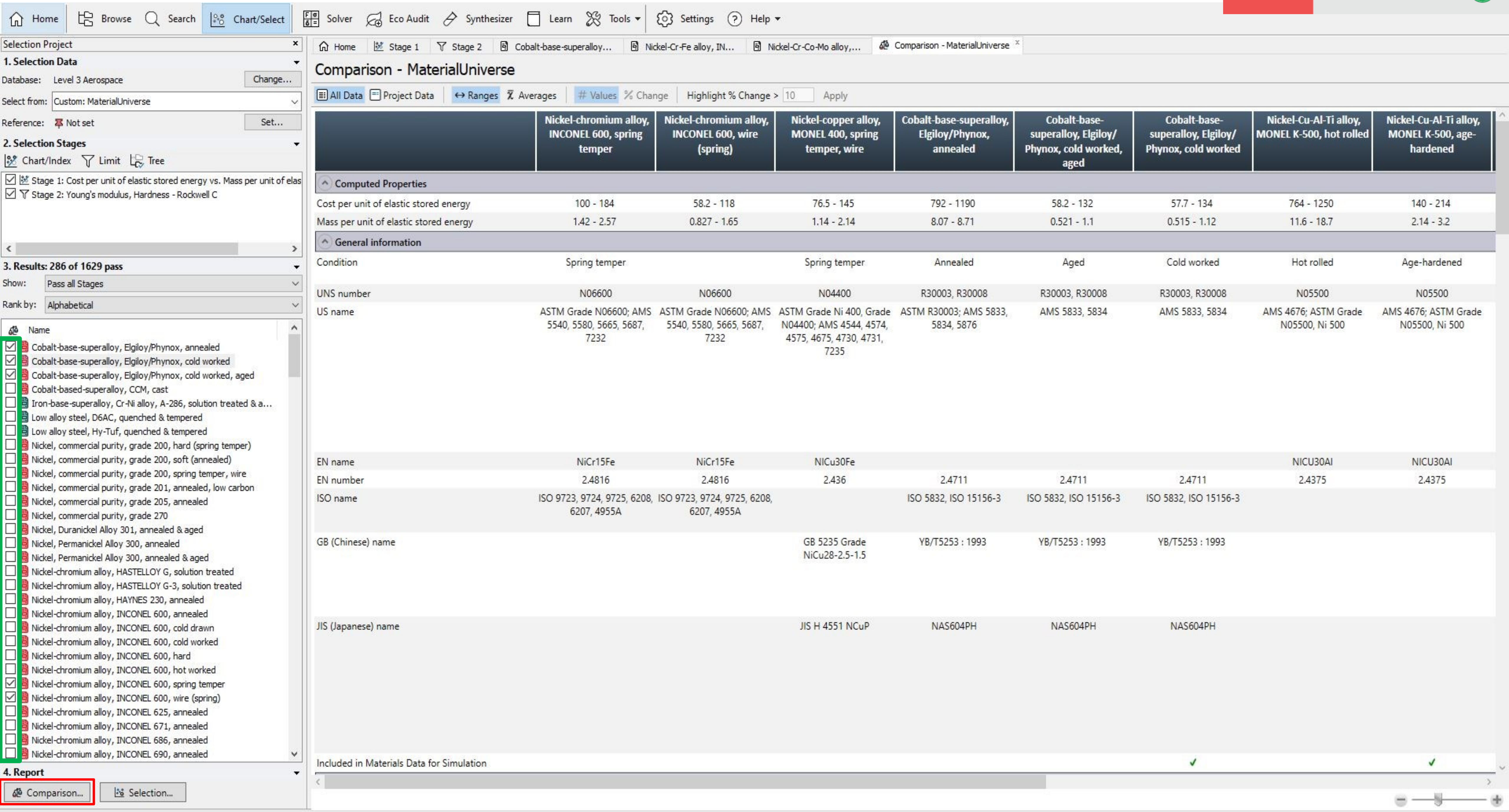
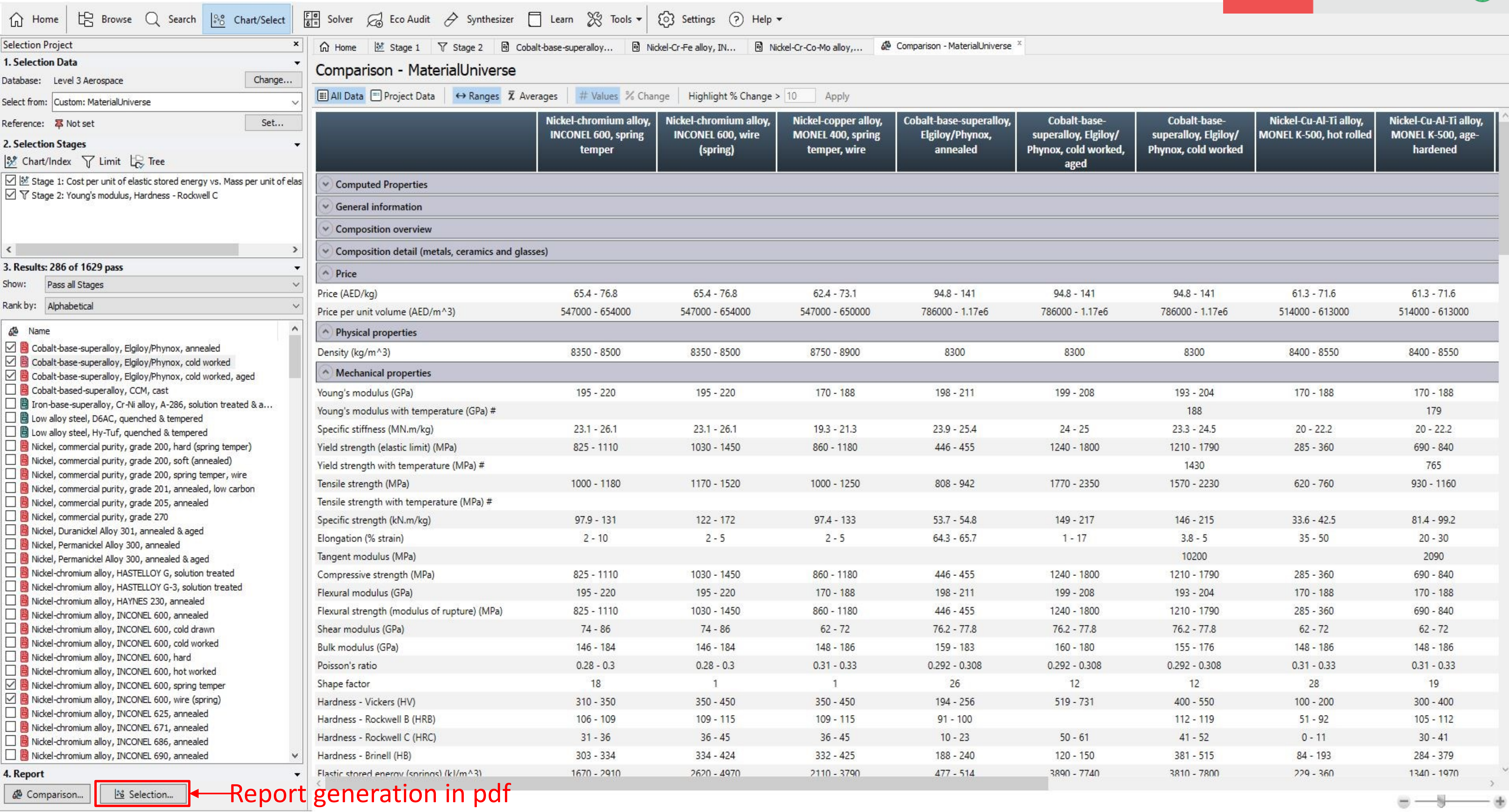


	Nickel-chromium alloy, INCONEL 600, spring temper	Nickel-chromium alloy, INCONEL 600, wire (spring)	Nickel-copper alloy, MONEL 400, spring temper, wire	Cobalt-base-superalloy, Elgiloy/Phynox, annealed	Cobalt-base-superalloy, Elgiloy/Phynox, cold worked, aged	Cobalt-base-superalloy, Elgiloy/Phynox, cold worked	Nickel-Cu-Al-Ti alloy, MONEL K-500, hot rolled	Nickel-Cu-Al-Ti alloy, MONEL K-500, age-hardened
Computed Properties								
Cost per unit of elastic stored energy	100 - 184	58.2 - 118	76.5 - 145	792 - 1190	58.2 - 132	57.7 - 134	764 - 1250	140 - 214
Mass per unit of elastic stored energy	1.42 - 2.57	0.827 - 1.65	1.14 - 2.14	8.07 - 8.71	0.521 - 1.1	0.515 - 1.12	11.6 - 18.7	2.14 - 3.2
General information								
Condition	Spring temper		Spring temper	Annealed	Aged	Cold worked	Hot rolled	Age-hardened
UNS number	N06600	N06600	N04400	R30003, R30008	R30003, R30008	R30003, R30008	N05500	N05500
US name	ASTM Grade N06600; AMS 5540, 5580, 5665, 5687, 7232	ASTM Grade N06600; AMS 5540, 5580, 5665, 5687, 7232	ASTM Grade Ni 400, Grade N04400; AMS 4544, 4574, 4575, 4675, 4730, 4731, 7235	ASTM R30003; AMS 5833, 5834, 5876	AMS 5833, 5834	AMS 5833, 5834	AMS 4676; ASTM Grade N05500, Ni 500	AMS 4676; ASTM Grade N05500, Ni 500
EN name	NiCr15Fe	NiCr15Fe	NiCu30Fe				NICU30AI	NICU30AI
EN number	2.4816	2.4816	2.436	2.4711	2.4711	2.4711	2.4375	2.4375
ISO name	ISO 9723, 9724, 9725, 6208, 6207, 4955A	ISO 9723, 9724, 9725, 6208, 6207, 4955A		ISO 5832, ISO 15156-3	ISO 5832, ISO 15156-3	ISO 5832, ISO 15156-3		
GB (Chinese) name			GB 5235 Grade NiCu28-2.5-1.5	YB/T5253 : 1993	YB/T5253 : 1993	YB/T5253 : 1993		
JIS (Japanese) name			JIS H 4551 NCuP	NAS604PH	NAS604PH	NAS604PH		
Included in Materials Data for Simulation						✓		✓

Report generation



	Nickel-chromium alloy, INCONEL 600, spring temper	Nickel-chromium alloy, INCONEL 600, wire (spring)	Nickel-copper alloy, MONEL 400, spring temper, wire	Cobalt-base-superalloy, Elgiloy/Phynox, annealed	Cobalt-base-superalloy, Elgiloy/Phynox, cold worked, aged	Cobalt-base-superalloy, Elgiloy/Phynox, cold worked	Nickel-Cu-Al-Ti alloy, MONEL K-500, hot rolled	Nickel-Cu-Al-Ti alloy, MONEL K-500, age-hardened
Computed Properties								
General information								
Composition overview								
Composition detail (metals, ceramics and glasses)								
Price								
Price (AED/kg)	65.4 - 76.8	65.4 - 76.8	62.4 - 73.1	94.8 - 141	94.8 - 141	94.8 - 141	61.3 - 71.6	61.3 - 71.6
Price per unit volume (AED/m^3)	547000 - 654000	547000 - 654000	547000 - 650000	786000 - 1.17e6	786000 - 1.17e6	786000 - 1.17e6	514000 - 613000	514000 - 613000
Physical properties								
Density (kg/m^3)	8350 - 8500	8350 - 8500	8750 - 8900	8300	8300	8300	8400 - 8550	8400 - 8550
Mechanical properties								
Young's modulus (GPa)	195 - 220	195 - 220	170 - 188	198 - 211	199 - 208	193 - 204	170 - 188	170 - 188
Young's modulus with temperature (GPa) #						188		179
Specific stiffness (MN.m/kg)	23.1 - 26.1	23.1 - 26.1	19.3 - 21.3	23.9 - 25.4	24 - 25	23.3 - 24.5	20 - 22.2	20 - 22.2
Yield strength (elastic limit) (MPa)	825 - 1110	1030 - 1450	860 - 1180	446 - 455	1240 - 1800	1210 - 1790	285 - 360	690 - 840
Yield strength with temperature (MPa) #						1430		765
Tensile strength (MPa)	1000 - 1180	1170 - 1520	1000 - 1250	808 - 942	1770 - 2350	1570 - 2230	620 - 760	930 - 1160
Tensile strength with temperature (MPa) #								
Specific strength (kN.m/kg)	97.9 - 131	122 - 172	97.4 - 133	53.7 - 54.8	149 - 217	146 - 215	33.6 - 42.5	81.4 - 99.2
Elongation (% strain)	2 - 10	2 - 5	2 - 5	64.3 - 65.7	1 - 17	3.8 - 5	35 - 50	20 - 30
Tangent modulus (MPa)						10200		2090
Compressive strength (MPa)	825 - 1110	1030 - 1450	860 - 1180	446 - 455	1240 - 1800	1210 - 1790	285 - 360	690 - 840
Flexural modulus (GPa)	195 - 220	195 - 220	170 - 188	198 - 211	199 - 208	193 - 204	170 - 188	170 - 188
Flexural strength (modulus of rupture) (MPa)	825 - 1110	1030 - 1450	860 - 1180	446 - 455	1240 - 1800	1210 - 1790	285 - 360	690 - 840
Shear modulus (GPa)	74 - 86	74 - 86	62 - 72	76.2 - 77.8	76.2 - 77.8	76.2 - 77.8	62 - 72	62 - 72
Bulk modulus (GPa)	146 - 184	146 - 184	148 - 186	159 - 183	160 - 180	155 - 176	148 - 186	148 - 186
Poisson's ratio	0.28 - 0.3	0.28 - 0.3	0.31 - 0.33	0.292 - 0.308	0.292 - 0.308	0.292 - 0.308	0.31 - 0.33	0.31 - 0.33
Shape factor	18	1	1	26	12	12	28	19
Hardness - Vickers (HV)	310 - 350	350 - 450	350 - 450	194 - 256	519 - 731	400 - 550	100 - 200	300 - 400
Hardness - Rockwell B (HRB)	106 - 109	109 - 115	109 - 115	91 - 100		112 - 119	51 - 92	105 - 112
Hardness - Rockwell C (HRC)	31 - 36	36 - 45	36 - 45	10 - 23	50 - 61	41 - 52	0 - 11	30 - 41
Hardness - Brinell (HB)	303 - 334	334 - 424	332 - 425	188 - 240	120 - 150	381 - 515	84 - 193	284 - 379
Elastic stored energy (springs) (kJ/m^3)	1670 - 2910	2620 - 4970	2110 - 3790	477 - 514	3890 - 7740	3810 - 7800	229 - 360	1340 - 1970

Thank You

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