MECHANICAL PROPERTIES OF MATERIALS pdf

1: List of materials properties - Wikipedia

Perhapsthemostnatural test of amaterial's mechanical properties is the tensiontest,in which astriporcylinderofthematerial,havinglengthLandcross-sectionalareaA,isanchoredatone end and subjected to an axial load P - a load acting along the specimen's long axis - at the.

Column Buckling Calculator Strain Hardening After a material yields, it begins to experience a high rate of plastic deformation. Once the material yields, it begins to strain harden which increases the strength of the material. In the stress-strain curves below, the strength of the material can be seen to increase between the yield point Y and the ultimate strength at point U. This increase in strength is the result of strain hardening. The ductile material in the figure below is still able to support load even after the ultimate strength is reached. However, after the ultimate strength at point U, the increase in strength due to strain hardening is outpaced by the reduction in load-carrying ability due to the decrease in cross sectional area. Between the ultimate strength at point U and the fracture point F, the engineering strength of the material decreases and necking occurs. In the stress-strain curve for the brittle material below, a very small region of strain hardening is shown between the yield point Y and the ultimate strength U. Note however that a brittle material may not actually exhibit any yielding behavior or strain hardening at all -- in this case, the material would fail on the linear portion of the curve. This is more common in materials such as ceramics or concrete. Because the strain hardening region occurs between the yield point and the ultimate point, the ratio of the ultimate strength to the yield strength is sometimes used as a measure of the degree of strain hardening in a material. This ratio is the strain hardening ratio: If a material is loaded beyond the elastic limit, it will undergo permanent deformation. After unloading the material, the elastic strain will be recovered return to zero but the plastic strain will remain. The figure below shows the stress-strain curve of a material that was loaded beyond the yield point, Y. Since the material was loaded beyond the elastic limit, only the elastic portion of the strain is recovered -- there is some permanent strain now in the material. Therefore, the material now has a higher yield point than it had previously, which is a result of strain hardening that occurred by loading the material beyond the elastic limit. Elastic and Plastic Strain Up to the elastic limit, the strain in the material is also elastic and will be recovered when the load is removed so that the material returns to its original length. However, if the material is loaded beyond the elastic limit, then there will be permanent deformation in the material, which is also referred to as plastic strain. In the figure above, both elastic and plastic strains exist in the material. The elastic strain and plastic strain are indicated in the figure, and are calculated as: Ductility Ductility is an indication of how much plastic strain a material can withstand before it breaks. A ductile material can withstand large strains even after it has begun to yield. Common measures of ductility include percent elongation and reduction in area, as discussed in this section. After a specimen breaks during a tensile test, the final length of the specimen is measured and the plastic strain at failure, also known as the strain at break, is calculated: It is important to note that after the specimen breaks, the elastic strain that existed while the specimen was under load is recovered, so the measured difference between the final and initial lengths gives the plastic strain at failure. This is illustrated in the figure below: The percent elongation is calculated from the plastic strain at failure by: Ductile and Brittle Materials A ductile material can withstand large strains even after it has begun to yield, whereas a brittle material can withstand little or no plastic strain. The figure below shows representative stress-strain curves for a ductile material and a brittle material. In the figure above, the ductile material can be seen to strain significantly before the fracture point, F. There is a long region between the yield at point Y and the ultimate strength at point U where the material is strain hardening. There is also a long region between the ultimate strength at point U and the fracture point F in which the cross sectional area of the material is decreasing rapidly and necking is occurring. The brittle material in the figure above can be seen to break shortly after the yield point. Additionally, the ultimate strength is coincident with the fracture point. In this case, no necking occurs. Because the area under the stress-strain curve for the ductile material above is larger than the area under the stress-strain curve for the brittle material, the ductile material has a higher modulus of toughness -- it can absorb much more strain energy before it breaks. Additionally, because the ductile material strains so significantly before it breaks, its deflections will be very high before failure. Therefore, it will be visually apparent that failure is imminent, and actions can be taken to resolve the situation before disaster occurs. A representative stress-strain curve for a brittle material is shown below. This curve shows the stress and strain for both tensile and compressive loading. Note how the material is much more resistant to compression than to tension, both in terms of the stress that it can withstand as well as the strain before failure. This is typical for a brittle material. Strain Energy When force is applied to a material, the material deforms and stores potential energy, just like a spring. The strain energy i. The total strain energy corresponds to the area under the load deflection curve, and has units of in-lbf in US Customary units and N-m in SI units. The elastic strain energy can be recovered, so if the deformation remains within the elastic limit, then all of the strain energy can be recovered. Strain energy is calculated as: The first equation is based on the area under the load deflection curve. The second equation is based on the equation for the potential energy stored in a spring. Both equations give the same result, they are just derived somewhat differently. Strain Energy Density It is sometimes more convenient to work with strain energy density, which is the strain energy per unit volume. This is equal to the area under the stress-strain diagram: Modulus of Resilience The modulus of resilience is the amount of strain energy per unit volume i. The modulus of resilience is calculated as the area under the stress-strain curve up to the elastic limit. However, since the elastic limit and the yield point are typically very close, the resilience can be approximated as the area under the stress-strain curve up to the yield point. Since the stress-strain curve is very nearly linear up to the elastic limit, this area is triangular. The modulus of resilience is calculated as: Note that the units of the modulus of resilience are the same as the units of strain energy density, which are psi in US Customary units and Pa in SI units. Modulus of Toughness The modulus of toughness is the amount of strain energy per unit volume i. The modulus of toughness is calculated as the area under the stress-strain curve up to the fracture point. An accurate calculation of the total area under the stress-strain curve to determine the modulus of toughness is somewhat involved. However, a rough approximation can be made by dividing the stress-strain curve into a triangular section and a rectangular section, as seen in the figure below. The height of the sections is equal to the average of the yield strength and the ultimate strength. The modulus of toughness can be approximated as: A better calculation of the modulus of toughness could be made by using the Ramberg-Osgood equation to approximate the stress-strain curve , and then integrating the area under the curve. It should be noted how greatly the area under the plastic region of the stress-strain curve i. Since a ductile material can withstand much more plastic strain than a brittle material, a ductile material will therefore have a higher modulus of toughness than a brittle material with the same yield strength. Even though structures are typically designed to keep stresses within the elastic region, a ductile material with a higher modulus of toughness is better suited to applications in which an accidental overload may occur. Note that the units of the modulus of toughness are the same as the units of strain energy density, which are psi in US Customary units and Pa in SI units.

MECHANICAL PROPERTIES OF MATERIALS pdf

2: Mechanical Properties of Materials

The mechanical properties of a material affect how it behaves as it is loaded. The elastic modulus of the material affects how much it deflects under a load, and the strength of the material determines the stresses that it can withstand before it fails.

ME Mechanical Team Last updated: Dec 16, Mechanical properties helps us to measure how materials behave under a load. Mechanical properties of materials are mentioned below. A material which regains its original size and shape on removal stress is said to be elastic stress. A material which can undergo permanent deformation without rupture aid to be plastic material. This property of the material is known as plasticity. Plasticity is important when a material is to be mechanically formed by causing the material to flow. A material which an undergo considerable deformation without rupture is said to be ductile material. The major portion of deformation is plastic. Mechanical Properties of a Metal Set of Permanent set: The deformation or strain remaining in a body after removal of stress is known as permanent set. This is due to elastic property of material. The greatest stress that a material can take without permanent set on the removal of stress is known as elastic limit. The greatest stress that a material can take without deviation from straight line between stress and strain is known as proportionality limit. Endurance limit or Fatigue limit: The greatest stress, applied infinite number of times, that a material can take without causing failure is known as endurance limit or fatigue limit. The maximum stress material can take is known as ultimate strength. Ultimate strength is equal to maximum load divided by original area of cross section. The energy stored per unit volume at the elastic limit is known as modulus of resilience. The amount of work required per unit volume to cause failure, under static loading, is called modulus of toughness. The ultimate strength in flexure or torsion is known as modulus of rupture. The increase in strength after plastic zone due to rearrangement of molecules in the material. The stress which is just sufficient to cause a permanent set elongation equal to a specified percentage of the original gauge length. Elastic strain is a dimensional change that occur in a material due to the application of loads and disappears completely on the removal of the loads. It is a dimensional change that occurs in a material due to application of the loads and does not disappear after the removal of the loads. The plastic response of material to tensile force is known as ductility and plastic response to compression force is known as malleability. The elongation and reduction of area of test piece tested to failure in tension are generally taken as measures of ductility of material. The long term deflection due to sustained constant loads. Factor of safety is defined as follows For Ductile materials, F.

MECHANICAL PROPERTIES OF MATERIALS pdf

3: Mechanical Properties of Materials - Mechanical Booster

A material which can undergo permanent deformation without rupture aid to be plastic material. This property of the material is known as plasticity. Plasticity is important when a material is to be mechanically formed by causing the material to flow.

Mechanical properties[edit] Brittleness: Ability of a material to break or shatter without significant deformation when under stress; opposite of plasticity,examples: Ratio of pressure to volumetric compression GPa or ratio of the infinitesimal pressure increase to the resulting relative decrease of the volume. Maximum stress a material can withstand before compressive failure MPa Creep: The slow and gradual deformation of an object with respect to time Ductility: Ability to withstand wear, pressure, or damage; hard-wearing. Ability of a body to resist a distorting influence or stress and to return to its original size and shape when the stress is removed Fatigue limit: Maximum stress a material can withstand under repeated loading MPa Flexibility: Ability of an object to bend or deform in response to an applied force; pliability; complementary to stiffness Flexural strength: The stresses in a material just before it yields. Ability to withstand surface indentation and scratching e. Brinnell hardness number Malleability: Ability of the material to be flattened into thin sheets under applications of heavy compressive forces without cracking by hot or cold working means. Ability of one substance to diffuse through another Plasticity: Ratio of lateral strain to axial strain no units Resilience: Ability of a material to absorb energy when it is deformed elastically MPa ; combination of strength and elasticity Shear modulus: Ratio of shear stress to shear strain MPa Shear strength: Maximum shear stress a material can withstand Slip: Ability of an object to resist deformation in response to an applied force; rigidity; complementary to flexibility Surface roughness: Maximum tensile stress of a material can withstand before failure MPa Toughness: Ratio of linear stress to linear strain MPa.

4: Mechanical Properties of Engineering Materials

Mechanical properties are the physical properties of the material which describes its behaviour under the action of loads on it. There are many mechanical properties of materials and some key properties among them are given below.

In this article we will learn about the various mechanical properties of materials. Knowing about them is very important to identify any material. It is the mechanical properties which provide the correct information about where the materials can be used. They are the measure of strength and how long the material can exist in its service. They play a key role in design of tools, machines and structures. Mechanical Properties of Materials The important mechanical properties of materials are 1. When an external load is applied on a material, than the capacity of the material to withstand that load without destruction is called strength of a material. The stronger the material the greater the load it can handle. Therefore it determines the ability of a material to withstand stress without failure. The strength of materials varies according to the types of load. The maximum stress that a material can withstand before destruction is called the ultimate strength. The tenacity of a material is the value of its ultimate strength in tension. The ability of a material to return to its original position after deformation when the external load acting on it is removed is called elasticity. Elasticity is the tensile property of the material. The resistance of a material to elastic deformation or deflection is called stiffness or rigidity. A material that suffers less deformation under the action of load possess high degree of stiffness or rigidity. For example a steel and aluminium beam is suspended. Both are enough strong to carry the required load but there is a greater deflection in the aluminium beam. This indicates that the steel beam has greater stiffness than aluminium beam. In tensile and compressive stress, it is called as modulus of stiffness or modulus of elasticity; In shear, modulus of rigidity; in volumetric distortion, the bulk modulus. It is defined as the ability of the material to bend easily. This mechanical properties of materials allows it to form in any shape. The plastic deformation appears when the material is stressed beyond the elastic range. Plasticity is important in shaping, forming, extruding and many other hot or cold working process. Generally plasticity increases with the increase in temperature. It is the property of a material by which it can be drawn into thin wires. The materials that possess this property are used in wire industries for manufacturing of wires. Malleability is the ability of a material to be hammered into thin sheets. Aluminium, copper, silver, tin, steel etc are malleable metals. Toughness is defined as the ability of a material to withstand both the plastic and elastic deformation. In other word it is the measure of the amount of energy a material can absorb before actual fracture or failure takes place. The materials that possess this property are used in the manufacturing of structural and machine parts which have to withstand shock and vibration. It is the capacity or ability of a material to absorb energy elastically. And on the removal of load this absorbed energy is given off same as spring does. The maximum energy that can be stored in a body upto elastic limit is called the proof resilience. And the proof resilience per unit volume is called as modulus of resilience. The materials having this property are used to manufacture springs. This property gives capacity to a material to bear shocks and vibration. The ability of a material by which it is able to resist to scratching, cutting, abrasion, indentation or penetration. It is closely related to strength. It is defined as the property of breaking of materials without much permanent distortion. There are so many materials which break without showing much permanent distortion. Such materials are said to be brittle such as glass and cast iron. Brittleness is the opposite of ductility. It is the ability of the material to be cut easily. The machinability of a metal in indicated by percentages which is called machinability index. All machinable metals are compared to a basic standard. The standard metal used for the percent machinability is free cutting steel. The machinability index of carbon steels generally ranged from 40 to 60 per cent and that of cast iron from 50 to 80 percent. The metals with higher range of machinability index can machined or cut easily. The creep is defined as the slow and progressive deformation of a material with the passage of time when it is subjected to constant stress. Viscous flow is the simplest type of creep deformation. In other words it is also defined as the time dependent strain occurring under stress. The creep deformation occurs in a material which is exposed for a long time to high level of stresses that are below yield strength. There are three stages of creep. In the first stage the material elongates rapidly but at a decreasing rate. In the second stage, the rate of elongation is constant. In the third stage, the rate of elongation increases rapidly until the material fails. The phenomena of weakening of material when it is subjected to repeated or fluctuating stress is called fatigue. When material is subjected to cyclic or fluctuating loading, there appears a minute cracks and these cracks grow with time and finally the materials gets fractured. Capacity of material to withstand load without destruction. The ability of the material to return to its original condition after deformation on removal of external load. Resistance to elastic deformation or deflection 4. The ability of the material to be bend. The ability of a material to undergo some degree of permanent deformation without rupture or failure. The ability of the material to be drawn into thin wires. The ability of the material to be hammered into thin sheets. The ability of a material to withstand both the elastic and plastic deformation.

MECHANICAL PROPERTIES OF MATERIALS pdf

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To finalize the material for an engineering product/application, we should have the knowledge of Mechanical properties of www.enganchecubano.com mechanical properties of a material are those which effect the mechanical strength and ability of a material to be molded in suitable shape.

Fatigue Strength It is the property of a material which opposes the deformation or breakdown of material in presence of external forces or load. Materials which we finalize for our engineering products, must have suitable mechanical strength to be capable to work under different mechanical forces or loads. Toughness It is the ability of a material to absorb the energy and gets plastically deformed without fracturing. Its numerical value is determined by the amount of energy per unit volume. Value of toughness of a material can be determined by stress-strain characteristics of a material. For good toughness, materials should have good strength as well as ductility. Conversely, materials having good ductility but low strength are also not tough enough. Therefore, to be tough, a material should be capable to withstand both high stress and strain. Hardness It is the ability of a material to resist to permanent shape change due to external stress. Scratch Hardness Scratch Hardness is the ability of materials to the oppose the scratches to outer surface layer due to external force. Indentation Hardness It is the ability of materials to oppose the dent due to punch of external hard and sharp objects. Rebound Hardness Rebound hardness is also called as dynamic hardness. Hardenability It is the ability of a material to attain the hardness by heat treatment processing. It is determined by the depth up to which the material becomes hard. The SI unit of hardenability is meter similar to length. Hardenability of material is inversely proportional to the weld-ability of material. Brittleness Brittleness of a material indicates that how easily it gets fractured when it is subjected to a force or load. When a brittle material is subjected to a stress it observes very less energy and gets fractures without significant strain. Brittleness is converse to ductility of material. Brittleness of material is temperature dependent. Some metals which are ductile at normal temperature become brittle at low temperature. Malleability Malleability is a property of solid materials which indicates that how easily a material gets deformed under compressive stress. Malleability is often categorized by the ability of material to be formed in the form of a thin sheet by hammering or rolling. This mechanical property is an aspect of plasticity of material. Malleability of material is temperature dependent. With rise in temperature, the malleability of material increases. Ductility Ductility is a property of a solid material which indicates that how easily a material gets deformed under tensile stress. Ductility is often categorized by the ability of material to get stretched into a wire by pulling or drawing. This mechanical property is also an aspect of plasticity of material and is temperature dependent. With rise in temperature, the ductility of material increases. Creep and Slip Creep is the property of a material which indicates the tendency of material to move slowly and deform permanently under the influence of external mechanical stress. It results due to long time exposure to large external mechanical stress with in limit of yielding. Creep is more severe in material that are subjected to heat for long time. Slip in material is a plane with high density of atoms. Resilience Resilience is the ability of material to absorb the energy when it is deformed elastically by applying stress and release the energy when stress is removed. Proof resilience is defined as the maximum energy that can be absorbed without permanent deformation. The modulus of resilience is defined as the maximum energy that can be absorbed per unit volume without permanent deformation. It can be determined by integrating the stress-strain cure from zero to elastic limit. Fatigue Fatigue is the weakening of material caused by the repeated loading of the material. When a material is subjected to cyclic loading, and loading greater than certain threshold value but much below the strength of material ultimate tensile strength limit or yield stress limit , microscopic cracks begin to form at grain boundaries and interfaces. Eventually the crack reaches to a critical size. This crack propagates suddenly and the structure gets fractured. The shape of structure affects the fatigue very much. Square holes and sharp corners lead to elevated stresses where the fatigue crack initiates.

MECHANICAL PROPERTIES OF MATERIALS pdf

6: 15 Mechanical Properties Of Engineering Material

Material Properties Reference for steel, cast iron, aluminum, composite materials, ceramics and more. This site is a large engineering and manufacturing reference directory for mechanical designers. Includes engineering data tables, material info, manufacturing methods, design guides and more!!

Mechanical Properties The mechanical properties of a material describe how it will react to physical forces. Mechanical properties occur as a result of the physical properties inherent to each material, and are determined through a series of standardized mechanical tests. Strength Strength has several definitions depending on the material type and application. Before choosing a material based on its published or measured strength it is important to understand the manner in which strength is defined and how it is measured. When designing for strength, material class and mode of loading are important considerations. For metals the most common measure of strength is the yield strength. For most polymers it is more convenient to measure the failure strength, the stress at the point where the stress strain curve becomes obviously non-linear. Strength, for ceramics however, is more difficult to define. Failure in ceramics is highly dependent on the mode of loading. The typical failure strength in compression is fifteen times the failure strength in tension. The more common reported value is the compressive failure strength. Elastic limit The elastic limit is the highest stress at which all deformation strains are fully recoverable. For most materials and applications this can be considered the practical limit to the maximum stress a component can withstand and still function as designed. Beyond the elastic limit permanent strains are likely to deform the material to the point where its function is impaired. Proportional limit The proportional limit is the highest stress at which stress is linearly proportional to strain. This is the same as the elastic limit for most materials. Some materials may show a slight deviation from proportionality while still under recoverable strain. In these cases the proportional limit is preferred as a maximum stress level because deformation becomes less predictable above it. Yield Strength The yield strength is the minimum stress which produces permanent plastic deformation. This is perhaps the most common material property reported for structural materials because of the ease and relative accuracy of its measurement. The yield strength is usually defined at a specific amount of plastic strain, or offset, which may vary by material and or specification. The offset is the amount that the stress-strain curve deviates from the linear elastic line. The most common offset for structural metals is 0. Ultimate Tensile Strength The ultimate tensile strength is an engineering value calculated by dividing the maximum load on a material experienced during a tensile test by the initial cross section of the test sample. Conversely this can be construed as the minimum stress that is necessary to ensure the failure of a material. True Fracture Strength The true fracture strength is the load at fracture divided by the cross sectional area of the sample. Like the ultimate tensile strength the true fracture strength can help an engineer to predict the behavior of the material but is not itself a practical strength limit. Because the tensile test seeks to standardize variables such as specimen geometry, strain rate and uniformity of stress it can be considered a kind of best case scenario of failure. Ductility Ductility is a measure of how much deformation or strain a material can withstand before breaking. The most common measure of ductility is the percentage of change in length of a tensile sample after breaking. It is often expressed in terms of the amount of energy a material can absorb before fracture. Tough materials can absorb a considerable amount of energy before fracture while brittle materials absorb very little. Neither strong materials such as glass or very ductile materials such as taffy can absorb large amounts of energy before failure. Toughness is not a single property but rather a combination of strength and ductility. The toughness of a material can be related to the total area under its stress-strain curve. A comparison of the relative magnitudes of the yield strength, ultimate tensile strength and percent elongation of different material will give a good indication of their relative toughness. Materials with high yield strength and high ductility have high toughness. Integrated stress-strain data is not readily available for most materials so other test methods have been devised to help quantify toughness. The most common test for toughness is the Charpy impact test. In crystalline materials the toughness is strongly dependent on crystal structure. Face centered cubic materials are typically ductile while hexagonal close packed materials tend to be brittle. Body centered cubic materials often display dramatic variation in the mode of failure with temperature. In many materials the toughness is temperature dependent. Generally materials are more brittle at lower temperatures and more ductile at higher temperatures. The temperature at which the transition takes place is known as the DBTT, or ductile to brittle transition temperature. The DBTT is measured by performing a series of Charpy impact tests at various temperatures to determine the ranges of brittle and ductile behavior. Use of alloys below their transition temperature is avoided due to the risk of catastrophic failure. Fatigue ratio The dimensionless fatigue ratio f is the ratio of the stress required to cause failure after a specific number of cycles to the yield stress of a material. Fatigue tests are generally run through or cycles. A high fatigue ratio indicates materials which are more susceptible to crack growth during cyclic loading. Loss coefficient The loss coefficient is an other important material parameter in cyclic loading. It is the fraction of mechanical energy lost in a stress strain cycle. The loss coefficient for each material is a function of the frequency of the cycle. A high loss coefficient can be desirable for damping vibrations while a low loss coefficient transmits energy more efficiently. The loss coefficient is also an important factor in resisting fatigue failure. If the loss coefficient is too high, cyclic loading will dissipate energy into the material leading to fatigue failure.

7: Chapter Mechanical Properties of Metals

Mechanical Properties of Materials the aggregate of indexes that characterize the resistance of a material to a load acting on it, the degree to which it will deform under the.

Mechanical Properties of Metals Introduction Often materials are subject to forces loads when they are used. Mechanical engineers calculate those forces and material scientists how materials deform elongate, compress, twist or break as a function of applied load, time, temperature, and other conditions. Materials scientists learn about these mechanical properties by testing materials. Results from the tests depend on the size and shape of material to be tested specimen , how it is held, and the way of performing the test. That is why we use common procedures, or standards, which are published by the ASTM. Concepts of Stress and Strain To compare specimens of different sizes, the load is calculated per unit area, also called normalization to the area. Force divided by area is called stress. In tension and compression tests, the relevant area is that perpendicular to the force. In shear or torsion tests, the area is perpendicular to the axis of rotation. There is a change in dimensions, or deformation elongation, DL as a result of a tensile or compressive stress. To enable comparison with specimens of different length, the elongation is also normalized, this time to the length L. This is called strain, e. One could divide force by the actual area, this is called true stress see Sec. For torsional or shear stresses, the deformation is the angle of twist, q Fig. When the stress is removed, the material returns to the dimension it had before the load was applied. Valid for small strains except the case of rubbers. Deformation is reversible, non permanent Plastic deformation. When the stress is removed, the material does not return to its previous dimension but there is a permanent, irreversible deformation. In some cases, the relationship is not linear so that E can be defined alternatively as the local slope: Elastic moduli measure the stiffness of the material. They are related to the second derivative of the interatomic potential, or the first derivative of the force vs. By examining these curves we can tell which material has a higher modulus. Due to thermal vibrations the elastic modulus decreases with temperature. E is large for ceramics stronger ionic bond and small for polymers weak covalent bond. Since the interatomic distances depend on direction in the crystal, E depends on direction i. For randomly oriented policrystals, E is isotropic. Anelasticity Here the behavior is elastic but not the stress-strain curve is not immediately reversible. It takes a while for the strain to return to zero. The effect is normally small for metals but can be significant for polymers. Elastic Properties of Materials Materials subject to tension shrink laterally. Those subject to compression, bulge. If the stress is too large, the strain deviates from being proportional to the stress. The point at which this happens is the yield point because there the material yields, deforming permanently plastically. The stress at the yield point is called yield stress, and is an important measure of the mechanical properties of materials. In practice, the yield stress is chosen as that causing a permanent strain of 0. The yield stress measures the resistance to plastic deformation. The reason for plastic deformation, in normal materials, is not that the atomic bond is stretched beyond repair, but the motion of dislocations, which involves breaking and reforming bonds. Plastic deformation is caused by the motion of dislocations. When stress continues in the plastic regime, the stress-strain passes through a maximum, called the tensile strength sTS , and then falls as the material starts to develop a neck and it finally breaks at the fracture point Fig. Note that it is called strength, not stress, but the units are the same, MPa. For structural applications, the yield stress is usually a more important property than the tensile strength, since once the it is passed, the structure has deformed beyond acceptable limits. The ability to deform before braking. It is the opposite of brittleness. Ductility can be given either as percent maximum elongation emax or maximum area reduction. Capacity to absorb energy elastically. The energy per unit volume is the area under the strain-stress curve in the elastic region. Ability to absorb energy up to fracture. The energy per unit volume is the total area under the strain-stress curve. It is measured by an impact test Ch. True Stress and Strain When one applies a constant tensile force the material will break after reaching the tensile strength. The material starts necking the transverse area decreases but the stress cannot increase beyond sTS. The ratio of the force to the initial area, what we normally do, is called the engineering stress. If the ratio is to the actual area that changes with stress one obtains the true stress. Elastic Recovery During

Plastic Deformation If a material is taken beyond the yield point it is deformed plastically and the stress is then released, the material ends up with a permanent strain. If the stress is reapplied, the material again responds elastically at the beginning up to a new yield point that is higher than the original yield point strain hardening, Ch. The amount of elastic strain that it will take before reaching the yield point is called elastic strain recovery Fig. Compressive, Shear, and Torsional Deformation Compressive and shear stresses give similar behavior to tensile stresses, but in the case of compressive stresses there is no maximum in the s-e curve, since no necking occurs. Hardness Hardness is the resistance to plastic deformation e. Thus, it is a measure of plastic deformation, as is the tensile strength, so they are well correlated. Historically, it was measured on an empirically scale, determined by the ability of a material to scratch another, diamond being the hardest and talc the softer. Now we use standard tests, where a ball, or point is pressed into a material and the size of the dent is measured. There are a few different hardness tests: Rockwell, Brinell, Vickers, etc. They are popular because they are easy and non-destructive except for the small dent. Variability of Material Properties Tests do not produce exactly the same result because of variations in the test equipment, procedures, operator bias, specimen fabrication, etc. But, even if all those parameters are controlled within strict limits, a variation remains in the materials, due to uncontrolled variations during fabrication, non homogenous composition and structure, etc. The measured mechanical properties will show scatter, which is often distributed in a Gaussian curve bell-shaped , that is characterized by the mean value and the standard deviation width.

8: Mechanical Properties of Materials | MechaniCalc

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Such allowable stresses are also known as "design stresses" or "working stresses. Many machine parts fail when subjected to a non steady and continuously varying loads even though the developed stresses are below the yield point. Such failures are called fatigue failure. The failure is by a fracture that appears to be brittle with little or no visible evidence of yielding. However, when the stress is kept below "fatigue stress" or "endurance limit stress", the part will endure indefinitely. A purely reversing or cyclic stress is one that alternates between equal positive and negative peak stresses during each cycle of operation. In a purely cyclic stress, the average stress is zero. Generally, higher the range stress, the fewer the number of reversals needed for failure. Failure theories[edit] There are four failure theories: Out of these four theories of failure, the maximum normal stress theory is only applicable for brittle materials, and the remaining three theories are applicable for ductile materials. Of the latter three, the distortion energy theory provides most accurate results in majority of the stress conditions. The maximum shear stress theory is conservative. For simple unidirectional normal stresses all theories are equivalent, which means all theories will give the same result. Maximum Shear Stress Theory â€" This theory postulates that failure will occur if the magnitude of the maximum shear stress in the part exceeds the shear strength of the material determined from uniaxial testing. Maximum Normal Stress Theory â€" This theory postulates that failure will occur if the maximum normal stress in the part exceeds the ultimate tensile stress of the material as determined from uniaxial testing. This theory deals with brittle materials only. The maximum tensile stress should be less than https: The magnitude of the maximum compressive stress should be less than ultimate compressive stress divided by factor of safety. Maximum Strain Energy Theory â€" This theory postulates that failure will occur when the strain energy per unit volume due to the applied stresses in a part equals the strain energy per unit volume at the yield point in uniaxial testing. This theory postulates that failure will occur when the distortion energy per unit volume due to the applied stresses in a part equals the distortion energy per unit volume at the yield point in uniaxial testing. The total elastic energy due to strain can be divided into two parts: Distortion energy is the amount of energy that is needed to change the shape. This important theory is also known as numeric conversion of toughness of material in the case of crack existence. Fractology was proposed by Takeo Yokobori because each fracture laws including creep rupture criterion must be combined nonlinearly. The engineering processes to which a material is subjected can alter this microstructure. The variety of strengthening mechanisms that alter the strength of a material includes work hardening , solid solution strengthening , precipitation hardening , and grain boundary strengthening and can be quantitatively and qualitatively explained. Strengthening mechanisms are accompanied by the caveat that some other mechanical properties of the material may degenerate in an attempt to make the material stronger. For example, in grain boundary strengthening, although yield strength is maximized with decreasing grain size, ultimately, very small grain sizes make the material brittle. Considered in tandem with the fact that the yield strength is the parameter that predicts plastic deformation in the material, one can make informed decisions on how to increase the strength of a material depending its microstructural properties and the desired end effect. Strength is expressed in terms of the limiting values of the compressive stress , tensile stress , and shear stresses that would cause failure. The effects of dynamic loading are probably the most important practical consideration of the strength of materials, especially the problem of fatigue. Repeated loading often initiates brittle cracks, which grow until failure occurs. The cracks always start at stress concentrations , especially changes in cross-section of the product, near holes and corners at nominal stress levels far lower than those quoted for the strength of the material.

9: Mechanical Material Properties - Engineer's Handbook

A material's property (or material property) is an intensive property of some material, i.e. a physical property that does *not depend on the amount of the material. These quantitative properties may be used as a metric by which the benefits of one material versus another can be compared, thereby aiding in materials selection.*

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