Free report on tensile test lab

Experience, Failure

Abstract

Tensile tests are instrumental in understanding the properties of various materials and the way will behave when subjected to a load. Four different materials were subjected to tensile test using universal testing machine. The materials that were tested were: steel and nylon. The data obtained from each experiment was used to calculate and graphically determine some of the valuable properties of the materials such as, yield stress, ultimate tensile strength and young's modulus. The material properties obtained from the various test were compared with the theoretical values and also amongst the materials themselves. The tensile test results showed that steel was the strongest material. Its ultimate tensile strength was 385MPa, young's modulus of 96000 MPa and yield stress of 340 MPa. Nylon had a yield stress, tensile strength and young's modulus of 59 MPa, 68 MPa and 925 respectively which were much less compared to that of steel.

Objective

The main objective of the experiment was to test the tensile properties of two different types of materials (nylon and steel), using a universal testing machine. The material properties that were tested included: tensile strength, yield stress and young's modulus.

Theory:

Most engineering materials can be defined by their physical properties. These properties include ultimate tensile strength, modulus of resilience, modulus of toughness, yield strength and modulus of elasticity. Once determined by the means of the experiment, the above properties are then applicable to all cases of that material experiencing similar stress thus allowing for the design of the structural components with predictable behavior. In real life, most of these qualities are affected environmental conditions such as temperature, loading frequency and the purity of the material. The presence of impurities and flaws affects the various properties of the material either negatively or positively. For pure materials that are lacking in one or more of the desirable properties impurities may be added to enhance the desirable properties. On the other hand the presence of flaws in the material has negative effects on the properties of the material which may lead to sudden failure or unpredicted behavior. To mitigate these negative effects, temperature is sometimes adjusted mathematically and the design of safety is taken into consideration during the design stage to take care for the uncertainties and the unpredictable loading hence ensuring that the material does not fail. The materials are also tested to ensure that they are mechanically sound.

The established material properties are mostly relied upon to determine the type of load and the range within which the materials used are safe. The properties also enable the comparison of strength, toughness, brittleness and other similar features. When testing a material with an intention of testing its mechanical properties, a stress-strain graph proves to be of help in the analysis and so is the mode of failure investigation. Every mode of failure is linked to an important material property: sudden fracture to ultimate strength, yielding to yield strength and elastic failure to the elastic limit. When doing a tensile test by the application of axial load to a test sample, the required data for a stress-strain graph can be obtained and by subjecting a material to tension until it fails by sudden fracture; it is possible to determine the conditions at which yielding and elastic failure occurs.

The Young's modulus or modulus of elasticity gives the direct relationship that exists between strain and stress for all stresses that is below the limit of proportionality. The stress at that gives a plastic deformation of 0. 2% is known as the nominal yield strength. While the amount of stress that can be withstood by a sample under tension before failure is known as ultimate tensile strength. Percentage elongation at failure basically gives the final change in the length of the sample that has already reached failure. The percentage area reduction gives the smallest possible cross-sectional area of a specimen that has undergone failure.

The modulus of toughness gives the amount of work done on a unit volume starting from where stress is zero up to the point of failure. The modulus of resilience indicates the ability of the material to absorb energy without undergoing plastic deformation. Engineering stress is the applied load divided by the area the initial cross sectional area of the material. The true stress is given by the amount of load applied divided by cross sectional area after taking into consideration the change in area due to the deformation. Engineering strain is the change in length divided by initial gauge length. On the other hand the true strain at the point of rapture is given by the natural log of the final length of the sample divided by initial length. In this case the initial length is obtained after taking into account each instantaneous change in length.

Figure 1. Stress vs. Strain showing major mechanical properties

The stress-strain graph can be used to determine the major mechanical properties of an engineering material. These properties when fully analyzed describe the mechanical performance of a material that is subjected to a load and equally apply to all kinds of engineering materials.

Yield Stress: σY = load at yield pointoriginal area(point A on the graph)

Tensile Strength: σTS = maximum loadoriginal area(point C on the graph)

Young’s Modulus: E = ΔσΔε(gradient of linear part of the graph)

Lastly, the ductility of a material is obtained by determining the percentage elongation experienced by the material up to its breaking point. This is normally determined by measuring the change in length of the material at the end of the test or by expressing OE as shown in figure 1 as a percentage.

Materials and equipment

- Tensile specimens (nylon and steel)
- Vernier calipers
- Universal testing machine

Experimental procedure

- The diameter and gauge length of each of the four tensile specimens was measured by the Vernier caliper and recorded in a table to be used for the calculation of engineering strain and engineering stress.
- The data acquisition software was then started after choosing the correct material. To ensure that only the tensile load applied to the specimen was measured the load cell was zeroed.
- One specimen at a time was loaded into the jaws of the machine and it was ensured that it was spaced equally between the clamps.
- After ensuring that the specimen was correctly loaded in the machine, the

load was released and the test started.

- The test went on until the fracture of the material occurred; the software automatically stopped and saved the recorded data. The specimen was detached from the jaws of the machine and the system was reset for another tensile test. The steps above were repeated for the other specimen.

- The values of the yield stress, young’s modulus and tensile strength were calculated from the experimental data.

Figure 2. Tensile testing machine used in the experiment

Figure 3. A test specimen ready for tensile test

Results and Analysis

The data obtained was used to calculate stress and strain

Stress = Force/Area

Strain = change in length/ original length

Area = ∏r2

The gauge length for the two specimens was 50mm while the average diameter of steel was 9. 92 mm and that of nylon was 10. 04 mm; the materials were of virtually the same diameter

Tensile strength, σTS = 6. 8 ×107 N/m2

Yield stress, Y = 5. 9 ×107 N/m2

Young’s Modulus: E = ΔσΔε = (48560000-4573000)/ (0. 05247-0. 004917)

= 92. 5 ×107 N/m2

Tensile strength, σTS = 38. 5 ×107 N/m2

Yield stress, Y = 34 ×107 N/m2

Young’s Modulus: E = ΔσΔε = (237610000-41855000)/ (0. 001139-0.

0001418)

= 196 ×109 N/m2

Discussion

The results obtained from the experiment were almost similar with the theoretical values of the specimens used. From the results of ultimate tensile strength as shown in table 1, it is evident that steel was the strongest material as compared to nylon. It can also be seen that all the values had a slight deviation from the theoretical values indicating that the data obtained was consistent and the procedure used proved to be valid and repeatable. The yield strength in table 1 provides a good indication of the yield stress at the yield point. The yield stress and tensile strength of Steel were much higher than those of nylon which indicated that steel is much stronger and ductile as compared to nylon. The young’s modulus of steel was also several times more to that of nylon again indicating that steel is much stiffer when compared to nylon. The difference in the mechanical properties of the two materials can be explained by the difference in the atomic structure of the materials. Steel has more desirable properties for the application in the construction industry while nylon as properties that are desirable in the textile industry where strength is not of much importance.

Conclusion

The tensile test of steel and nylon had consistent and accurate results. It was shown that the strength and stiffness properties of steel were much higher than those of nylon. The experimental results for the material properties tested of the two specimens were close to the established values. This shows that the test procedure used was accurate and the material tested were free of major flaws. The slight variations of the results from the established values were properly due to instrumental error and variations of the atomic structure properties of the materials used.

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