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Mechanical comparison and statistical study of metallic and plastic material used in industry

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Abstract:

Hence the interest of the present work which is firstly the mastery of mechanical behavior of plastic and metallic material to improve and optimize the mechanical characteristics of the two materia(ABS material and P265GH steel material), another characterization approach was considered in this paper; it is a statistical study of Student that allows the selection of the most reliable results with a risk threshold of 10% for the both types of materials. On the other hand, a Weibull statistical study is carried out to extract the Weibull elements and subsequently define the reliability theory and damage of Weibull.
As result of this study, the maximum stress of the studied material of steel is significantly higher than that of ABS, it is also noticed that P265GH steel material have a high specific energy in elastic phase

Keywords

ABS material, P265GH steel material, Weibull study, Statical study

1. Introduction

Steel material and ABS material are often used in industry thanks to their enormous utilities, By the external environment and operating conditions of these materials, they are subjected to stresses of various kinds. Despite the protective ways surrounding the effects of moisture and external aggressions.

The aim of this paper is to study the mechanical behavior of steel and ABS material. Results are supported by student statistical analysis that process the reliability and another statistical study results (Weibull) is performed to plot the reliability and damage curves. A comparative study of the two types of materials is conducted in order to review the various advantages and disadvantages of each material.

2. Experimentation

- **Studied Specimen**

The two studied samples are:

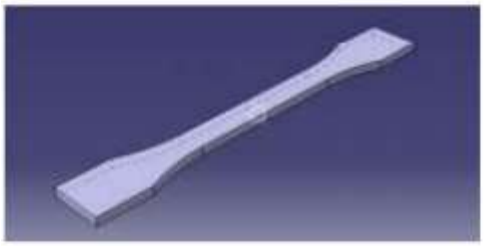

Figure 1 specimen of ABS material according to ASTM D638-03 [2].

Figure 2 specimen of P265GH steel material according to ISO 6892 [3].

3. Mechanical properties of materials

Different mechanical properties extracted from stress-strain curves are summarized in the table 1 and table 2

Table 1. Mechanical properties of P265GH steel material

Young's modulus E (MPa)	elastic limit: σ_e (MPa)	Breaking stress: σ_g (MPa)	Elongation %	Poisson's ratio v
2.105	320	470	35	0,3

Table 2. Mechanical properties of ABS material

Young's modulus E (MPa)	elastic limit: σ_e (MPa)	Breaking stress: σ_g (MPa)	Elongation %	Poisson's ratio v
2.000	29	34	6	0,3

We note that the elongation of the steel is of the order of 35% which is greater than 14% required by the standard.

As a result, this P265GH steel has high mechanical characteristics, yet the ABS material exhibits low elongation and rigidity similar to that of P265GH steel[4]..

4. STUDENT Statistical study of the ABS and P265GH steel material

The STUDENT distribution is used to identify the appropriate confidence limits. STUDENT law determines a confidence interval in which the limits of the maximum stress of the studied specimens is 90 out of 100 to regulate the average distribution of the tensile tests. The relation STUDENT [3] is applied to results obtained in the static tensile tests on ABS and P265GH steel material [4].

5. Weibull distribution on maximum stress of aluminum and copper wires

Another statistical technique on the experimental results of tensile test on ABS and P265GH steel material is studied, it is Weibull statistical method. The purpose of this study is to provide a statistical processing to derive the maximum stress that can be applied on the material so that the failure probability (damage) is less than 1%, and then estimate the survival probability (reliability) and the probability of failure**[5]**.

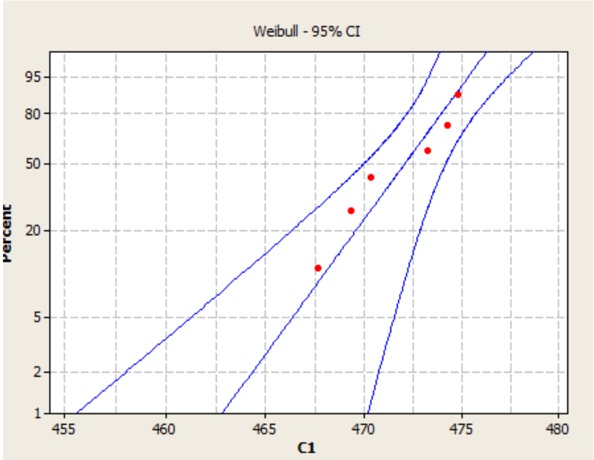

Figure 3. Weibull distribution curve of the P265GH steel

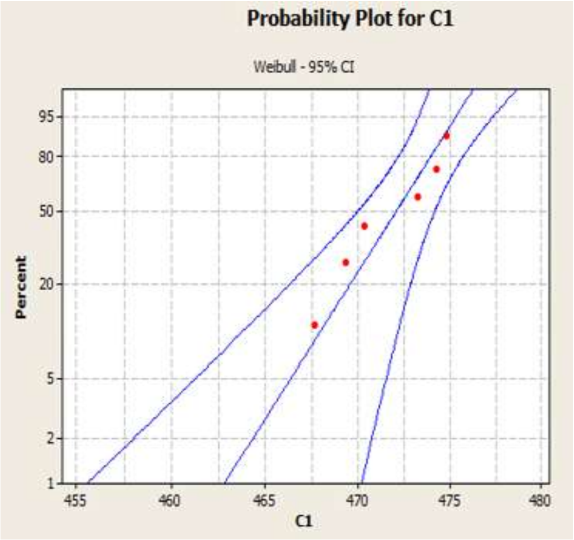

Figure 4. Weibull distribution curve of ABS material

We define Weibull characteristics of steel and plastic material and we find :

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For P265GH steel material

m = 214.63 and $\sigma 0$ = 472.88 (4)

For ABS material

m = 20.38 and $\sigma 0$ = 39.45 (5)

5. Results and discussion

5.1. STUDENT distribution

To develop a statistical study of the studied ABS and P265GH steel material, we conducted a tensile test of 24 specimens for each material[6] .

The confidence interval (CI) at 90% is an interval of values which have 90% chance to contain the true value of the estimated maximal stress. It is possible to say that the CI represents the interval of values within which we are 90% certain to find the real search value. The confidence interval is the set of values reasonably compatible with the observed result. It provides a visualization of the incertitude[7] .

We have

CI P265GH steel = $[469.29, 473.16]$

CI ABS = [38,39.54]

5.2 *Weibull distribution*

The probability of survival(realibility) of specimen undergoing stress could be modeled using the following Weibull model:

$$Ps = e^{-(\frac{\sigma}{\sigma 0})^m} \quad (3)$$

The probability of survival curve and the probability of failure(damage) in function of life fraction β for the two materials are presented in Fig 5.

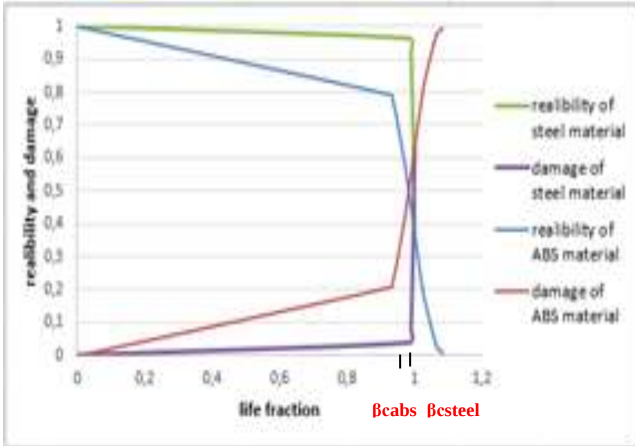

Figure 5. Probability of survival-Probability of failure curves in function of life fraction

We find that survival probability of steel maintain a superior value until β=0.98.

According to figure 5, it is clear that the life fraction of P265GH steel material is greater than the life fraction of ABS.

The task is to estimate the maximum stress that can be applied to the materials so that the failure probability is lower than 1%. This means that:

$$Ps > 0.99 \quad (4)$$

It has been shown previously that our specimens follow Weibull distribution. We have:

$$e^{-(\frac{\sigma}{\sigma 0})^m} = 0.99 \quad (5)$$

The value of the maximum stress obtained that could be applied on the material so that the failure probability is less than 1%:

For steel material:

σ =462.85 MPa

For ABS material:

σ =31.48 MPa

7. Conclusion

P265GH steel material have several strong advantages in their mechanical properties, they have a greater maximal stress and an important strain (35 % of strain) than ABS material, in studied statistical analysis, it is noticed that the specimens of ABS material have a less dispersion than P265GH steel material; STUDENT distribution helped us to refine the confidence interval.

The value of the maximum stress obtained that could be applied on the P265GH steel material so that the failure probability is less than 1% is 462,85.

On the other hand, ABS material has a great critical life time near that of P265GH steel material, which means that it has a important life time

Weibull modulus m is a characteristic parameter of material defects dispersion, the lowest it is, the more heterogeneous is the defect distribution. On the other hand, Weibull distribution permits the definition of survival probability therefore determine the aluminum wires damage, and thus to intervene in time for predictive maintenance, in order to ensure the efficiency of electrical aluminum wires and electrical installation generally.

6. References

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