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Mechanical comparison and Weibull statistical study of different plastic material used in industry

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Abstract:

The interest of the present work which is to master mechanical behavior of plastic material to improve and optimize the mechanical characteristics of the three study materials (ABS ,PVC and PR material), another characterization approach was considered in this paper; it is a statistical study of Weibull that allows to have information for the different caracteristics. 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 ABS is significantly high, it is also noticed that material have a high specific energy in elastic phase

Keywords

ABS material, PVC material, Weibull study, Statical study

1. Introduction

Plastic materials 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 elements.

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[1].

2. Experimentation

- **Studied Specimen**

The three studied samples are:

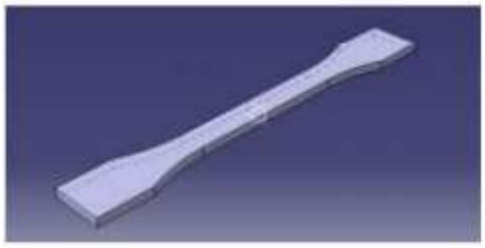

Figure 1 specimen of ABS material according to ASTM D638-03 [2].

Figure 2 specimen of PR and PVC material according to ISO 6892 [3].

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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 PVC material

Young's modulus E (MPa)	elastic limit: σ_e (MPa)	Breaking stress: σ_g (MPa)	Elongation %	Poisson's ratio v
160	7,8	14	143	0,47

Table 2. Mechanical properties of PR material

Young's modulus E (MPa)	elastic limit: σ_e (MPa)	Breaking stress: σ_g (MPa)	Elongation %	Poisson's ratio v
2,8	10	23	237	0,5

Table 3. 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

4. Weibull distribution on maximum stress of Different plastic materials

The purpose of this study is to drow the probability of survival and failure for the materials studied [4].

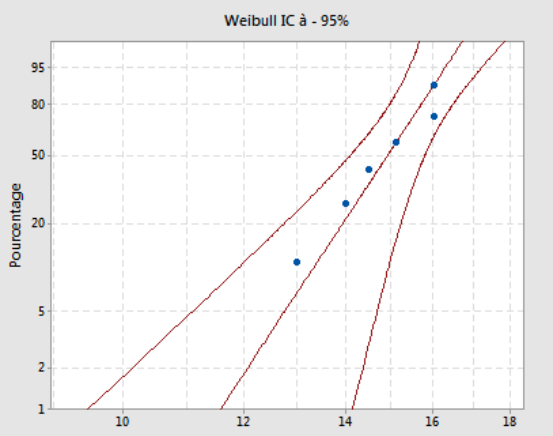

Figure 3. Weibull distribution curve of the PVC material

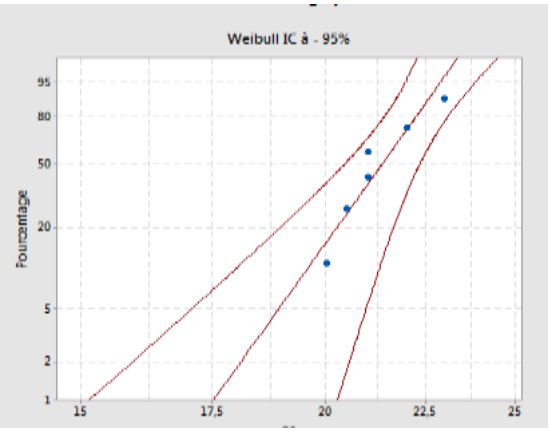

Figure 4. Weibull distribution curve of PR material

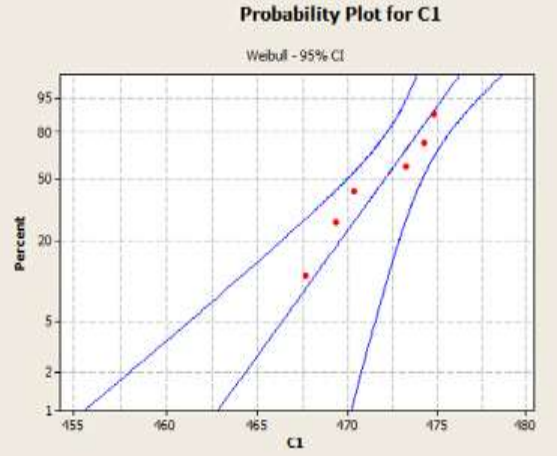

Figure 5. Weibull distribution curve of PR material

We define Weibull characteristics and we find :

For PVC material:

$$m = 16,65 \text{ and } \sigma 0 = 15,25 \qquad (4)$$

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For PR material:

m = 21.32 and σ0 = 21.42 (5)

For ABS material:

m = 31.32 and σ0 = 38.74 (6)

4. Results and discussion

4.1 *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 Plastic materials is presented in the figure 4,

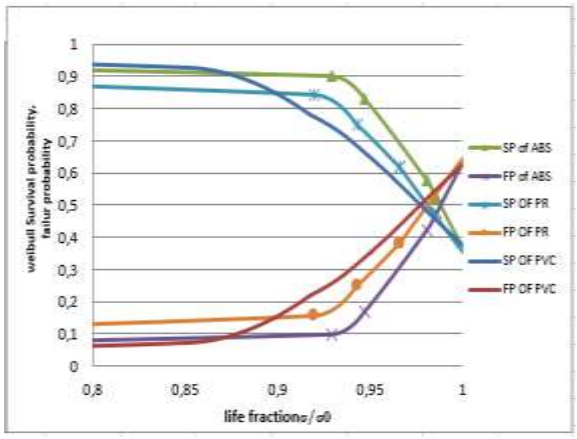

Figure 4. Probability of survival-Probability of failure curves in function of life fraction

We find that survival probability of ABS maintain a superior value until β=0.98
And after we haveβ=0.97 for PR material and β=0.96. for PVC material.

According to figure 5, it is clear
That the PVC material deteriorates so fast than the other materials, on the other hand and the ABS material have the reliable behavior than the other plastic materials

4.1 *specific energy in the elastic phase of plastic materials*

energy of a system is the potential to perform work or produce heat. The specific energy in elastic phase is the energy associated with the elastic deformation of a material. The absorption capacity and energy release per unit mass of a substance undergo elastic deformation is expressed by the relationship[5]:

$$\frac{w}{m} = \frac{\sigma^2}{2 \times \rho \times E} \text{ in joule/kg}$$

with
ρ: the density in kg / m3
E: Young modulus in MPa
σ: maximum stress in MPa

So for the different components of our cable we studied the results summarized in the following table:

Table 4. Specify energy of different component:

material	Specify energy(J/Kg)
PVC material	306,3
PR material	744,2
ABS material	210,25

7. Conclusion

ABS steel material have several strong advantages in their mechanical properties, they have a greater maximal stress, in studied statistical analysis, it is noticed that the specimens of ABS material have a less dispersion than Other material;

On the other hand, ABS material has a minimal specific energy,and the PR and PVC material have a high energy , which means that it have 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 damage, and thus to intervene in time for predictive maintenance, in order to ensure the efficiency of materials.

5. References

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