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Research Article

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Approach of Calculating a Parameter of Ductility in Tensile Test

Regaiguia B[1]* and Abderrazak D[2]

[1]*Département de métallurgie et génie des matériaux, Laboratoire de métallurgie et génie des matériaux, Université Badjimokhtar 23000 Annaba, Algeria*
[2]*Département de métallurgie et génie des matériaux, Laboratoire de mise en forme, Université Badjimokhtar 23000 Annaba, Algeria*

Abstract

Ductility by the sum of longitudinal elongation ΔL and reduction of diameter Δd which is the difference of initial diameter and necking diameter assumes that it is represented by the sum of the total longitudinal movement made by ΔL and transverse displacement of necking diameter.

Keywords: Ductility; Longitudinal elongation; Necking diameter; Diameter reduction; Tensile test

Introduction

Ductility by the sum of the distributed elongation and necking with the difference of initial diameter and necking assumes that it is represented by the sum of the total longitudinal movement made by ΔL and transverse displacement Δd (Figure 1).

We purpose to work on the upper half test piece, then we generalize the formula to the whole of the test piece by multiplying the found result of our approach because of the assumptions that we have made suppose that the test piece is perfectly symmetrical compared with the longitudinal and transverse axes passing through its middle point [1-20].

Materials and Methods

Materials

To develop and analyze the second step of our work, we experiment tensile test on 03 different grades of carbon steel. For each grade we use 03 specimens test grades are XC18 carbon steel, XC38 and XC48. Ductility values of the above-mentioned steels is known because of the carbon content, in other words it is known that XC18 is more ductile than XC38 and XC48 because it contains less carbon, and XC38 is more ductile than XC48. Based on this fact we test the ductility approach and we have to prove this order of ductility values of XC18, XC38 and XC48.

The various test pieces in number (03) for each grade were tested in the tensile test; the different values that we identified (final length and final diameter), are used to calculate average ΔL and necking diameter for calculating our approach parameter of ductility [21-40].

We experiment the approach that we called D_2 obtained as we said by the sum of total longitudinal elongation ΔL and reduction of diameter Δd on XC18, XC38 and XC48 after that we compare results.

For proving the task of ductility approach D_2, we must have linear deformation represented by D_2 of XC18 higher than XC38 and XC48; and also linear deformation of XC38 higher than XC48.

Methods

As the sum of the total elongation and the reduction in diameter is obtained:

$$\frac{\Delta L}{2}+\frac{\Delta D}{2}+\frac{\Delta L+\Delta D}{2}$$

From a geometrical point of view the progress of this approach is performed in a linear geometry before starting the initial test point and extending over a right characterizing the uniform elongation in homogeneous deformation then it becomes a geometric form L as soon as appearance of necking.

From Figure 2, we note that the elongation and reduction of diameter whose intersection gives the L-geometric form are perfectly identical on both sides of the axis through the necking which leads us note that the final geometry of the ductility approach D_2 is inverted to T form on the left side in this case because it can also be reversed on the right side. This is the length (mm) of this geometric form which T represents is the ductility approach D_2 characterized by the sum of the total elongation with the difference of initial and necking diameter [41-58].

So we have:

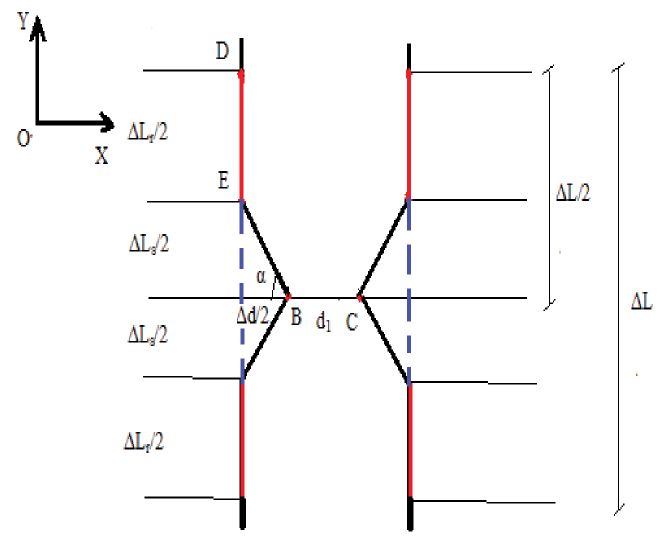

Figure 1: Geometric representation of the ductility approach D_2.

***Corresponding author:** Regaiguia B, Département de métallurgie et génie des matériaux, Laboratoire de métallurgie et génie des matériaux, Université Badjimokhtar 23000 Annaba, Algeria, Tel: +213 661 04 08 93; E-mail: bregaiguia@yahoo.fr

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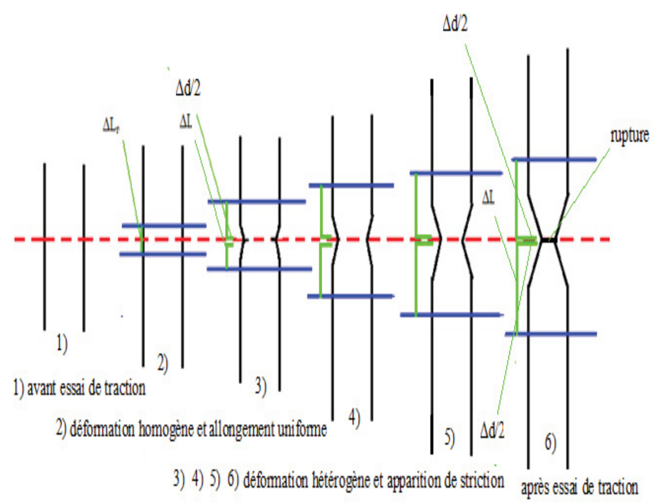

Figure 2: Different phases of geometric evolution of parameter D2 on a tensile.

Checking D_2 ductility approach

$D_2 = \Delta L + \Delta d$

For a brittle material ductility is zero.

So logically,

$D_2 = 0$

it means that $\Delta L = 0$ and $\Delta d = 0$ which is true for a brittle material.

For a superplastic material ductility is very significant.

So logically $D_2 >> 0$

Where: $\Delta L >> 0$ and $\Delta d > 0$, which is true for a superplastic material.

For a plastic material ductility is significant and positive,

So $D_2 > 0$

Where: $\Delta L > 0$ and $\Delta d > 0$, which is true for a plastic material.

So the modeling approach of ductility D_2 offer us à good appreciation of ductility on the other hand its easy to use for calculus.

D_2 also activates simultaneously as a summation key 02 variants influencing ductility: the elongation ΔL and the variation of the diameter Δd. In Figure 3, there is no ductility, it is a brittle material.

Figures I.3.2, I.3.3, I.3.4, I.3.5, I.3.6 show the onset and progression of ductility according to D2 approach.

So,

$DUCT = D_2 = \Delta L + \Delta d$

Finally we note that the ductility approac $D_2 = \Delta L + \Delta d$ h is a measurable quantity of linear dimension (mm). And we can say that this parameter represent a linear deformation with dimension 1 (Figures 4-7).

Results and Discussion

Experimental study of the ductility approach D_2 of XC18

We notice that:

D_2(XC18) = 16.1 mm > D_2(XC38) = 14.2 mm and D_2(XC38) = 14.2 mm > D_2(XC48) = 10.9 mm

So the linear deformation of XC18 symbolized physically by the parameter of ductility approach D_2 is higher than other steels wich is true (Tables 1-4).

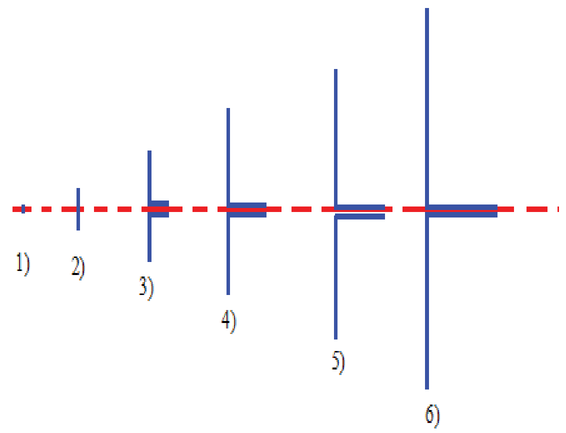

Figure 3: Different stages of geometric evolution of ductility.

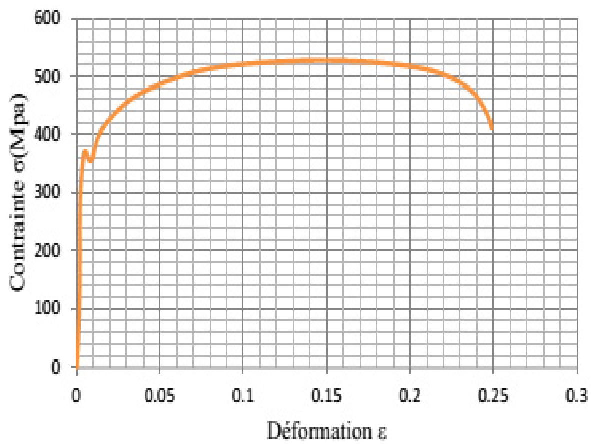

Figure 4: Tensile test curve of XC18.

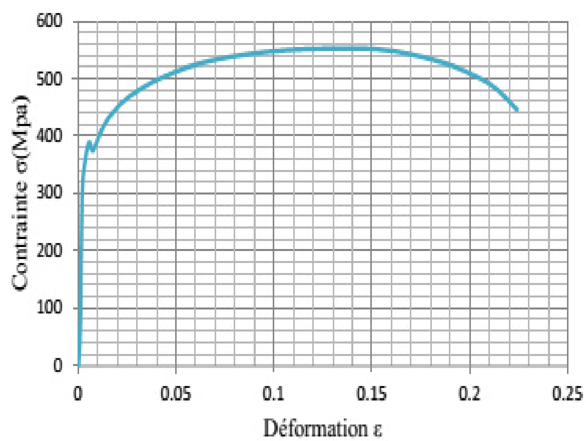

Figure 5: Tensile test curve of XC38.

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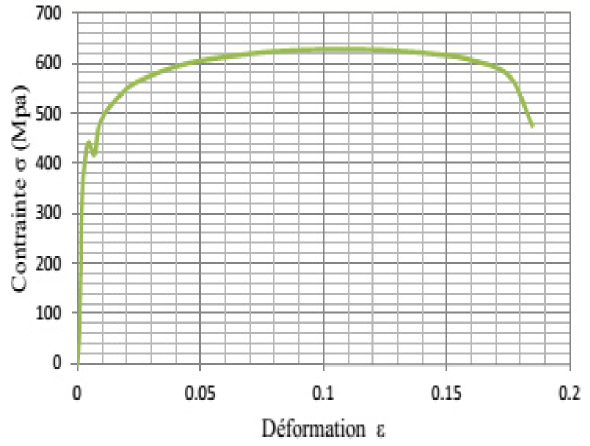

Figure 6: Tensile test curve of XC48.

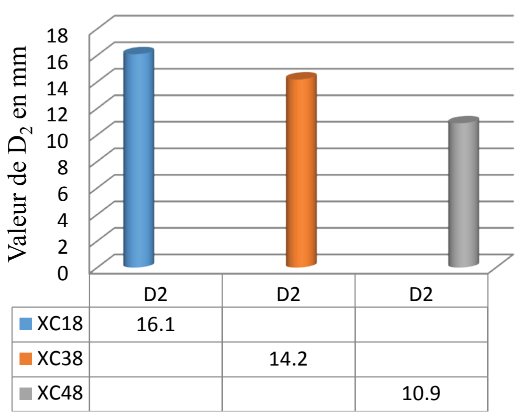

Figure 7: Values of A, Z and D_2 of XC18, XC38 and XC48.

Légend	$A = \frac{L_0 - L1}{L_0}$	$Z = \frac{\Delta S}{S0}$	$D_2 = \Delta L + \Delta d$
Unit	%	%	mm
Specimen 1	25.4	61.5	16.5
Specimen 2	25	60.3	16.2
Specimen 3	24	59	15.6
Calcul de la moyenne $\sum \frac{x_i}{3}$	24.8	60.3	16.1

Table 1: Average values of A, Z and D_2 of XC18.

Légende	$A = \frac{L_0 - L1}{L_0}$	$Z\% = \frac{\Delta S}{S0}$	$D_2 = \Delta L + \Delta d$
Unité	%	%	mm
Spécimen 1	22.7	57.7	14.8
Spécimen 2	22.2	50.9	14.1
Spécimen 3	21.9	48.2	13.7
Calcul de la moyenne $\sum \frac{x_i}{3}$	22.3	52.3	14.2

Table 2: Average values of A, Z and D_2 of XC38.

Légende	$A = \frac{L_0 - L1}{L_0}$	$Z = \frac{\Delta S}{S0}$	$D_2 = \Delta L + \Delta d$
Unité	%	%	mm
Spécimen 1	19.56	45.2	12.4
Spécimen 2	17.24	39.1	9.7
Spécimen 3	18.42	42.1	10.6
Calcul de la moyenne $\sum \frac{x_i}{3}$	18.4	42.1	10.9

Table 3: Average values of A, Z and *D2* of XC48.

Paramètres de ductilité	**A%**	**Z%**	$D_2 = \Delta L + \Delta d$
Unité	%	%	mm
XC18	24.8	60.3	16.1
XC38	22.3	52.3	14.2
XC48	18.4	42.1	10.9

Table 4: Values of A, Z and D_2 of XC18, XC38 and XC48.

Conclusion

Finally the linear and monodimensional approach $D_2 = \Delta L + \Delta d$ (mm) is intersting because it gives the measurement of deformation as a linear deformation easy to calculate.

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