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Experimental Development of Fracture Analysis in AISI D2 Steel Subjected to Accelerated Aging Conditions

Misael Flores-Baez[1,2], Israel Flores-Baez[1,2], Guillermo Urriolagoitia-Sosa[1], Beatriz Romero-Ángeles[1], Israel Fernando Barajas-Ambriz[1], Diego Iván Islas-Jiménez[1] and Guillermo Manuel Urriolagoitia-Calderón[1].

[1]Instituto Politécnico Nacional, Escuela Superior de Ingeniería Mecánica y Eléctrica, Sección de Estudios de Posgrados e Investigación, Unidad Profesional Adolfo López Mateos "Zacatenco", Edificio 5, 2° Piso, Grupo de Biomecánica, Col. Lindavista., Ciudad de México, México.

[2]Universidad Politécnica de Tecámac, Centro de Ingeniería Avanzada y Manufactura, Prolongación 5 de mayo, No. 10, , Tecámac de Felipe Villanueva, km 24.7, Estado de México, México.
* Corresponding authors: misaelfloresbaez@yahoo.com.mx, israelfb364@yahoo.com.mx, guiurri@hotmail.com, bromeroa@ipn.mx, ifba2001@hotmail.com, islas-jimenez_17@hotmail.com, urrio332@hotmail.com.

Many of the components that work in internal combustion engines are subjected to static and dynamic loads. Nevertheless, they also suffer from the operating conditions, causing the failure of these materials, especially when adequate preventive maintenance is not carried out. Cracking failure most commonly occurs in arrows rotating at high RPM.

Applying a greater approximation of the study area, the Scanning Electron Microscope (*MEB*) was applied and formation of micro voids was found. In Figure 1, it can be observed that the characteristic cavities are appreciated. The deterioration of the material they generate can be maximized by the effect of accelerated aging, which would be equivalent to the working cycles of the material exposed to very extreme environmental conditions. In this case, the material mechanical properties will be obtained by characterization of specimens that have suffered the attack of accelerated aging conditions.

The methodology developed by this research involves the attack of the material through accelerated aging, which is comparable to the effect that is present due to atmospheric corrosion. The obtained data can be used to predict or determine the change in the mechanical properties of components under the effect of aging over time. The aging process involves the application of salts, which adequately simulate exposure to environments near the coasts. Together with the temperature factor, they become the main agents that cause accelerated aging in materials [1].

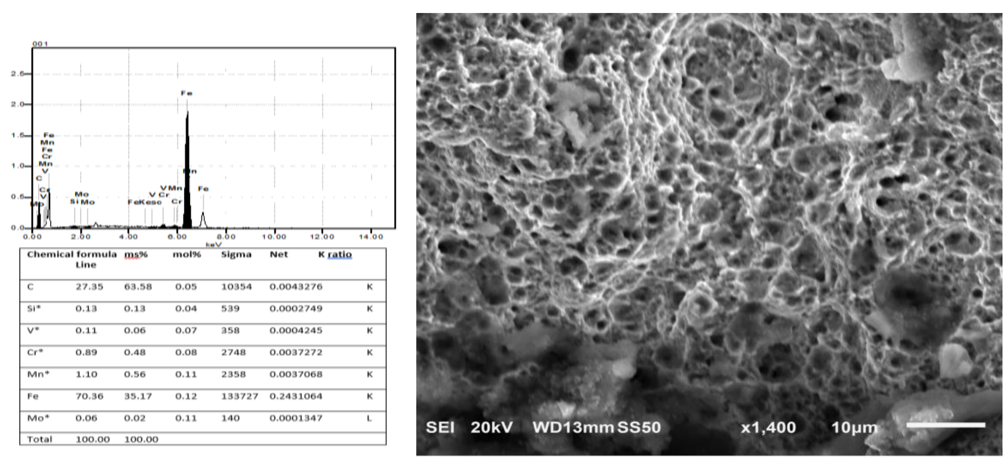
In this research, AISI D2 steel specimens were utilized. Material aging was developed by applying aging cycles of 12 hours, fluctuating temperatures from 35 °C to 43 °C, and handling percentages of humidity from 25% to 45%. Finally, the humid environment contained 3% by weight of NaCl. The total number of hours spent on the specimens during accelerated aging was 150 [2]. The characteristics of each application cycle consisted of the application of the following steps:

1.- Heating of the water with salt constantly applied at 45 ºC.
2.- Application of the dew system for 1 min each cycle.
3.- UV radiation was constantly applied.

Once the specimens were aged, the characterization of the AISI D2 steel material was carried out by standard tensile testing. For comparison, two groups of material were prepared (non-aged and aged specimens). In both cases, the load was gradually applied at an ambient temperature of 19 °C. The tensile results obtained for the first group of specimens (non-aged condition) show a maximum stress of 955 MPa with an applied load of 27.0 kN. These specimens had the application of an annealing treatment to eliminate residual stresses prior to the tensile evaluation. The yield limit of the material is set at a value of 200 MPa [3].

In the case of aged specimens (material was processed at an accelerated aging of 150 hrs., with the cycle previously explained in Figure 1), we identified the value of maximum stress at 809.98 MPa, while the value of the applied force was at 22.8 kN. The yield limit of the material is not very noticeable since the area of the elastic section of the material has considerably decreased [4]. Nevertheless, this value is found at 40 MPa [5]. The behavior of the materials is shown in the following figures. In the same manner, the hardness values for the specimens in non-aged and aged conditions were found. In this research, the *HRA* scale was used, which is equivalent to 60 kg/mm^2, and *HRD* is equivalent to 100 kg/mm^2. The following table and figures present the obtained results [6].

When comparing the set of groups of AISI D2 steel specimens evaluated by the tensile procedure, it was clearly noticed that the changes generated by accelerated aging were significant. Since the decrease in the maximum stress and the yield stress of the material were very high for the aging group, these changes significantly affected the rigidity and elastic zone of the material. In Figure 2, it is possible to observe a comparison between groups of specimens and the drastic changes that the aged material underwent. The variation between groups that was generated by the aging procedure is also reflected in the hardness data obtained. Significant changes in the hardness evaluation were also identified as a result of the application of the accelerated aging procedure, demonstrating a decrease in these values that corroborated the response of the material in the test to the tensile procedure. Hardness data obtained could also be related to the substantial decrease in the maximum stress, the yield limit, and the young modulus of the aged specimens (Figure 2 shows these observations). Additionally, we can see that, according to the results shown in Figure 2, the decrease in the elastic zone of the material causes an embrittlement in the component, which can cause a sudden failure of the component.



Chemical formula Line	ms%	mol%	Sigma	Net	K ratio	
C	27.35	63.58	0.05	10354	0.0043276	K
Si*	0.13	0.13	0.04	539	0.0002749	K
V*	0.11	0.06	0.07	358	0.0004245	K
Cr*	0.89	0.48	0.08	2748	0.0037272	K
Mn*	1.10	0.56	0.11	2358	0.0037068	K
Fe	70.36	35.17	0.12	133727	0.2431064	K
Mo*	0.06	0.02	0.11	140	0.0001347	L
Total	100.00	100.00				

Figure 1. Micrograph developed using *MEB*

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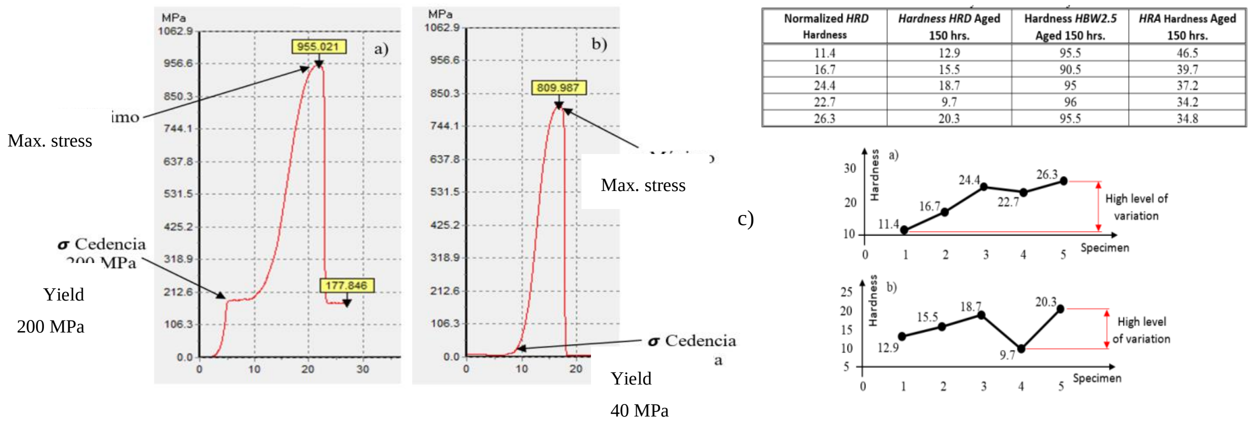

Normalized *HRD* Hardness	*Hardness HRD* Aged 150 hrs.	Hardness *HBW2.5* Aged 150 hrs.	*HRA* Hardness Aged 150 hrs.
11.4	12.9	95.5	46.5
16.7	15.5	90.5	39.7
24.4	18.7	95	37.2
22.7	9.7	96	34.2
26.3	20.3	95.5	34.8

Figure 2. Development of experimental evaluation.
a) Non-aged tensile results. b) Aged tensile results. c) Hardness test results.

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