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Damage model for different strain rates for monotonic loading

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***Abstract**: Monotonic damage model for two different strain rate 0.5mm/min and 0.2mm/min for aluminium alloy Al6061 is worked out damage model or continuum damage may be defined as an isotropic factor which scale between 0 to 1. By the current research we have evaluated and calculated critical damage for both the strain rates that are 0.117 and 0.135 for 0.5mm/min and 0.2mm/min.*

Keywords: *Crack initiation; Damage; Life prediction model;Monotonic loading; Strain rate.*

I. Introduction

For any structural component crack or stress prone zone is very critical after crack propagation, stress life of structure reduce drastically.A fatigue life has been divided into 3 stages that are crack initiation, crack propagation and catastrophic failure, which gives whole life of structural component. Crack initiation for a fatigue loading has been calculated by various methods which uses strain controlled loading in multiple step method. Where loading and unloading in a tensile specimen has been subjected, which will help to calculate damage with respect to fatigue loading. But in this paper, monotonic strain controlled loading has been performed, continuous strain controlled loading is applied till the facture of specimen.

Damage which is a scale factor to decide that the surface of any component have voids which could be converted as an initial stage of a crack. As we know within elastic limit, material behaviour depends on interatomic force of attraction. But after that, behaviour governs by nonlinearity of material, voids etc. it can be calculated directly with area reduction on a damaged surface. And can be calculated indirectly by change in properties which are modulus of elasticity, electrical conductivity, ultrasonic-wave propagation.

Damage is considered as 0 for undamaged surface and 1 for fully damaged surface. Critical damage is defined as point where crack has initiated. For indirect method, Lemaitre and Rabotnov has suggested elastic damage model, where they considered a bar in three stages that are undamaged, partially damaged and fully damaged surface, which represent homogeneity as fully homogeneous, heterogeneous and discontinuous damage solids respectively. [9]

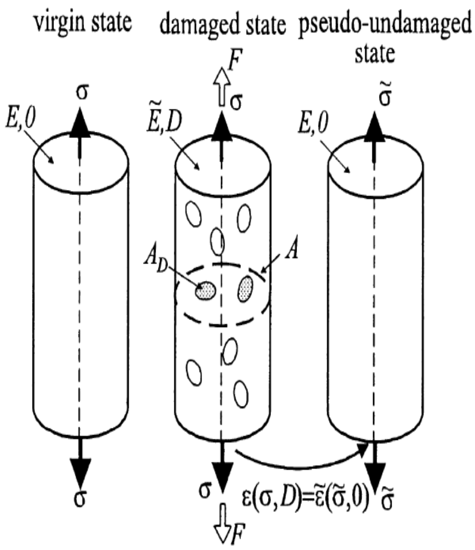

Figure 1. One Dimensional Effective Stress Concept[9]

II. Objective and Methodology

Objective of the work is to compare monotonic damage value for two strain rates that are 0.5mm/min and 0.2mm/min. For achieving this we have selected tensile specimen as per ASTM E08[7] which is a flat tensile specimen as shown in figure 2.Mentioned below is chemical composition of aluminium alloy Al6061

Table 1. Composition Al6061 – T6

Component	Al	Cr	Cu	Fe
percentage	98.6	0.3	0.4	0.7

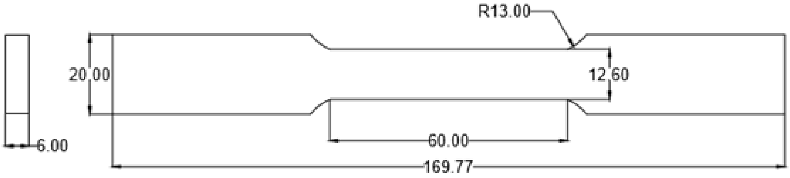

Figure 2. Tensile Specimen (all dimensions are in mm)

III. Experiment

The specimen is subjected to uniaxial tensile load for specific strain rates as per ASTM E646[8]. Whose monotonic properties has been calculated and compared as shown in table 2 and their true stress strain behaviour has been shown in figure 3. For damage growth model, damage is calculated as per Lemaitre and Rabotnov Model and has been compared with strain which shows behaviour of damage as shown in figure 4.

Table2. Result Comparison between strain rates

Properties	Experimental Data(Average of 0.5mm/min strain rate)	Experimental Data(Average of 0.2mm/min strain rate)	Percentage difference
Ultimate tensile strength	366.83MPa	378.98MPa	3.2%
0.2% Offset yield Strength	56.06MPa	59.29MPa	5.05%
Modulus of elasticity	28600MPa	30685MPa	6.79%
true fracture ductility strength	395.1MPa	373.325MPa	5.5%
Elongation on gauge	12.59%	13.73%	8.3%
Monotonic strain hardening exponent	0.071	0.080	11.25%
Monotonic strength coefficient	435.357MPa	465.61MPa	6.5%

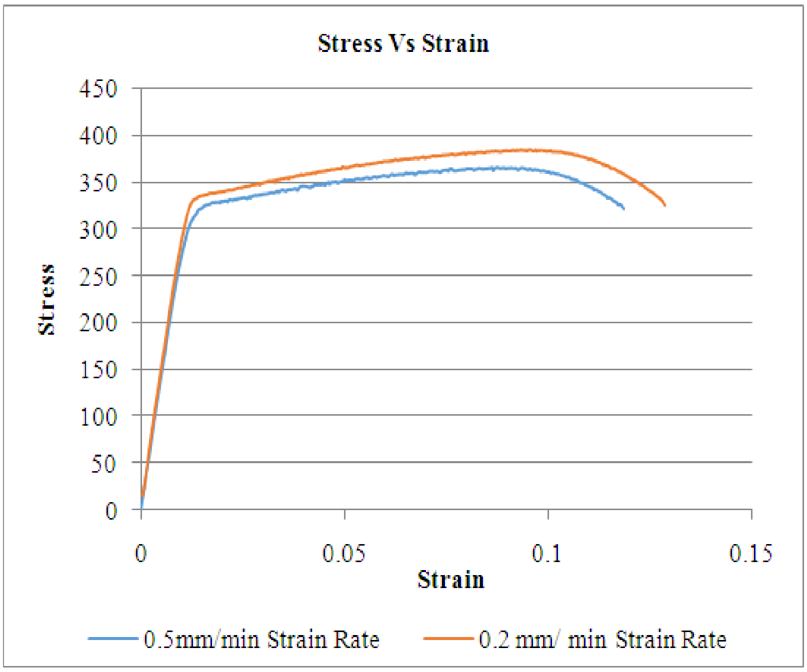

Figure 3. Stress – Strain behaviour of two different strain rate

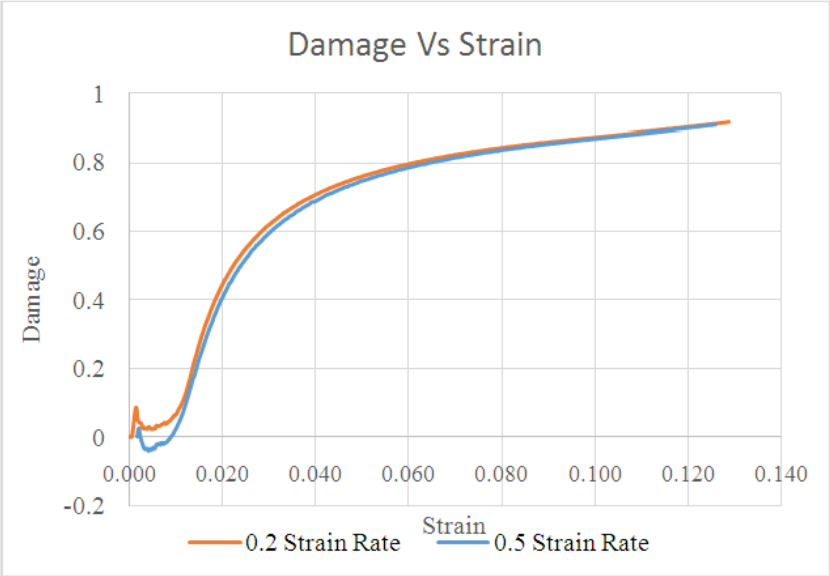

Figure 4. damage versus strain rate

For the material Al 6061 critical damage calculated for 0.5mm/min is 0.117 and for strain rate 0.2mm/min critical damage calculated is 0.135.

IV. Conclusion

It is being observed that for different strain rate material shows differentcritical damage value. By which we can conclude that for slower strain rate void formation is slower than higher strain rate. And hence, a crack to initiate for lower strain rate will need more time than higher strain rate. This conclude that damage is dependent on strain rate.
Hence predicted damage life can be used for prediction of a structural component and the critical damage value calculated for monotonic behaviour helps to determine its crack initiation point.

References

1. Y. S. Upadhyaya and B. K. Sridhara, “Fatigue Crack Initiation and Propagation Life Prediction of Materials”, International Conference On Mechanical Electronics and Mechatronics Engineering, March 2012.
2. Baidurya Bhattacharya And Bruce Ellingwood, “Continuum Damage Mechanics Analysis of Fatigue Crack Initiation’, By International Journal Of Fatigue, Vol 20 No. 9, Pages 631-639, March 1998
3. S. Dhar, P.M. Dixit, R. Sethuraman, “A Continuum Damage Mechanics Model For Ductile Fracture”, International Journal Of Pressure Vessel And Piping, No. 77, Pg. 335-344, Feb 2000.
4. S. Chandrakanth And P. C. Pandey, “An Isotropic Damage Model For Ductile Material”, Engineering Fracture Mechanics, Vol 50 No. 4, Pg. 457-465, 1995
5. J L Chaboche, “Continuum Damage Mechanics –general concept”, Journal of Applied Mechanics ASME, Vol. 55, pg. 59-64, 1988.
6. By A. Manes, L. Peroni, M. Scapin, M. Giglio, “Analysis of strain rate behaviour of an Al 6061 T6 alloy”, Procedia Engineering, Vol. 10, Pg. 3477-3482, 2011.
7. ASTM (American Standard Testing Method) E08 Standard Test Methods for Tension Testing of Metallic Materials.
8. ASTM E 646 Standard test Method for Calculation of Strain Hardening Exponent.
9. Jacek Skrzypek,“Modelling of Material Damage and failure of Structure”.
10. Series 641 Hydraulic Wedge Grips MTS Manual
11. Flextest User Information and Software Reference MTS Manual.
12. Model 793.10 MultiPurpose TestWare User Information and Software Reference MTS Manual

