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Dear Amini, M., Ekhteraee, H., Shariati, M.

We appreciate your active participation in X-MECH 2016, also thank you for presenting your paper in this conference, entitled:

Experimental Study of the Ratcheting Effect on the Fatigue Life of Welded Aluminium 2024-T351

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Experimental study of the ratcheting effect on the fatigue life of welded aluminium 2024-T351

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Abstract- **In this paper, the effects of pre-ratcheting deformations upon the fatigue life of aluminum 2024 welded specimen is studied. Ratcheting, as a characteristic of unbalanced cyclic plasticity, can accelerate fatigue damage or even acts as a failure mode by itself. In this study the combination of two levels of ratcheting loadings and their interactions are studied. In this regard, some tests are performed. The effects of such factors as mean stress, stress amplitude, stress frequency and the number of ratcheting cycles are investigated. The stress-controlled fatigue tests are carried out at ambient temperature. The results reveal how the mixed- ratcheting states can reduce the fatigue life expectancy of plain and welded specimens.**

Keywords **- Fatigue life, Ratcheting, Aluminum weldment, Experimental test, Taguchi analysis.**

I. INTRODUCTION

Fatigue behavior is a complex phenomenon that is influenced by various factors such as ratcheting, mean stress, stress amplitude, microscopic structure and loading history. Ratcheting is the cyclic accumulation of inelastic strains. It is an important factor in the design and safety assessment of structural components subjected to asymmetrical stress-induced cyclic loadings. The existing results show that ratcheting level depends on different aspects of external loading conditions, e.g., loading level, rate, waveform, and history, as well as ambient temperature [1-7]. In a regime of unbalanced stretching, both the destructive effects of ratcheting phenomenon and hidden damage of fatigue loading can be combined in the low cycle fatigue condition. Other factors that may affect the fatigue life are the average stress and stress amplitudes. Low-weight alloys are frequently selected for many applications where low density and high strength-to-weight ratios are required. It is mainly supposed that ratcheting phenomenon does not have a significant rule on the behavior of aluminum alloys [8]. Accordingly, this study is focused on the experimental study of ratcheting effect upon the life expectancy of aluminum specimens in unbalanced high stress levels. In order to reduce the number of tests, one could use the method of design of experiments. In this regard the Taguchi's method is used.

II. SPECIMENS AND TEST SETUP

As in Fig. 1, several fatigue test specimens are prepared as per E 606 -92 standard of ASTM. The gage length is 15 mm. All tests are performed in stress-controlled condition and room temperature.

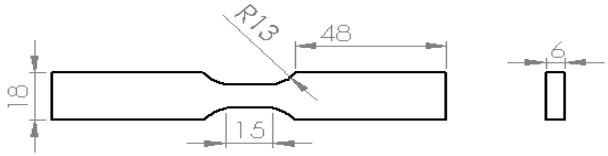


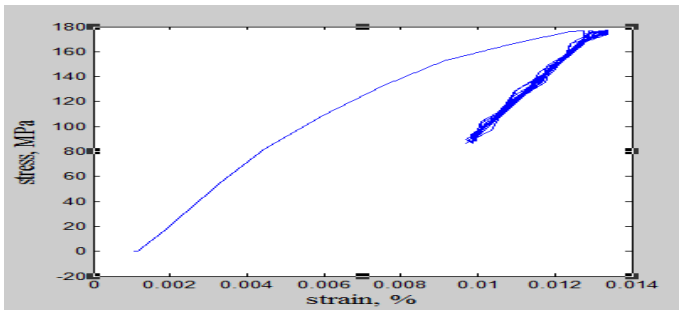
Fig. 1: Fatigue test specimen geometric dimensions in millimeters

The tests are performed on 100kN Zwick Fatigue Testing Machine in Ferdowsi University of Mashhad. In testing stage firstly, the specimens are put under some pre-ratcheting cycles. Then another lower stress ratcheting cycle is applied and continued until the fracture of specimens is attained. Accordingly the effect of some parameters on the fatigue life of welded Aluminum specimens is studied. In each test the lower stress level is changed and the number of second ratcheting cycles to fracture is counted up. Mean stress level (m), stress amplitude (A), applied frequency (f) and the number of ratcheting cycles (N) is given in Table (I).

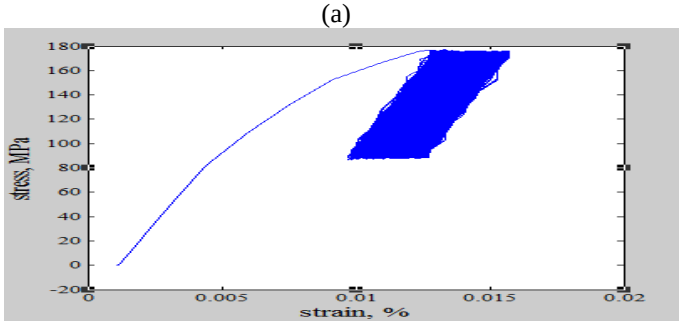
TABLE I: Experiments data in Minitab

	R	m	a	f	N
1	600	4.95	4.05	8	114852
2	600	4.675	3.825	10	151437
3	600	4.4	3.6	12	176684
4	1150	4.95	3.825	12	120247
5	1150	4.675	3.6	8	152374
6	1150	4.4	4.05	10	160867
7	1650	4.95	3.6	10	124467
8	1650	4.675	4.05	12	135292
9	1650	4.4	3.825	8	164864

The typical cyclic stress-strain hysteresis loops generated by uniaxial ratcheting experiment of the specimens under positive mean stress levels are presented in Figs. (1- a and b).



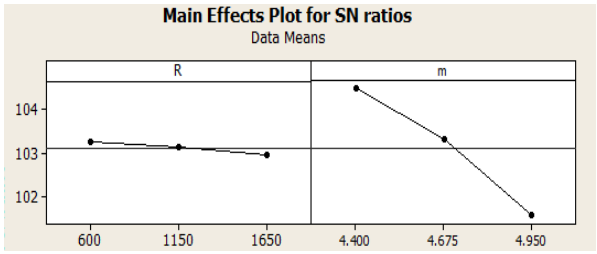
(a)



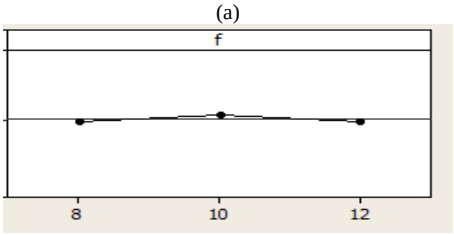
(b)

Fig. 1: (a) The first 10 cycles of hysteresis loops generated by a uniaxial ratcheting fatigue tests (b) Complete 1650 cycle-to-fracture history of hysteresis period, created by uniaxial ratcheting test of Aluminum.

The importance and efficiency of different factors are evaluated by a statistical survey in outcomes. The analyses are performed by Taguchi Design Analysis in Minitab and the results are provided in Fig. 2. The figures show that, mean stress factor (m) deserves the most important effect on the fatigue life (N). The number of pre-ratcheting (R) cycles has the second position. The frequency (f) does not show an appreciable effect on the fatigue life of the weldments.



(a)



(b)

Fig. 2: (a) The effect of pre-ratcheting cycles number (R) and mean stress on SN ratio (m). (b) The effect of frequency on SN ratio.

III. CONCLUSION

In this study, the stress-controlled tests of Aluminum weldments are performed at ambient temperature and the effect of different combinations of mean stress and stress amplitude levels are examined. The following upshots are the main results of this study.

-For tensile specimens of Aluminum weldments under fatigue cycling, mean stress is the most important factor that should be considered in the life assessment. By increasing the mean stress, fatigue life is decreased.

-Afterwards, the number of pre-ratcheting cycles should be considered as the second risk factor, even though it is much less important than the mean stress.

-Finally, the frequency does not show a considerable effect on the fatigue life and it could be omitted from the design considerations.

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