AN EXPERIMENT ON THE EFFECT OF THE PRE-STRAIN ON THE FATIGUE STRENGTH OF MILD STEEL (continued)

SHIMIZU, Shigetoshi
Research Institute for Applied Mechanics, Kyushu University : Associate Professor

IMAI, Ryoichi
Kurume Technical College : Lecturer

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NOTE

AN EXPERIMENT ON THE EFFECT OF THE PRE-STRAIN ON THE FATIGUE STRENGTH OF MILD STEEL
(continued)

By Shigetoshi SHIMIZU* and Ryoichi IMAI**

In the previous paper[1], we reported about the effect of the pre-strains on the rotary-bending fatigue strength of mild steel. The kinds of pre-strains were pure tensile strain ε, torsional strain γ and especially their combinations $(\varepsilon+\gamma)$ which were at first given tensile strain ε and then torsional strain γ.

In order to investigate the effect caused by reversing the order in the perevious report of the combined pre-strains, in this paper we report the effects of the combined pre-strains $(\gamma+\varepsilon)$, which are at first given tosional strain γ and then tensile strain ε, on the fatigue strength of mild steel. The material used in this experiment is just the same as in the previous expriment and its chemical compositions are shown in Table 1. The dimensions of the specimens are the same as in the previous experiment and are shown in Fig. 1 and 2.

Similarly to the previous paper the Nadai's octahadral shear strains[2] γ_n, γ_{n1} and γ_{n2} in Table 2 are translated by the conventional tensile strain ε and torsional strain γ using the following expression

$$\gamma_n=\gamma_{n1}+\gamma_{n2}=\sqrt{2}\,ln(1+\varepsilon)+\sqrt{\frac{2}{3}}\,ln\left\{1+\frac{\gamma^2}{2}+\gamma\left(1+\frac{\gamma^2}{4}\right)^{1/2}\right\}$$

The fatigue test results are shown in Fig. 3. The fatigue strength of most pre-strained specimens is higher than that of the original material.

The relation between the octahedral shear strain and the fatigue strength are shown in Fig. 4a and 4b, respect to the repeated cycles of stress $N=10^6$ and 10^7. The curves show the mean values in previous experiment. The rational reasons why the fatigue strength of the pre-strained specimens in this experiment decrease below that of those in the previous results are not yet obvious. As far as these experimental results are concerned, it is clear that the pre-torsional stain is more advantageous than the pre-tensile strain in increasing the fatigue strength of this material.

* Associate Professor, Research Institute for Applied Mechanics, Kyushu University.
** Lecturer, Kurume Technical College.

There are no abnormal appearance of the fatigue fracture. The most of the fracture surfaces were perpendicular to the longitudinal axis.

The relation between the ultimate strength σ_B and the fatigue limit σ_{WO} are shown in Fig. 5. We see that σ_{WO} are nearly equal to the half of σ_B as the specimens treated in the previous experiment.

References

1) Shimizu, S. and Imai, R., An Experiment on the Effect of the Pre-Strain on the Fatigue Strength of Mild Steel, (*Note*), Rep. Res. Inst. Appl. Mech., Vol. XVII. No. 56, 1969.
2) Nadai, A., Plastic Behavior of Metals in the Strain-Hardening Range. Part 1, Journal of Applied physics, March, 1937.

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Table 1 Chemical composition of material

Material	Symbol	Chemical composition (%)				
		C	*Si*	*Mn*	*P*	*S*
Mild Steel	JIS SR 24	0.18	0.21	0.54	0.030	0.021

Table 2 The combinations of the pre-strains (%, deg/MM)

This experiment

$\varepsilon / \gamma_{n1}$	3.6/5	7.3/10	11.2 15	11.2/15	19.4/25
θ / γ_{n2}	1.757/15	1.165/10	0.582/5	1.757/15	0.582/5
γ_n	20	20	20	30	30

The previous experiment

$\varepsilon / \gamma_{n1}$	2/2.79	10/13.48	20/25.77	2/2.79	10/13.48	20/25.77
θ γ_{n2}	3.6/30.32	3.6 30.32	3.6/30.32	7.2/60.14	7.2/60.14	7.2/60.14
γ_n	33.11	43.80	56.09	62.93	73.62	85.91

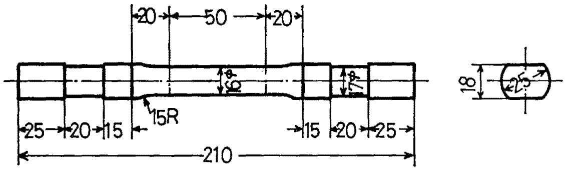

Fig. 1 Torsion and Tension Specimen

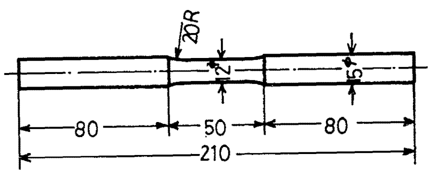

Fig. 2 Fatigue Specimen

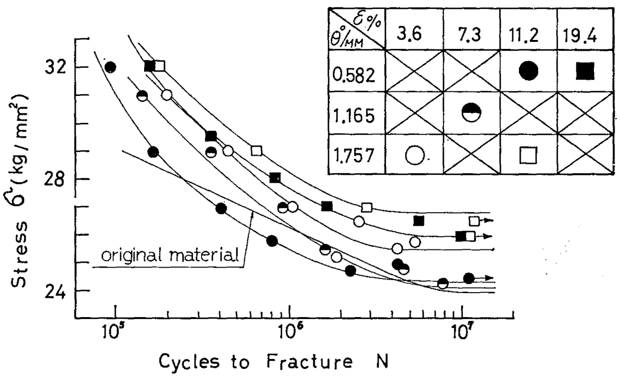

Fig. 3 S—N diagrams of pre-strained materials

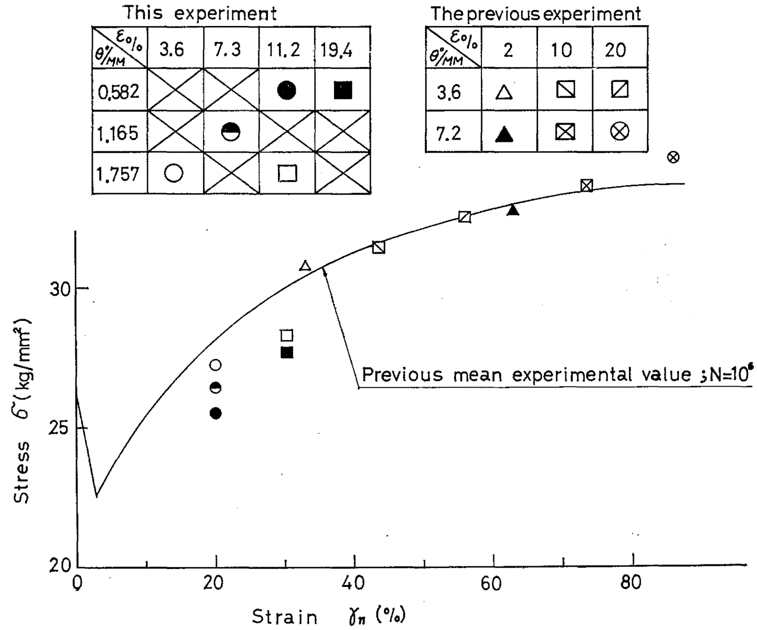

Fig. 4a Effect of the pre-strain, replaced by the Nadai's octahedral shear strain, on the fatigue strength under rotary bending, $N=10^6$

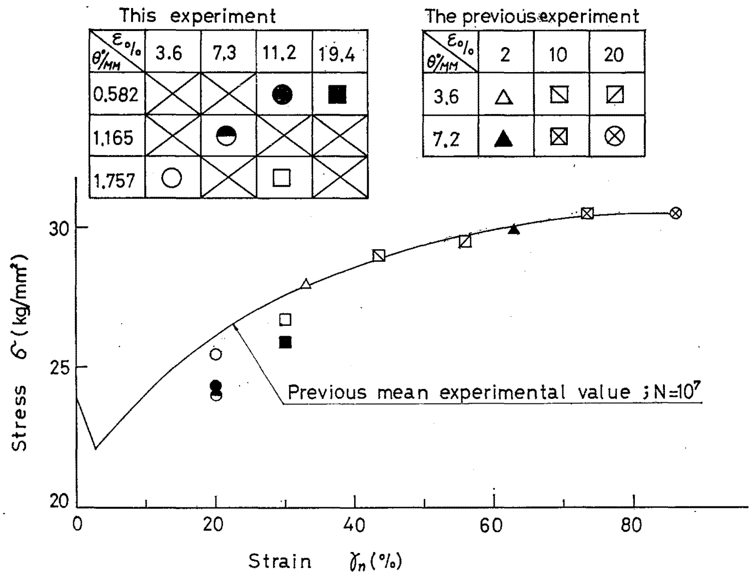

Fig. 4b Effect of the pre-strain, replaced by the Nadai's octahedral shear strain, on the fatigue strength under rotary bending, $N=10^7$

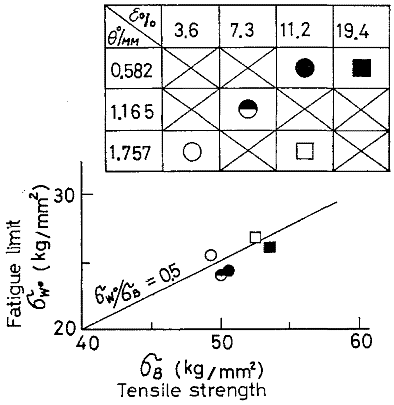

Fig. 5 Relation between rotary bending fatigue strength and tensile strength of pre-strained mild steel