

### §3. Development of Reduced Activation Ferritic Steels with Improved Heat Resistance and Elemental Property Characterization for High Efficiency Water-Cooled Blankets

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For a life-time design of a blanket for fusion power reactors, thermal fatigue property of structural materials is particularly important. The cyclic stress loading in blankets mainly comes from pulsed generation of fusion neutrons under the current operation scenarios of fusion reactors. Although materials-wall interaction and radiation damage by fusion neutrons have a strong influence on the stress loading and strain responses, the cyclic loading depends on operation conditions, including cycle length, material properties, including thermal properties and blanket design, including cooling system design. Thus fatigue resistant Reduced Activation Ferrite steels (RAFs) development and establishment of fatigue evaluation methodology and design code including fatigue resistance design are of urgent needs for ITER and ITER-BA activities.

This study focused on influence of surface morphology to fatigue properties in order to establish design and fabrication of test blanket module for ITER.

The material used was F82H IEA heat which was normalized at 1313 K for 40 min air-cooled and tempered at 1023 K for 60 min air-cooled. The mini-sized hourglass type specimens (SF-1) were used for low cycle fatigue (LCF) tests. It is well known that the hourglass type specimen has good resistance to buckling, which is a very important issue to miniaturize specimens for push-pull tests. Test specimens with three kinds of surface roughness were used in order to investigate the effect of surface roughness on fatigue properties. For the test, an electromotive testing machine with a 200 kg load cell was used. Diametral strain controlled fatigue tests were carried out with a triangular stress waveform and a total diametral strain range,  $\Delta\epsilon_d$  of 0.4-0.6 %.  $\Delta\epsilon_d$  was converted to total axial strain range,  $\Delta\epsilon_a$ , by the following formula;

$$\Delta\epsilon_a = (\sigma / E) (1 - \nu_e) - 2\Delta\epsilon_d,$$

where  $\sigma$  is applied stress, E the elastic modulus,  $\nu_e$  is the elastic Poisson's ratio.

In this work, the surface roughness profiles in seamless tube and rectangular channel for ITER-TBM were measured with a laser microscope, as shown in Fig.1.

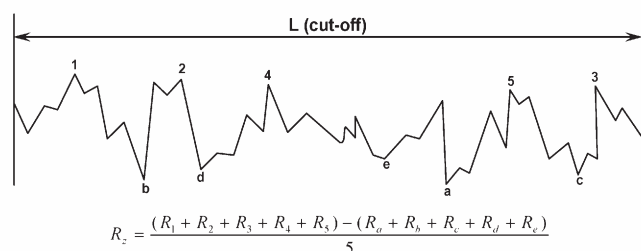


Fig. 1 Surface roughness calibration (JIS B 0601)

The surface roughness was defined by “ten point median height roughness ( $R_z$ )”. The seamless tube used showed surface roughness ( $R_z$ ) of 2.695  $\mu\text{m}$ , and the rectangular channel before and after pickling shows a surface roughness ( $R_z$ ) of 3.163  $\mu\text{m}$  and 7.625  $\mu\text{m}$ , respectively. The surface roughness traces of the seamless tube showed a large difference before and after pickling (Fig.2).

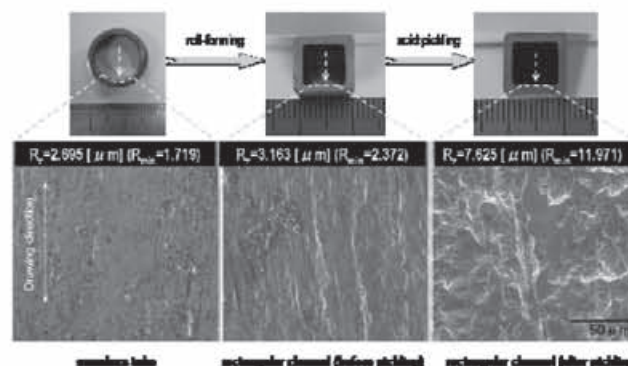


Fig. 2 Surface configuration of cooling channels

The fatigue lifetime of fine finishing specimens ( $R_z = 0.53 \mu\text{m}$ ) was slightly longer than those of rough finishing specimens. In the mean time, the fatigue lifetime of very fine finished specimen ( $R_z = 0.89 \mu\text{m}$ ) significantly increased about 61.3%. As the fatigue lifetimes are strongly dependent on the surface conditions, surface roughness of the various LCF specimens tested from the rough finishing, fine finishing and very fine finishing specimen were characterized.

Fig. 3 shows the surface roughness as a function of the number of cycles. Linear regressions of the data shown in this figure demonstrate the trends of the fatigue lifetime decrease with increasing surface roughness. From these results, it can be assumed that the fatigue lifetime of cooling channels for ITER-TBM might be decreased significantly compared with the fatigue life of standard test specimen. Thus the surface roughness control in blanket to meet fatigue property requirement is very important.

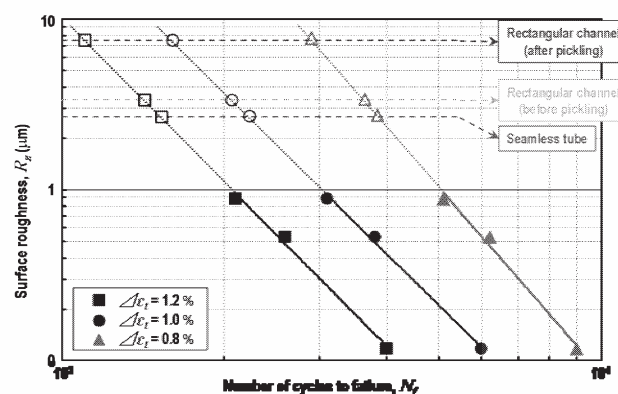


Fig. 3 Relationship between surface roughness and fatigue life in F82H steel

#### References

- 1) Hirose, T. et al. : J. Nucl. Mater. 283-287 (2000) 1018.
- 2) Kim, S.W., et al. : Presented at ICFRM-12 (Dec. 2005 Santa Barbara).