R&D of the gas turbine cogeneration systems at Toho Gas Co. Ltd.

MIWA Masataka
Fundamental Research Dept. of Tohogas. Co. Ltd.

1. Introduction

Toho Gas Co., Ltd. is constantly conducting R & D of the city gas in the fields of production, supply, environmental preservation, and cost reductions. R & D has been positioned an important management strategies.

The technical research center represents the core of R&D activities at Toho Gas. The center is made up of Fundamental Research Department and the Energy and Technology Development Department; these departments employ approximately 80 researchers. The main research themes are as follows: natural gas combustion technology, structural reliability assessment for gas equipment and pipelines, environmental preservation, natural gas resources, computer simulation technology, IT, efficiency improvement in gas cogeneration systems and air conditioning systems, industrial heating technology such as heat treatment and the development of residential fuel cells.

Research in gas turbine cogeneration systems conducted by the Fundamental Research Department primarily include the residual life prediction of high temperature materials such as those used in turbine blades, assessments of reliability and durability of the micro-gas turbine systems, the improvement of maintenance and engineering technology with an emphasis on domestic and imported micro-gas turbines.

In this report, research into the residual life prediction of turbine blades being conducted by the Fundamental Research Department, is presented briefly.

2. A study of the damage assessment technique for the turbine blades.

The gas turbines of interest in this research are those used in industrial cogeneration systems, with a focus on creep-damage.

There are several parameters for measuring accumulated creep-damage [Ref. Lemaitre]. However, some hold the view that the conventional methods of detecting creep-damage for the blades are not sufficiently precise and are difficult to detect due to the wide variation in strength and of service conditions [Ref. Mino].

To assess the amount of accumulated creep-damage,

Fig. 1 Fundamental Technology Research Institute of Toho Gas Co. Ltd.

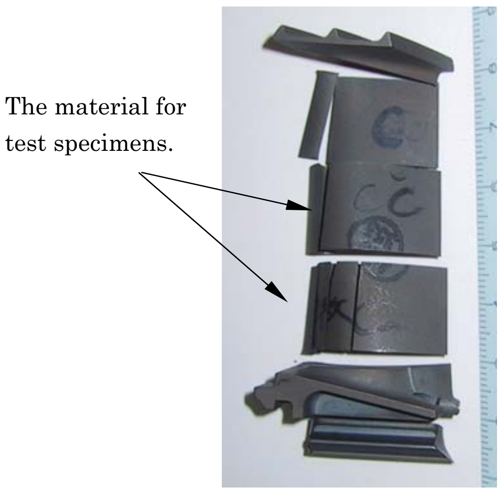
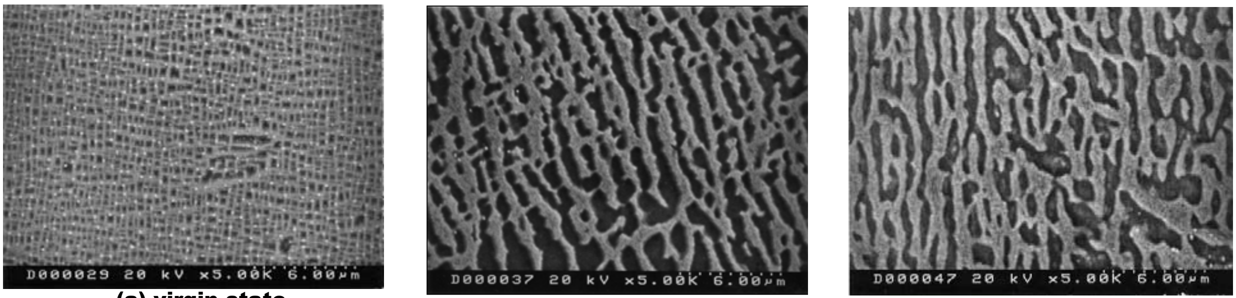


Fig. 2 Gas Turbine Blade and Machining Positions of Test Specimens.

Toho Gas Co. Ltd., Fundamental Research Dept.,
507-2, Shinpo-machi, Tokai-city, 476-8501, JAPAN
Phone: +81-52-603-5311 Fax: +81-52-601-8671



(a) virgin state (b) 125 (hr) (b) 256 (hr)

Fig 2. Changes in the microstructure of the cross section

the relationship between the life ratio, which is defined as the ratio of time at a given temperature and stress condition to creep life, and its relationship with the material properties that change with creep was the approach taken. A gas turbine blade, made of MarM247, a Nickel base alloy, was employed for the creep tests. The austenite (γ) and the precipitate (γ′) phases can be observed on the micrographs of this alloy. In addition it shows a particular microstructural change (to a raft structure) due to creep. In this research the relationship of the damage accumulation and life ratio was examined through change in the γ phase.

The creep test was conducted in the atmosphere. The test temperature was between 1223K and 1323K, and the duration was 800 hr to 1000hr. The test specimen was a round bar specimen, with a diameter of 2mm and a length of 6mm. The test section of it was machined from the vicinity of the leading edge, parallel to the edge.

Figure 2 shows changes in the microstructure of the cross section from a virgin state to a point in time after the creep test. The microstructure was observed by SEM on a plane perpendicular to the stress axis. Here, the principal stress axis corresponds to the lateral direction in the pictures. The white lattice-like structures in the picture corresponds to the γ phase of interest, and the black is the γ′ phase. Although, at the virgin state, the fine γ′ phase is dispersed within the γ phase matrix, the γ′ phase coarsened over time and a raft structure almost perpendicular to the principal stress axis developed. Most notably, it appeared that the width of the γ phase in the direction of stress axis tends to increase.

Figure 3 shows the change of the γ phase width at 1323 K. The ordinate shows the γ phase width normalized to the initial width. The normalized γ phase width increases monotonically with creep time. This fact suggests that the γ phase width can be regarded as one index of accumulated creep-damage. Thus by examining the relationship between microstructural change and accumulated creep-damage through creep tests, it was confirmed that there are effective parameters to estimate amount of damage accumulated. At present, basic research of detection methods of damage accumulated in a material is ongoing.

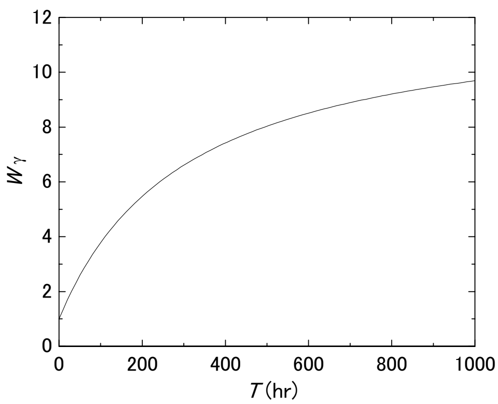


Fig 3. Change of the γ phase width

3. Conclusions

As stated in the previous sections, Toho Gas Co. Ltd. is conducting ongoing R & D to promote the increased use of gas turbine cogeneration systems.

Finally, we would like to continue contributing to society by creating innovations in gas technology.

References

Lemaitre , J., A Course of Damage Mechanics, 2nd ed., (1990), Springer, p. 35.

Mino, K. et al., *Proc. Int. Cong. Adv. Mat.* (2000), No.1055.