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論文要約

Thesis Outline

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Development of a novel method to measure the creep strength of adhesively bonded joints

Chapter I　Introduction

The introduction and importance of this study are explained in this chapter. To improve the bonding performance especially in mechanical engineering field, conventional fastening methods have been replaced by adhesive bonding. Adhesive bonding has become popular because of its advantages such as contributing to the lightweight of the products, providing uniform stress distribution, joining similar and dissimilar materials and so on. The contents of this research include investigating the strength of adhesive joints at high temperature in the air and argon gas, as well as proposing a novel method to measure the creep strength of adhesive joints. Even though, there has been much research about adhesive bonding, the results however do not describe the whole picture of the phenomena. Therefore, extend studies should be done in regard to this subject.

Chapter II　Strength of adhesively bonded joints subjected to high temperature in argon gas

Experiments concerning the strength of adhesively bonded joints exposed to 150°C in the air and argon gas from 0 to 100 h were conducted in this chapter. Single lap joints manufactured from SS400 and bonded with one component epoxy resin (main component: bisphenol A) were utilized as the specimens. To observe the color change of adhesive at high temperature, some adhesive was applied to the specimens and called as reference surface. Results show that the color of adhesive at reference surface changed drastically by the exposure to a high temperature of 150°C in both the air and argon gas. The strength of adhesive joints did not decrease, but slightly increased from 0 to 100 h. Degradation of adhesively bonded joints exposed to 150°C in the air and argon gas can be neglected in short time up to 100 h.

Chapter III　Development of novel testing machine for creep tests of adhesively bonded joints

In this chapter, a novel method to measure the creep strength of adhesively bonded joints is proposed. Five adhesively bonded butt joints were mounted in a specimen holder and tested simultaneously by a hydro-pneumatic testing machine. The hydro-pneumatic loading system fulfills the requirement to absorb shock produced by a fracture among those five butt joints and as a result successive failures

can be avoided. It was experimentally verified that the choke valves introduced in the hydraulic circuit of the system worked as a damper when a failure occurred, so that the remaining butt joints do not fail simultaneously. The specimen holder introduced in this study is also equipped with five pairs of restraint devices installed to the connectors that hold the specimens. Each pair of restraint devices has different length of elongated holes. When the failure of a butt joint occurred, an adherend of the ruptured specimen was shifted to the end of the elongated holes and stopped by bolts. The displacement of the moving specimen is according to the length of the elongated holes, therefore it is easy to determine the sequence failure of those five butt joints.

In Chapter III, stainless steel (SUS304) was selected as the material of the adherends due to the corrosion resistance. Specimens treated with a primer comprising of 10 wt% of DGEBA mixed with methyl ethyl ketone (MEK) and bonded with Denatite 2204, which is a commercially available epoxy adhesive, were chosen to perform creep test subjected to constant loading. Times to creep rupture were measured respect to the applied load. Results verified the effectiveness of the proposed method, where only failure occurred at a time. The time to creep rupture of the butt joints increased with the decreasing of applied stress, i.e., the joints have longer lifetime when they are subjected to lower stresses. The lifetime can be fitted with a line on a stress-lifetime diagram.

Chapter IV　Creep strength of butt joints subjected to variable loading

Extended investigations to Chapter III were performed in order to study the behavior of creep strength subjected to variable loading. The same specimens and slightly modified experimental setup were utilized. Because the technical term of “variable loading” includes a wide range of meaning, in this study, we selected an interval loading condition described as repetition of constant loading and unloading of the same time duration. To control the loading value easily in order to provide loading and unloading conditions, an electro-pneumatic regulator was installed to replace the manual precision pneumatic regulator in the creep testing machine utilized in Chapter III.

The creep strength of the butt joints depended only on the total time at high loading plateaus. Experimental results show that the different condition of loading in this study exhibits quite similar tendency such that fracture times decreased as applied loads increased. Thus, it can be concluded that the creep strength does not depend on the interval length, but the total loading time for interval loading conditions.

Chapter V　Conclusions

Chapter V consists of conclusions of each chapter. The results and presented methods of adhesively bonded joints must be applicable to evaluation of adhesives, design of real products, or estimation of lifetime for bonding parts with adhesives, especially included in the structures of space-crafts, aircrafts and automobiles. Remained topics such as, more varieties of loading conditions and combinations of high temperature, humidity and continuous loading should be investigated in terms of energies and Arrhenius’ equation.