Viscoelastic Clamp-up Relaxation of Blind Fastener Joints in Composites

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Introduction

THE structural integrity of fastened joint can directly affect the performance and safety, so the knowledge of response of the joints is critical in design of the structures. Blind fasteners are practical to use when only one side of the joint is accessible. In many instances, the structures needing to be fastened are only accessible from one side, which necessitates the use of "blind", or "one-sided", fasteners. A typical blind fastener and a joint are illustrated in Figure 1. The blind fastener consists of a stem and a sleeve which forms the fastener head. The stem extends through the sleeve head in the form of a threaded shank. The other end of the stem has a diameter slightly larger than the sleeve. The sleeve head is rested against the part being fastened and the stem is pulled out, flaring the sleeve and thus forming a bulb which serves as a nut. The blind fasteners are typically installed by in-situ drilling of the holes followed by fastener installation. The quality of the joint, the clamp-up force and the strength of the joint have been shown to depend on the ratio of the part thickness to the manufacturer specified grip length [1].

Viscoelasticity for a material is defined as material's time dependent response to applied stresses or prescribed strains. This time dependent response can be quick depending on the intensity of the stress, or rate at which the stress is applied. In many engineering applications viscoelastic effects can be ignored, however, when designers attempt to maximize performance of the materials to their limits, time can literally be an important factor. Some examples of applications where time dependent responses are important include mechanically fastened joints, building foundations and internal support structure, rotating equipment. Numerous studies have been conducted on the viscoelastic nature of the composites. Unlike conventional materials, composites do exhibit transient response or show a great amount of relaxation[2]. Stress relaxation or simply relaxation is defined as a material's stress response to an applied constant strain input. The bearing strength of the joint has been shown to be proportional to the clamp-up force generated by the fastener. Thus, the relaxation of clamp-up force due to viscoelastic effects may be detrimental to the long-term performance of the joints. This study investigates the clamp-up force relaxation of blind fasteners joining composite parts, with time for different grip length ratios.

Experiment, Results and Discussion

The clamp-up force relaxation in blind fastener joints using NAS1919-M06[3] series protruding head fasteners has been investigated experimentally. The 3/16 inch diameter fasteners were used join $[\pm 45/0]_S$ laminates fabricated using graphite/epoxy material. The clamp-up force was measured using Transducer Techniques [4] LWO-2 bolt force sensor which has a capacity of 2400lbs. The typical arrangement for clamp-up force measurement is illustrated in figure (2). Note that a regular fastener is shown in the figure instead of a blind fastener. Since the load cell and the fastener head possess the same diameter, the load cell was placed in between the fastener head and the composite parts being fastened, in the actual arrangement. The clamping force was recorded using Data Translations [5] DT-301 data acquisition board. The data was acquired form the time of fastener installation, at a frequency of 0.1Hz.

The clamp-up force was measured for three different ratios of part thickness to recommended grip length. The part thickness was varied by adding thin steel washers between the fastener head and the load cell. The clamp-up force was observed to decrease with increase in part thickness as illustrated in figure(3). A 40% reduction in clamp-up force was observed for 7% increase in part thickness. The relaxation curves are summarized in figure (4). It can be observed from this figure that the relaxation in clamp-up force is inversely proportional to the clamp-up force during installation. Further, the rate of relaxation is higher for lower installation clamp-up forces.

Conclusions

The experimental results indicate that the initial clamp-up force is inversely proportional to grip ratio. A slight increase in grip ratio can reduce the clamp-up force by appreciable amounts. The clamp-up force relaxation of up to 8% maximum to 3% minimum occurred after 21 days of monitoring at room temperature/dry conditions. In addition, it was found that the relaxation rate increases with increase in grip ratio. Based on the limited experimental results, it can be concluded that deviations from recommended grip ratio can significantly reduce the installation clamp-up force and the relaxation occurs faster for low clamp-up force. Thus, maintaining recommended grip ratios will be detrimental to the long-term performance of the joint.

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[4] Transducer Techniques, Inc., 42480 RIO NEDO, TEMECULA, CA 92590
[5] Data Translation, Inc., 100 Locke Dr., MA 07152-1192.

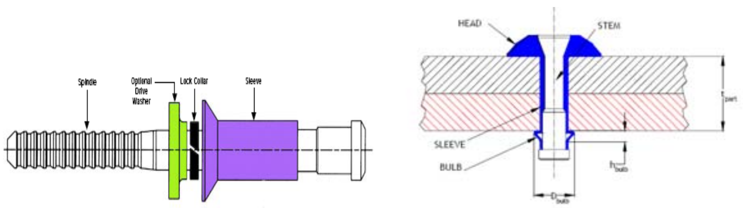


Figure (1): Huckmax® Blind Fastener and a typical blind fastener joint

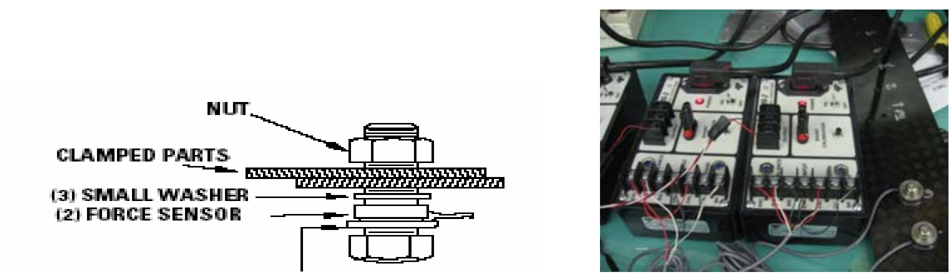


Figure (2): Test arrangement for measuring clamp-up force.

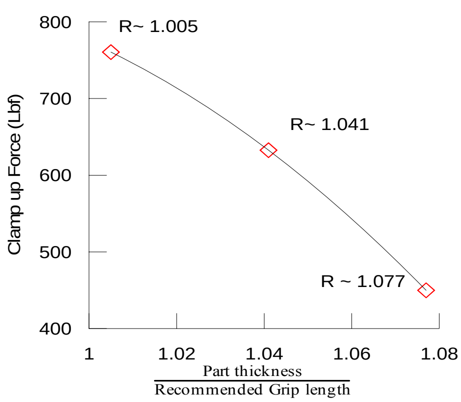
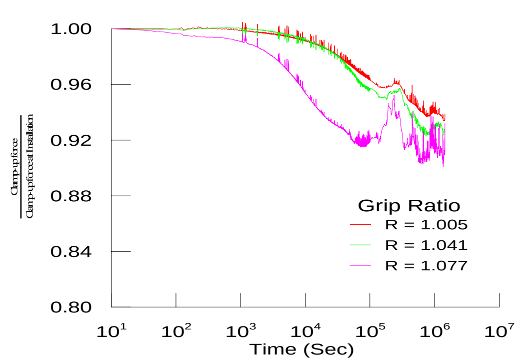


Figure (3): Installation clamp-up force vs. grip ratio



Figure(4): Clamp-up force relaxation curves