

Evaluation the Effect of Pretension on the Fatigue Life of Double Lap Bolted Joint - A Review

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Abstract: *The main objective of this paper is to improve the fatigue life of bolted joints. To investigate this aircraft grade aluminium alloy with double lap joints are studied. To improve the fatigue life bolt pretension is done on the double lap joint. The effect of the bolt pretension is studied and analyzed, both experimental and numerical methods are used to investigate the fatigue behaviour of bolted joint. Possible factors that affected the fatigue life of the bolted joints are discussed and conclusions are drawn with respect to the beneficial effects of tightening torques on the double lap joints.*

Keywords: Double Lap Bolted Joint, Stress Concentration, Fatigue life, Pretension, Friction coefficient

1. Introduction

Design of structures and the optimum selection of materials, in industries such as the aerospace industry have always been considered of critical importance if they are to be efficient and safe, and thus resistant to the effects of dynamic loads as occurs during flights. Aircrafts are continually subjected to stresses and harsh conditions, leading to cracking due to corrosion and fatiguing. Mechanical joints, especially bolted joints are most important components in aircraft structures. The fatigue life performance of a bolted joint is dependent on several factors, such as size of the bolt, the number and position of bolts used, the level of preload or torque tightening applied to the bolt, the material, plate thickness, coefficient of friction and surface roughness.

Fatigue crack is initiated, where the stress concentration is high. Structure or machine parts are assembled by means of fasteners. These fasteners not able to suppress the vibration between assemble parts. These vibration causes fatigue failure in parts.

Previous work say that the fatigue prone sites in aerospace parts are bolted joints, so that the study of fatigue behavior of bolted joints is important. To improve the fatigue performance of bolted joints by introducing favourable compressive stresses. This is achieved by bolt pretension in bolted joint.

In this paper efforts have been made to present how the pretension of bolted joints improves the fatigue life of joints. In this paper the effect of various parameters like size of the bolt, the number and position of bolts used, the level of preload or tightening torque applied to the bolt, the material plate thickness, coefficient of friction and surface roughness have been studied.

B. A. T.N.Chakherlou [1] has presented numerical simulation and experimental results showed that the fatigue life of bolted plates improve because of the compressive

stresses created around the plate hole due to clamping force. The life improvement is greatest at the high cycle fatigue life region of the S-N curves.

H. T. M. M. A. A. T.N. Chakherlou [2] his study incorporates both of the crack initiation and crack propagation concepts while differentiating between them. The results demonstrate that interference fit has positive influence on improving the fatigue life of both fatigue crack initiation and fatigue crack growth stages. However, the estimation proves that fatigue life improvement at the fatigue crack growth stage is more prominent than at the fatigue crack initiation stage particularly in low load levels.

J. V. Jose Maria Miguez [3] in this paper demonstrates how both pretensioning the bolts and the material thickness influence the fatigue life of double lap joints. The tightening torque applied to the bolts results in a compression of the joint plate members, which causes friction between them, and so prevents their relative slipping. Thus the bearing of the bolt against the hole edges is avoided, and load transmitted through the joint by friction. So the load is distributed over a larger area around the hole, the SCF becomes negligible and so the fatigue performance of the joint is much improved.

M. D. A. N. V. D. Croccolo [4] have presented every maintenance operation (loosening and tightening) provides a loss in preloading force, which is particularly evident in the presence of dry conditions: wear pattern indicates that coating is progressively peeled off. Tightening torque should be increased with the number of tightening in order to guarantee the same preloading force and coupling pressure between the parts assembled by means of the clamp.

J. C. B. L. T.-G. K. Hong-Chul Lee [5] has presented experimental and finite element results which shows that the cold expanded plates have longer fatigue life compared to as drilled plates in double shear lap joints and the life enhancement is more for lower alternating longitudinal loads. U.A. Khashaba, H.E.M. Sallam [6] has presented the bolt bearing strength increased as the tightening torque increased.

The results in this figure indicate that, in the range of the investigated tightening torques, the bolt bearing strength increases with increasing the tightening torque.

A. Benhamena [7] said that the wear mechanism and contact surfaces degradation depends on the magnitude of tightening torque. The adhesive wear dominates at tightening torque and fretting fatigue cyclic number lower while the abrasive wear dominates for tightening torque and fretting fatigue cyclic number higher. The size of the adhesion and slip zones on contact zone is related at the magnitude of tightening torque. This means that the wear mechanism is related to the torque value. In other words, the increasing of torque leads to an increasing of the frictional stresses and to reduce the relative slip at the interface of bolted assembly.

Babak Abazadeh, T.N. Chakherlou [8] says that bolt clamping and interference fitting of a plate containing a hole in a joint create pre-stresses around the hole. In addition, the clamped mating surfaces of the specimen (plate) and connector parts introduce resistant shear stress in the double shear lap joint.

N. Eliaz, G. Gheorghiu [9] gives mathematical relation between wrenching torque required and preload. A specially designed bolt force sensor, which is based on strain gauge technology, was used to monitor the actual load that develops in the bolt when it is torque-wrenched into a nut. Maintenance of helicopter is done by replacing the material of bolt and increasing the pre-tension in bolt.

2. Discussion

From earlier papers it is clear that S-N curves generated from the experimental test results that tightening a bolt and nut in the hole of a plate generally leads to an increase in the fatigue life of the plate. This fatigue life improvement is greater for the bolted specimens that tightened with larger torques. The improvement in fatigue life can also be attributed to the residual compressive stress surrounding the bolt hole caused by the compression of the member material by the bolt pretension. As the torque is increased the pretension is also increased, so the member material is placed under greater compression. This residual compressive stress, besides assisting in negating the stress intensity factor caused by the loading of the bolt hole by the bolt sank, will be beneficial to prevent fatigue cracks from growing from the bolt hole. Finally, the extension of the residual compression area in the material surrounding the bolthole, caused by the torque applied to the bolt, may be greater the greater the rigidity of the splice plates and of the joint members. This is the reason for the thicker joint (5 mm) benefitting more from a higher tightening torque than the thinner joint (2 mm).

3. Conclusion

It has been observed that how both pretensioning the bolts and the material thickness influence the fatigue life of double lap joints. The tightening torque applied to the bolts results in a compression of the joint plate members, which causes friction between them, and so prevents their relative slipping. Thus the bearing of the bolt against the hole edges

is avoided, or at least relaxed, and a high proportion of the shear load may be transmitted through the joint by friction. In this way, the load is distributed over a larger area around the hole, the stress concentration factor is diminished and so the fatigue performance of the joint is much improved. In fact, in all torque tightened joints a greater fatigue life resulted, typically greater than 10 times longer than with the none torque tightened joints, which is very much in favour of applying tightening torques to the joints.

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