Effect of Slight Pitch Difference on the Fatigue Life of Bolt

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ABSTRACT

This study examines fatigue failure in bolt-nut connections when a slight pitch difference is introduced. Three pitch variations (0 μm, 5 μm, and 15 μm) are analyzed using experimental and finite element methods. Results show that introducing a small pitch difference improves fatigue life.

Keyword: - *Bolt-Nut Connection, Pitch Difference, Finite Element Method, Fatigue life*

1. INTRODUCTION:

It is not widely understood how a bolted joint carries a direct load. A fully tightened bolt can survive in an application that an untightened, or loose bolt, would fail in a matter of seconds. When a load is applied to a joint containing a tightened bolt it does not sustain the full effect of the load but usually only a small part of it. The bolt is an elastic member. It has a spring constant k, and will develop a load based on the stretch of the bolt. Bolts are elastic and can recover from stretching, as long as the elastic limits are not exceeded.

1.1 Problem Definition:

Fatigue failure in bolt is observed due to effect of pitch difference in nut and bolt connection. Find the solution to increase the fatigue life of bolt to avoid the crack in first engagement of thread by using suitable pitch difference.

1.2 Objectives:

1. Study pitch difference effect
2. Analyze fatigue using experiments and FEM
3. Find optimal pitch difference

2. LITERATURE REVIEW

Nao-Aki et.al [1] Introduces that pitch difference having slight variation between a bolt and nut is affecting on fatigue failure. Fatigue testing is done using three pitch differences by varied stress amplitudes. It is found that the life of fatigue for the bolt can be increase while some pitch difference is taken in the account. Here the criteria for fatigue failure are discussed in terms of variation of pitch difference. They also showed that how importance of pitch difference affecting fatigue limits. They show that the fatigue life can be increase while some pitch difference is considered

Dragoni [2] found that slight pitch on the fatigue value of strength of ISO steel bolts which are used for analysis. It can have studied boundary element analysis and cross- comparison with theory and photo elasticity, the load capacity of the bolt is ultimately related to a comprehensive stress concentration dependencies. In the work of plotting the function of nominal diameter verses the thread pitch of bolt for the steel bolts. It concludes endurance phenomenon for load lightly increases if the value of pitch is decreased for small diameter bolts of low value of grade steel. Conversely, the value of endurance load increases with the pitch large bolts of high value of grade steel.

Chen et.al [3] Focused on fatigue failure, for bolt and nut connections, while pitch difference is introduced between the connection of bolt and nut. For improvement the fatigue life, there are three types of pitch difference are produced on the specimens which are compared with experimental results and discussed in terms of FEM analysis.The analysis results shows that it can improve the fatigue life of bolt.

3.EXPERIMENTAL SETUP

The 60-ton Servo Fatigue Testing Machine with cycling frequency of 9 Hz is used in this experiment. he assembly drawing is illustrated in Figure 24. In the first place, the fatigue experiment is performed for the specimen of α=15 μm, which is subjected to an axial force of F=30±14.1 KN. Since the cross sectional area of the bolt A_R=192.60 mm^2, the corresponding stress amplitude is 100 MPa. After repeated 1.94×10^5 stress cycles, fracture does not happen. This experiment is conducted to investigate the fatigue life until the fracture with confirming the fracture position of the specimens under different pitch differences. To obtain the results in a short time, therefore, the fatigue load was changed to

F=30±18.3 kN, for which the corresponding stress amplitude increased to 130 MPa. Under this loading, the fatigue experiment continues for another 2×10^5 cycles, where the fracture happens. In the case of α=0 μm, under the load of F=30±18.3 kN the fracture happened at 2.19×10^5 cycles, and for α=5μm, the fracture happens at 2.71×10^5 cycles under the same loading conditions. Figure 28 shows the fracture positions of the three different specimens. For the standard bolt-nut connection (α=0 μm), the fracture happens at the first bolt thread. However, for α=5 μm and α=15 μm, fracture happens at thread No.-3.

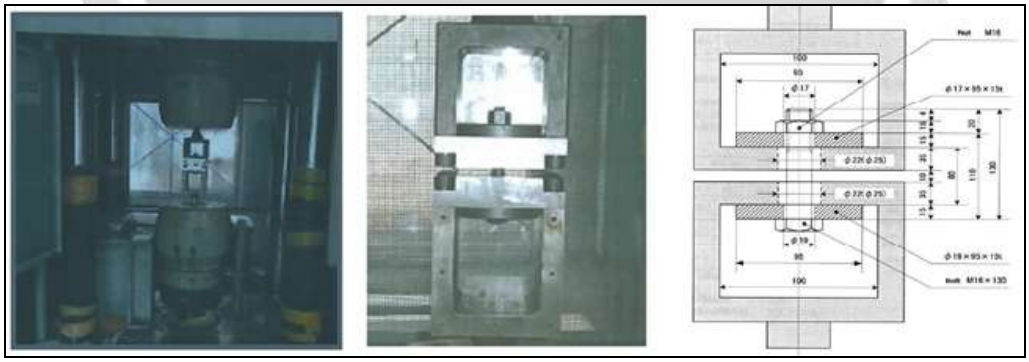

Fig-1 Fatigue experimental device

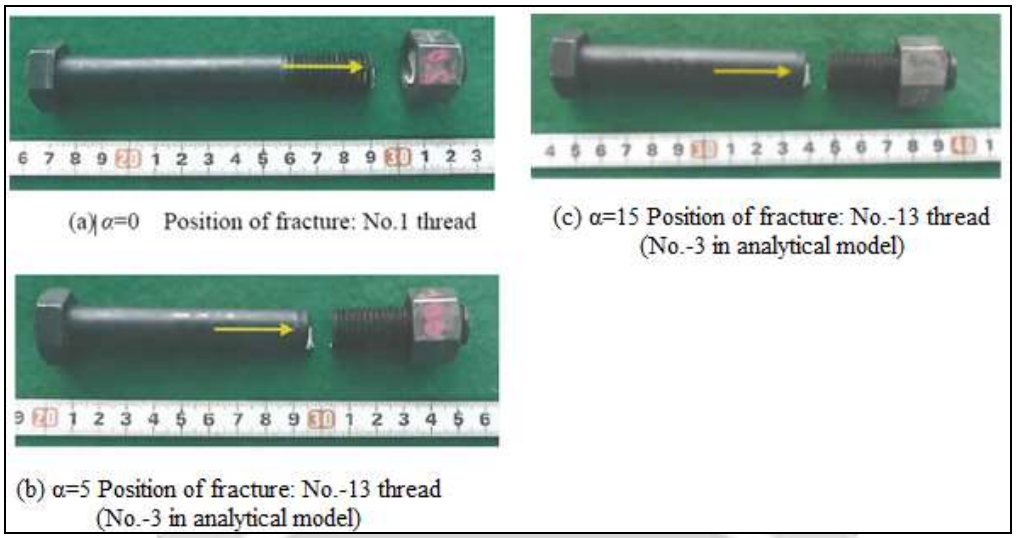

Fig-2 Fractured specimens

4.RESULT AND DISCUSSION

Utilizing a similar fatigue experimental result, the slope of S-N curves for α=0 μm, α=5 μm and α=15 μm are depicted in Figure 29. Then, Miner's rule is applied to calculate the equivalent fatigue life of α=15 μm under the load of F=30±18.3 kN, and the result is shown in Table 2. It can be seen that the fatigue lives of α=5 μm and α=15 μm are longer than that of α=0 μm. Among the three specimens, the specimen of α=5 μm has the longest fatigue life.

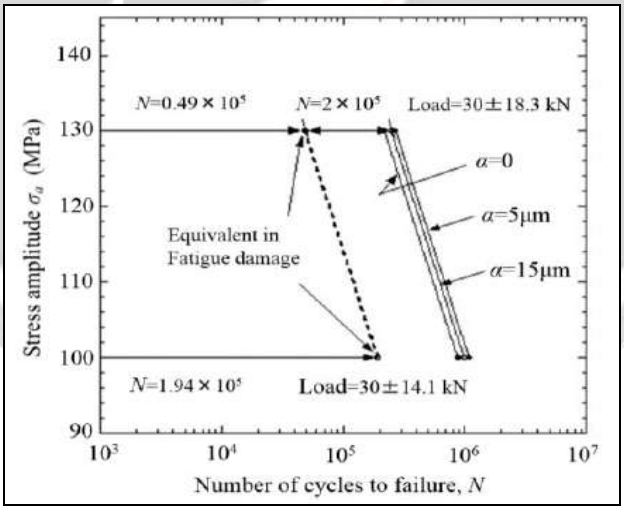

Fig-3 S-N Curve

It should be noted that the stress concentration at No.-3 thread can be reduced easily to avoid the fracture by changing No.-3 thread shape because of no contact of the nut. Thus, for α=5 μm and α=15 μm, a longer fatigue life can be expected by controlling the fracture from No.-3 to No. 1-No. 8.

Specimens	α = 0μm	α = 5μm	α = 15μm
Axial force F (KN)	30±18.3		
Stress σ (MPa)	213±130		
Number of cycles until fracture happen at No.1-8 threads	2.19×10^5	$>2.71 \times 10^5$	$>2.49 \times 10^5$
Position of fracture	No. 1 thread	No.-3 thread	No.-3 thread

TABLE-1 Result of fatigue experiment

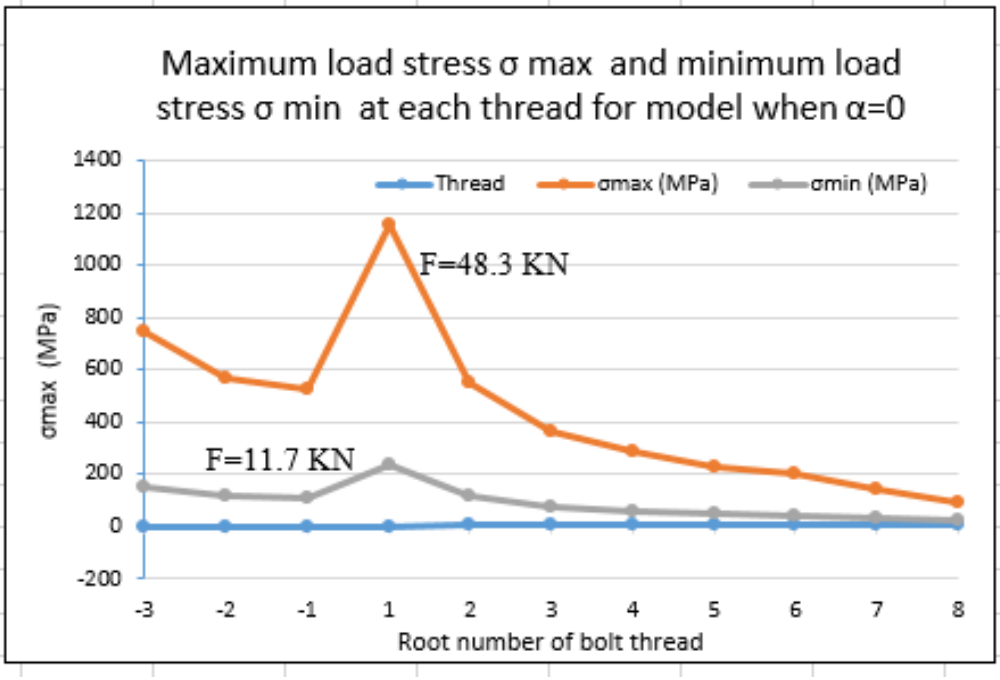

Chart-1 Stress Vs Root Number force α=0

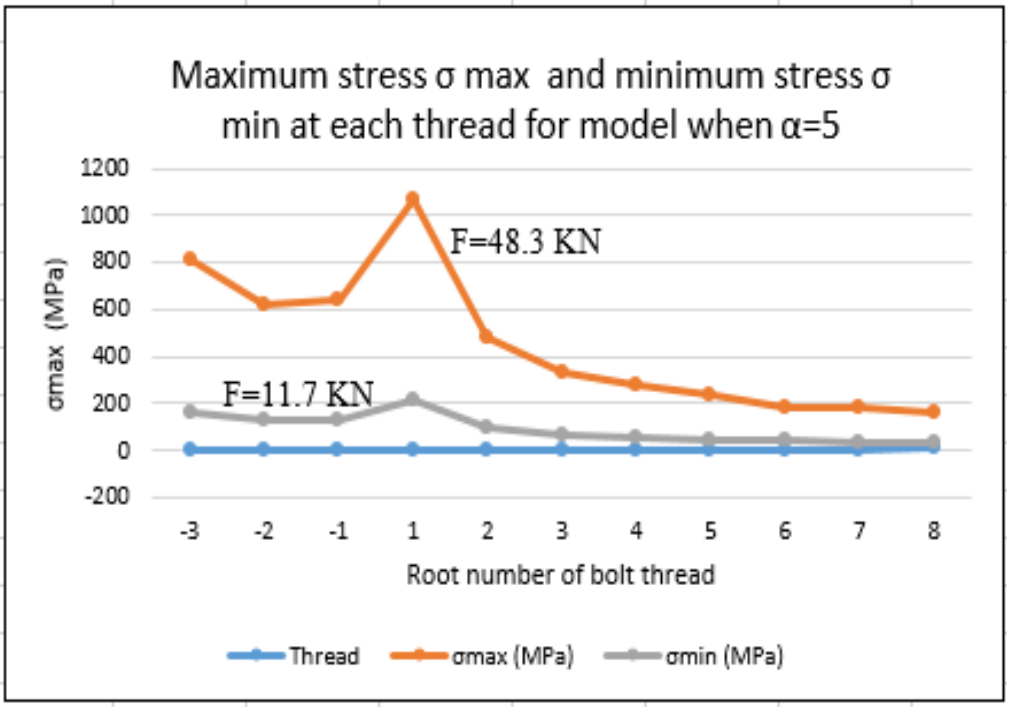

Chart-2 Stress Vs Root number force α=5

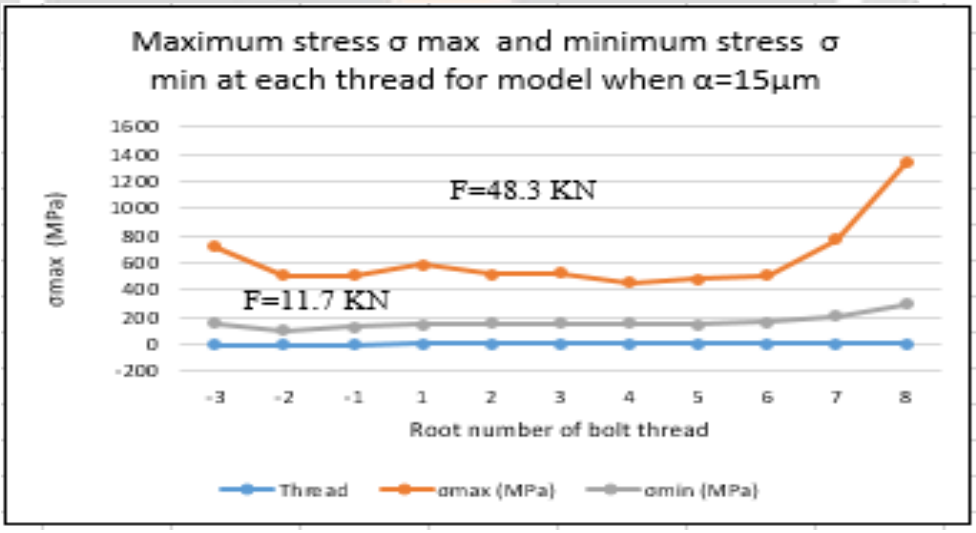

Chart-3 Stress Vs Root number force α=15

5.CONCLUSION

In this Paper, the study of fatigue life of bolt-nut connections having a slight pitch difference was considered, using experimental analysis and further it is validated by using FEM analysis. After FEM implementation was done. The result shows that stress states at each root of bolt threads was presented. The conclusions can be summarized as follows:

For the standard bolt-nut connection (α=0 μm), the fatigue fracture happens at No. 1 thread. It is observed that the fatigue life of bolt can be extended by introducing a suitable pitch difference, such as α=5 μm and α=15 μm.
For α=5 μm, FEM analysis shows that both the stress amplitude and average stress at No. 1 bolt thread is reduced compare to α=0 μm
For α=15 μm, instead of No. 1 thread, large stress appears at No. 7 and No. 8 threads although the fracture at No. 7 and No. 8 does not mean the finial bolt fracture.
Hence stress amplitude and average stress for No. 1 root thread can be decreased by introducing a slight pitch difference which tends to increase fatigue life of bolt.

6.REFERENCES

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