AN ADVANCED PREVENTIVE APPROACH FOR INSPECTING BOLT TORQUING IN WIND TURBINE ASSEMBLY SECTION

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Abstract - *The combination of bolts, nuts, and washers is widely utilized in joining two pieces of various objects such as assembly sectors, machinery, equipment, and other industrial products. Specifically, in wind turbine tower assembly by fasteners combinations such as bolts, nuts and washers are one among the foremost important joints within the installation. Nowadays the tower height is increasing due to capture the wind and maximizes the energy at the required height. Ultimately tower joints are increased in MW class turbines and this is often critical and this is essential to the secure operation in this application. Hence, proper token is required to clamp the bolts and nuts. The tightening of the fastener's consequences in an opposing clamp force that holds the two sections of the joint together. The tower joints of the parts of the fastener of washers are usually wider than the bolt head, with the additional surface vicinity, including extra friction to the joint to maintain the clamping force. If the bolt comes free or missing the washer or fix in the wrong direction it causes this clamping force weakens. Hence alleviates the drawbacks to overcome these issues to solve through a thorough inspection.*

1. INTRODUCTION

To capture more wind energy than increasing the tower[2] height of wind turbine hubs tap wind resources beyond the reach of today's 2 MW turbines more than about 100 meters. The tower top carries the weight of at least 175 tons, which comprises the group of nacelle components, rotor, hub, and blade weight. Accordingly, the wind turbine tower[2] made of conical shape in multiple segments with each segment ends is fixed with flanges as transversal weld connection and longitudinally welded in the circular shape of cylinder bent from the high-grade steel plate. Currently, the segments of tubular steel towers[2] are assembled with bolted ring flange connections which are designed for the intermediate assemblies of a tower[2] are considered. In the bolted design, two kinds of force including tension or shear forces should be considered. In order to this current generation of wind turbine design vary from one another, Such as nacelle weight is balanced to the tower or nacelle weight is offset to the tower. Hence, for this construction of the load case, the tower[2] is affected by the thrust load and it creates a bending moment[2], i.e. inversely proportional to the height above the ground. To cope with this increasing bending moment, it is favorable to make the tower conical in shape, to the limit of buckling.

The linear segment of the flange is connected between two segments of the flange is the number of bolts based on the circumference nominally the flange is used in the materials are S355 minimum higher steel grades. Partial safety factors of 1.35 and 1.00 are already included for static and fatigue loads respectively, which are provided by the turbine manufacturers. The visual inspection follows to be ensured that the flange surfaces are sufficiently flat and parallel. Here the sequence of assembly flows from bolt head, washer, and the segment of steel flanges, washer and then finally ends with nuts. In this flange connection, the bolt tightening sequence for a circular bolt pattern method to be follows

Fig -1. Before Bolting in tower

Fig -2. Inserting bolting in tower

PASS 1: Squeeze the nuts slowly by hand in the first case as per cross-bolt tightening pattern, then hand-tighten evenly.
PASS 2: Using a torque wrench, torque to a maximum of 30% of the final torque value in accordance with the torque sequence. Check that tower flange is getting compressed uniformly.

PASS 3: Torque to a maximum of 60% of the final torque value as per cross-bolt tightening pattern
PASS 4: Torque to the final torque value (100%), according to the cross-bolt tightening pattern.
PASS 5: Ensure the final torque value as per pattern followed in cross-bolt tightening.
After the five basic torque passes are completed, repeat torqueing the nuts at least once using the final torque in an applied sequence manner or "crisscross" pattern or "star" pattern until no further rotation of the nut is observed.

Fig -3. After bolting

2. PROBLEM DESCRIPTION

[3]According to the present method is carried out with four problems categorized in bolt connection of a wind turbine tower installation. In the first case of the study, we applied the tightening is the direct axial stretching of the bolt to achieve preload an uneven value in the proper sequence of clockwise or anticlockwise and/or also a sequence for circular bolt pattern method follows between tower flanges. [1]The second statement of the problem includes the variation in friction coefficients affect the amount of preload achieved at a specific torque in an improper sequence of clockwise or anticlockwise direction and/or also sequence for circular bolt pattern method follows the connection between tower flange regions. The third statement clearly states that missing few washers in some areas of the nut has been tightened to torque loss is inherent in any bolted joint resulted effects of bolt relaxation and distribution of pressure is absent. The fourth case study of the washer has been placed in the wrong direction of the tower flange resulted from the bolt relaxation such as vibration in the system or the creation of gap surface contact is more during bolt tightening contribute to torque loss.

3. ANALYSE AND INTERPRETATION

Bolt specification for static structural analysis of steel adapters

Size of the bolt	: M42
No of bolt	: 144
Grade	: 12.9
Pitch thread	: 4.5 mm
Specified torque value	: 4075 Nm

Case 1: Megawatt class wind turbine requires the accurate tightening method for multiple bolts and nuts of pretension in a sequential clockwise pattern or else pretension in star patten.

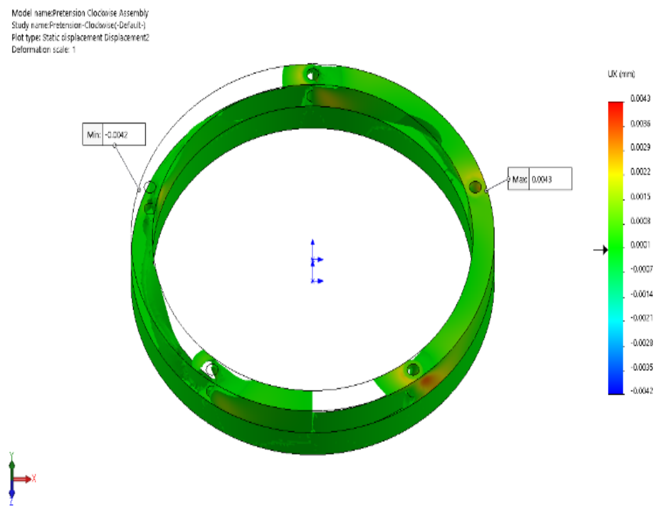

Fig -4. Case 1

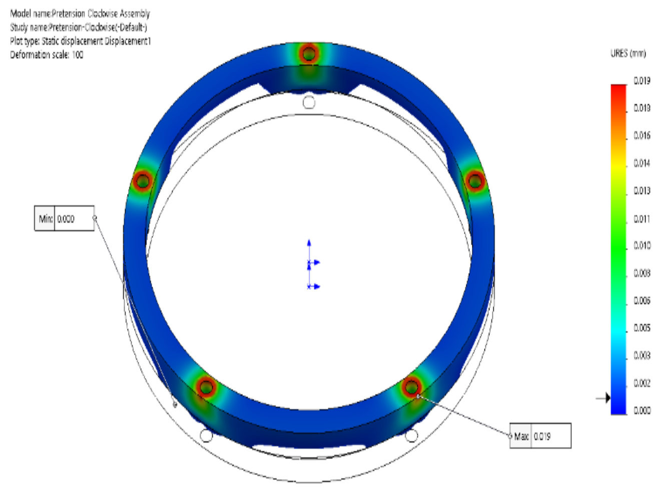

Fig -5. Case 1

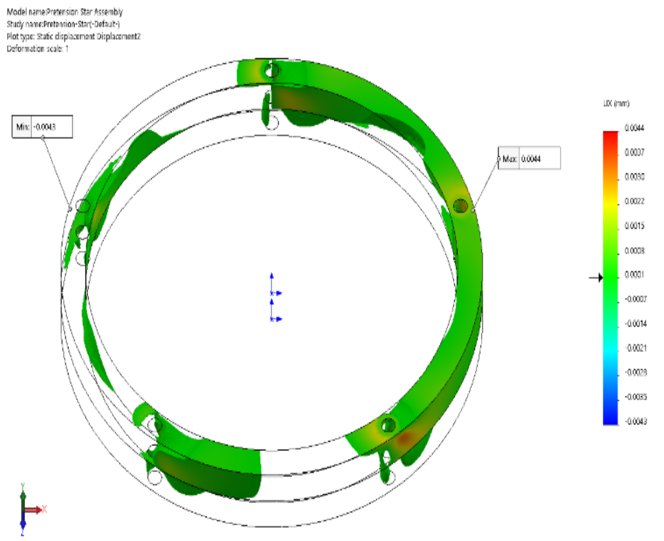

Fig -6. Case 1

The even torque force value is selected on the manual tool and pretension load is applied to the flange connection bolts in clockwise direction. As a result of the tightening method is observed as 1657Nm, 1690Nm, 1712Nm, 1700nm and 1675Nm. As below fig.-4 shows that, significantly the applied loads are varied in the flange joint concentrated bolt for small changes in the joint opening displacements between minimum to maximum range.

Likewise, the resulted states that same value is selected and applied manually by tightening the bolts and nuts in star tightening sequence for circular bolt pattern observed in variably distributed clamping forces along the surfaces of contact between the tower flanges in 1660Nm, 1670Nm, 1685Nm, 1710Nm, 1700Nm and the displacement shows the above fig-6 from minimum to maximum range.

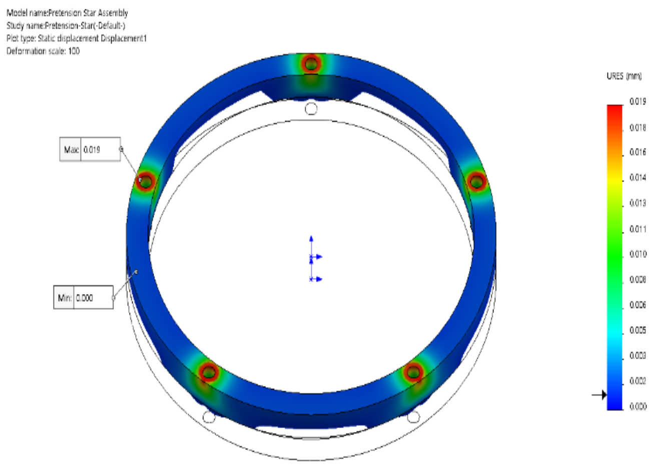

Fig -7. Case 1

Case 2: Coefficient of friction varies in sequential clockwise pattern and Coefficient friction vary in star pattern method

Due to the role of friction forces and the dynamics of the phenomenon, this process is nonlinear and currently performed manually; it is also time consuming, requiring high-cost equipment and expert operators.

The tightening sequence for circular bolt pattern requires to control friction for two reasons: by achieving as closely as possible the desired load on the bolts and achieving the same load on all of the bolts in the flange. As well as some good practices to help control friction such as

- Remove burrs and flat spots from threads[1],
- Nuts run freely past anticipated point of travel by hand,
- Replace worn, corroded, damaged or over torqued bolts (When replacing bolts, place them in the flange so that they are evenly spaced from each other)[1]
- Bolts should pass through the flanges at right angles
- Use hardened steel washers
- Apply the correct lubricant
- Avoid getting trash on the lubricated bolt

Case 3: Placing of washer missing in some areas of the particular joints during the installation of tower flanges joint connection (bottom and top flange) in the top surface of the flange.

The relative fasteners assembly between the flanges is entering the bolt from bottom flange to top flange, substantially the flat washer is placed on below face of the bottom flange or else fix next to the bolt head, then the bolt shank and thread enters into the flange joints in tower from bottom to top, then the bolt ends are come out of the top flange and fix the washer on the tail end of the bolt or might be said as surface of the top flange and ends with nut4] to close the assembly joint of connection.

Here the operation of multiple bolts and nut of the same size are tightened sequence by the circular bolt pattern followed in the tower joints, substantially some bolts and nut combinations have missed washers in top flange portion during the installation process, that also applied the same torque value in the combination of bolt, washers in bottom flange, nut and some number of washers missed in the top flange provision. Hence the results state that there would be variation in the torqueing value of the bolts and nut[4] combination of tower flange connections - they won't have all the same value.

If there is no washer the results states that the bolt has been found loose in the bolted joint due to vibration or shock or self-turning of the bolt[3] or absence of clamp force, can lead to a high amount of pressure, can lead to creep and bolt preload loss. This variation is influenced by such factors as variation characteristics in the total bolt strength must not be evenly divided over the whole flange surface, variations in the surface flatness etc.

Case 4: Washer properly following with the sequence of nut side placed in the top of the tower flange surface as the wrong direction towards bolt head portions. The flat washer contains there is one side that has a chamfer portion of the edge and the hole. The other side has a flat surface edge to it. By mistakenly few of the flat type washer placed incorrect position in tower flange connections and it follows the tightening with the specified torque by manual tools.

During the practice in installation time, the observed results on the nut[4] side as the washer fixing in improper direction has less surface area in contact with the thing being connected than the correct position of the washer, so that it does vibrate loose, absence of spreading the load/stress, the load hasn't been evenly distributed, chances to bend during tightening.

4. CONCLUSIONS

According to the discussed cases, the most common cause of a flange joint connection is due to insufficient initial preload developed at installation, improper installation and improper inspection, therefore before beginning any bolting process. Hence the following preliminary steps must be taken to avoid future issues and prevent the collapse of wind turbine towers.

- Clean the flange faces in both mating part of top and the bottom of the tower.
- Inspect all bolts, nuts and washer for free from damages[1].
- Lubricate threads of the bolt and surface of the nut face.
- Following the installation process is by slowly bringing the flanges together in a parallel line.
- Check flange alignment and its bolting as per ASME B16.5
- Ensure the calibration of torque equipment according to ISO standards.
- Experienced and well-trained workforces who can carry out the techniques to flange bolt tightening include manual or hydraulic tools.
- Using wermac's tightening sequence[1] to follow the circular bolt pattern method in flange joints.
- Ensure that the selected tensioning procedure[1] has been correctly applied and that all bolts are fully tensioned.
- If any nut or bolt head is turned during the job-inspection, then torque shall be applied to all other bolts in the connection and all bolts whose nut or head is turned, by the job inspection torque shall be tensioned and re-inspected. Alternatively, the workforce may re-tension all of the bolts in the connection and then resubmit the connection for inspection.

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BIOGRAPHIES

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