THE ASSEMBLY PROCEDURE OF THE TRACKER RAIL WEELDING SUPPORT FOR ATLAS ITK AT CERN – THE SIGNIFICANCE OF THE EXPERIMENT

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Abstract
The article is focused on finding the correct assembly procedure of the welding support. The first step of finding the assembly procedure was based on the theoretical analysis - relationship between torque and axial force in the bolt - of the support which was then verified by the simple experiment in the second step. The support forces depending on the tightening torque were measured in the experiment. The experiment proved to be very important to understand the behavior of the welding support during the assembly procedure and the final assembly procedure is based on the experiment.

Key words: *experiment; assembly process; ATLAS ITk; CERN.*

INTRODUCTION

This year in February, we installed a welding tool (Tracker Rail Welding Support = TRWS) in CERN. The tool was developed and manufactured at our department, the information of this topic was provided last year. The tool is designed to lock the rails in defined position during their welding to the outer housing (Inner Warm Vessel = IWV) of the ATLAS inner detector. This modification of the mock-up is required so that its design will correspond to the intended design within the upgrade of the ATLAS detector and so that it could be trained and tested the assembly procedures for the individual components in detail. The visualization of the installation of the tool in the housing of the inner detector is presented in fig. 1.

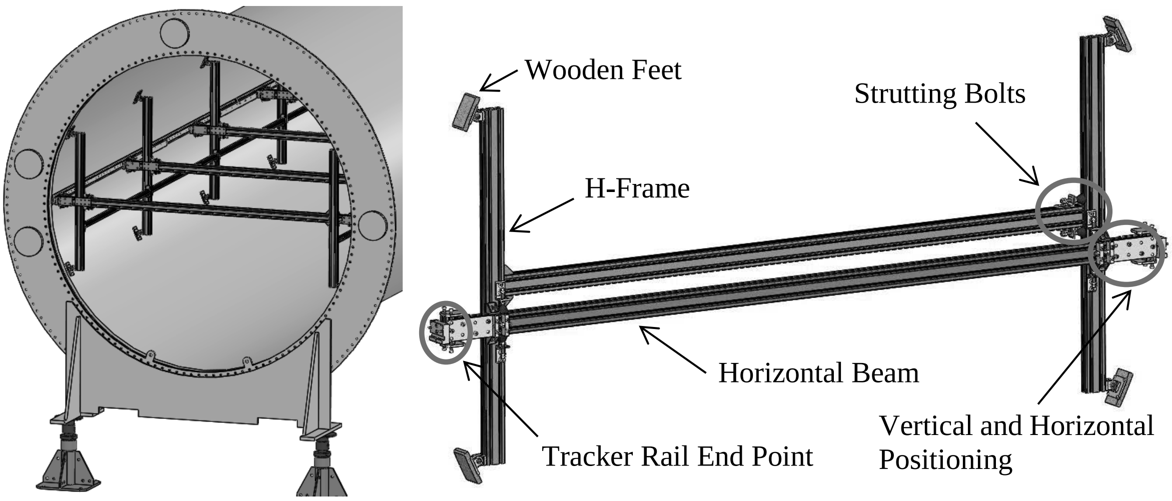

Fig. 1 Installation of the tool in the housing of the inner detector.

It is important to note that the tool consists of two parts. The H-frame is used to lock the tool position in the housing of the detector. The purpose of the horizontal beam is to carry the welded rails. While the position of the tool is secured, it is possible to change the position of the horizontal beam and thus set the required position of the rails very precisely. The reliable locking of the position of the H-frame in the housing of the detector is the essential condition, which is achieved by an adequate tightening of the H-frame strutting bolts, so that even when applied up to 1000 N in the direction of the longitudinal axis of the detector, the shifting of the tool will not be able. The aim of this article is to bring the readers closer to the problematics, which the authors encountered finding the correct assembly procedure.

MATERIALS AND METHODS

The assembly instruction was searched for by two approaches, where the first mentioned was also used as a basis to set up the conditions for the second one. The first approach was based on the classical relationship between torque and axial force in the bolt. The second one is based on the experimental finding of the actual torque relation with the measured supporting force. The first approach works with the scheme of Figure 2, which also describes the calculation of the required tightening torque.

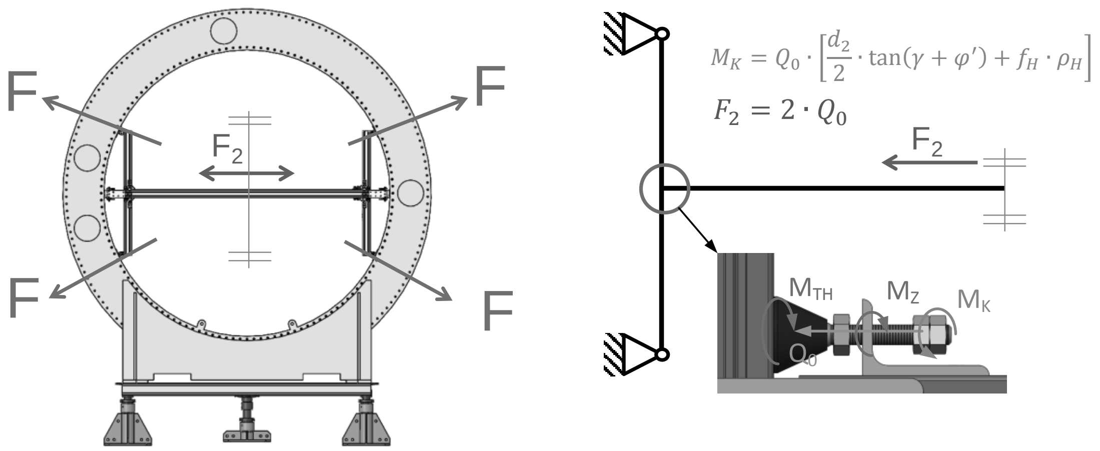

Fig. 2 Theoretical analysis of the welding support.

The diagram in Fig. 2 presents huge simplification in comparison to the reality where the considered force is not introduced by one but by two bolts positioned about the width of the horizontal beam apart and whereas the fact that the coefficients of friction are chosen values, the results of the calculation have to be taken with reserve and must be experimentally verified and specified. However used mathematical model provided us the value of tightening torque required to meet the structure conditions listed above. This value of the tightening torque (ca. 4.0Nm) was used as one of starting-points to set up the experiment.

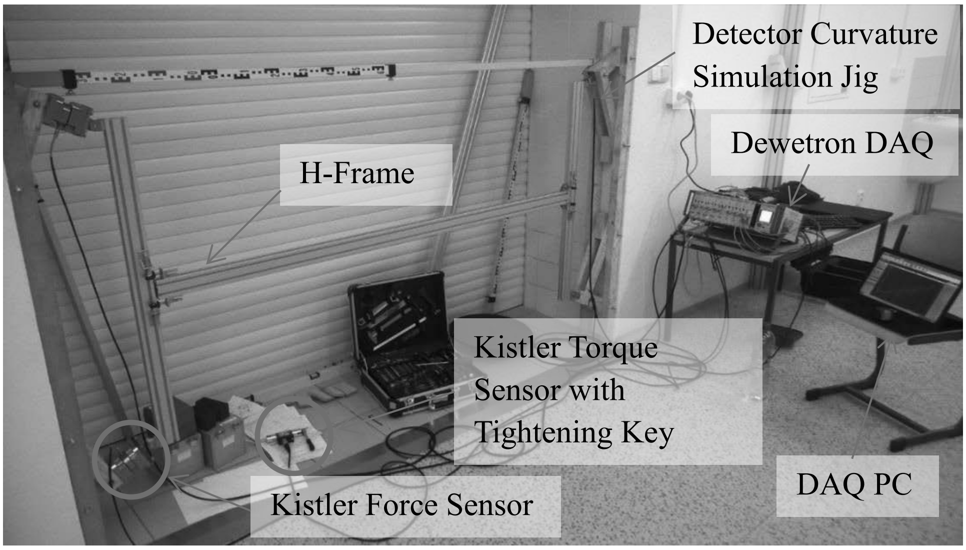

Fig. 3 Experimental measurement of the welding support the welding support in the Laboratory of Extreme Loading.

For the purpose of the experiment, a Kistler torque sensor with a sensitivity of 0.1 Nm was used. The sensor was connected directly on the head of the used tightening key. The tool was installed in the door of the Laboratory of Extreme Loading in special templates ensured a faithful simulation of the curvature of the detector housing (Fig. 3). The tightening process was acquired by the Dewetron apparatus and subsequently processed in the Matlab software. As the primary outputs of the data processing, courses over time of the tightening torque and of the contact forces in the end-plates of the tool are presented (Fig. 4).

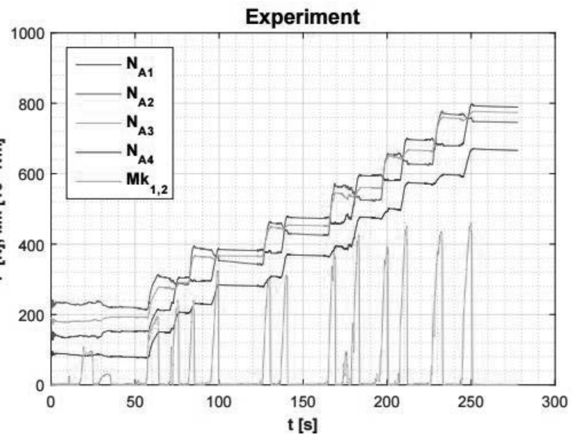

Fig. 4 The data (Forces and Tightening torque) measured over time.

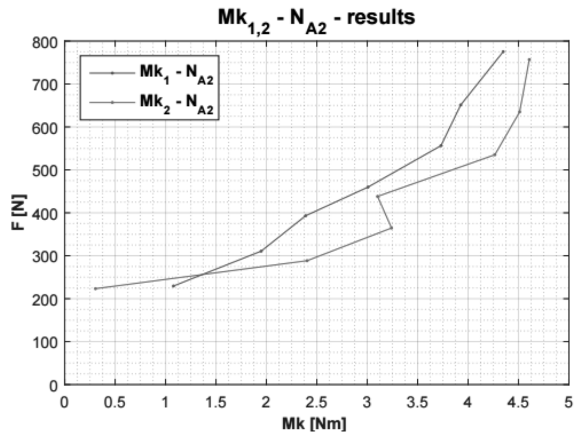

Fig. 5 The contact forces in dependence on tightening torque.

The measured data were also displayed in direct context – the contact forces in dependence on tightening torque (Fig. 5).

Based on presented courses, it will be appreciated that in order to achieve the necessary contact forces in the end-plates of the tool, the repeated tightening of the strutting bolts to the specified torque value is necessary. This fact is explained partly by the fact that there are two strutting bolts on the tool, i.e. there is not clearly defined junction between the horizontal and vertical beam of the H-structure in terms of loading distribution from both bolts, and partly by the fact that the total stiffness of the structure becomes to be changed during the tightening process. The principle of this change is schematically illustrated in Fig. 6, where the model works with partial stiffness k_1 and k_2).

$$F_2 = 2 \cdot Q_0 = 2 \cdot F_y \quad \rightarrow \quad F = \frac{M_K}{\left[\frac{d_2}{2} \cdot \tan(\gamma + \varphi') + f_H \cdot \rho_H\right] \cdot \cos\alpha}$$

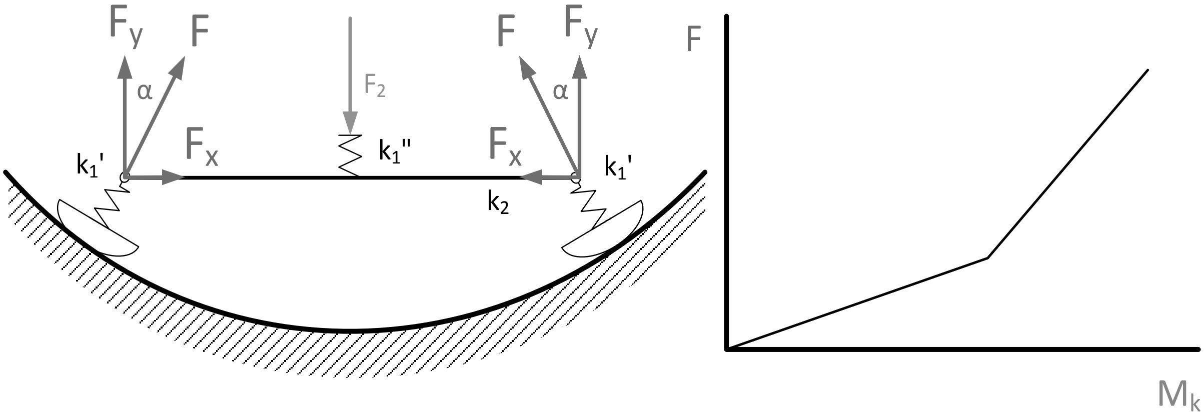

Fig. 6 Mathematical model of the structure stiffness changes

RESULTS AND DISCUSSION

Based on the above, it is obvious that used mathematical model was too simplified to provide us complete information on how to set up the tightening process. Nevertheless, the analysis provided us the value of tightening torque, which has proved to be usable in experimental measurement.
By linking both of these approaches, the essential information usable for design of the assembly process and adjusting the calculation model was obtained. The adjustment of the mathematical model was made despite the huge simplification by replacing of the two central supports with a central single one. The concept explains the stiffness changes due to the "contacting" of the articulating surfaces of the individual components more than sufficiently and offers also the possibility to consider the friction ratios in the tightening bolts.

CONCLUSIONS

The aim of the article was to highlight the problematics of strutting constructions and the danger of using simplified computational models without experimentally verification of their behavior. The experimental measurement shown the importance of an engineering experiment which was quite simple for the given case, but still provided crucial data for the correctness of the tool installation process. Based on this representative experience and on other similar experiences the recommendation of the application of experimental methods, also in cases where it may appear at the first glance that there is not any reasonable argument for can be concluded.

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