Experimental analysis of welding tooling for ITk ATLAS

M. Rachač[1, a], M. Dub[1, b], M. Janda[1], P. Malý[1], J. Kamenický[1], O. Berka[1], V. Dynybyl[1], P. Kubový[2], F. Lopot[1,2,c]

[1]CTU in Prague, Faculty of mechanical engineering, Department of designing and machine components, Technická 4, 166 07, Prague, Czech Republic

[2]Charles University, Faculty of sports and physical education, Dep. of anatomy and biomechanics, Lab. of extrem loading, José Martího 31, 162 52, Prague, Czech Republic

[a]marek.rachac@fs.cvut.cz, [b]martin.dub@fs.cvut.cz, [c]frantisek.lopot@fs.cvut.cz

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Introduction

The paper deals with the testing of a recently developed welding tooling which will be used for welding of a new type of rails inside a mock-up of ATLAS internal detector in CERN, readiness for its upgrade.

The detector is used for detection of radiation at collisions of particles in the accelerator by means of CCDs which underwent a rapid development in the last decade in terms of performance, speed and sensitivity, and that is why the overall upgrade of the detector is being undertaken.

On the detection carriers (staves) exchange, the complete reconstruction of related systems, such as wiring, cooling circuits design and system for creating and maintaining a vacuum in XHV is bound. The detector as an assembly creates a highly complex structure where all errors resulting from installation of individual components are very difficult to detect. This is one of main reasons for mock-up construction.

The preparation of the mock-up corresponding in detail with the final design of the inner detector is crucial because the mock-up enables training and check of all assembly procedures in real conditions but without radiation. And thus the health risks for staff are minimalized in fact.

For the detector upgrade, with an effort to reduce the total costs, the mock-up constructed for present ATLAS version is reused and in detail adapted to the intended engineering design.

Tooling design

Firstly, the force limit, which the tooling after the installation must withstand without any change of its geometry and position. This demand is justified by the fact that technicians will be moving in the surrounding space during the installation of the rails and their contact with the tooling cannot be avoided (*Fig.* 1).

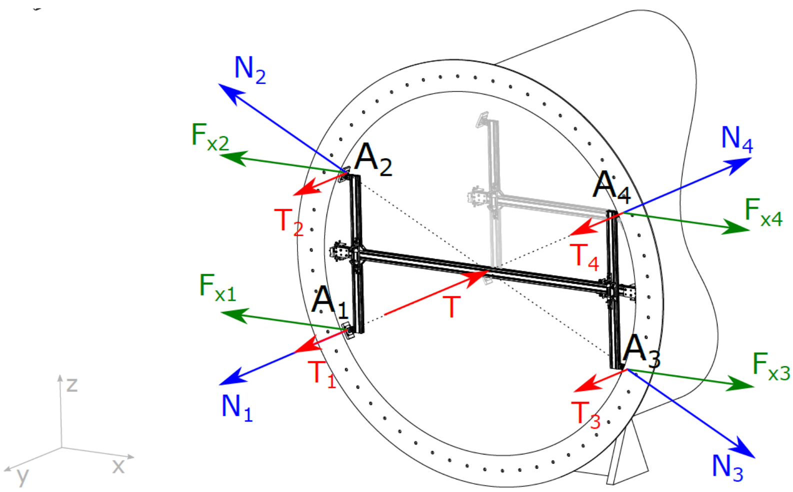

Fig. 1 - Forces diagram

On the other hand, there was a requirement for the maximal allowable deformation of the detector tube caused by the tooling installation (*Fig*. 2).

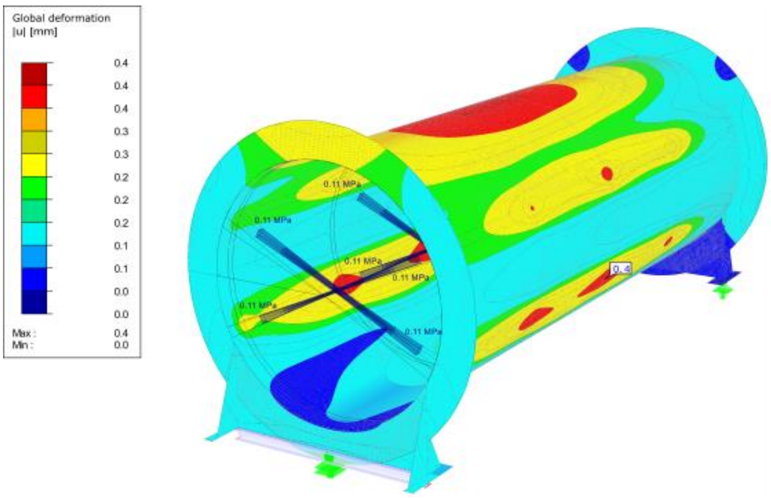

Fig. 2 - FEM analysis

The tooling is designed according to the request from CERN from standardized Bosch al-profiles which are also used in their other workshops (*Fig*. 3).

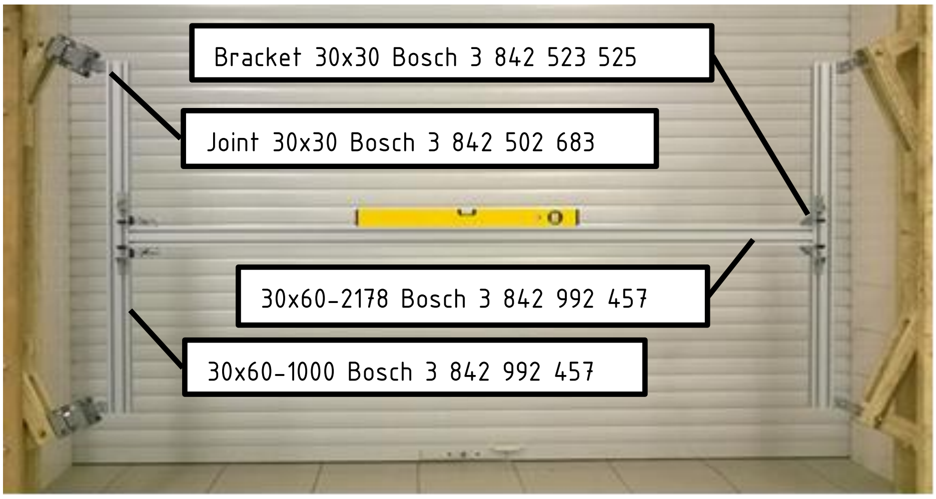

Fig. 3 - Parts of welding tooling

The tooling consist of T-part, vertical beam and an independently adjustable horizontal beam with terminals for fastening and adjustment of rails according to instructions from CERN people. In the tube, the tooling is secured by strutting of T-part and vertical beam using two strutting bolts. The contact area of endplates of the tooling is shaped according to the tube diameter. The end plates are made from a hard wood to prevent damages of the inner surface of the tube. Fig. *3* provides an illustrative picture of the design solution of the tooling.

Measurement and instrumentation

Needed experiment was carried out in Laboratory of Extreme Loading because of appropriate space and instrumentation. Sensor application is obviously seen in *Fig.* 4**Chyba! Nenašiel sa žiaden zdroj odkazov.**.

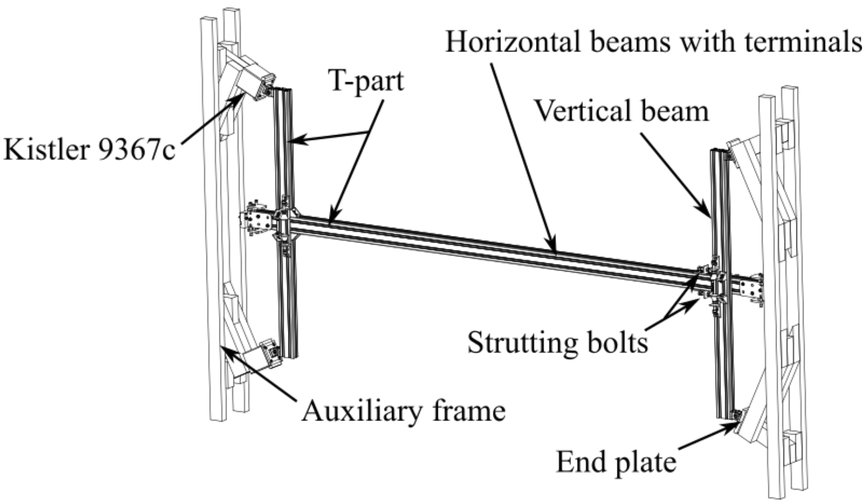

Fig. 4 - The tooling installed into the auxiliary frame

The tooling was installed into the auxiliary frame simulating the inner cylindrical surface of the detector tube. Contact forces in endplates of the tooling are detected by peizoelectric sensors Kirstler 9-series with sensitivity of 0.001 N. The torque on strutting bolts was monitored by tenzometric spanner Kistler with sensitivity 0.01 Nm in range from 0 to 10 Nm.

All data were acquired by Dewetron Sirius station using Kistler amplifiers with 1 kHz sampling frequency.

In order to avoid both damage of the tooling and exceeding of the deformation limit of the detector tube, the tightening torque was restricted on 4.5 Nm by a slip clutch application in the spanner. The operating stuff was instructed to tighten firstly the upper and then the bottom strutting bolt always either about one half of the turn allowed by surrounding space or up to the limit value of the torque. A short breaks of about 20s between particular steps of the tightening proces were added in order to identify each step in recording definitely (*Fig*. 5).

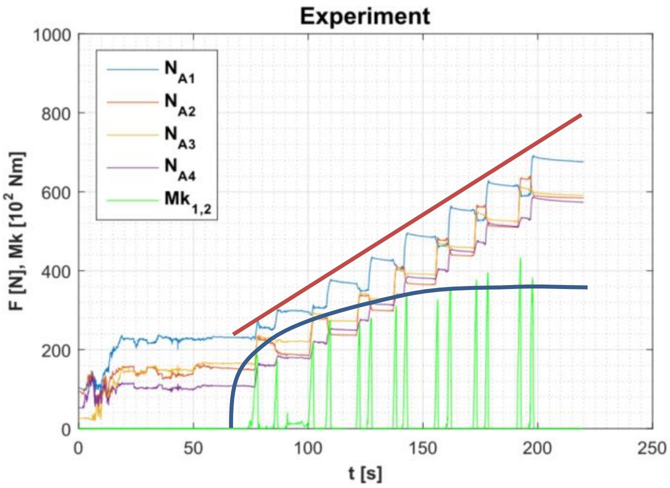

Fig. 5 - Graph Contact force, Torgue - Time

The data acquisition was started before inserting the tooling into the auxiliary frame and stopped when the contact force on endplates reached the limit.

Results

It is important to assess the measured data were both in the coordinates “contact force – torque” and torque, contact force – time” [1].

From acquired time courses, the force magnitudes related to the peaks of the torque (see *Fig*. 5) are read and separated. By this way, the graphs with force-torque coordinates could be installed (*Fig*. 6).

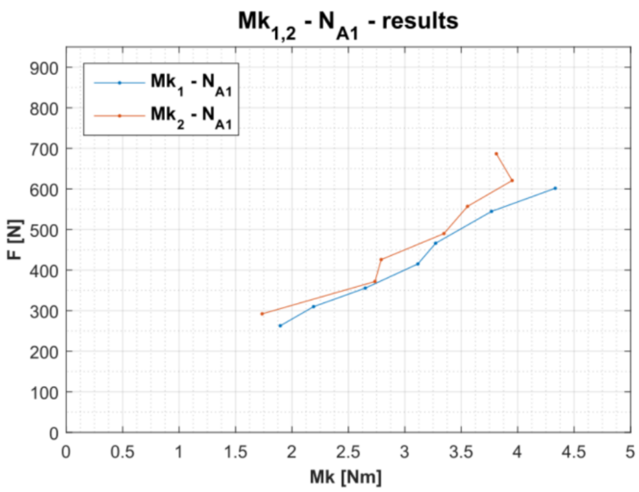

Fig. 6 - Graph Contact force - Torgue

But besides the above mentioned dependency, the time aspect seen from the graph in Fig. 5 must be considered in. The detailed analysis of the course of the experiment implies the knowledge essential for creation of a simple assembly procedure.

Here is not enough information about tightening of bolts by defined torque, but it is necessary to monitor the number of revolutions of the bolts after the moment of their contact with a vertical beam.

The courses of mentioned graphs show that for correct installation of the tooling in the detector tube, its geometrical change as the result of turns of strutting bolts is crucial. Due to this careful approach, the Relatively uniform distribution of the force from Strutting bolts to the contact forces on endplates of the tooling with a minimal risk of its damage or of exceeding the limit of deformation in the detector tube during installation.

Conclusion

The acquired data brought important findings to set up a simple assembly instructions for actual conditions of the tooling installation.

Because there is impossible to count with lengthy installation of measuring equipment in the real assembling conditions, the number od halfturns of strutting bolts calculated always from initial contact between the bolt and the vertical beam (tightened by hand) was assigned as the appropriate and effective quantificator for the immediate state of the tooling instalation. This parameter shall be monitored and controlled by the operating stuff directly without need of any special equipment. The installation of the tooling is finished reaching of prescribed number of halfturns for both strutting bolts.

During writing this paper, the tooling was installed in CERN and succesfully used to the intended purpose (*Fig*. 7).

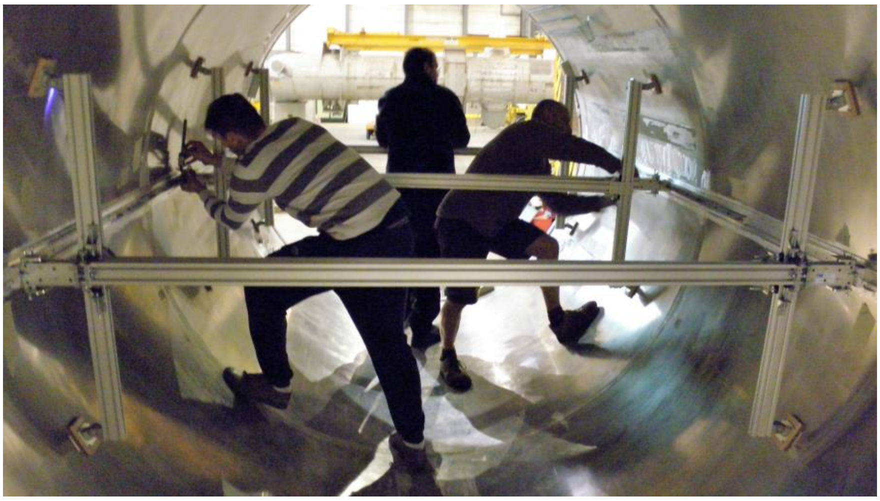

Fig. 7 - Installation in CERN

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References

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