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Experimental Testing of Piston Lock

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Abstract. This paper describes the experimental testing of piston lock. The purpose of the lock is to support the piston of the single acting cylinder (JF jack) during transport of New Small Wheel in CERN. The lock is a special designed locking system that utilizes the principle of rubber O-rings and conical springs expansion in the hole. The function of the lock was verified and properties were obtained with help of the experimental testing.

Introduction

The manipulation and transport of large heavy objects is very often in CERN (European Organization for Nuclear Research). Therefore, the need of different special tools and equipment is essential. New Small Wheel (nSW) is a part of the ATLAS muon subsystem which has 9,3 m in diameter and weighs over 100 tons. One of the special tooling for the transport of nSW uses single acting cylinders (JF jacks) that are placed in vertical position with piston pointing down (see figure 1). Locking system for support of the piston (JF piston lock) was designed and its function was verified with help of experimental testing.

Experimental testing on machines and newly designed structures becomes very important for the development and verification in these days. Firstly, measurements during real condition are crucial for designing of reliable products. Examples of experimental testing of different machines, elements and devices can be found in [1], [2], [3].

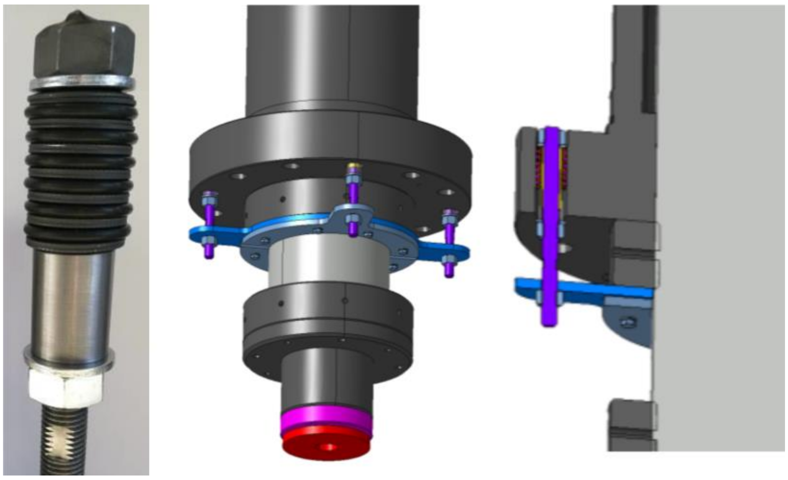

Fig. 1 Tested specimen (piston lock)

Method

The testing was carried out to obtain the maximum pullout force and the behavior of the piston lock during loading.

Investigated specimen. The prototype of the piston lock and test hole was produced for the test, the scheme of the specimen and the function are in figure 2. The locking force is induced by tightening of the fastening nut and compressing of the O-rings. The rings come into contact with the wall and the locking is achieved, allowing also resistance movement thanks to friction. The size of the thread is M16, the diameter of the hole is 32 mm, the length of the O-rings set is approx. 50 mm.

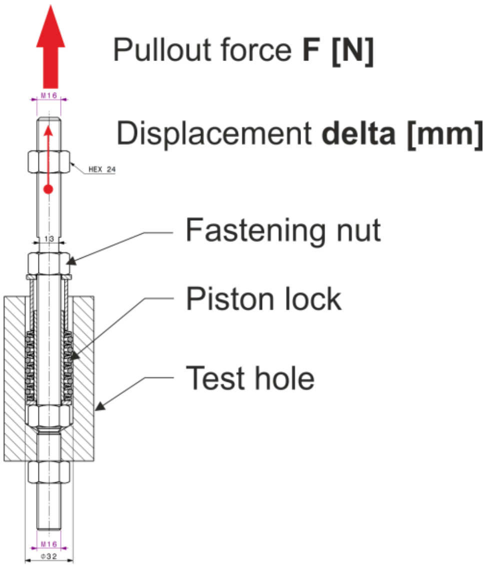

Fig. 2 Scheme of tested specimen

Measurement protocol. The specimen was subjected to the experimental testing when the piston lock was pulled out of the test hole with the constant velocity along the whole depth of the test hole. The time dependent displacement and force was measured with the constant sampling frequency of 20 Hz. The number of nut turns *n* from the initial state was the locking parameter for testing. Number of used O-rings was another parameter that influences the properties of the piston lock. The measurement was carried out several times for some parameters configuration to obtain average values.

Instrumentation. The mechanical test was carried out with a UTS™ electro-mechanical testing machine equipped of a 20 kN load cell at velocity of 20 mm/min, figure 3.

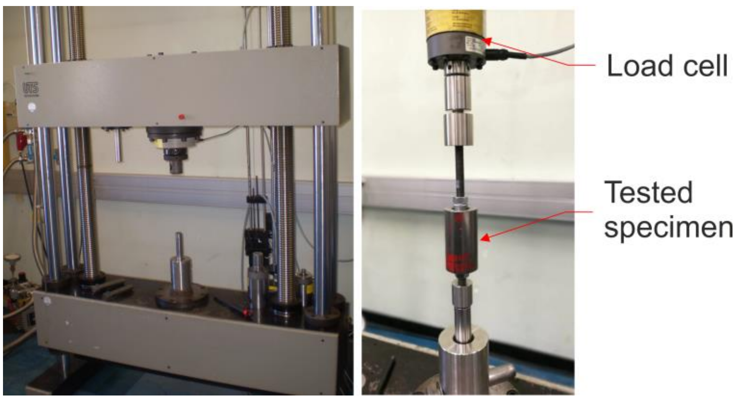

Fig. 3 Testing machine and specimen

Data acquisition and processing. The measured time dependent data of load and displacement were obtained using control software of the testing machine, further the data were processed to the graph of force dependent on the displacement using Matlab. The typical course of force (figure 4) can be divided into three parts. The first part is characteristic with the linear increase of force up to the maximum. The force in the second part is rather constant with possible fluctuation which can be explained by the friction sliding of the rings on the wall of the testing hole. The last third part is characteristic by the decrease of the force as the piston lock and O-rings are gradually extracted out of the testing hole. The maximum applicable pullout load, i.e. locking, was determined at the end of the linear increase of force course when the function of the piston lock is reliable.

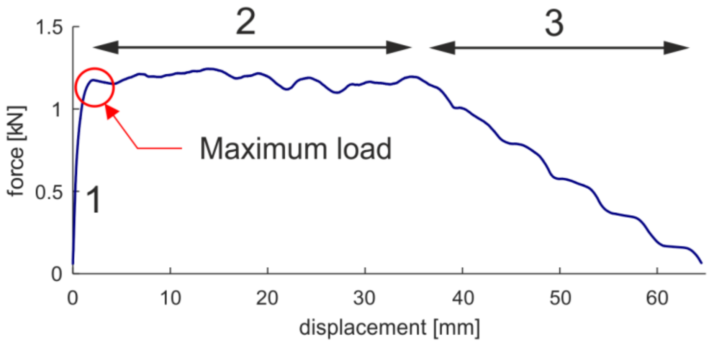

Fig. 4 Measured data (pullout force - displacement)

Experiment outcomes

The basic configuration of the piston lock was with 6 O-rings. The testing was repeated several times for locking parameter of nut turns n = 1 and n = 2. The testing for n = 3 was done once because large deformations of rubber rings and their crushing or displacement from the correct position occur (figure 5) with higher number of nut turns. The resultant graphs are in figure 6.

Fig. 5 Crushing and lose of O-rings

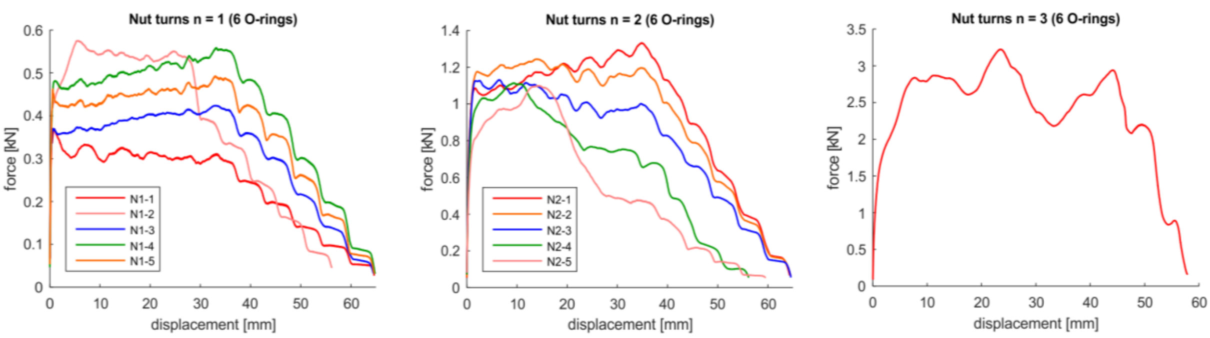

Fig. 6 Measured data for different locking parameter of nut turns

The detailed first part of the measured data for different locking parameter is in figure 7. It is obvious that the locking, i.e. maximum pullout force, increases with higher number of nut turns. Also the difference of the force course for locking parameter n = 2.5 and n = 3 is negligible. The second graph in figure 7 shows results depending on the number of O-rings. The difference between 6 and 8 O-rings for locking parameter n = 1 is evident, however is not important and crucial. The results of maximum pullout load for different piston lock configurations are summarized in table 1.

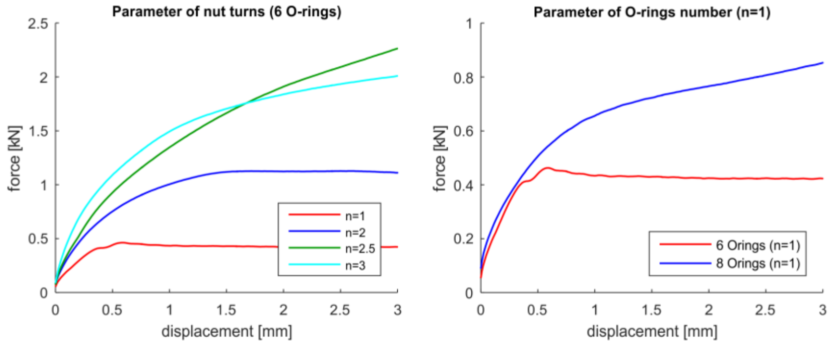

Fig. 7 Measured data for different locking parameter and number of O-rings

Tab. 1 Results of the testing

Number of turns n [1]	Number of O-rings [1]	Max. load F [kN]
1	6	0.45±0.08
1	8	0.64
2	6	1.06±0.09
2.5	6	0.95
3	6	2.84

Conclusions

The maximum pullout load for different configuration of the piston lock (number or nut turns and number of rubber O-rings) were obtained with the experimental testing. The maximum applicable load for locking parameter of 3 nut turns and six O-rings was 2.84 kN. However, crushing and lose of O-rings occurred for some tests when higher number of nut was used. Focusing on the application of the piston lock, maximum recommended nut turns is 2 when the max. load, i.e. locking, is 1.06±0.09 kN.

References

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