

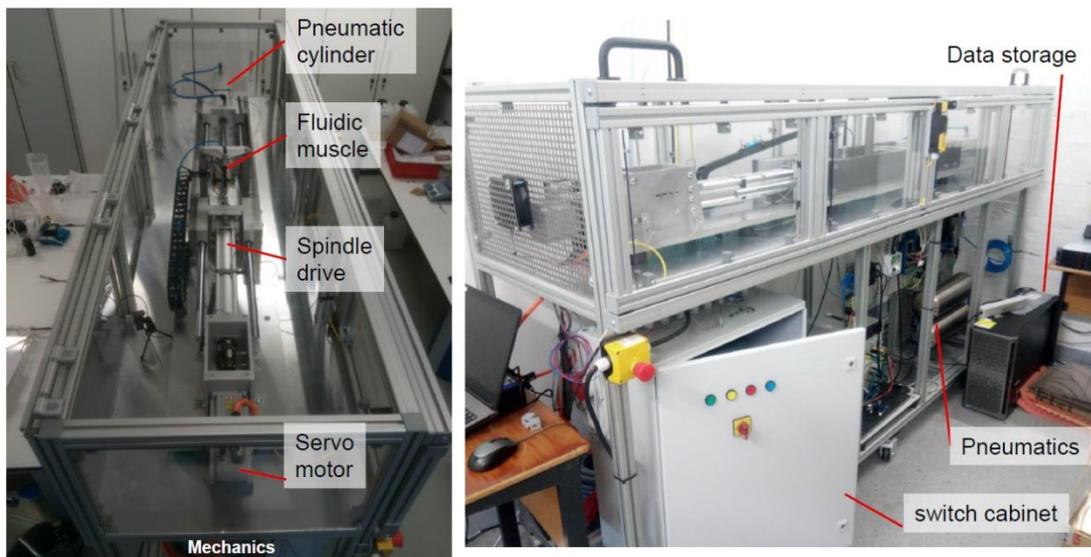
ZEMA TESTBED

A testbed for electromechanical cylinders

August 2018

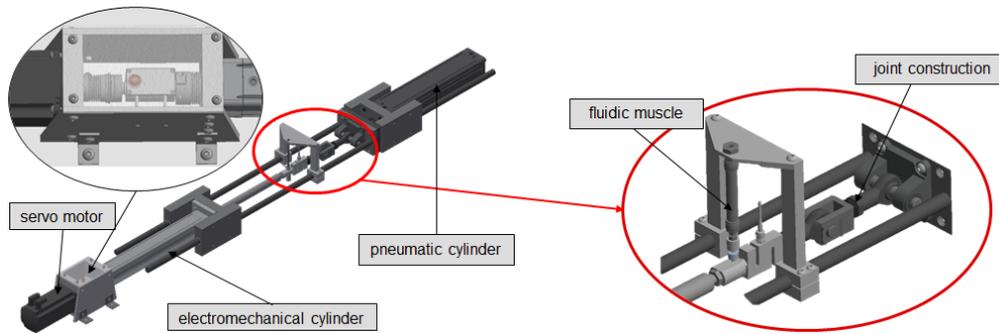
THE ZEMA TESTBED

The ZeMA testbed was developed for condition monitoring, lifetime prognoses and end-of-line tests of electromechanical cylinders (EMCs) with a spindle drive. Long-term high load and speed driving tests are carried out at the testbed until an EMC failure occurs. Based on this, relevant sensors and characteristic signal patterns can be identified for condition monitoring as well as residual lifetime estimation of the EMCs.



ZeMA testbed for condition monitoring of EMCs [ZeMA gGmbH]

The test set-up consists of the tested EMC and a pneumatic cylinder to simulate a variable load on the EMC in axial direction. To accelerate the wear progression, a force in lateral direction can also be applied with a fluidic muscle on the EMC. The actuators are coupled with a joint construction to allow lateral displacements. The servo motor and the EMC are coupled through a torque measurement box.



Experimental set-up with torque measurement box and joint construction [ZeMA gGmbH]

After the first test, the joint construction was replaced by a rigid connection. So, no lateral force is actually applied on the EMC.

Sensors in the ZeMA testbed

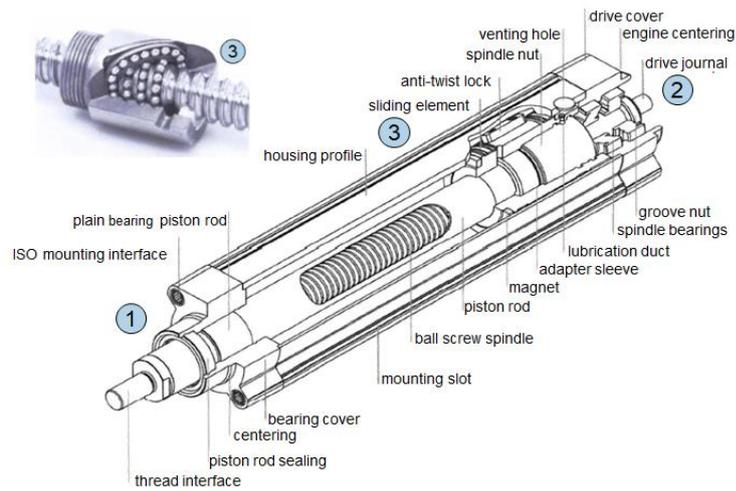
The following table gives an overview of the various process sensors used in the testbed.

location	sensor	amplification	interface	range	bandw.
motor current 3x	Sensitec CMS2005	Internal	-12..12V SE	-15..15 A	200 kHz
encoder motor	Festo CMMP-AS motorcontroller	Internal	-10..10 V	stroke range	-
torque motor	Lorenz DR2112	Internal	-10..10V SE	-15..15 Nm	10 kHz
axial force	Lorenz K-25	Lorenz E-LCV / I12	4..20 mA	-10..10 kN	1 kHz
lateral force	Althen AUMM-50	Althen TLB	4..20 mA	-500..500 N	200 Hz
vibration ball bearing	Kistler k-shear	-	IEPE	-50..50 g	20 kHz
vibration plain bearing	Kistler k-shear	-	IEPE	-5..5 g	8 kHz
vibration piston rod	Kistler k-shear	-	IEPE	-50..50 g	20 kHz
sound emission of spindle	G.R.A.S. 46 BE	-	IEPE	35..160 dB	4..100 kHz
pneumatic pressure	Festo VPPM pressure valve	internal	0..10 V	0..10 bar	-

Sensors used in the ZeMA testbed [ZeMA gGmbH]

Electromechanical cylinder (EMC)

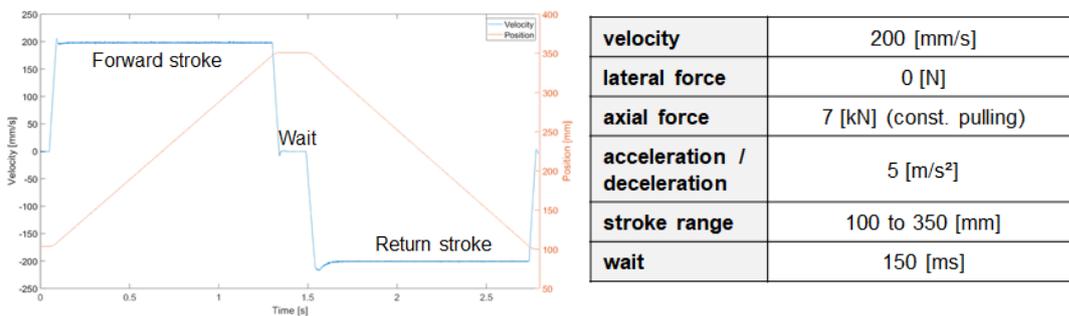
Electromechanical cylinders are widely used in applications that require a high repetition accuracy of $\sim 10 \mu\text{m}$ and high forces. Due to their capability to combine high loads and precision, both assembly / handling systems and tool machines are typical applications of EMCs. The spindle drive as a passive mechanical component of an electromechanical cylinder converts the rotary movement of the driving servo motor into linear stroke. The wear and failure relevant parts of the EMC are the plain bearing (1), the ball bearing (2) and especially the ball screw drive (3).



Components of an electromechanical cylinder [Festo AG & Co. KG]

Laboratory tests

The first test started in 2017. A working cycle during the test consists of a forward stroke, a waiting time and a return stroke, always using maximum acceleration. The entire working cycle lasts 2.8s. The combination of a high axial load, a high traverse velocity and a high acceleration results in a fast wear progression.



Working cycle (left) and relevant experimental parameters (right) [ZeMA gGmbH]

The deviation of the setpoint from the actual value of the control parameters of the motor controller is used as failure criteria, i.e. the test is completed when the EMC can no longer follow the drive commands due to increased friction.

Acknowledgements

This test bed was developed in the frame of the project MoSeS-Pro funded by the German ministry for Education and Research. Support by Festo AG for designing and realizing the test bed is gratefully acknowledged.