Theoretical and Applied Mechanics

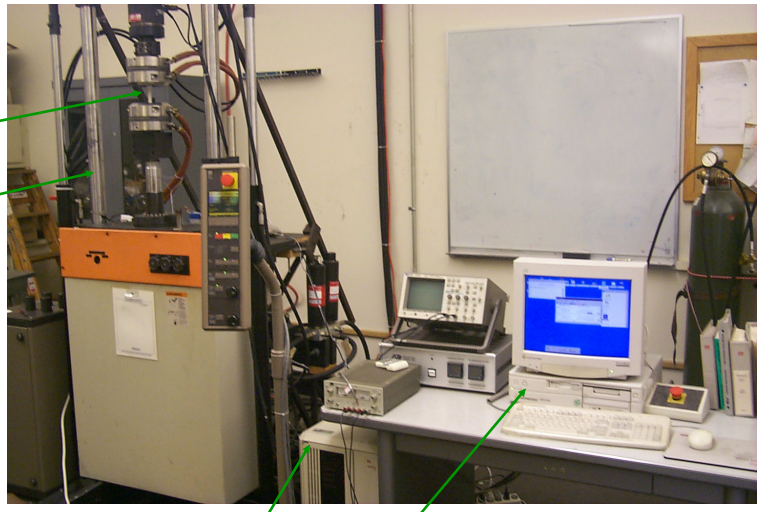
Virtual Labs, Real data
Materials Testing System

CORNELL

Overview

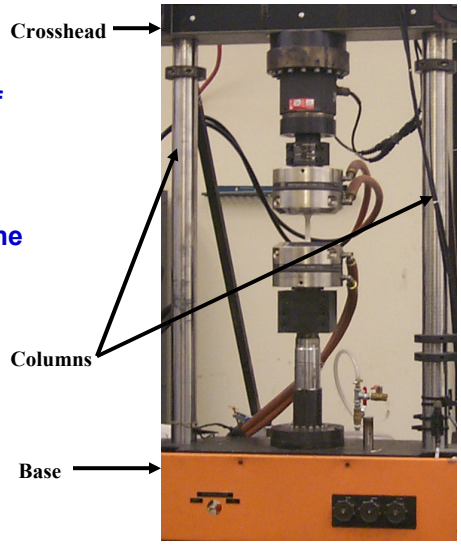
- System can test materials in tension, compression, torsion.
- Can apply tension or compression only, torsion only, or a combination of tension and torsion.
- Loading can be static or dynamic.
- Digital data acquisition is integrated into system.
- Maximum load capacity is 88,000 N (20,000 lbs).
- Maximum torque capacity is 1100 N-m (10,000 lb.-in).
- Displacement range ± 50mm (100 mm total).
- Rotation range ± 50^0 (100^0 total).

Test System Photograph



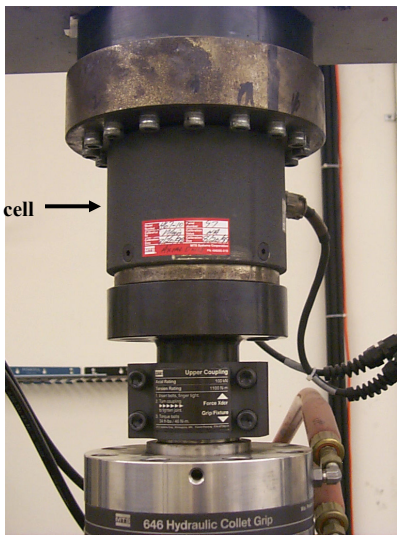
Load Frame

- Load frame consists of two rigid columns, a crosshead and a base.
- Provides mounting for other components of the machine.
- Movable crosshead accommodates specimens of different sizes.



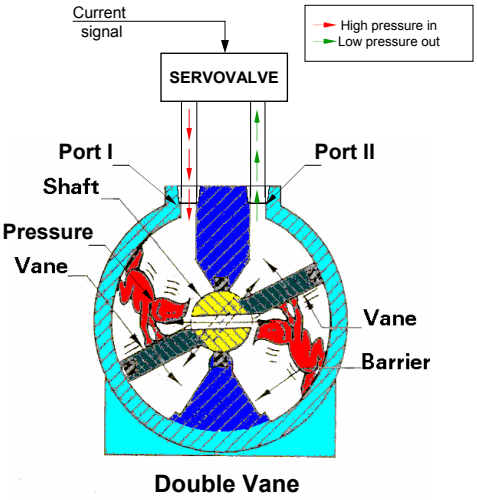
Load Cell

- Bi-axial load cell measures axial force and torque.
- Transducer converts force or torque into an electrical signal read by the control system.
- Calibration is done by factory technicians.
- Calibration values stored in test system software.



Rotational Servohydraulic Actuator

- Applies torsional loads
- Powered by high pressure hydraulic oil.
- Has built-in transducer (RVDT) to measure rotation.
- Servovalve controls oil flow into and out of actuator.
- Smallest possible weight/size ratio
- Fast response
- Figure shows the working principle of a rotary actuator



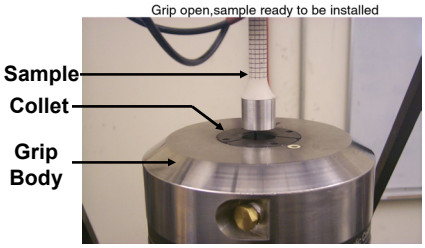
Double Vane

Arrows indicate direction of fluid flow

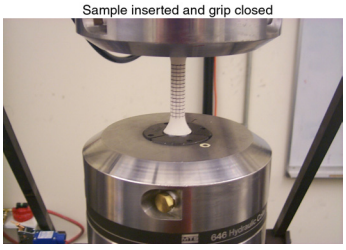
Hydraulic Grips

- Oil pressure tightens collets around the samples.
- Can grip any sample up 2.54 cm (1 in.) dia.
- Other shapes and sizes can be accommodated by changing the grip inserts.
- Axial and torsional load can be applied simultaneously.

Grip open,sample ready to be installed

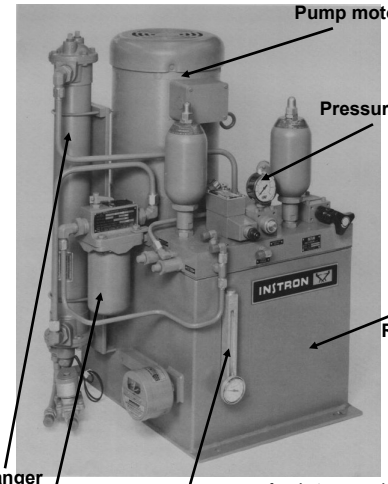


Sample inserted and grip closed



Hydraulic Power Supply

- Provides hydraulic oil to the servohydraulic actuator.
- Provides a constant flow of 22.7 liters per minute @ 21 MPa (5 gallons per minute @3000 psi).
- Uses oil-to-water heat exchanger to keep the oil at safe temperature.

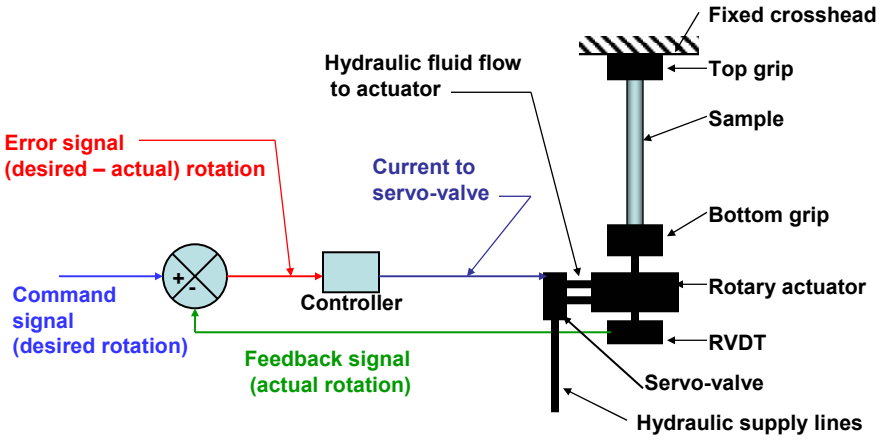


from Instron manual

Actuator Control System

- Rotational control system can apply either a specified rotation history or a specified torque history – for example twist at a rate of 1 degree/second, or load at a rate of 10 N-m per second.
- Axial system can apply either a specified displacement history or a specified load history.
- Feedback system, shown on next slide, is used to maintain control.

Feedback Control System Diagram (Rotation control example)



Summary

- Test machine can apply a static or dynamic programmed load.
- Test machine elements include: load frame, load cell, grips, actuator, hydraulic power supply.
- Control system uses feedback to maintain desired position or load.

Slide 1

In this presentation we look at the features and working of the test machine system that we use to perform the torsion test. The test machine is a versatile system capable of performing different tests according to user needs. The test machine can perform tension, compression and torsion tests or a combination of tension and torsion. The loading can be static or dynamic. Data acquisition is integrated into the test system and stores the test data in the hard disk of the attached computer. The maximum axial load that the machine can apply is 88,000 Newtons. The maximum torque capacity is 1100 Newton-meters. The displacement range is ± 50 mm and the rotation range is $\pm 50^0$.

Slide 2

This is a photograph of the test system. On the right is the computer which provides a user interface with the test system. The computer also stores the test data. The digital controller provides an interface between the computer and the test system. On the left is the test machine.

Slide 3

Now we will look at the various elements of the machine. This slide shows a close up view of the machine. The two columns and the base form the load frame. The load frame provides mounting for other components of the machine. The height of the crosshead above the base can be changed to accommodate specimens of different sizes.

Slide 4

The bi-axial load cell is capable of measuring axial force and torque. It consists of a transducer which converts the force or torque into an electrical signal. This electrical signal is read by the control system and the data acquisition system. Calibration of the load cell is performed by factory technicians and the information is stored in the test system software.

Slide 5

The rotational servohydraulic actuator is used to apply torsional loads. It is driven by high pressure hydraulic fluid. The actuator has a built-in rotary variable differential transducer, or, RVDT to measure rotation. An attached servo-valve controls both the direction and volume of the hydraulic fluid into and out of the actuator. Vane type rotary actuators have the smallest possible weight to size ratio, fast response with no backlash and long life. The figure on the right shows the working principle of a double vane rotary actuator. Let's look at the mechanism of anticlockwise rotation of the actuator. High pressure oil is pumped inside the actuator from port I and the shaft begins to rotate in the anticlockwise direction. Opposite chambers in the actuator communicate through a hole in the shaft. Low pressure oil flows out the actuator through port II. Similarly, for clockwise rotation the direction of fluid flow is reversed.

Slide 6

The hydraulic grips can be used to apply axial and torsional loads simultaneously. The oil pressure is used to make the collets grip or ungrip the sample. The grips can be used to hold any sample of 2.54 centimeter, or one inch, diameter. Other sample sizes can be used by changing the grip inserts. The pictures on the right show the grips open and closed.

Slide 7

The hydraulic power supply system is used to supply hydraulic fluid to the system. It can provide oil to the system at a constant flow of 22.7 liters per minute at a pressure of 21 megapascals. It uses a shell and tube type heat exchanger to cool the oil that gets heated during the machine operation. The picture shows the hydraulic power system. The arrows show the heat exchanger, oil filter, pump motor, pressure gauge, the oil temperature indicator and the oil reservoir. In this particular system the pump is immersed in the oil reservoir.

Slide 8

The actuator control system consists of two parts, the axial control and the rotation control. The rotation control can be applied by specifying a pre-programmed rotation or torque history. For example, we can specify a rotation of one degree per second or apply a torque loading of ten newton meters per second. The axial control can be used to apply an axial load or displacement history. Feedback is used to maintain control and is shown on the next slide.

Slide 9

The sketch is a schematic of the machine with a sample gripped between the top grip and the bottom grip. The portion above the top grip shows the fixed crosshead. The RVDT and the hydraulic servo valve are connected to the rotary actuator. The first step is to apply a command signal, in our case a desired rotation. The command signal goes to a comparator where the actual rotation of the machine is compared with the command signal. This generates the error signal.

The error signal is the desired rotation subtracted from the actual rotation. The error signal is fed to the controller. The controller then generates a current and sends it to the servo valve. Depending on sign and intensity of the current, the servo valve adjusts the flow of hydraulic fluid to the actuator in order to move the actuator closer to the desired rotation, i.e. to minimize the error signal.

Slide 10

We have looked at the features and working of the test machine. The test system can be used to apply a programmed static or dynamic load. We have had a look at various elements of the test machine- load frame, load cell, grips, actuator and the hydraulic power supply. Lastly, we looked at how the control system uses feedback to maintain the desired position or load.