What is a Dynamometer

Dynamometer – is an apparatus for measuring the mechanical power generated, or absorbed by a rotating machine.
Modes of Operation

**Loading** – resisting the motion of a rotating device.

**Motoring** – driving the motion of a rotating device.
What are Quadrants

1 Quadrant – load in one direction
2 Quadrant – load in both directions
4 Quadrant – load or motor in both directions
Types of Dynamometers

- Frictional
- Hydrokinetic (Water brake)
- Hydrostatic
- Electric
  - DC
  - AC
  - Eddy Current
  - Hysteresis Brake
Frictional Dynamometers

- Typical on chassis type systems
- Torque provided by disc brakes
- Power dissipated as heat
- Low speed operation only
- Simple design
- High maintenance
- Low cost
- No way to account for glazing or breakdown of friction materials.
Hydrokinetic Dynamometers (water brake)

- Typically seen on engine dynamometers
- Torque by turbulent shear forces
- Power dissipated as heat through waste water
- Can develop high torque/speed
- Poor low speed capability
- Low inertia (fast response)
- Two quadrant operation only
- Low cost
Hydrostatic Dynamometer

- Positive displacement hydraulic pump
- Power dissipated as heat
- High torque/speed
- Excellent low speed capability
- Can provide 4 quadrant operation
- Involves high pressure oil
- Moderate cost
Electric Dynamometers
DC

• DC electric motor/generator
• Power dissipated as electrical energy – can regenerate
• Limited maximum speed
• Good low speed operation
• High inertia
• 4 quadrant operation
• Relatively complex/expensive
Electric Dynamometers
AC

- AC electric motor with vector drive
- Power dissipated as electrical energy – can regenerate
- Limited maximum speed
- Excellent low speed operation
- Moderate inertia (typically ¼ of DC unit)
- 4 quadrant operation
- Most complex/expensive
Electric Dynamometers
Eddy Current

• Torque by electromagnetic induction
• Power dissipated as heat
• Limited maximum speed
• Poor low speed operation
• Relatively low inertia
• 2 quadrant operation only
• Simple robust
• Moderately expensive
Electric Dynamometers
Hysteresis Brake

- Torque by electromagnetic induction
- Power dissipated as heat
- Excellent high and low speed operation
- Low inertia
- 2 quadrant operation
- Simple/robust
- Limited to low power (approx. 10 Hp)
- Relatively inexpensive
Control System Considerations

- Integrated Control & DAQ or separate systems
- Channel count
- Control Rates
- Acquisition Rates
- Location
- Cost
- Scalable
- Proprietary or Open Architecture
Dynamometer Control / DAQ Systems

- Black Box
- PC Based (non-realtime)
- Real-time Based
PC Based

- Non-proprietary systems typically using COTS I/O boards
- Poor Control – open loop control, non-deterministic
- Scalable typically in-expense and limited
- Location outside the cell
- Low channel count
- Control speed depends on configuration and subsystems used.
- Acquisition depends on configuration and I/O Boards
- Low cost
Black Box

• Proprietary systems
• Excellent control – closed loop control of both torque and speed
• If scalable typically expense and limited
• Closed architecture – hardware available only from vendor
• Location typically outside the cell
• High channel count
• 500 – 1000hz control and acquisition
• High cost
PXI Based Realtime

• Non-Proprietary
• Excellent control – closed loop control of both torque and speed
• Highly scalable cost effective virtually unlimited
• Open architecture – hardware available from over 60 vendors
• Location both inside & outside the cell
• High channel count
• Control and acquisition as high as 10kHz
• Moderate cost
Safety Systems

- Integrated with Controls
- Independent
Integrated with Controls

- Software Alarms & over limit shut downs
  - Global alarms
  - Channel alarms and conditionals
  - Programmatic shutdowns with defined procedures
- Hardware wired
  - E-stops
- Cell Safeties
  - Door interlocks
  - Fire suppression
- Requires deterministic control
Independent

- PID controllers for temperature
- Subsystems – fuel delivery, etc.
- PLC based cell safeties
  - Door interlocks
- Communicate to the controller via Bus or integrated digital I/O
Common Measurements

Sensors

- Torque – mV with excitation; load cell, in-line torque transducer, non-contact torque flange
- Speed – TTL pulse, inductive sine, quadrature; magnetic pick-up, encoder
- Temperature – low mV with CJC; J,K,T type thermocouples
- Pressure / strain – mV, 4-20mA or high level voltage; pressure transducers, strain gauge, load cell
- Flow – Pulse, 4-20mA, high level output; flow meters
- Relays / Switches – Various voltages
Common Measurements

Subsystems & Other Requirements

- Spark/Fuel Control
- Cooling towers
- Emissions
- Hydraulic systems
- Environmental
- Vehicle Bus – CAN, J1939, J1850
INERTIA Demonstration
Wineman Technology has successfully developed a full turnkey solution clutch dynamometer including a motor, drive bearings, clutch engagement, guarding, and control system. The control system provides closed loop control of drive speed (up to 7,800RPM) as well as clutch engagement torque (up to 30,000inch pounds,) distance (up to 1 inch,) and force (up to 5,000lbs.)
The Thermal Acquisition System utilizes Wineman Technology’s INERTIA™ real-time software and National Instruments’ real-time controllers to acquire over 530 channels of input including thermocouples, RTDs, voltages, and frequencies at acquisitions rates ranging from 10 Hz to 200 Hz. It also features the capability to perform up to 1,000 real-time air and thermal calculations on all inputs while performing redundant data logging to the real-time controller and host PC.
The enclosure pictured above houses a wide variety of electrical components required to upgrade the customer’s Seat Durability Tester. The Seat Durability Tester is a complex machine requiring tight control of several loops including hydraulic load, motor speed and acceleration. The enclosure houses a National Instrument's PXI Real-Time controller running WTI's Inertia software to operate the system's many control loops. Additionally, the system contained six variable frequency drives for controlling six of the system’s eight motors.
Available Configurations and products
Available Configurations and products
Real-time Experience

INERTIA Systems

- AW Dynamometer – 1500 HP Dynamometer Controller
- Borg Warner, Truck Chassis Roll Dynamometer Controller
- Borg Warner – Air Pump Test System
- Brose, Multi-axis Hydraulic Controller
- Case New Holland, Powertrain Dynamometer Controller
- Caterpillar, General DAQ System
- Continental Teves, Load Frame Controller
- Delphi – Engine Durability
- Durst, Gear Box DAQ System
- Eaton Truck, Hybrid Motor Dynamometer Controller
- Federal Mogul – Champion Spark Plug, Engine Dynamometer Controllers, IMEP Spark Plug Rating Controllers
- Federal Mogul, Hydraulic Piston Impulse Controller
- GE Aircraft, High Speed Gear Dynamometer Controller
- Georgia Tech University, General Dynamometer Controller
- General Dynamics, Abrams Tank Wind Tunnel DAQ System
- Hitachi Automotive, Dual Hybrid Motor Dynamometer Controller
- John Deere – Horicon, Gator Chassis Roll Dynamometer Controller
- John Deere – Waterloo, Diesel Engine Dynamometer Controller
- John Deere – Waterloo, Multi-axis Hydraulic Controller
- John Deere – Waterloo, Wind Tunnel DAQ System
- Kubota – Engine Durability
- Parker Hannifin, 600 HP Hybrid Transmission Controller
- Princeton University, General Controller
- Richard Childress Racing, 800 hp Engine Dynamometer Controller
- RCO Technologies, Multi-axis FMVSS Controllers
- RCO Technologies, Fatigue Test Station Controllers
- Refractory Composites – JSF Clutch Test
- Rochester Institute of Technology, Gearbox Dynamometer Controller
- Steelcase (3) – Drop / Vibration / Durability
- Toyota, Automotive Seat – Jounce and Squirm Controller
- University of Dayton Research Institute, Helicopter Swashplate Hydraulic Controller
- University of Texas, 1200HP Waterbrake Dynamometer Controller
- WaveCrest Labs, Chassis Roll Dynamometer Controller
- Williams International, Turbine Engine DAQ System
- Woodbridge Group, Hydraulic Load Frame Controller
- Wright-Patterson AFB, Wind Tunnel DAQ System
- Wright Patterson AFB, 192” Landing Gear Dynamometer Controller