

# Designing a Mechanically Adjustable Speed Drive for AC Motor Applications to Eliminate Vibrations Without Additional Harmonics

Introducing Flux Drive® - A patented, permanent magnet Coupling and Adjustable Speed Drive

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# Why Develop a Mechanical ASD?

Problems encountered in electric ships using AC motor applications pointed to the need for a mechanical ASD.

- Vibration and harmonics interfere with navigation and other sensitive equipment
- Harsh environment at sea
- Ship board personnel not trained in VFD installation and maintenance.
- Real-estate to house VFD filters and air conditioning is expensive.

# Design Challenges

- Must run in harsh and harmonic sensitive environments
- Must not interfere with sensitive equipment
- Must meet or exceed performance standards of products currently on the market
- Must be easy to install by low tech workers
- Must work on multiple voltages
- Must be cost effective to install and maintain

# Existing Technology Considerations

## Eddy current devices

### Pros:

- No touching parts (air gap)
- minimal vibration, no harmonics,
- works in multiple voltages

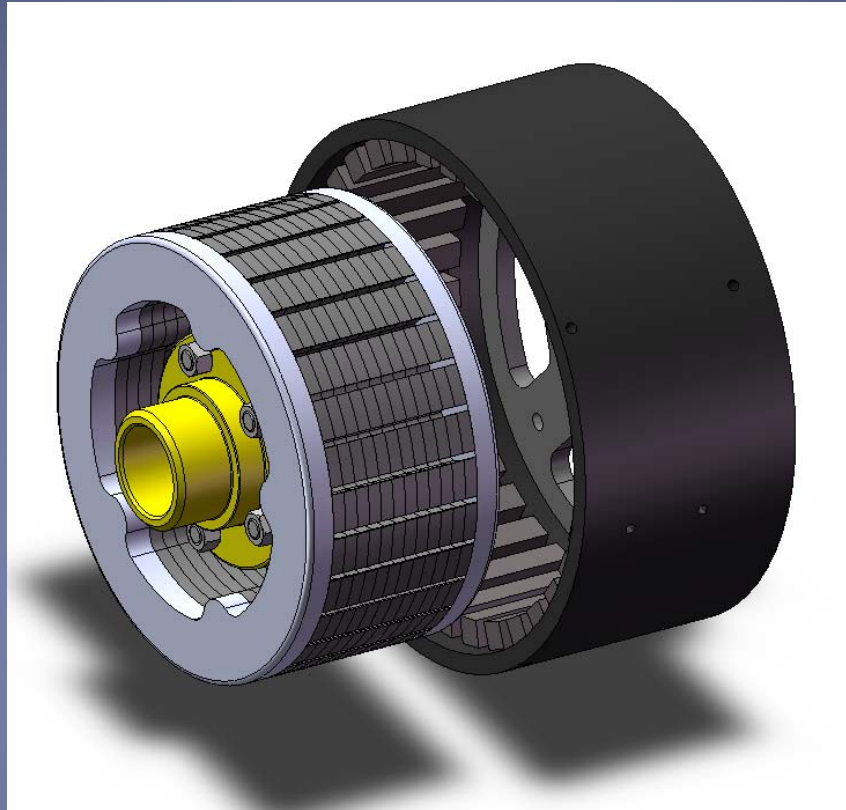
### Cons:

- chaotic eddy currents generate heat
- Don't scale well (large footprint)
- Requires external power source and expensive to manufacture

*But what if you create a closed circuit with the permanent magnets and eliminated the Eddy Currents?*

# Merging Permanent Magnets with Induction Rotor Theory

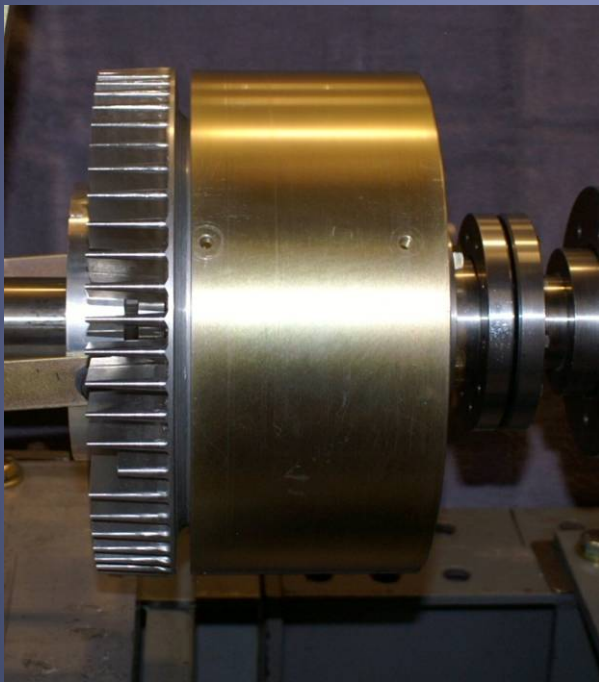
- Create a closed magnetic circuit that mirrors the role of the electro-magnetic circuit of the AC motor
- Introduce an induction rotor that can be slid in and out of the closed magnetic circuit to control the output speed of the motor



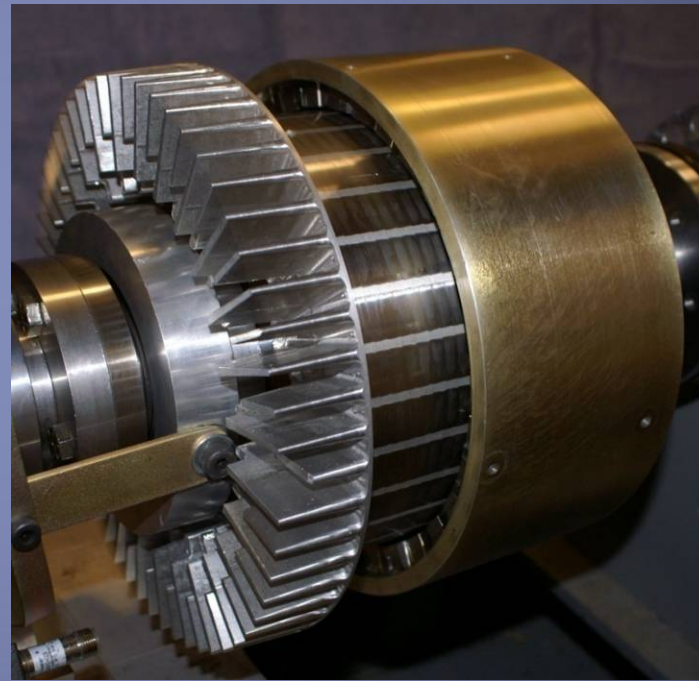
View of a Flux Drive<sup>®</sup> ASD

# From ASD to Coupling

Fully Engaged



Rotor Disengaged



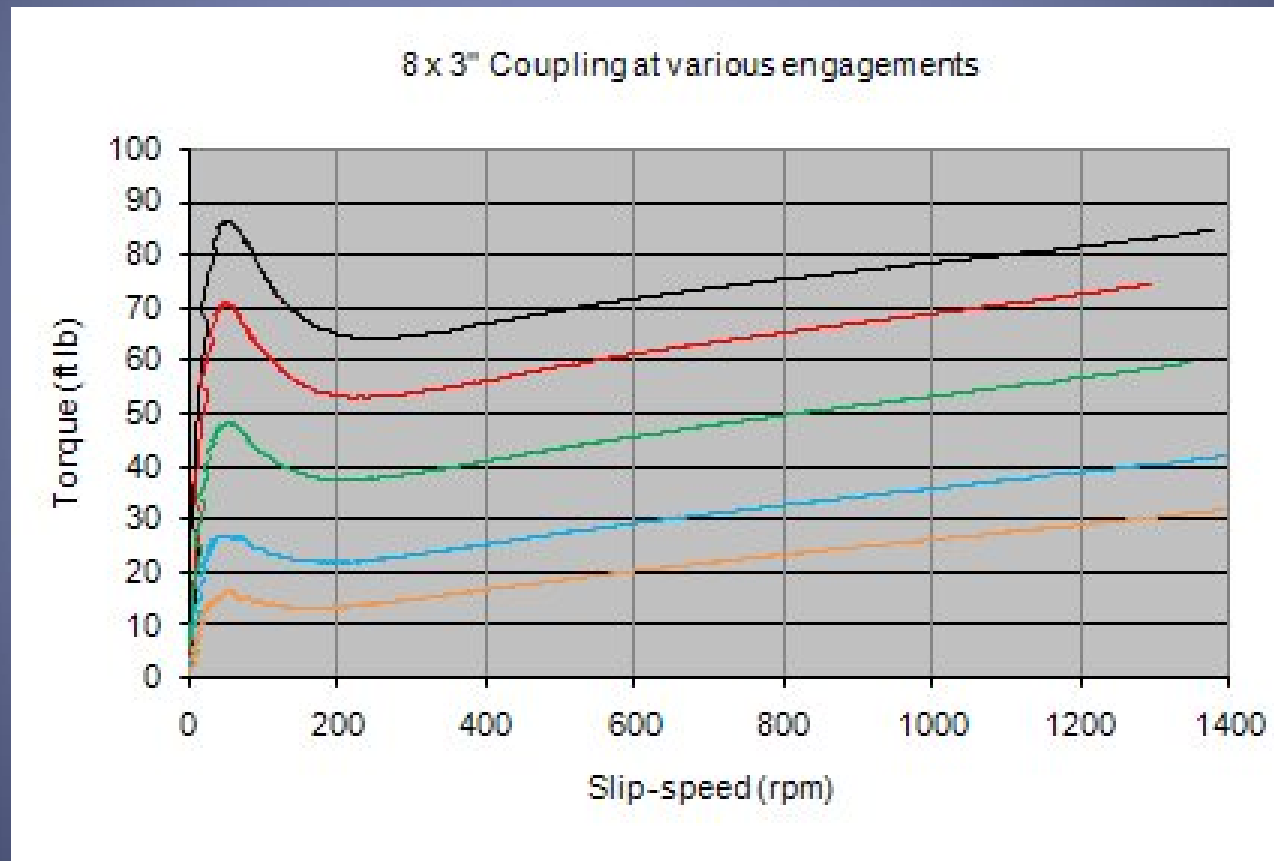
By changing the percentage of overlap of the Can and Rotor, you control the transfer of torque between the two members

# First ASD Prototype

- Discovered the “soft-start” characteristics during full engagement.
  - Rotor breaks away from the magnetic circuit
  - Allows the load to come up to speed slowly
  - Prevents “locked rotor” currents in the motor
  - Reduces ‘in-rush’ currents



# Experimental speed / torque characteristics of a Flux Drive<sup>®</sup> product



# From ASD to Coupling

- Disengage the Rotor from the Can, and the output speed can be controlled, creating an Adjustable Speed Drive.
- Fully engaged, the Flux Drive product operates as a “soft-start” coupling

# Performance Testing of Mechanical Soft-Start Coupling

25 hp Motor connected to Blower (Belt Driven)

Current vs. Time

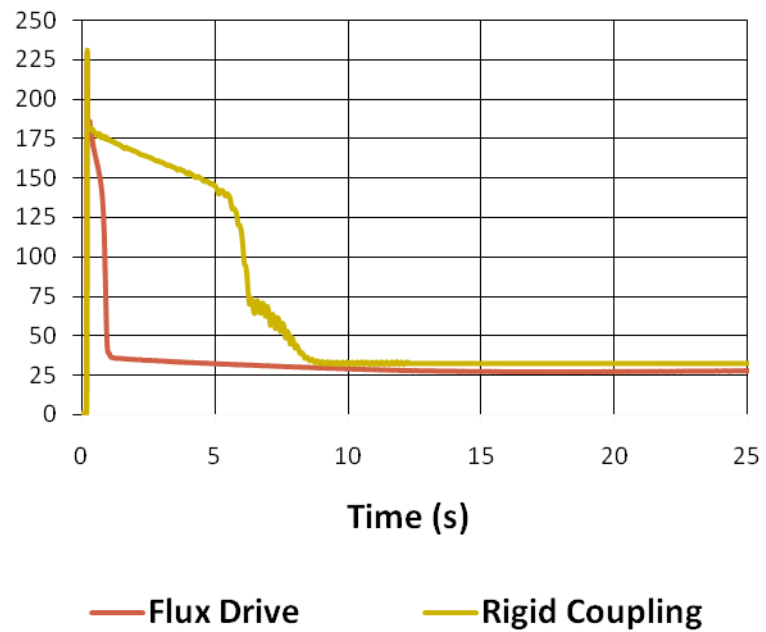
Power vs. Time

Power Factor vs. Time

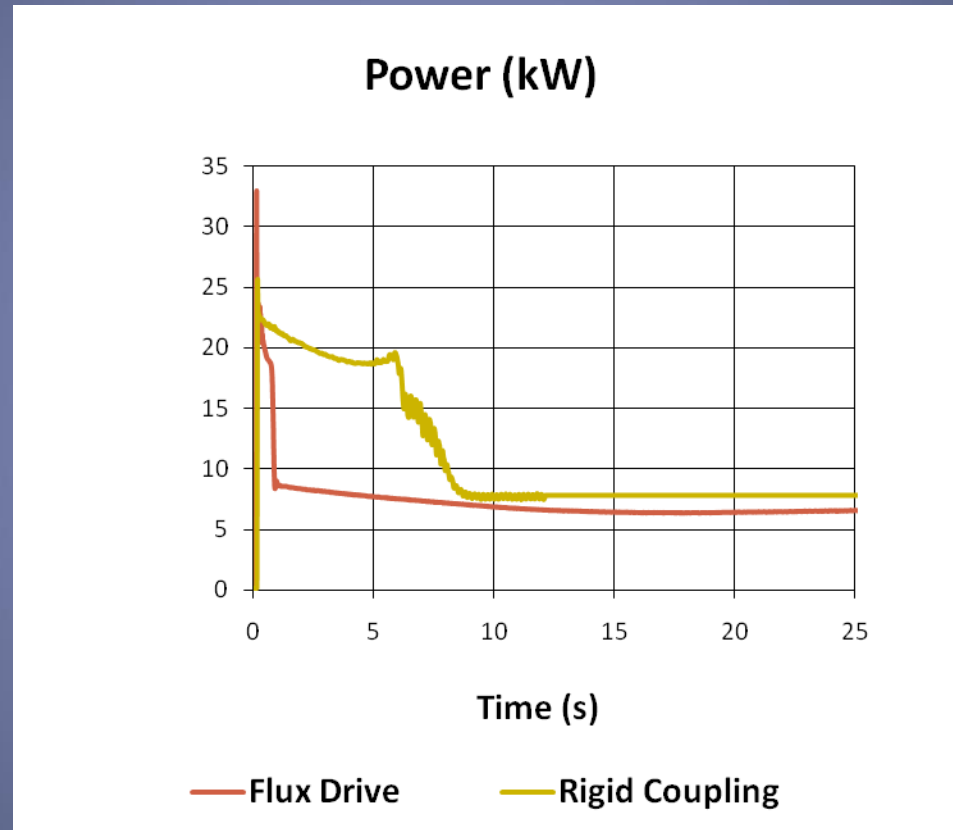
Energy vs. Time

# Soft-Start Current vs. Time

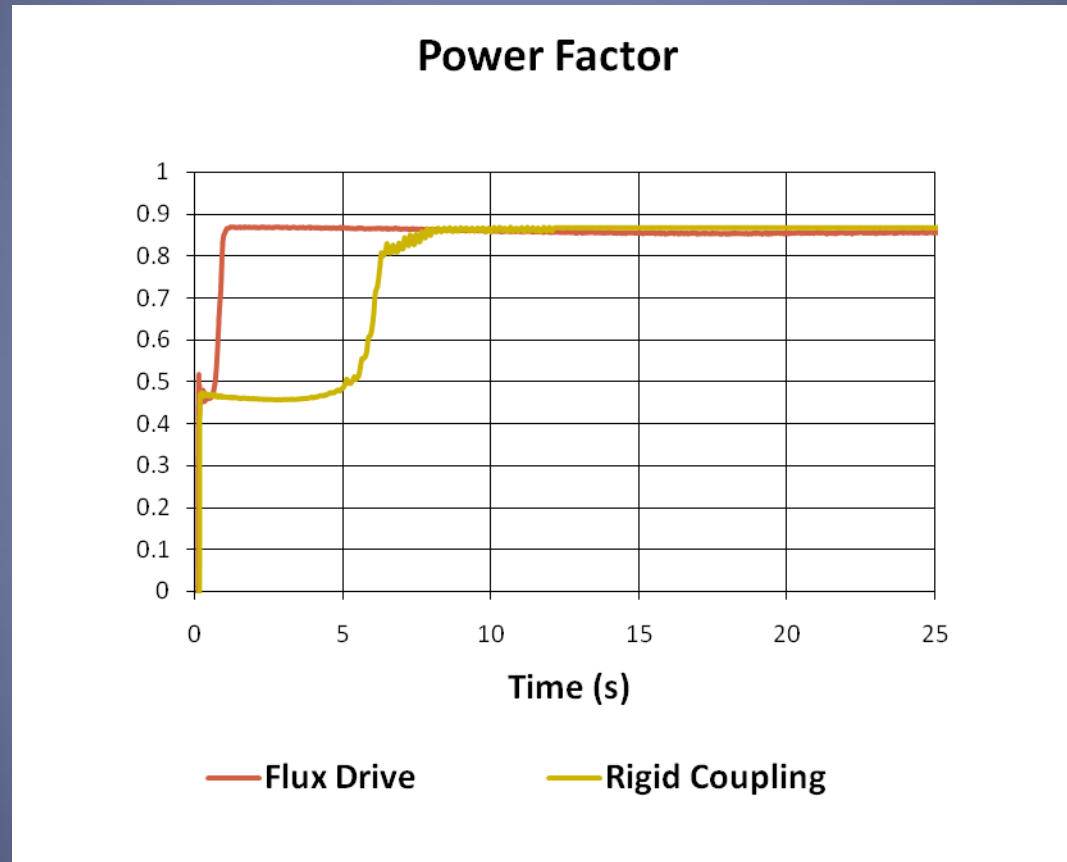
Start Up Current (A)



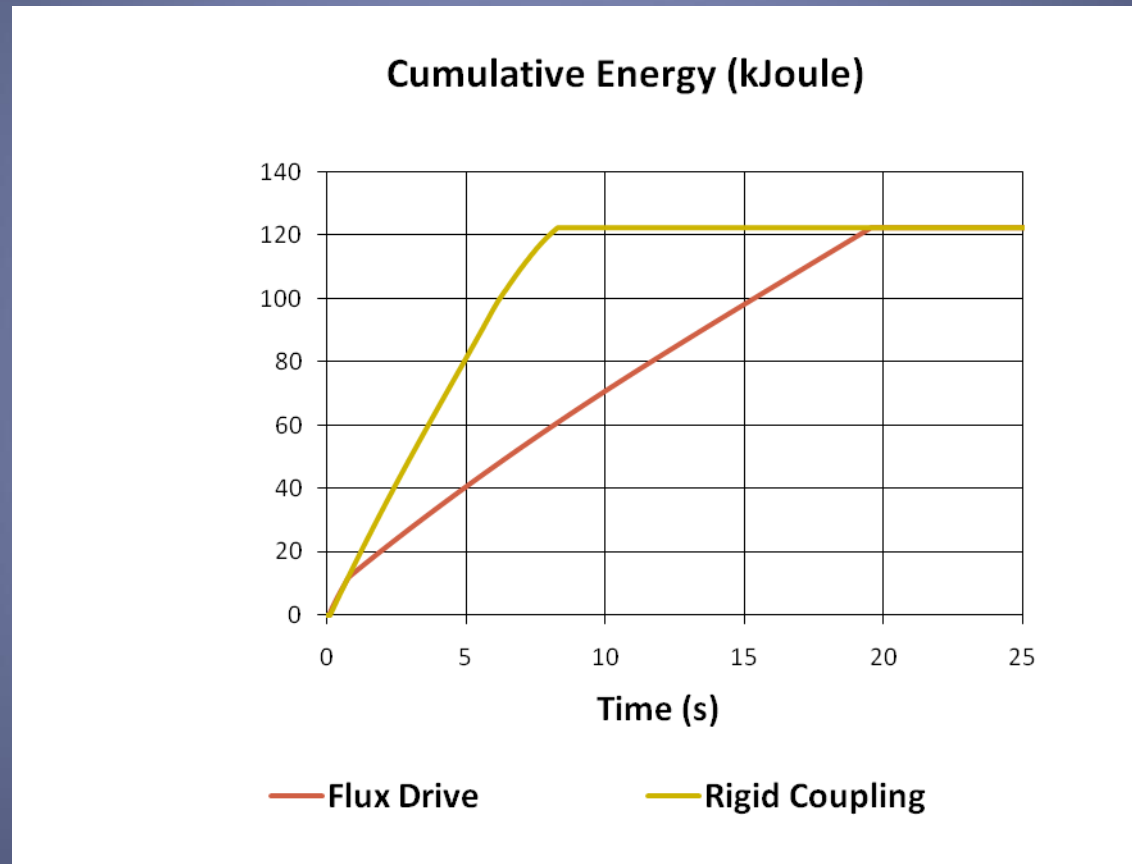
# Soft-Start Power vs. Time



# Soft-Start Power Factor vs. Time



# Soft-Start Cumulative Energy vs. Time

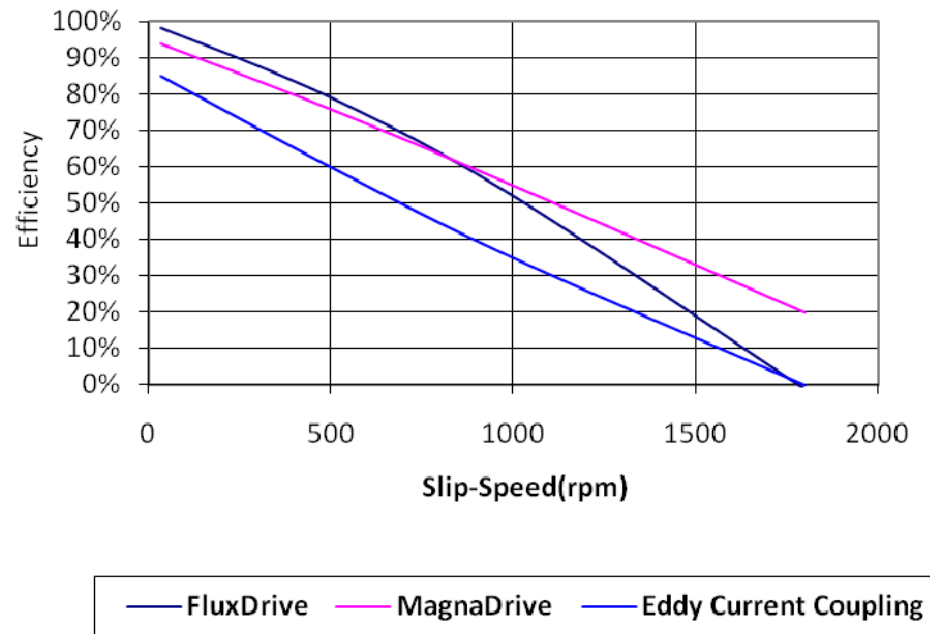


# Performance Data Summary

- 'Soft-start' characteristics
- Power Input
- 'In-rush' Current
- Operates <2% slip at full torque/HP
- Operating temperature <25 degrees F above ambient

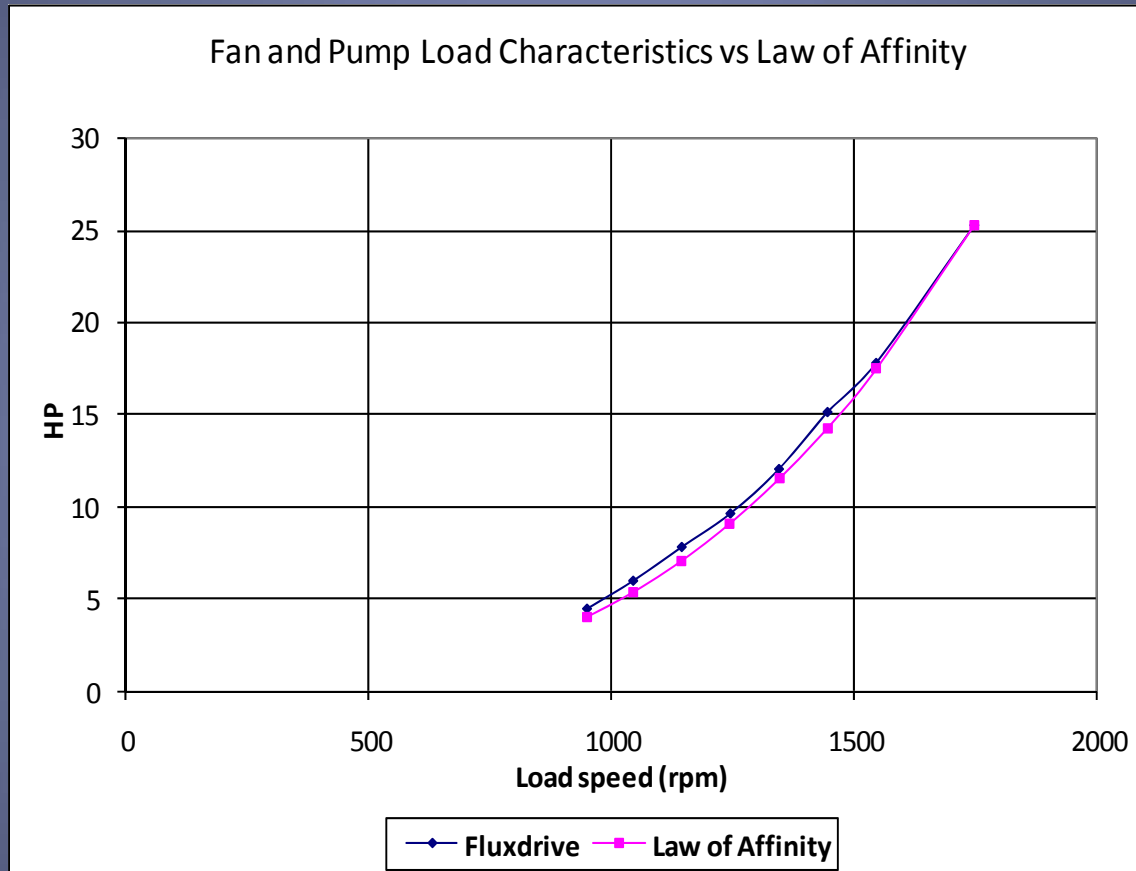


# ASD Characteristics



Efficiency plots of ASDs

# ASD Characteristics



Flux Drive<sup>®</sup> vs. Laws of affinity

# FIRST COUPLING INSTALLATION

## Evergreen State College – Olympia, WA

### Customer Problems:

- Boiler Application experiencing excessive vibration.
- 30yr old motor and bearings worn and misaligned

# FIRST COUPLING INSTALLATION

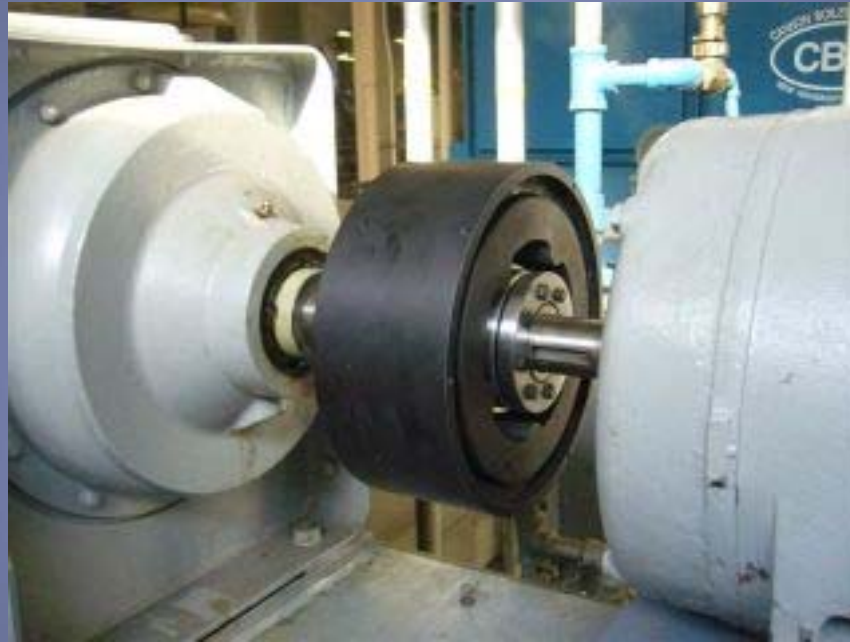
## Evergreen State College – Olympia, WA



Old boiler coupling

# FIRST COUPLING INSTALLATION

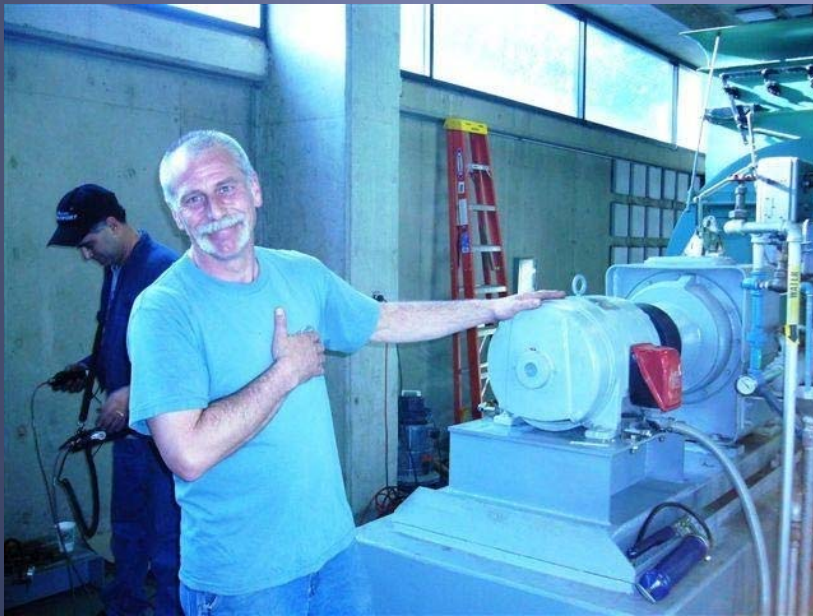
## Evergreen State College – Olympia, WA



Flux Drive<sup>®</sup> coupling

# Results of “Soft-Start” Installation

- The Flux Drive ‘soft-start’ coupling reduced the vibration by a factor of five. Additionally, the coupling ran with 0.035” of offset misalignment and tolerated a fluid drive which had input bearing housing looseness of approx. 0.025”.



**The Tony Test.** The first time in his 30yrs at Evergreen that the motor has run smooth, with no vibration.

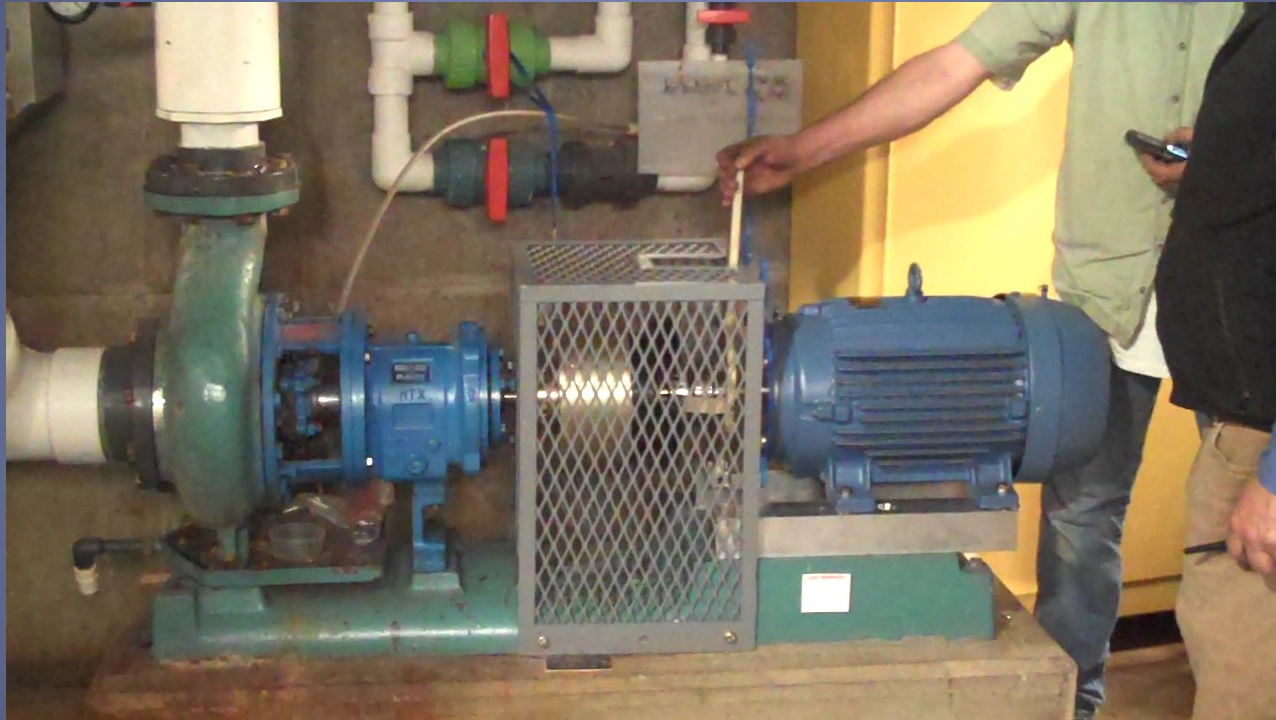
# Seattle Aquarium Installation



Old aquarium coupling



# Seattle Aquarium Installation



Flux Drive<sup>®</sup> ASD



# Review of Product Performance

- Runs in harsh and harmonic sensitive environments
- Does not interfere with sensitive equipment
- Meets and exceed performance standards of products currently on the market
- Easy to install by low tech workers
- Work on multiple voltages
- Cost effective to install and maintain

## CONCLUSION

- Reduce power required to operate machinery at variable speeds compared to VFDs and eddy current couplings,
- Eliminate introducing harmonic frequencies that cause distortion in the electrical systems
- Eliminate the need to install complex electronic filtering systems to reduce %THD to acceptable levels
- Reduce the ambient noise associated with VFDs and other competitive products,
- Reduce the life cycle costs of replacing and repairing expensive electronic components of other drives,
- Reduce peripheral costs (e.g., separate Filter rooms and air conditioning) involved with introducing a single (or multiple) VFDs to a system requiring speed control,
- Provide cost effective operations in harsh environments (saltwater, gases, etc.).
- Allow medium and high voltage applications to have an ASD that does not increase in price dramatically due to the higher voltage requirement of electronic drive products.