

TM  ANOTEK MOTION TECHNOLOGIES



**ANOTEK**  
**MOTION TECHNOLOGIES**

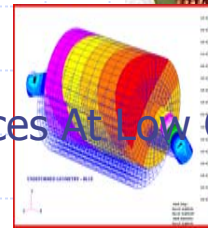
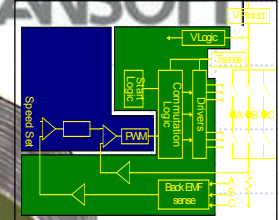
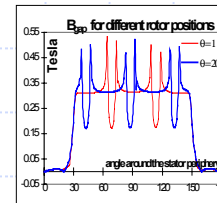
## *Electro-Mechanical Innovation*

**Motors, Generators**  
**Drive Systems**  
**Controls**  
**Actuators**

High Performance Electromagnetic Optimization  
For Automotive Application.

# Mission

- ◆ **Motor and Control Systems** Optimization
- ◆ **Low-Cost Production.**
- ◆ **Leverage Existing Manufacturing**
- ◆ Deliver Advanced **Design Consulting** Services At Low Cost.



# Strategic Focus

## TARGETED PRODUCTS

- Integrated Brushless Motors With Optimized Mating Digital Controls
- Low cost high volume motors & drives
- 12-42 Volts automotive applications
- Electric drives for vehicles/boats
- Ultra-High Efficiency Systems
- Electro-mechanical specials

## TARGETED MARKETS

### Transportation & Energy Industry

- Automotive, Marine
- Fuel Cell
- Electric Vehicle & Hybrid
- Pumps – Variable Speed
- Flywheel Systems
- Distributed Power Systems

## Company Profile



**Headquarters Offices**  
Ann Arbor, MI

Co-Located With ***Independent Engineering Laboratories Corp (IEL)***

- **Quick Product Development, Prototypes and Testing**
- **65k Sq-ft Building for Manufacturing & Assembly**

### **Headquarters: Ann Arbor, Michigan**

- **Strategic Location for Automotive Market and Academic Resources.**
- **Machine shops & automotive rated testing**

### **Engineering Team with 20 yrs average experience**

- **Majority from General Electric**
- **Extensive Automotive Experience**
- **Highly talented >100 Patents**
- **Design & Manufacturing Experience**
  - **Motor design experts**
  - **Power Electronics Experts**
  - **Motor Drives and Digital Control Experts**
  - **Mechanical & Thermal Engineering**
  - **Manufacturing and Quality Control**
  - **Six Sigma, QFD, AQPQ, FMEA, DFMA**

**Co-Located With  
Independent Engineering  
Laboratories Corp.**

Dyno



- ◆ Quick Product Development, Prototypes and Testing
- ◆ 65k Sq-ft Building for Manufacturing & Assembly.

Proto-Shop



Vibration



Thermal  
Permeation

DAQ



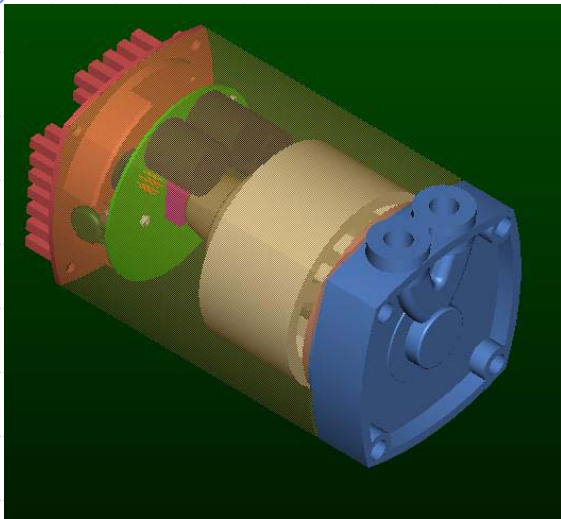
## Danotek Automotive Innovation Designs

- High Performance Motor for Steering
- Steering Tilt
- Air moving low cost “brushless”
- Fuel-pump
- Fuel-cell Accessory Drives
- Electric Vehicle Drive
- Wireless tire pump

### Key Objectives

- ✓ Cost
- ✓ Reliability, Durability
- ✓ Performance
- ✓ Technology

## Products: Integrated VS Seal-Less Pump 1/3-3/4 HP



### Production Variable Speed Pump

- Variable Speed Seal-less pump **PATENT PENDING.**
- 200 – 600 Watts
- 12-100 Vdc
- 115, 220 AC
- Feedback
  - 4-20 mA
  - 0-10V
  - PWM
  - Adjustable Feedback

### Pump types:

Centrifugal – high flow

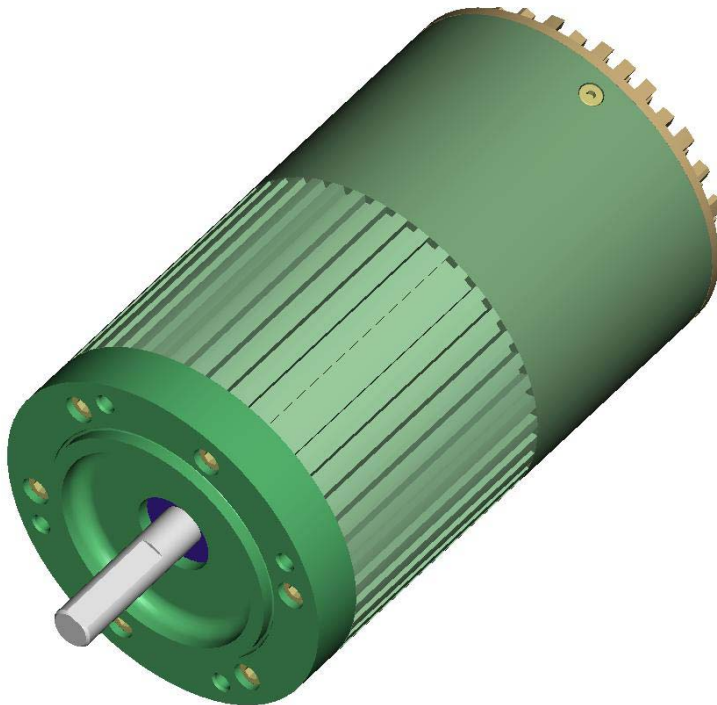
Regenerative Turbine pump – high pressure

### What is unique about it?

- Small, quite, efficient – low operating cost
- Variable flow/pressure, regulated
- Low system cost
- Seal less
- Works on AC 115/220: DC 12-100 V

**Extensive Demand Through OEM Channels**

## General Purpose Integrated Control Variable Speed Brushless Motor & Control



- ◆ ¼ to 5 Hp upto 12000 rpm
- ◆ NEMA 48 C or other Interface Standards
- ◆ Simple convection or fan-cooled
- ◆ Up to 12,000 RPM
- ◆ Speed Regulation
  - Manual
  - Fixed speed
  - Feedback
    - ◆ 4-20mA
    - ◆ PWM
    - ◆ 0-5 V

## Automotive Experience

### ◆ Production

- HVAC Blower Motor –
- Engine Cooling Fan PM
- Starter Alternator –
- EV Drive Induction motor
- Fuel pump motor
  - ◆ Brush
  - ◆ Brush-less
- Steering Tilt –
- Steering

### ◆ Research & Development

- EV Drive Hybrid (DCX, GM, DOE)
- Wireless Tire Pump
- Transmission actuator motor
- High performance steering motor, magneto resistive position sensor

## Brushless PM Options

### Construction

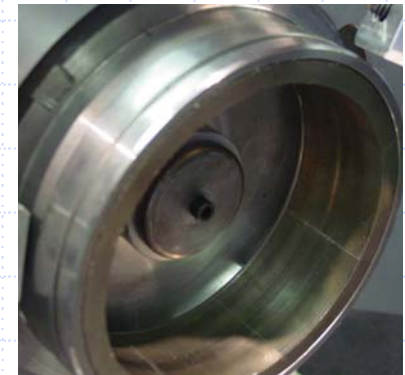
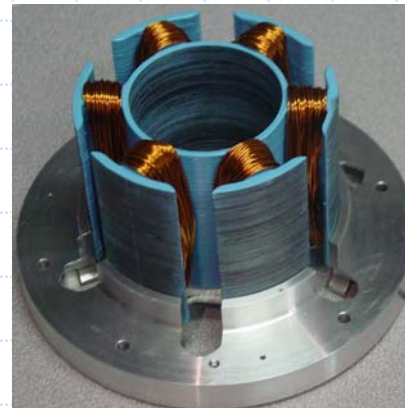
- Inner Rotor
- Outer Rotor
- Axial Gap
- High performance\* PP

### Drive & Control

- Sine Wave (SVPWM)
- Trapezoidal, SixStep
- Sensorless, sensors
- Salient pole vs distributed

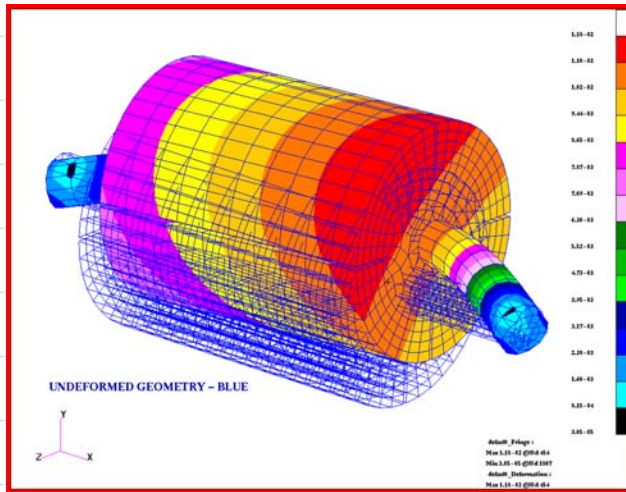
### Magnet type

- Rare Earth NdFeB, SmCo
- Ferrite, Ceramic
- Bonded Nd, Ferrite
- Other

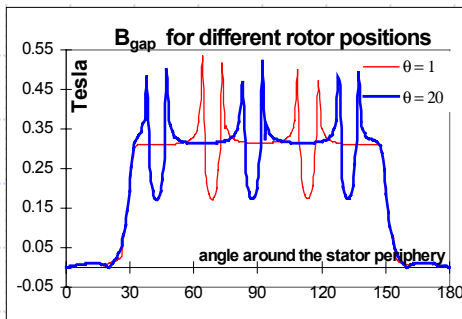


# Design Optimization & Analysis

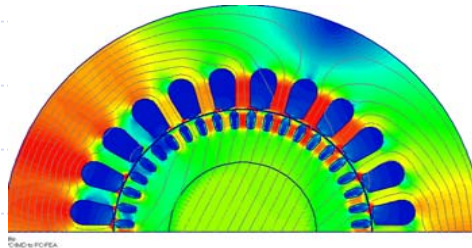
Stress,  
Modal



- ◆ **Analysis & Simulation**
  - Electromagnetic **ANSOFT**
  - Power Electronics, control
  - Thermal
  - Mechanical stress, vibration
- ◆ **Manufacturing & Quality Control**
  - QFD, Six Sigma, DOE, TQM
  - APQP, FMEA, DFMA
  - Low/high volume production experience



Electromagnetic



# Design Variables

$$X1 = L_m$$

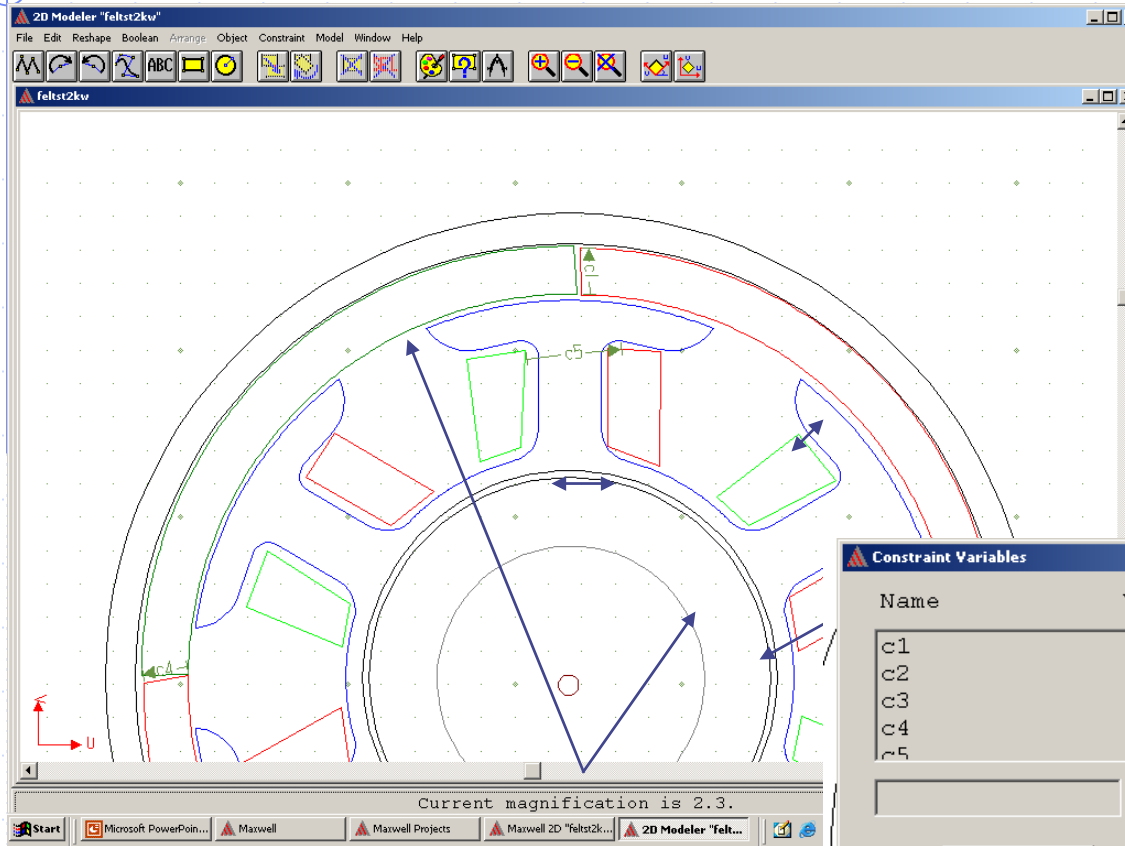
$$X2 = Thw$$

$$X3 = Thl$$

$$X3 = Syk$$

$$X4 = Ryk$$

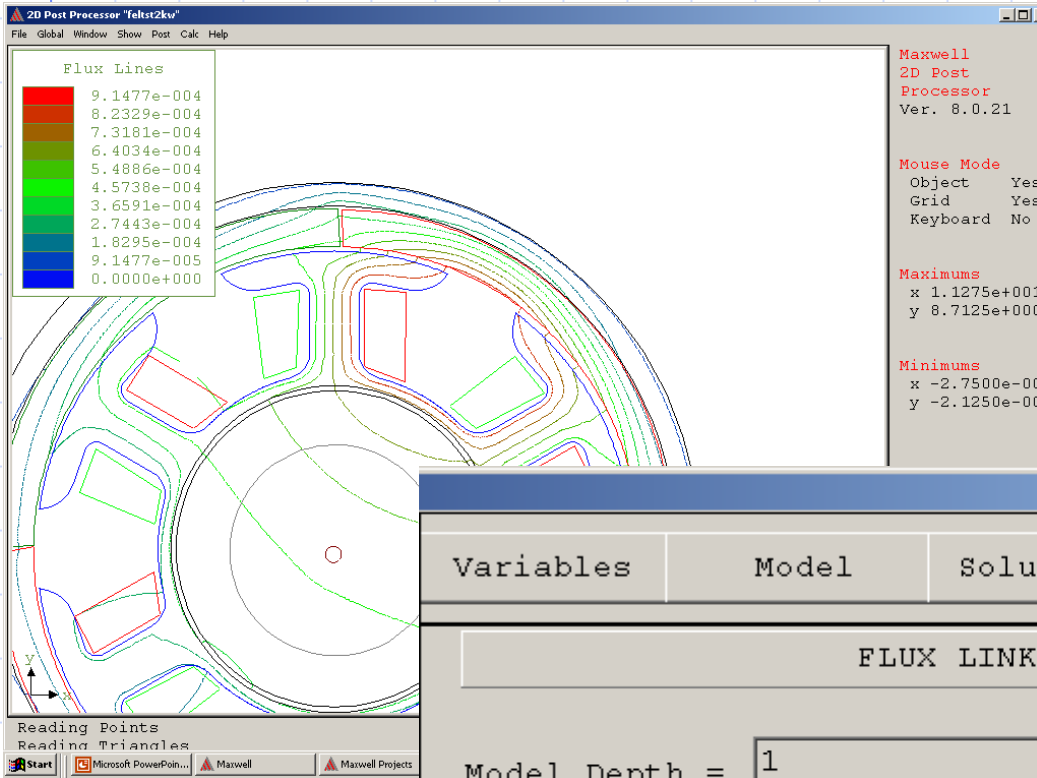
$$X...11$$



| Name | Value      | Expression       |
|------|------------|------------------|
| c1   | 0.28039334 | 0.28039333988454 |
| c2   | 0.25136085 | 0.25136084967621 |
| c3   | 0.24417103 | 0.24417102678944 |
| c4   | 0.26782494 | 0.26782494046625 |
| c5   | 0.57010762 | 0.57010762493508 |

Below the table, there is an input field with an equals sign, and buttons for Update, Add, Delete, Help..., Dataset, and Done.

# Output



Y1= Torque

Y2= Flux linkage

Y3= Inductance

Bg= f(angle)

Calculated,... BEMF, Res....

TQ/Speed

| Variables             | Model                  | Solutions | Convergence | Profile |
|-----------------------|------------------------|-----------|-------------|---------|
| FLUX LINKAGE SOLUTION |                        |           |             |         |
| Model Depth =         |                        | 1         | m           |         |
| Object Name           | Calculated Flux (Wb/m) | Turns     | Total F     |         |
| coil1                 | -0.00049395898         | 1         | -0.0004     |         |
| coilp2                | -0.00027170736         | 1         | -0.0002     |         |

# Project Experience *Joint Tactical Electric Vehicle (JTEV) – US Military*



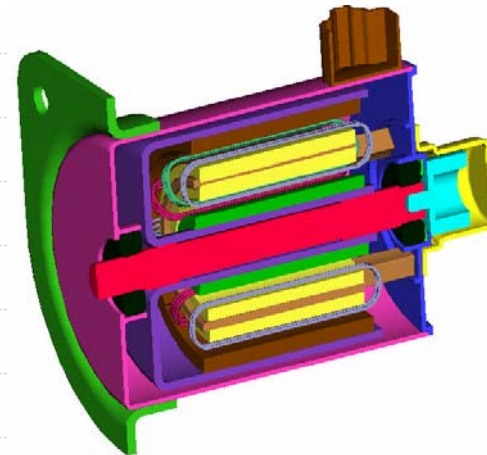
- ◆ Hybrid Electric Vehicle
- ◆ APU 60KW generator / motor



## DANOTEK NEW PRODUCTS (patent Pending) Automotive steering

### Electric Steering Motor

- High efficiency
- High power density
- Low cost
- Reliable
- New in the industry
- Unique position sensing



**Objective... Demonstrate the Concept**

# **Wireless Tire Pump While A Vehicle is Moving**

- **Counteract a Slow Leak**
- **Transfer Power Across Air Gap**
- **Wireless Power Transfer**
- **Remote Control**
- **Improves: Safety, Fuel Economy, Tire Life**

# Options Considered

| Alternatives                                   | Options                | Evaluation  |
|--|------------------------|---|
| <b>ElectroMagnet</b>                           | Vertical               | <ul style="list-style-type: none"> <li>◆ Modeled. Prototype Built.</li> <li>◆ Concept Validated. Meets Criteria.</li> </ul>   |
|  | Horizontal             | <ul style="list-style-type: none"> <li>◆ More Complex</li> <li>◆ Feasible – Needs More Work To Evaluate</li> </ul>  |
| <b>Hybrid Permanent Magnet + ElectroMagnet</b> | Vertical or Horizontal | <p>Concept Discarded</p> <ul style="list-style-type: none"> <li>■ Contamination Risk – Stray metal in air gap.</li> <li>■ May work if magnet is located within the tire in a horizontal layout</li> </ul>   |
| <b>Induction Generator + Electric Pump</b>     | Located Inside Tire    | <p>Superior Option</p> <ul style="list-style-type: none"> <li>■ Moving Coil Generator “belt” up to 100 Watts</li> <li>■ Integrate with Electric Pump and Sensor in One Encapsulated Package – Inside Tire, through Rim</li> <li>■ Generator Concept Layout Complete</li> <li>■ Initial Prototype Being Fabricated</li> <li>■ Needs Development Funding</li> </ul> |

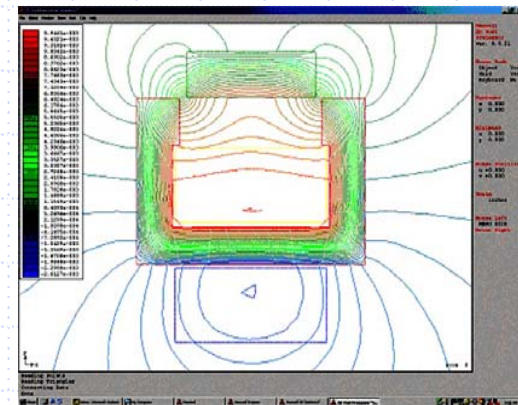
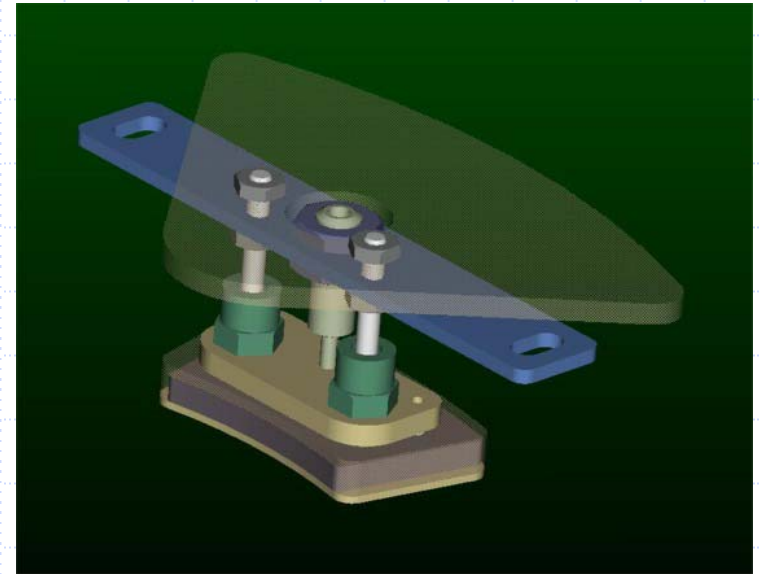
# Delivered Prototype Characteristics

## Vertical Stroke Design

- ◆ **Dimensions: 5" x 2" approx.**
  - Scalable
- ◆ **Electro-Magnet**
  - **13 lb. Peak force**
    - ◆ 250 wire turns @ 10 amps
    - ◆ Can achieve more than 60psi with different pump-spring

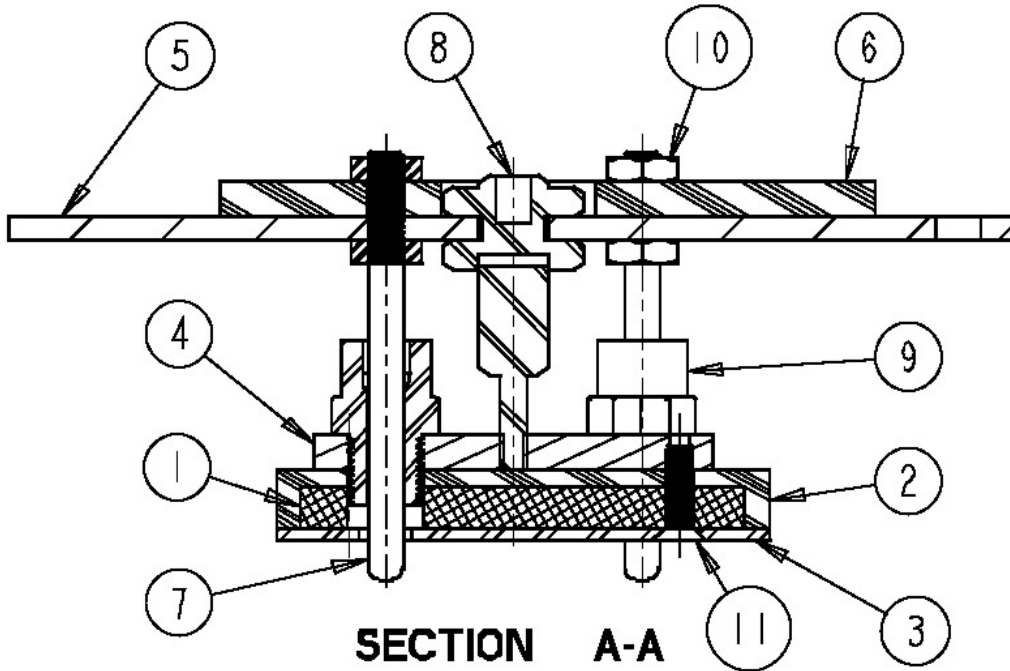
## ◆ Pump

- Stock-Catalog Item
- 1/4" Diameter Piston, 1/4" Stroke
- 0.20 cc per Stroke
- **1.5 lb. Spring Force... Approx**
  - ◆ Use greater force spring in future designs for higher pressures



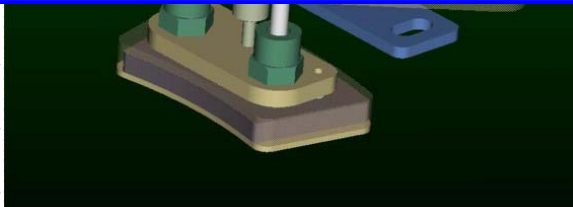
**Finite Element Analysis**

# Prototype Components



## COMPONENTS

1. Steel Core
2. PVC Core Casing
3. Flux Plate
4. Guide Mount Plate
5. Rim Mounting Plate
6. PVC Cover
7. Guide Shaft
8. Pump
9. Bushing
10. Nut
11. Machine Screw



# Prototype Results

## OBJECTIVE

- ◆ 43 psi
- ◆ 0.15 cc
- ◆ 0 – 1200 RPM
- ◆ Activated Remotely
- ◆ Integrated with Wheel

## RESULTS

- ◆ Actual: 20 psi @ 2 Volts, 5 Amps  
Achievable: 60 psi @ 12 Volts, 2 Amps
- ◆ 0.20 cc air pumped per revolution
- ◆ Operates at normal driving speeds
- ◆ Energizing Circuit Remotely Controllable
- ◆ Bolts to Wheel Rim