Novel Long-Life Mechanical Pump for Spacecraft Thermal Control

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Background

- Advanced Bionics Inc, a biomedical started in 1998
- Initial goal was development of medical blood pumps having low hemolysis and thrombosis for long-term use
- Intellectual Property
  - * US Patents #5,685,700, #5,924,848, #5,938,412, #6,206,659
  - * One US Patent is allowed
  - * Several Foreign Patents

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Pump Concept

- Centrifugal pump with a rotary impeller
- No-bearings and no-seals
- Density of impeller is lower than density of pumping fluid

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Pump Concept (cont'd)

- Impeller support
  - In non-operational mode: impeller free-floats inside the housing
  - In operational mode: impeller stably rotates in the center of the housing passively supported by fluidic forces acting on impeller:
    - centrifugal forces in radial direction
    - drag and pressure forces in axial direction
  - When impeller is not in the center, the result of the system force is not zero and acts towards the center until it rebalances the impeller
- Impeller coupling configurations
  - Magnetic drive pump: impeller permanent magnets are coupled to outside permanent magnets, which are rotated by electric motor
  - Canned motor pump: impeller permanent magnets are magnetically coupled to outside rotating field produced by windings

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Advantages of ABI Pump

- High durability and maintenance-free since no parts in mechanical contact and no parts to break
- is an intrinsic force balance (vs.active magnetic bearings)
- No stagnation regions
- Explosion-proof
- Contamination-free
- Outside leaks-free
- Use for aggressive and delicate fluids
- Low shear stress
- Low mass (impeller is a shell structure)

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Advantages of ABI Pump (Cont'd)

- Large clearances between the impeller and the housing
- Suitable for harsh environments
- Simplicity (less parts, many elements such as bearings, shaft, seals, etc. are eliminated)
- No tight manufacturing tolerances and balance since the impeller always finds its own position where all forces are balanced
- Impeller stability in the outer space is improved since gravity forces are reduced or eliminated
- Low costs (cost reduction by 80% in some applications)
- High reliability
- Noise vibration (signature) free

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Pump Applications

- This pump technology is applied to the cases where long term reliability and low cost are required. Also, specific advantages benefit other application
- Applications under development:
- Medical Blood Pumps
- Short-term Artificial Heart (by-pass surgery), 2 gal/min flow, 10 psid
- Long-term Artificial Heart (Implantable Ventrical Assist Device), 10 years life, 2 gal/min flow, 3 psid
- Chemical industry – up to 400 gal/min flow and 140 psid
- Spacecraft thermal control – 0.4 gal/min, 8 psid

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NASA SBIR Phase I Effort

- Phase I Contract NAS5-00084, 1999
- Proof-of-concept prototype
  - Fluid = CFC –11 (Freon 11)
  - Flow rate = .053 to .106 gal/min (.2 to .4 liter/min)
  - Pressure rise = 3 to 6 psid
  - RPM = 6,000 – 9,000
  - Material = Aluminum coated with Alumina
  - Impeller diameter = .75"
  - Maximum clearance between impeller and housing = .020"
  - Maximum operating pressure = 108 psi
  - Configuration = magnetic pump drive
  - Impeller / fluid density ratio = .7

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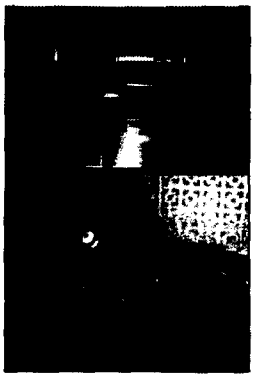
NASA SBIR Phase I Effort

- Engineering analysis
  - Impeller hydraulic design study
  - Impeller structure integrity study
  - CFD analysis
  - Manufacturability and cost analysis



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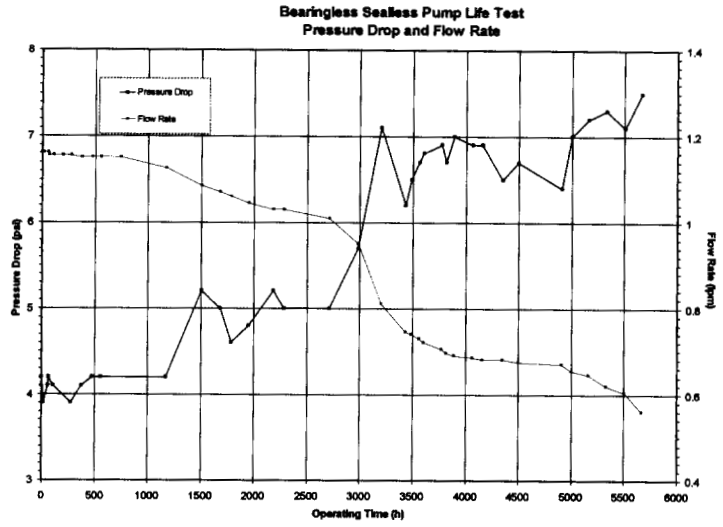
Phase I Life Testing at JPL



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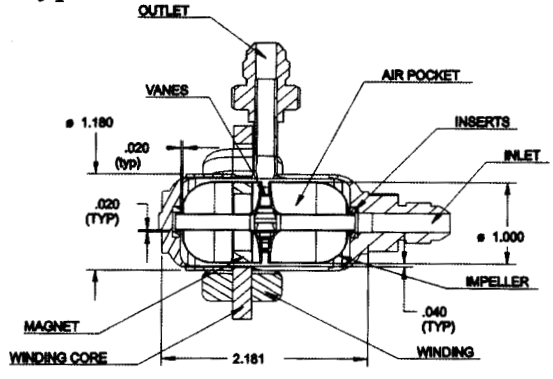
NASA SBIR Phase II Effort

- Phase II Contract NAS5-00221, December 2000
- Configuration = canned motor pump
- Prototype schematics



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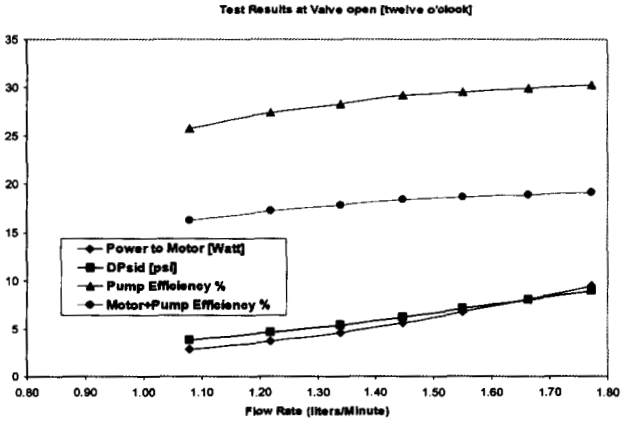
Pump Hydraulic Performance

- Valve open (twelve o'clock)
- RPM range = 4500 - 7000



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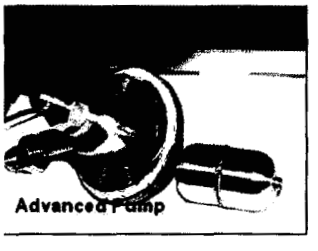
Prototype Parameters / Spec

- Fluid = HCFC (Hydrocloroflurocarbon) – 123
- Flow rate = .2 to .4 gpm
- Pressure head = 4-8 psid
- Pump material = St St 316 L
- Operating temperature = -30C to 50C
- Number of start/stop cycles = 1000
- Impeller/fluid density ratio = .7
- Operating life = 2 - 10 years



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Prototype Parameters / Spec

- Smallest clearances = .020"
- Total assembly mass (impeller+magnet+housing+motor) = 243 g
- Housing: OD = 1.2", Length = 2.4"
- Maximum Structural Pressure = 450 psi
- Occupied Space = 77 cc
- Magnet = NdFeB, Grades 39H to 45
- Sensorless Controller

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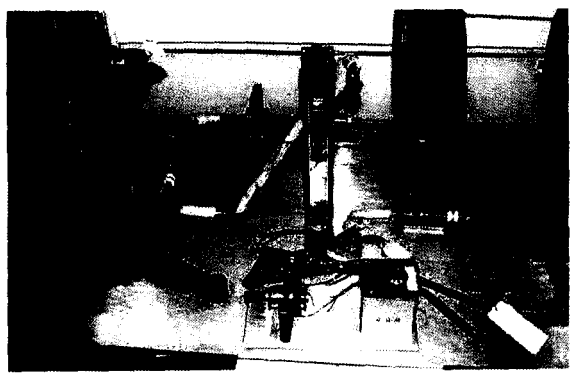
Life Testing at JPL – Test Setup



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Future Spacecraft Applications

- Deep space missions to outer planets (Jupiter, Titan, with 5 years or longer mission life) require long-life pumps
- Future Mars Surface systems with longer operational life on the Martian surface
- Earth orbiting instruments and platforms with 3 years or longer mission life
- Communication satellites using active thermal control

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Conclusion

- Technical feasibility of the novel long-life mechanical pump for spacecraft thermal control has been demonstrated
- Pump is of bearing and seal-free design with large clearances between the rotating parts
- Low cost, long-term reliability centrifugal pump has low mass and volume
- ABI has developed expertise in design and manufacturing pumps for space and aerospace applications
- ABI pumps can be designed to any specific fluids, performance specs, or application requirements

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