**Industrialization of a Small Scale Cryocooler**

**Introduction**
- Honeywell Hymatic have over 60 years experience in manufacturing JT coolers, Cryocoolers and Space Compressors (as sold by Northrop Grumman e.g. HEC Compressors).
- In 2003 Honeywell Hymatic signed a licence with RAL to industrialise a Small Scale Cryocooler (SSC) for Space and Earth markets.
- Honeywell delivered a protolype SSC to an industrial customer for integration to a sensor and performance evaluations. Positive feedback and suggestion for improvements were received.
- Continuous operation in customer’s devices, >12 months and counting with no change in performance reported.
- This presentation highlights the design characteristics of the SSC and the process of justifying and implementing these characteristics to the SSC and its performance requirements.

**Design Features of the SSC**
- Compact, scalable.
- Lower part count – No expensive moving Coil Former.
- No expensive radial magnet spring assembly.
- Good agreement over a wide range of operating conditions.
- The state of the art is represented by a parallel inductance and resistance. The total impedance includes the wiring resistance. Core losses arise from the core resistance which is a function of frequency and core characteristics. Dynamic losses arise from magnetic (damping) and eddy current losses from material properties. Fit the magnet and coil parameters into an equation to give the total impedance.
- Dynamic measurements as a function of current and frequency give the functional form of the coil characteristics, and also the core inductance. If simple function of current and frequency give the functional form of the coil and core inductance, the total impedance may be made.
- Dynamic measurements as a function of frequency and stroke give the core resonance and also the core characteristics.
- Fixed resonance frequency and the recoil rate may be derived from knowledge of the total impedance under particular operating conditions.

- **Motor Constant at Increased Radial Gap**
  - A larger radial gap between magnet and yoke is beneficial as it reduces the magnetic reluctance. The motor constant increases as the radial gap between the magnet and yoke increases. This is because the coil is more closely aligned with the magnetic field lines in the air gap. This results in a higher motor constant, which leads to a lower current requirement. The higher motor constant also helps to reduce the heat generated in the coil, resulting in better thermal performance.

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**Typical Motor Configuration – Radial Forces**
- The new motor
  - Lower part count.
  - No expensive moving Coil Former.
  - No expensive magnet assembly.
  - Compact.
  - Low magnetic interference.
  - Stepper coil, no moving electrical connections.
  - High reliability design (No. 9 cooling).
  - Enhanced design flexibility – Adjust frequency, modify scalable.
  - Radial force at increased Radial Gap
    - Radial magnetic force decreases with increasing gap is in inverse square law.
    - Idea radial force occurs at mid-stroke.
  - Radial magnetic force at mid-stroke position.

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