



neo

Magnequench

Development of Bespoke Epoxy Binder system for Home Appliance Application

Pr

Ce

Y

Ga

Nd

Ta

Introduction



- The presentation summarizes Magnequench's capability in developing a bespoke epoxy binder system.
- The compound developed using the bespoke binder system is useful in making a cost optimized magnet offering higher mechanical strength at high temperature.
- The magnets with higher mechanical strength allows to run the motor at higher speed and hence able to make the motor lighter and smaller.

Effect of Motor Speed on Size and Weight of the Motor



- The size of the motor depends on,

$$P_{out} = KB_{avg}acD^2LN_s$$

Where,

P_{out} = Output power (W)

K = Constant

B_{avg} = Average airgap flux density (T)

ac = Electrical loading (amp-turn/m)

D = Rotor diameter (m)

L = Length of rotor (m)

N_s = Motor speed (rpm)

- For the same output power the size of the motor can be reduced by increasing the motor speed.

Cordless Vacuum Cleaner: Present Technology and Need



- The market requirement on home appliances like cordless vacuum cleaner,
 - Smaller and lighter
 - Longer usage time between two charging cycles
- Necessitates smaller, lighter and efficient motors
- Improved performance (Suction)
- Conventionally used motor types: (i) Universal motors and (ii) PM brushed DC (PM DC) motors.
 - Disadvantages:
 - Presence of brushes
 - Restricting the maximum speed at which these motors can operate.
 - The maximum motor speed is about 25000 to 40000 rpm
 - Brush loss leading to lower operating efficiency and increased battery drain and need for frequent charging

Cordless Vacuum Cleaner: Upcoming Technology and Challenges



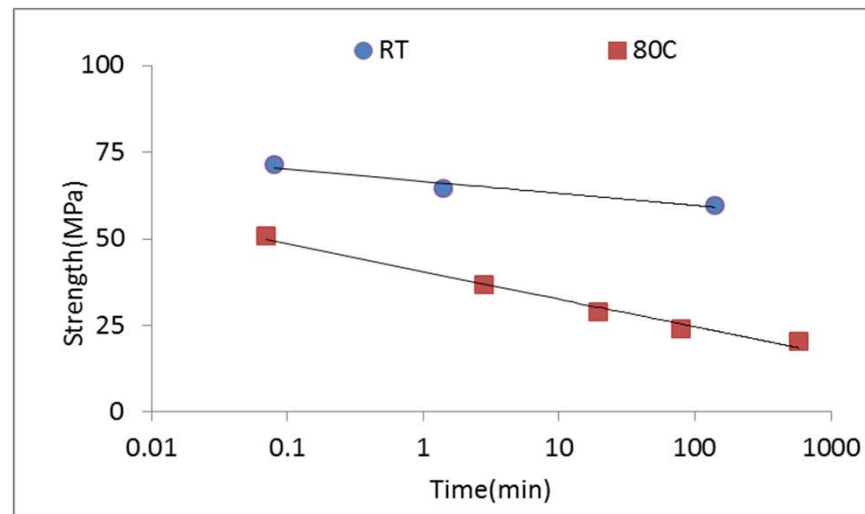
- The new generation vacuum cleaners are using the Permanent magnet Brushless DC (PMBL DC) Motors.

- Advantages:
 - No brushes and hence no brush losses – Better efficiency – Reduced frequency for charging
 - No restriction on the motor speed
 - Can designed to operate at 100000 rpm – Smaller and light weight motor

- Challenges:
 - For Surface mounted PMBL DC motors, increase in motor speed means magnets are rotating faster, higher centrifugal forces on the magnets – Magnet with better mechanical strength are needed.
 - When the motor is loaded the magnet temperature increases and mechanical strength decreases

Cordless Vacuum Cleaner: Challenges with High Speed Motor

- Many industry standard compound use the epoxy binder with low glass transition temperature (T_g) for sufficient mechanical strength.
- Temperature above $T_g \Rightarrow$ Binder softens \Rightarrow Mechanical strength of magnet
 $\downarrow \Rightarrow$ Magnet breakage \uparrow



Stress rupture strength of standard compound

Addressing the Need for Higher Mechanical Strength from the Magnet

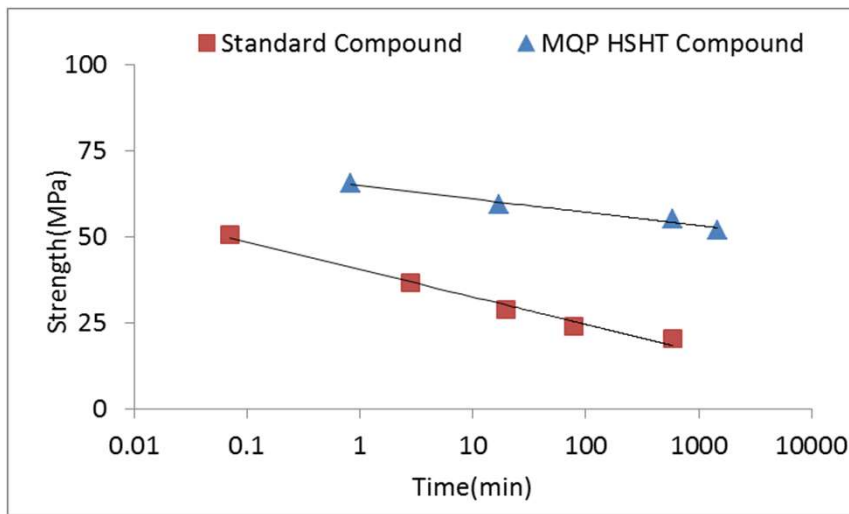


- Two potential approaches to address the need of higher mechanical strength,
 1. Use of the non-magnetic steel or carbon fibre sleeve on the magnet.
 - The presence of steel or carbon fibre sleeve increases the effective airgap and hence reduces the permeance co-efficient of the magnetic system, and airgap flux. To achieve target airgap flux relatively higher magnet volume needed – Increased magnet cost
 - Additional process steps related to the sleeve in motor assembly increases the cost.
 2. Develop a bespoke epoxy binder system leading to higher creep rupture strength of the magnet
 - The Researchers at Magnequench has addressed the issue by modifying the compound technology

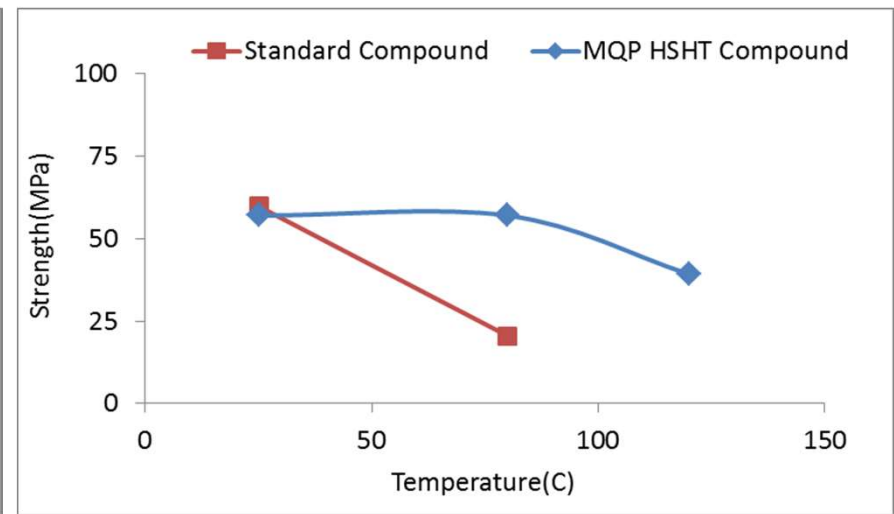
An Example of Compound offering Higher Mechanical Strength at High Temperature



- A compound (MQP- HSHT Compound) can be developed, enhancing mechanical strength at elevated operating temperature, while maintaining the other key performance criteria.



Stress rupture strength of standard and HT-compound at 80° C



Stress rupture strength of HT-compound at different temperatures

- Charts show an example of a new compound developed by MQ
- The HSHT MQEP can be tailored to meet the requirement of other home appliance applications needing motor to run at high speed (e.g. hair dryer and power tool etc.)

Co-development Opportunity



- If low mechanical strength at high temperature is a problem for you, we would like to jointly develop a solution for your specific problem.
- Please share with us the following if you have encountered problem with mechanical strength at high temperature,
 - Existing value of the mechanical strength at the targeted elevated temperature
 - Desired mechanical strength at the same target elevated temperature
 - Present epoxy and lube type as well as their respective amounts used in compounding
 - Any other specific performance criteria to be fulfilled