**N4 - SOLID PROPULSION TEAM**

**Internal Insulation in Solid Rocket Motor**

It is a layer of heat barrier material placed between the internal surface of the motor case and the propellant. The primary purpose of internal insulation is to prevent the motor case from reaching temperatures that could endanger its structural integrity. During combustion, the propellant generates intense heat. Without insulation, this heat would directly transfer to the motor case, potentially causing structural failure. By placing insulation between the case and propellant, we ensure that the case remains within safe temperature limits.

Reduced Erosion: The insulation layer minimizes erosion of the motor case caused by hot gases and combustion products.

Improved Performance: By controlling temperature distribution, insulation contributes to stable thrust and efficient combustion.

**Challenges in Insulation Development**

Material Selection: These materials must withstand high temperatures, mechanical stresses, and chemical reactions during combustion.

Thickness Optimization: The insulation layer’s thickness affects performance. Too thin, and it won’t provide adequate protection.

Adhesion and Bonding: Proper adhesion between the insulation and motor case is crucial. Adhesive failure could compromise the entire motor.

**Insulation Materials**

Ablative Insulation: Some SRMs use ablative materials that char and erode during combustion. As the material erodes, it carries away excess heat.

Composite Insulation: Composite materials, such as carbon phenolic or fiberglass phenolic, offer good thermal protection and mechanical strength.

Ceramic Insulation: Ceramics, like silica-based materials, withstand extreme temperatures but can be brittle.

**Our design**

Factors to consider:

Availability: Ensure that the chosen materials are readily available for production.

Price: Evaluate the cost-effectiveness of the materials, considering both initial production costs and long-term performance.

Ease of Manufacture/Assembly: Simplify manufacturing and assembly processes to reduce production time and costs.

In our design, we’ve combined ablative material with ceramic insulation to achieve optimal performance and safety.

Ablative Material and Ceramic Insulation:

Ablative Layer: Our insulation system features an ablative layer, which acts as the first line of defence against the intense heat generated during combustion.

Ceramic Cloth: Specifically, we employ a high-temperature ceramic cloth with an impressive rating of 1260°C. This cloth serves as the ablative layer, shielding the motor case from direct heat transfer.

Epoxy Resin Sealing: To secure the ceramic cloth, we use thermosetting epoxy resin. This adhesive ensures robust bonding and prevents any leakage.

Heat-Resistant Silicon (Ceramic Silicon):

Critical Sealing: In crucial regions—the bulkhead and nozzle—we rely on heat-resistant silicon (ceramic silicon). This material boasts a temperature rating exceeding 1000°C.

Leak Prevention: By effectively sealing these areas, we safeguard the motor casing against any potential leaks.

Thermal Conductivity of the Composite:

Range: The composite insulation, formed by combining the ablative material and ceramic insulation, exhibits a thermal conductivity falling within the range of 1.4 to 2.0 W/(mK).

Calculation: We estimate this range based on the individual materials’ properties. Our goal is to strike the right balance between thermal protection and overall motor efficiency.

Temperature Considerations:

Combustion Temperature: During combustion, the KNSB (potassium nitrate-sorbitol-based) propellant reaches temperatures of approximately 1600K (approx. 1300°C) at the rated pressure.

External Casing Temperature: To maintain safety, we aim to keep the external casing temperature below 300°C.

Optimization and Practical Factors:

Insulation Thickness: We carefully determine the appropriate insulation thickness. Too thin, and it won’t provide adequate protection; too thick, and it may hinder combustion efficiency.

Weight Considerations: Balancing insulation effectiveness with overall motor weight is crucial for mission success.

Sourcing materials

1. Epoxy – TC110A and TC110B – 1kg – Ksh.2500:  
   <https://jiji.co.ke/nairobi-central/art-collectibles/epoxy-resin-and-hardner-arts-1kg-pnItPjicdhvxY3sOVpXo98hE.html>
2. Heat resistant silicone – Ksh.3500 – Jogoo Rd – 0722401175
3. Ceramic cloth – Jogoo Rd – 0722401175 – price to be confirmed
4. A2 papers