HSLU Lucerne University of Applied Sciences and Arts

Engineering and Architecture
B.Sc.. Energy and Environmental Systems Engineering
Bachelor-Thesis

Portable Cooker with Thermal Energy Storage

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1. Introduction, Goals and Research Questions

Existing portable cooking solutions rely on combustion fuel, such as wood, coals or gas, producing carbon dioxide, harmful volatile organic compounds as well as particulate matter [1]. This project develops a compact, reusable, combustion-free, cooker using phase change material (PCM) to store latent heat, charged from a conventional household oven, capable of cooking 200g of raclette cheese to a surface temperature of 70°C [2], after 2 hours of transport, with a desired weight of under 2 kilograms.

2. Method Overview and Materials

Four concepts were evaluated using a weighted morphological matrix. Concept 2 was selected: consisting of a stainless steel PCM container filled with PlusICE H120, a hydrated salt PCM, housed within an ABS case filled with rockwool as insulation.

Using an energy balance of total energy stored by the PCM (Latent + Sensible) is equal to the energy required to melt 200g of cheese to the desired serving temperature of 70°C and the thermal losses during 2 hours of transport.

$$E_{PCM} = E_{cheese} + E_{losses}$$

From this a design was developed (Figure 1), dimensioned around a commercial raclette pan, after which the PCM container was laser cut, welded together and pressure tested, outer shells 3D printed and filled with insulation.

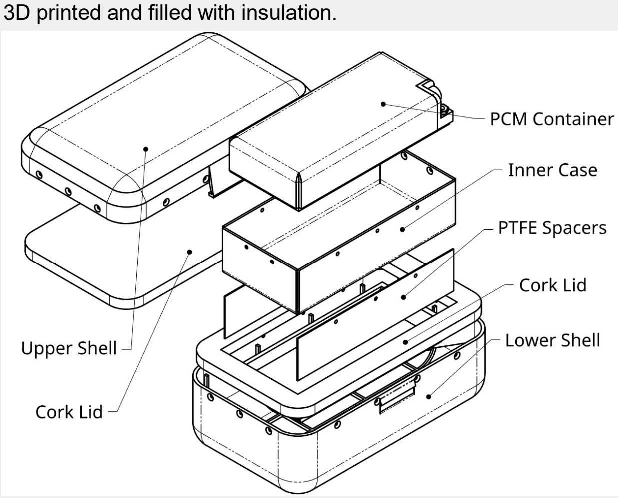

Figure 1: Explosion View CAD

Two PCM containers were constructed, one filled with erythritol, a sugar alcohol, and the second with $LiNaKNO_3$, was used as a substitute to PlusICE H120 for testing purposes. Thermal performance was quantified by heating a known water mass on the cooking surface post-transport, with energy delivery calculated from the measured temperature rise and evaporated water.

3. Results and Discussion

The prototype demonstrated robust construction and excellent structural integrity, with the PCM container withstanding pressures up to 3.5 bar (Figure 2). In Figure 3 the thermal profile during use can be seen, both PCMs delivered approximately half their stored energy to the water as a simulated load, exceeding the required 62kJ by 22-50%, with the remainder being dissipated to the surroundings during transport and use. Desired cooking temperatures were achieved within 6 minutes. Primary limitation was extended charging time due to material thermal properties.

Figure 2: Assembled prototype

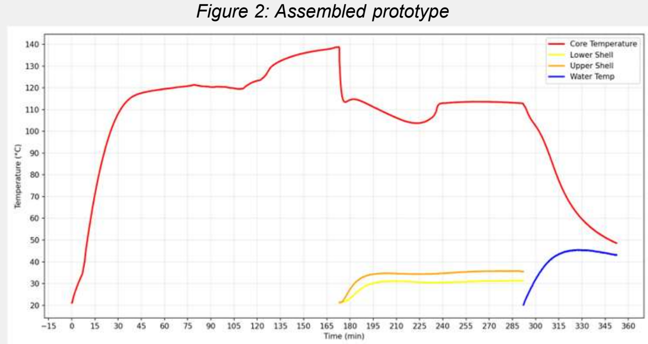

Figure 3: Temperature curves during operation

4. Conclusion and Recommendations

The prototype proves the concept is technically viable: a portable, combustion-free PCM cooker charged from a household oven can store and deliver sufficient thermal energy for outdoor raclette cooking after 2 hours of transportation. Key must-criteria, PCM containment, pressure safety, and energy delivery, were met ensuring user safety during operation. More work is required to increase charging time and reduce the overall weight of the concept.

References

[1] Afifa, Arshad, K., Hussain, N., Ashraf, M. H., & Saleem, M. Z. (2024). Air pollution and climate change as grand challenges to sustainability. Science of the Total Environment, (p.2). https://doi.org/10.1016/j.scitotenv.2024.172370

[2] Fontannaz, A. (2025). The science behind perfectly melting raclette cheese.

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