Microwave-Assisted Heating in Rock

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INTRODUCTION AND OBJECTIVES

A popular method in excavating tunnels for mining is with Tunnel Boring Machines (TBMs). Contrary to drilling and blasting methods, Hard Rock TBMs are costly to fuel and wear down over time, leading to expensive replacements.

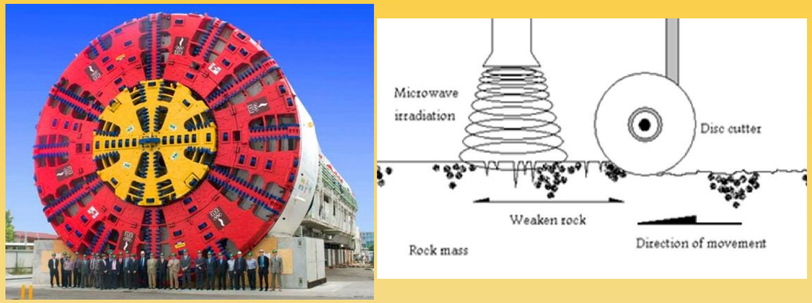

Figure 1: A Tunnel Boring Machine (TBM) (left). Schematic representation of how microwave technology is implemented on TBMs (right).

Expansive heating through microwaves breaks up the rock, which reduces the stress on the machines and saves expensive equipment replacements. The goal of this project is to understand the mechanisms and parameters governing the heating rate of a material.

PROCEDURE

Figure 2: Pictures for the procedure of the experiment. Top left: Core Drill. Top middle: Diamond Saw. Top left: Lathe. Bottom left: Polished and stacked samples. Bottom middle: Prepared sample in microwave. Bottom right: Cracked and broken rock after irradiation.

RESULTS: HEATING RATE AND GEOMETRY

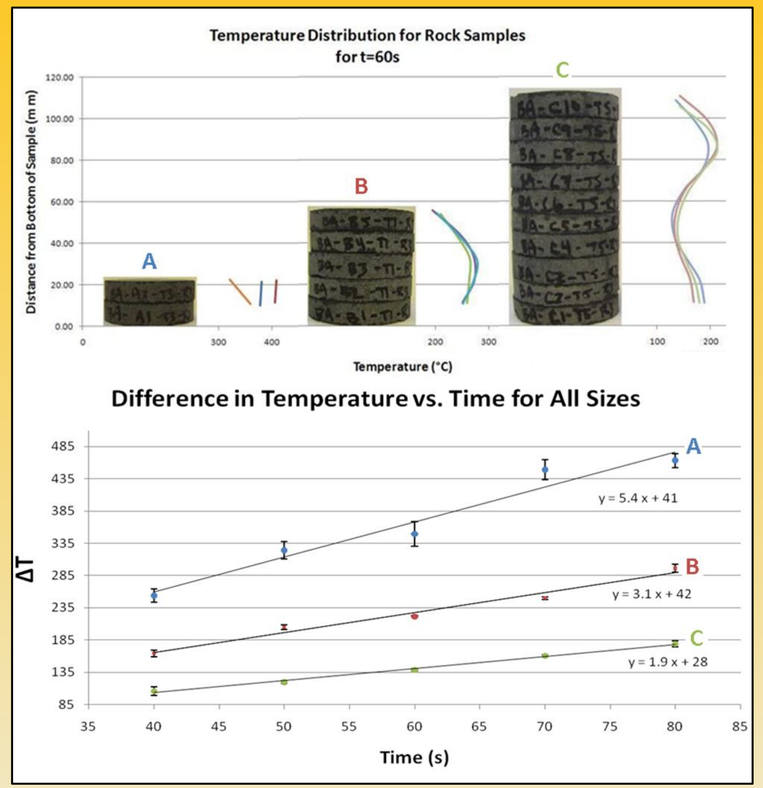

Figure 3: The heat distribution for all three samples, irradiated at 3kW for 60s (top). The average temperature increase vs. time of exposure for each sample size (bottom). The slope obtained is the average heating rate.

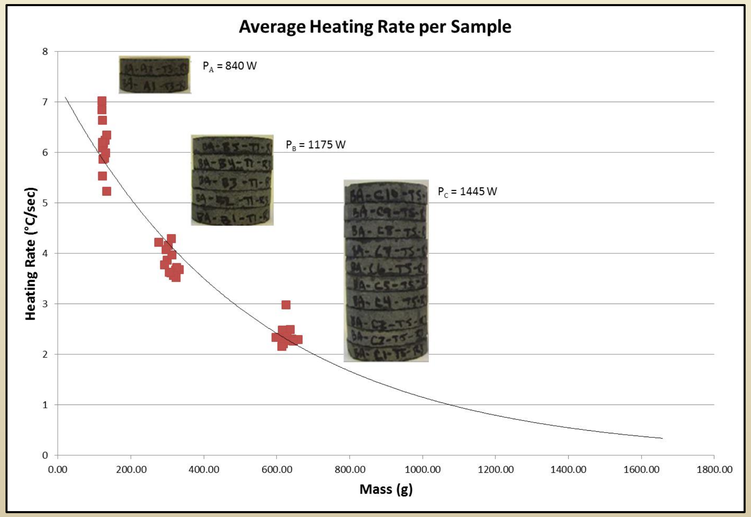

Figure 4: The average heating rate and the associated mass for each sample size. An exponential curve has been fitted to the data for extrapolation to other sizes.

CONCLUSIONS

- It is most effective to approach microwave-assisted heating from two angles: determining the average heating rate, and finding the temperature distribution of a material of many masses and geometries.
- The average heating rate will tell you how quickly or slowly a material of a specific mass will heat.
  - Smaller masses will heat up quicker than larger masses.
- Once the geometry of the object is well understood, the heating rate can be modified from area to area to better predict how the object will heat as a whole.
  - Areas that have more exposure points to microwaves will heat up quicker relative to the parts that do not.

FUTURE WORKS

- More experimentation should be completed with materials of many masses and geometries to predict how microwaves will affect its heating.
- The same procedures should be done using a horn applicator instead of an industrial microwave oven for TBM implementation.

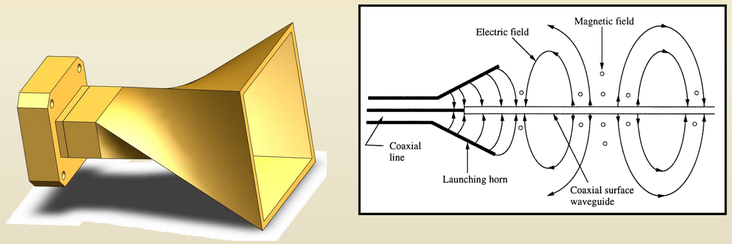

Figure 4: A drawing of a microwave-horn applicator (left). A schematic representation of a horn applicator and its electric and magnetic field distribution (right).

ACKNOWLEDGEMENTS

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