Simulation of Rectangular Microwave Cavity for Thermal Treatment of Clay

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Outline

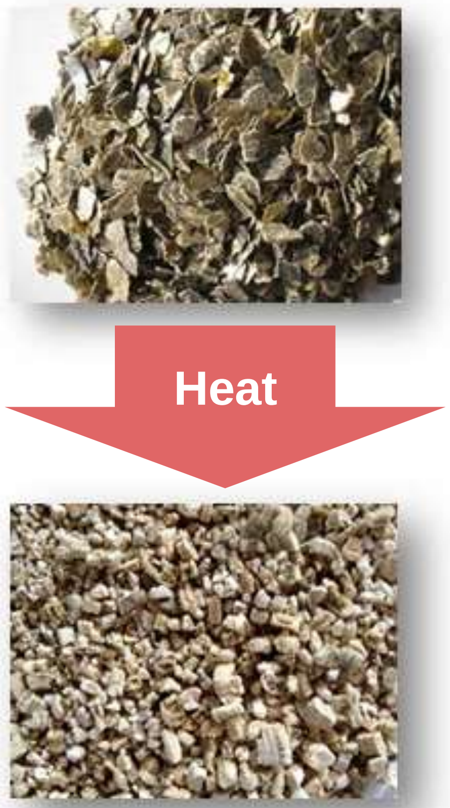
- Introduction;
- Cavity and Sample Design;
- Results;
- Future Works Proposals;
- Conclusion.

Introduction

- Since the application of microwave to heat materials, an important issue is to evaluate the efficiency of the process during the material heating.
- There are several ways to increase the efficiency of a microwave heating process.
- One helpful way is optimize the size and shape of the heating cavity.
- The cavity dimension is important to save power and microwave energy.

Introduction

- The vermiculite is a material usually heated by conventional ovens.
- This micaceous material is used in several applications: construction, agriculture, and etc.
- The expanded material presents the advantage to be light, absorption, and isolation. Hence, it's crucial to survey the microwave heating and its efficiency.
- The simulated cavity prototype for heating is rectangular.



Cavity and Sample Design

- The cavity proposed is rectangular with the cylindrical sample.
- COMSOL Multiphysics® Version 5.0 was used to simulate the distribution of the electric field, reflection coefficient S_{11} and heating into the material.
- The vermiculite was used in the proposed simulation.

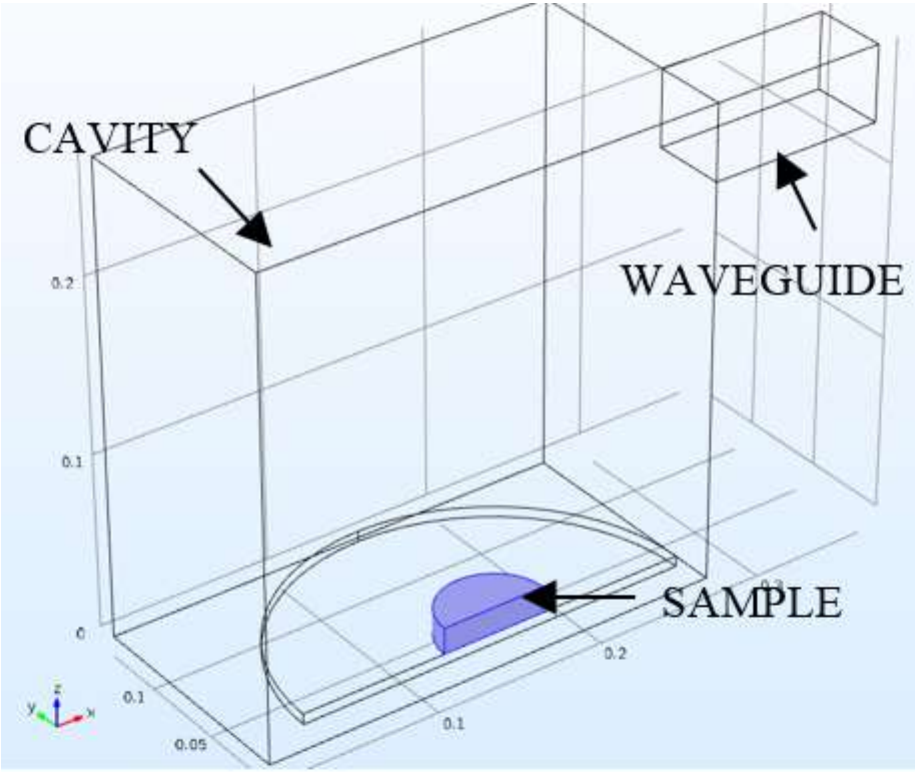


Fig 1: Simulated cavity in COMSOL®.

Simulation Results

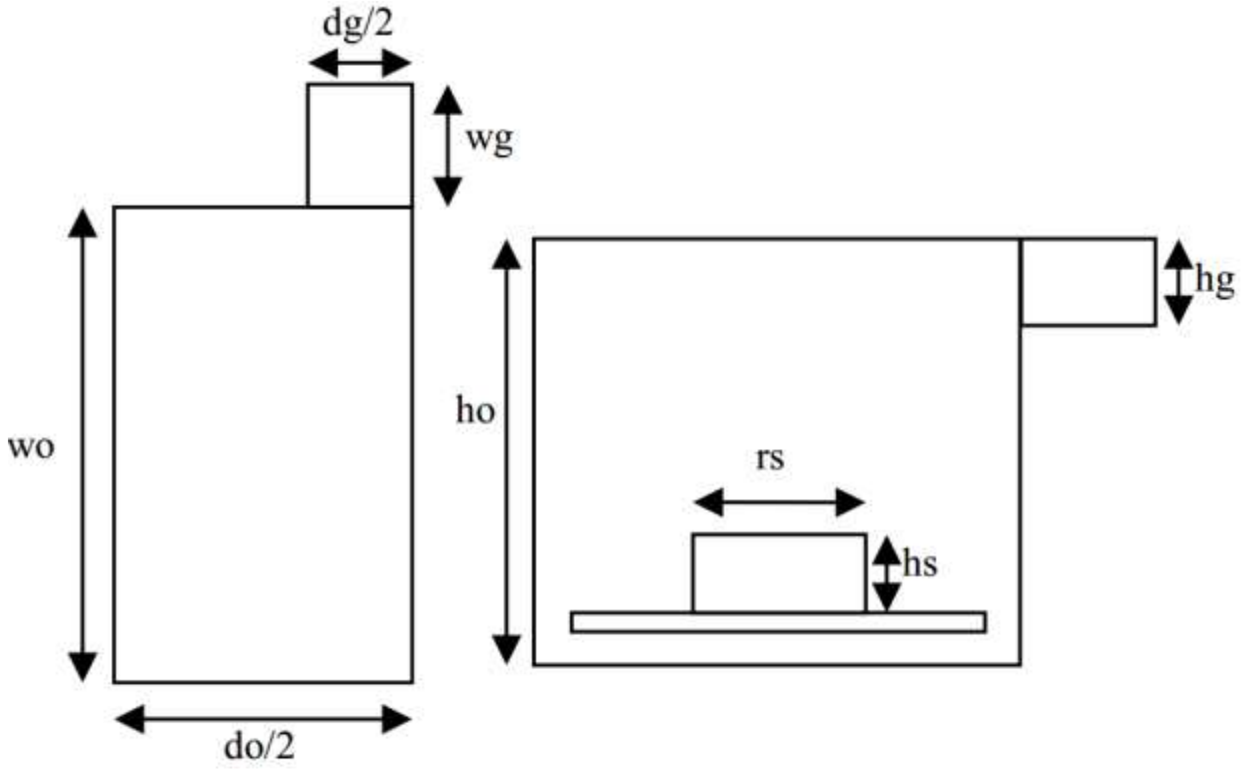


Fig. 2: Non-chamfered cavity.

TABLE I
PARAMETERS OF SIMULATION

Parameters	Value(mm)	Descriptions
wo	267	Oven width
do	270	Oven depth
ho	270	Oven height
wg	100	Waveguide width
dg	86	Waveguide depth
hg	43	Waveguide height
rs	30	Sample radius
hs	21	Sample height
hs	21	Sample height

$$(f_c)_{max} = \frac{1}{2\pi\sqrt{\mu\epsilon}}\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{m\pi}{b}\right)^2}$$

Cavity Optimization & Results

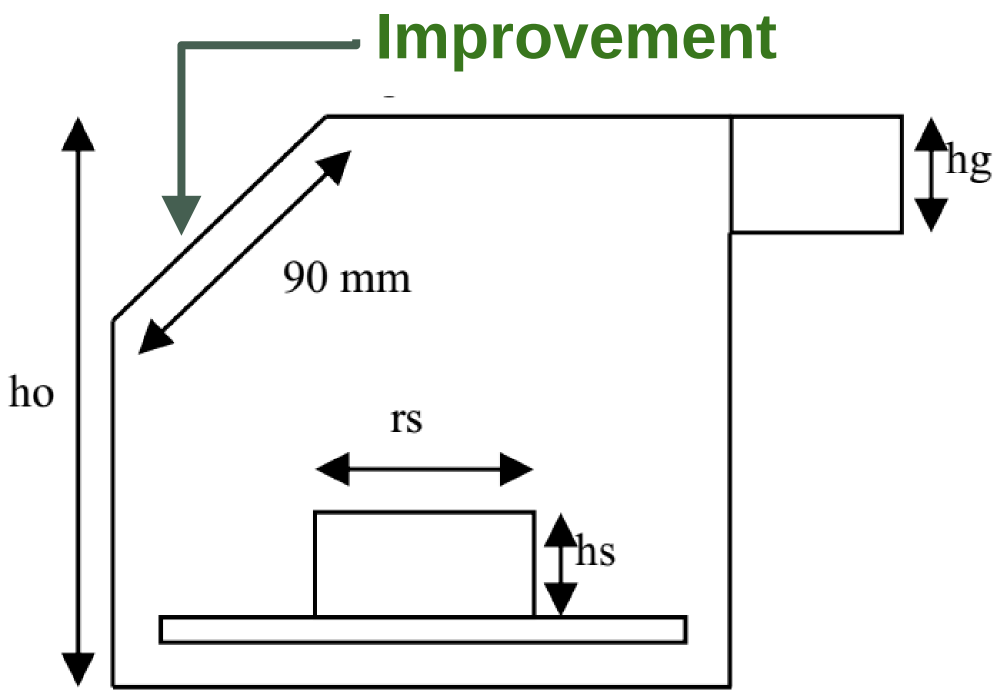


Fig. 3: Chamfered cavity.

- Improvement of the reflection coefficient;
- Expected to reach the highest temperatures in the sample;
- Faster sample heating.

TABLE II
VALUES OF PERMITTIVITY, PERMEABILITY AND ELECTRICAL CONDUCTION FOR VERMICULITE.

Parameters	Value(mm)
Complex permittivity	3.50-j0.44
Realitive permeability	1
Eletrical conductivity	0

S-Parameters Results

- In the frequency of 2.45 GHz we can observe a shortly reduction of reflection coefficient S_{11} considering the chamfered introduced on the cavity.
- More than 6 dB improvement in the reflection coefficient.

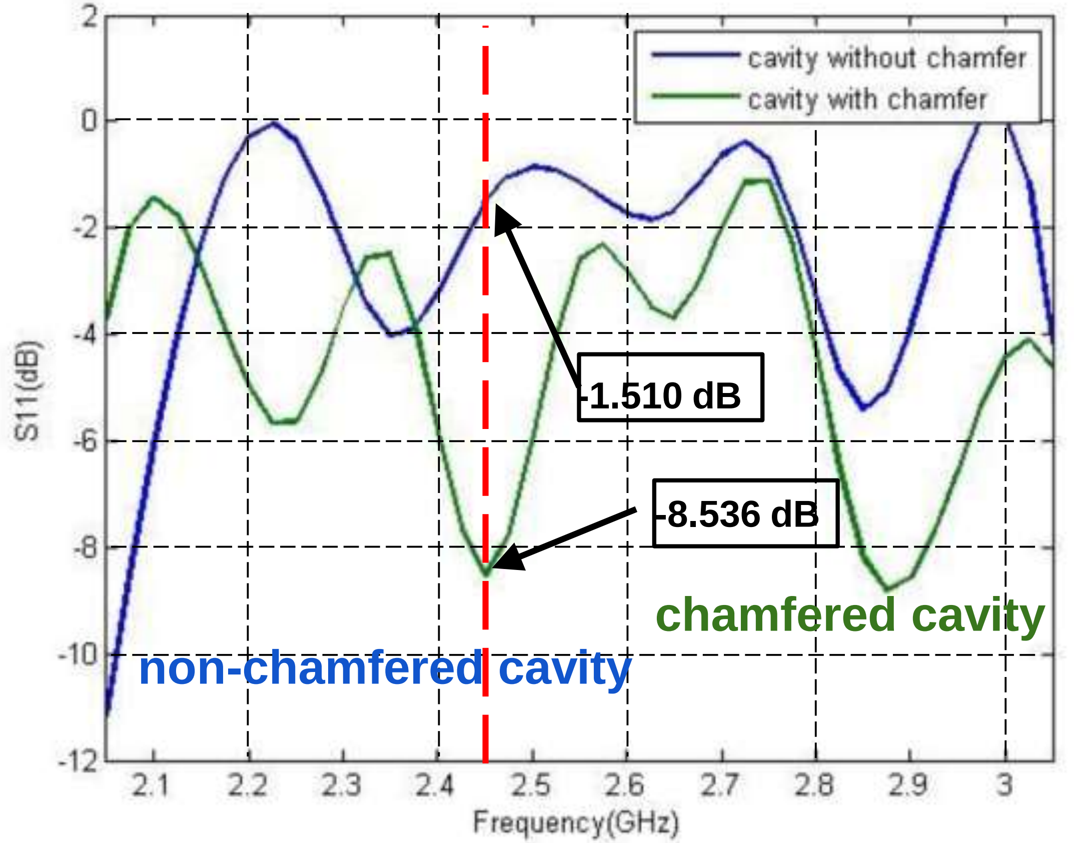


Fig. 4: Comparison between chamfered and non-chamfered cavity.

Sample Temperature Results

- It can be seen that the final temperature in the sample with chamfered cavity increased 27° C above the temperature achieved inside the original cavity, without chamfered.

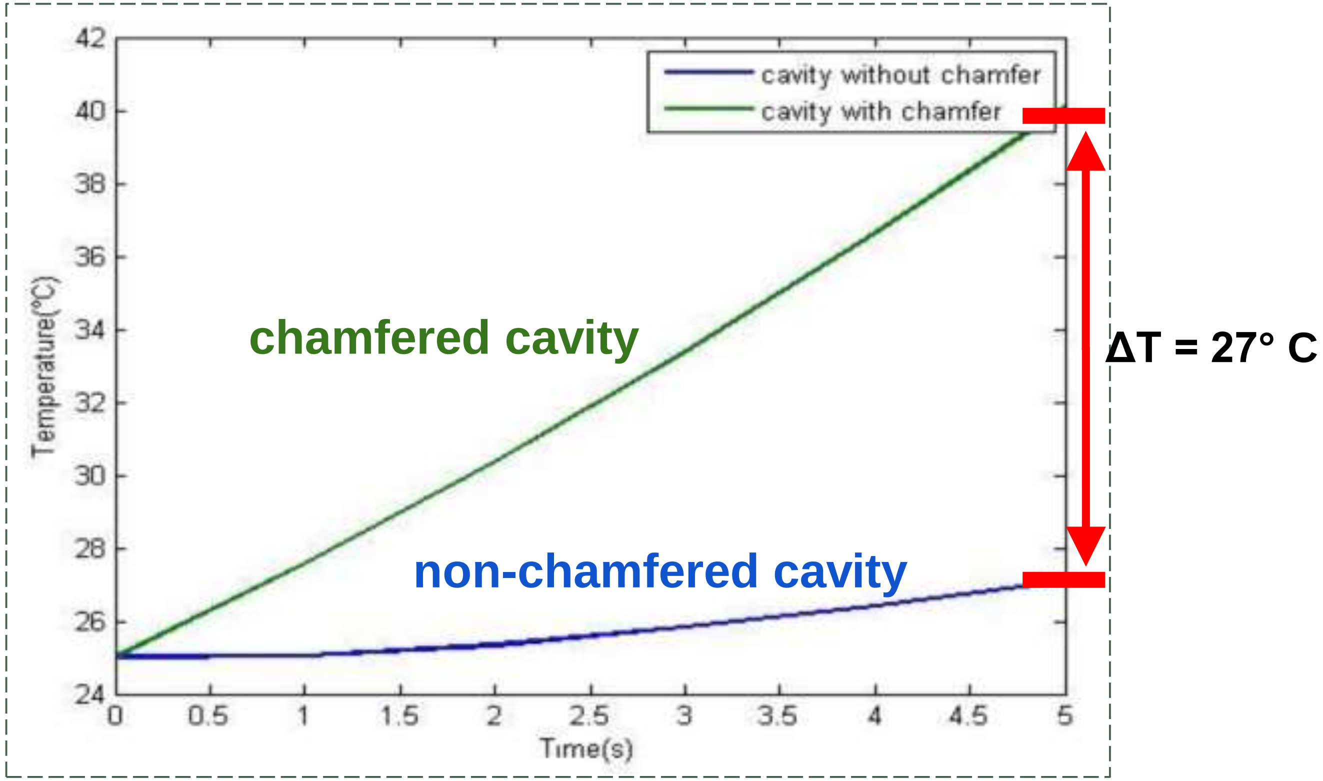


Fig. 5: Temperature response on the vermiculite sample of the cavities.

In development - Monomode WG test

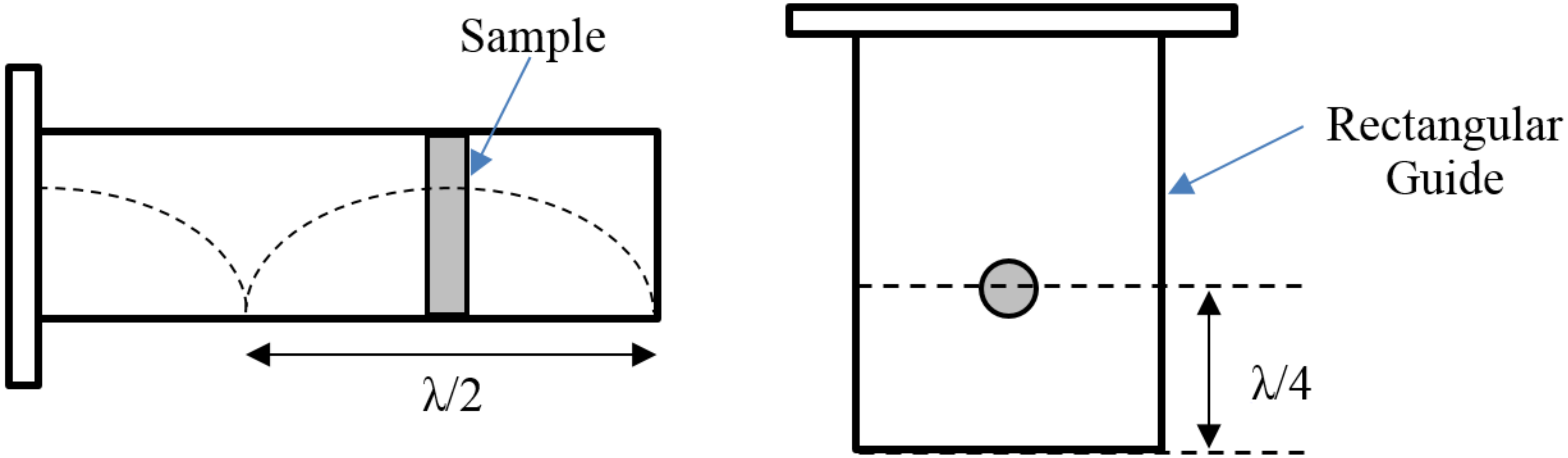
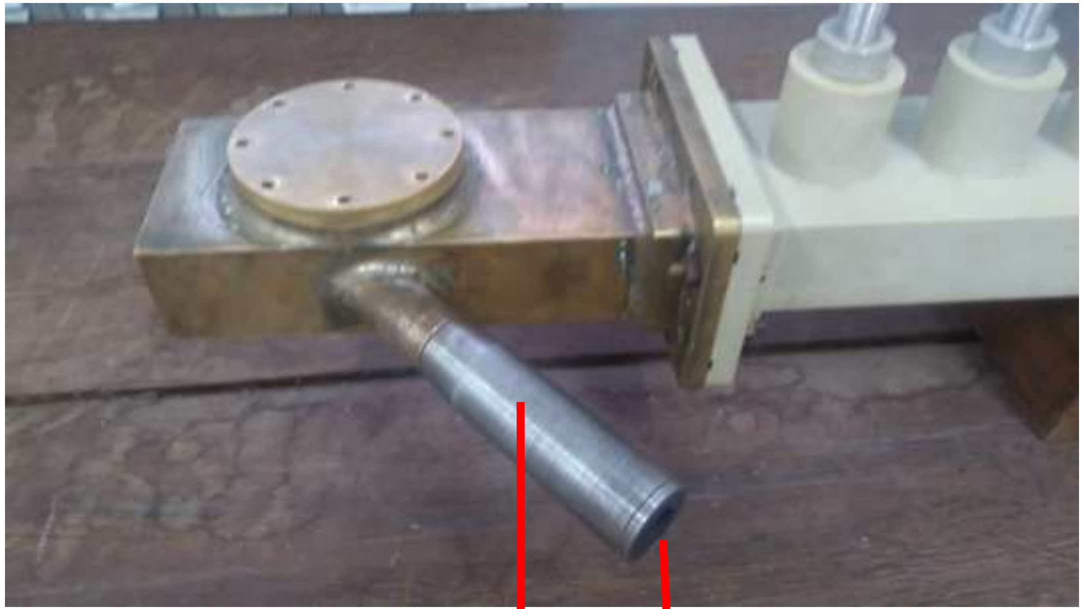


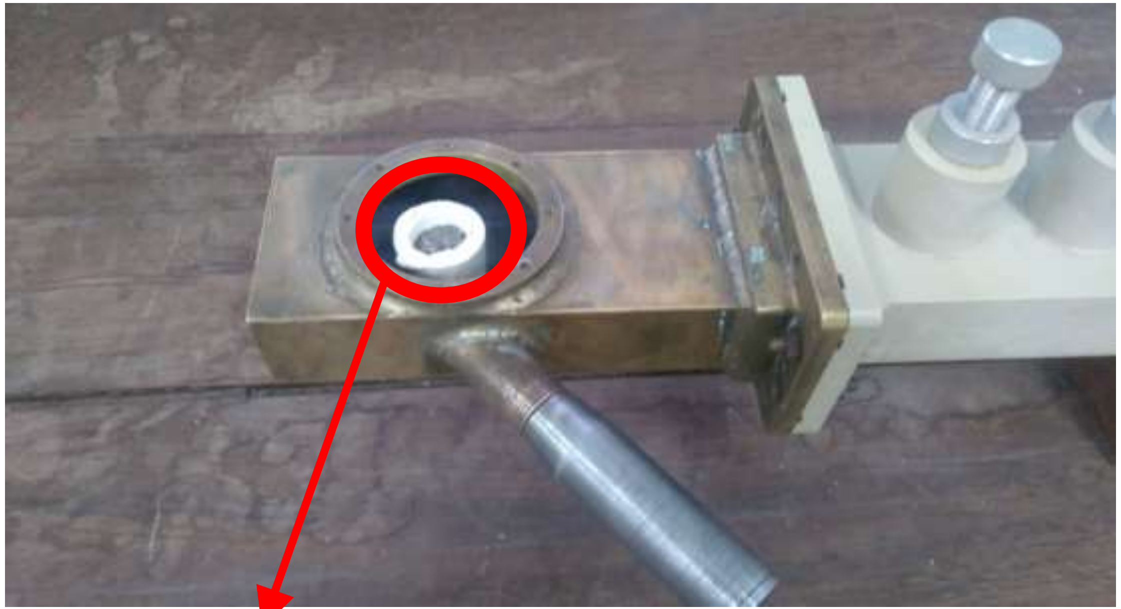
Fig. 6: Monomode aplicator.

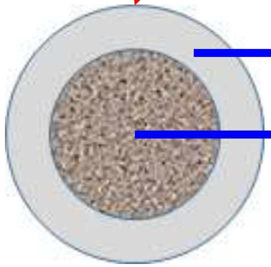
$$\lambda = \frac{c}{f} = \frac{1}{\sqrt{1 - \left(\frac{c}{2\pi f}\right)^2}}$$

$$(f_c)_{max} = \frac{1}{2\pi\sqrt{\mu\epsilon}}\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{m\pi}{b}\right)^2}$$

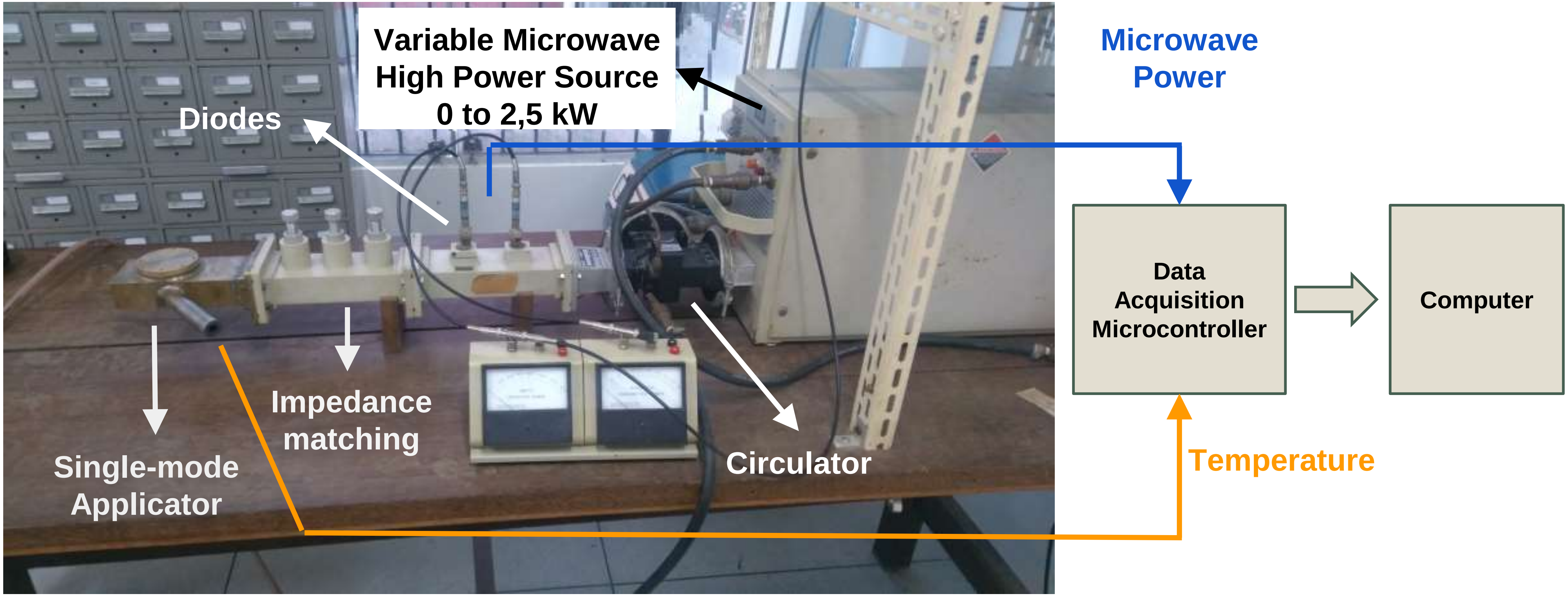
In Development - Prototype WG test







In Development - Control System



Conclusion

- Both simulated cavities have different efficiencies.
- The chamfered cavity presented higher performance.
- Such difference represents higher processing speed and lower cost of production.
- It’s important to consider the prototype and simulation of a cavity for microwave heating process, to improve its efficiency and ensure better heating.

Thank You!