2015

The Perfect Coffee Cup

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MECHANICAL AND NUCLEAR

The Perfect Coffee Cup

CAPSTONE DESIGN EXPO 2015

Introduction

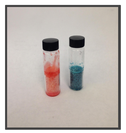
The idea of the "Perfect Coffee Cup" entails a double-walled coffee cup with the inner chamber being filled with a phase changing material.

- Phase changing material serves as a heat sink for the coffee when it is poured into the cup at brewing temperature, 90˚C
- Also serving as a heat source to maintain the coffee at preferred drinking temperature, 60˚C. (range: 55˚C-65˚C)

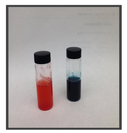
Design Challenges

Several different design challenges were encountered throughout the project. Some of those challenges include:

- Material of the cup
- Chamber size for the PCM
- Finding a premade cup that fit desired outcomes
- Insulating the cup
- Making the correct assumptions for the calculations
- Finding the correct information about the PCM for the calculations
- Getting the dye to mix with the PCM (the PCM is a hydrophobic material)
- Finding a Non-toxic food grade PCM limited options in finding the most optimal PCM



Solid Colored PCM



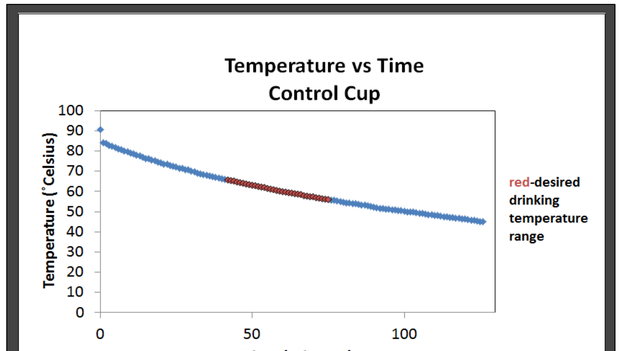
Liquid Colored PCM

Double-Walled Glass Cup

Double-Walled Plastic Cup

Double-Walled Ceramic Cup

Data

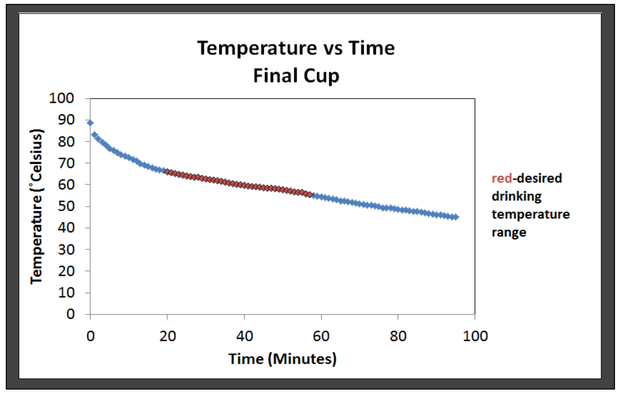


The Control Cup:

- Stainless steel inner wall
- Acrylic outer wall
- Air in inner chamber
- Acrylic top
- Drinking range: 44-77 minutes

The Final Cup:

- Stainless steel inner wall
- Acrylic outer wall
- Phase changing material in inner chamber
- Acrylic top
- Drinking range: 22-58 minutes

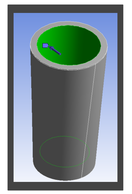


- The final cup reached the drinking range in half the time taken by the control
- The final cup remained in the drinking range about 10% longer than the control

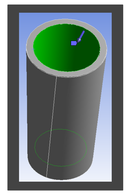
Analysis

Some of the basic boundary conditions taken into consideration for transient heat analysis were:

- The temperature of the steel wall was assumed equal to the coffee (highly conductive)
- The temperature of the acrylic wall was assumed equal to ambient (perfect insulator)
- The temperature of the coffee and temperature of the PCM were assumed uniform (lumped capacitance)
- Negligible radiation and heat loss due to evaporation



Heat into Phase Changing Material



Heat out of Phase Changing Material

Conclusion

- It was concluded that the most optimal coffee cup would be one with a metal interior wall and acrylic exterior wall with PCM in between
- The optimal drinking temperature, 60˚C, is melting point of the PCM that we chose (PureTemp 60)
- The stainless steel inner wall helps direct the heat transfer from the phase changing material to the liquid in the cup
- The preferred drinking temperature was prolonged by approximately 10%

VCU School of Engineering

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Make it real.

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