PACCMAN User/Developer Guide

(Python Analysis of Conformal Cooling Molds And/or desigNs)

This guide is meant to be used as a resource for using, adding to, or integrating the PACCMAN program. It is expected that users will have a package manager such as Anaconda or another program with Numpy, Scipy, Matplotlib, etc.

In order to install Pytest with Anaconda, open the Anaconda Powershell Prompt and run the command ”conda install -c anaconda pytest ”.

Feedback is welcome. Please report all bugs to hughfeehan353 on Github. Thanks.

Basic Use:

When run, the program first presents three options.

Selecting ”N” uses the first mold material properties (KM1, etc.) and then asks the user to choose the heat transfer coefficient correlation.

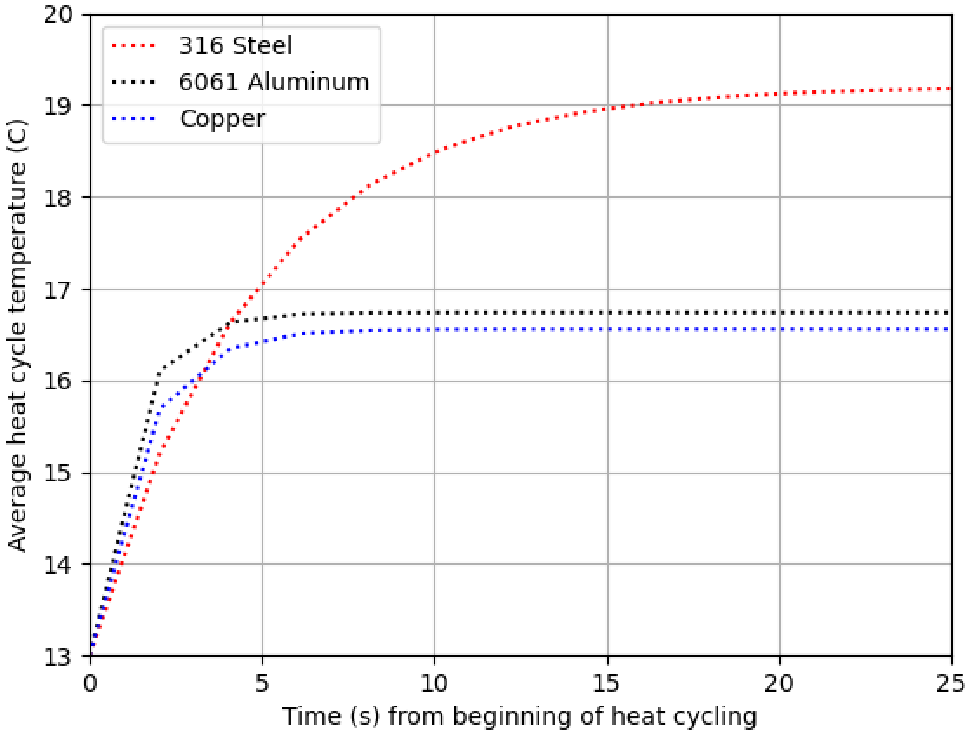
Selecting ”M” compares the three mold materials using the Gnielinski correlation.

Selecting ”H” compares the three heat transfer coefficient correlations using the first mold material property (KM1, etc.).

For all three choices, the program asks the user if they would like to save graphs of the average heat cycle temperature over time.

Choosing ”Y”, downloads the graph in .png and .eps formats.

Choosing ”N” will not download the graphs



An example graph for option ”M” (mold material comparison).

The program is written so that by changing the variables, it can analyze any desired conformal cooling design and will report the following data:

> flow velocity, kinematic viscosity, Reynolds number, Prandl number, Darcy friction factor, heat transfer coefficient, average heat cycle temperature of the mold, time constant, and coolant pressure drop.

Application Fundamentals for Advanced Use:

At the beginning, the program initializes and assigns all the basic variables. By default, these are imported from the ”basedata.py” file.

In order to change the values, the data in this file can either be edited directly or the import location can be changed. In order to do this, locate the import statement on line 12 of ”paccman.py” and change ”basedata” to the desired new file. All of the variables in ”basedata.py” are necessary for the program to function properly so none should not be completely omitted if a new file is used.

Afterwards, all the necessary functions are defined. These cannot be removed as they are necessary for the program’s function but could be added to.

At this point there is an “if” statement to check for the user’s desired function for the program. This “if” statement contains all of the program’s calculation functions in order to ensure that nothing will break if the user chooses an invalid letter.

The first thing inside the “if” statement are some calculations that must be completed no matter the chosen choice of the program’s function.

The rest of the calculations contain nested “if” and “elif” statements so that the correct variables are used for the chosen program function.

Once the calculations are completed, the program creates a plot of the average heat cycle temperature over time that the user has the choice of downloading.

The program can be tested using Pytest by running the ”pytest” command in the program’s directory.

Variables Used:

Part Thickness: L_P

Coolant Line Diameter: D

Average Height of Coolant Line Surface Irregularties: ε

Coolant Line Length: L

Coolant Thermal Conductivity: K_C

Coolant Density: ρ_C

Mold Specific Heat Capacity: C_C

Coolant Temperature: T_C

Part Density: ρ_P

Part Specific Heat Capacity: C_P

Thermal Conductivity of Mold: K_M

Coolant Line Pitch Distance: W

Distance from Coolant Line to Mold Wall: L_M

Difference in Part Temperature Between Inserted Into Mold and Released: T

Cycle Time: T_{Cycle}

Mold Density: ρ_M

Mold Specific Heat Capacity: C_M

Initial Mold Temperature: T_{MO}

Coolant Flow Rate: $\dot{V}$

Coolant Dynamic Viscosity: μ

Coolant Dynamic Viscosity When Near Wall: μ_W

Equations Used:

Flow Velocity of Coolant (U): $\frac{\dot{V}}{\pi \cdot (\frac{D}{2})^2}$

Coolant Kinematic Viscosity (KV): $\frac{\mu}{\rho_C}$

Reynolds Number (Re): $\frac{U \cdot D}{KV}$

Prandtl Number (Pr): $\frac{\mu \cdot C_C}{K_C}$

Darcy Friction Factor (Haaland Equation) (f): $(\frac{1}{-1.8log[(\frac{\varepsilon}{3.7 \cdot D})^{1.11} + (\frac{6.9}{Re})]})^2$

There are three chooseable equations for the Nusselt Number (Nu):

1. Dittus-Boelter: $0.023 \cdot Re^{\frac{4}{5}} \cdot Pr^{0.4}$

2. Gnielinski: $\frac{\frac{f}{8} \cdot (Re - 1000) \cdot Pr}{1 + [12.7 \cdot (\frac{f}{8})^{0.5} \cdot (Pr^{\frac{2}{3}} - 1)]}$

3. Sieder-Tate: $0.027 \cdot Re^{\frac{4}{5}} \cdot Pr^{\frac{1}{3}} \cdot (\frac{\mu}{\mu_W})^{0.14}$

Heat Transfer Coefficient (h): $\frac{K_C}{D} \cdot Nu$

Average Temperature of the Mold (ATM): $T_C + \frac{\rho_P \cdot C_P \cdot L_P \cdot T \cdot [(2 \cdot K_M \cdot W) + (h \cdot \pi \cdot D \cdot L_M)]}{h \cdot \pi \cdot D \cdot K_M \cdot T_{Cycle}}$

Time Constant ($T_{Constant}$): $\frac{\rho_M \cdot C_M \cdot L_M^2}{K_M} \cdot (1 + \frac{2 \cdot W \cdot K_M}{h \cdot \pi \cdot D \cdot L_M})$

Pressure Drop: $\frac{Df \cdot L}{D} \cdot \frac{\rho_C}{2} \cdot \dot{V}^2$

Equation for Graphs: $y = ATM + (T_{MO} - ATM) \cdot e^{\frac{-x}{T_{Constant}}}$