SuTSys USER MANUAL

(Surface Temperature Calculation Simulation Software)

Version:

Beta 1.0.1

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When this software is installed, user accepts all of the above.

SOFTWARE DESCRIPTION

SuTSys – Surface Temperature Calculation Simulation Software is a software that calculates the surface temperature for any given variables such as inner and outer temperatures, wall thickness and wall thermal conductivities.

Description

When you have an equipment that is hot inside but needs to be cold outside so you can safely touch it, you need to use insulation. However calculation of the thickness of the insulation or which material to use might come a bit tricky sometimes. That's when our software come to the help. Without the need of any simulation software, you can calculate the outer surface temperature with just only putting in few variables.

Benefits and Value

Value and benefits provided by the SuTSys software are:

- It eliminates the need for a paid simulation software.
- It can store material database for future uses, so don't have to put the same material all over again.
- You can compare different materials and thickness and see the result of the surface temperature in a matter of time.
- Since it's a free software, it only aims to help fellow engineers to gain knowledge and ease their design and engineering activities.

Keywords

#Software #Simulation #HeatTransfer #SurfaceTemperature #Insulation

1. HOW TO DOWNLOAD and INSTALL THE SOFTWARE
    a. First go to the page https://www.stpektas.com/en/applications
    b. Select the version as Beta-1.0.1
    c. Click Windows Download Button.
    d. A .Rar file will be downloaded. Unzip it.
2. USING THE SOFTWARE
    a. How to Open the Software
        i. Go into the folder that you've downloaded in section 1.
        ii. Open the "SuTSys.exe"
    b. Main Screen

    When the software is opened, you're welcomed with the screen below. (Fig2-1)

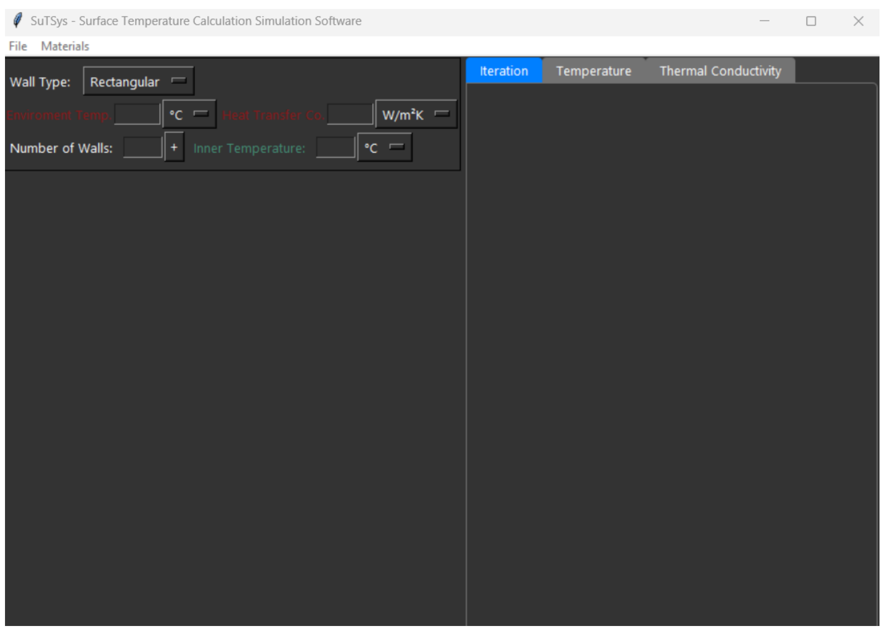

Fig2-1. Main Screen of SuTSys

        i. File: Includes Options Screen
        ii. Materials: Includes material database.
        iii. Wall Type: Rectangular or circular. Depends on your choice. Your design, equipment or environment can consists of rectangular or circular shapes. This will be explained with more details.

iv. Environment Temperature: This is the temperature of the environment. Can only be numbers with integers (20, 30) or floats (20.5, 30.125)
v. Heat Transfer Coefficient: Heat Transfer Coefficient of the environment. There is no exact data for what this number can be, however there are some academic works on this and will be detailed.
vi. Number of Walls: This represents how many different materials, insulations or sheets there are.
vii. Inner Temperature: This is the temperature of your system that is hotter or colder than environment.
viii. Solve: After putting in every data, to calculate the surface temperature solve button can be clicked.
ix. Iteration: This page is on the right side of the screen and it's revealed after solving. It shows how many elements are in your calculation and what is the confidence level.
x. Temperature: This page holds the surface temperature that has been calculated according to your variables. Also temperature at any thickness through your system can be calculated from here.
xi. Thermal Conductivity: Thermal Conductivity change with thickness can be shown here.

c. File Screen: File Screen contains options which for this version only theme can be changed as Dark or Light.

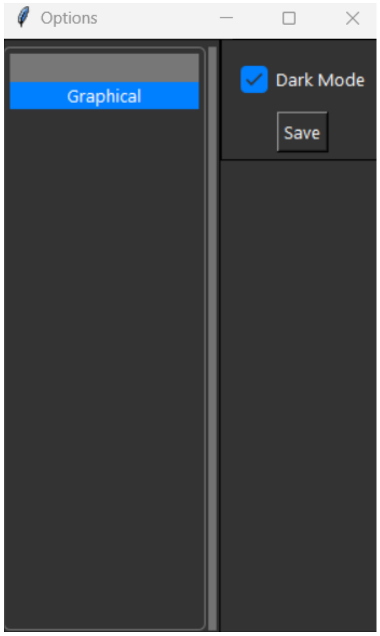

Fig2-2. Options Menu

d. Material Screen: Material Screen contains the material database. From material database you can add different materials that has different thermal conductivity at different temperatures.

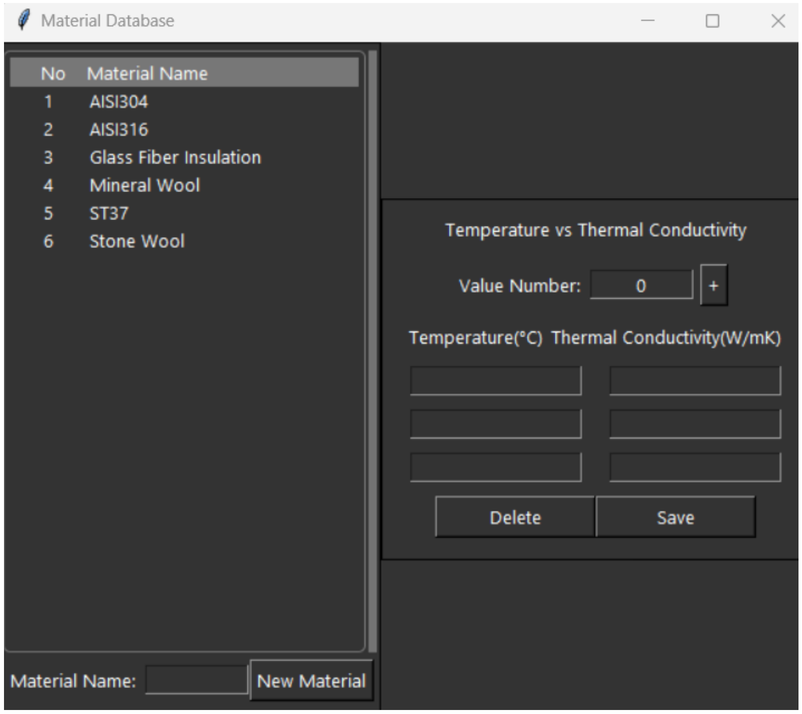

Fig2-3. Materials Database

i. How to use the material database:
   1. On the down left side of the screen, enter the new material name (example: “Newly Added Material”), click new material. “Newly Added Material” will be added to the list.
   2. Click the “Newly Added Material” from the list and on the right you will only see value number. As an example let’s assume that you material has the thermal conductivity values at different temperatures as below:

Temperature (°C)	Thermal Conductivity(W/mK)
50	21.458
100	20.685
150	18.874
200	16.125

   3. We have 4 different temperatures so we’ll be writing 4 to the value number and click “+”

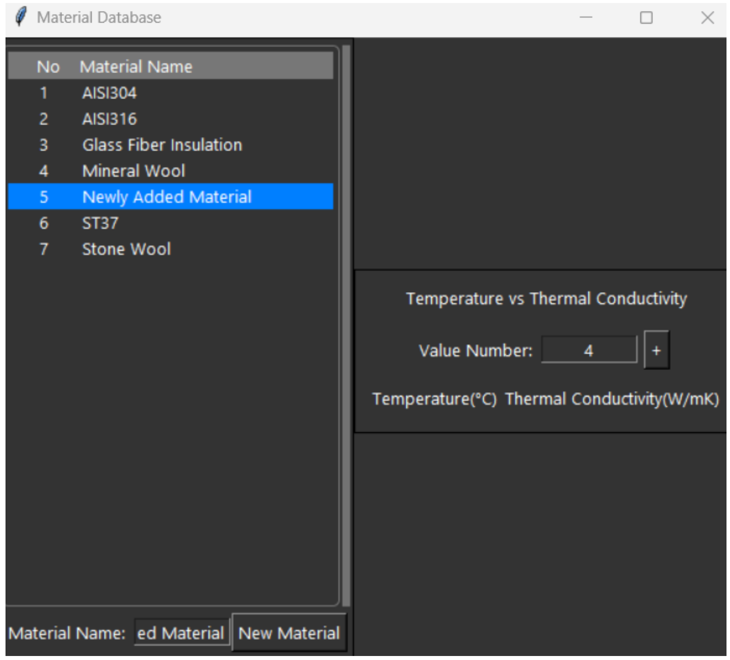

Fig2-4. Material Database "Newly Added Material"

4. When "+" button is clicked, 4 boxes will appear below. Left side boxes are for temperatures and right side boxes are for thermal conductivities. Temperature unit is °C and thermal conductivity unit is W/mK.
5. Enter all temperatures and thermal conductivities to the boxes and click save.

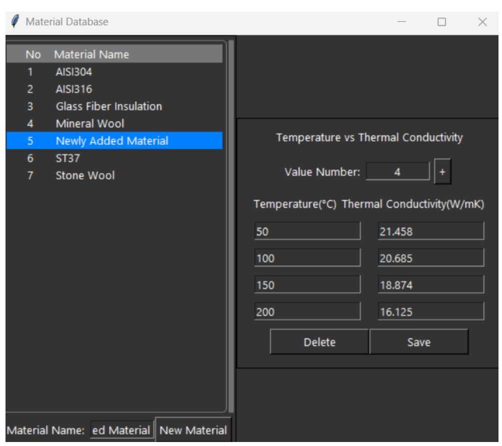

Fig2-5. Entering the empty boxes

6. Values are saved and can be used in the software.

7. If a material needs to be deleted, select it from the list and click delete.

e. Entering Variables:

i. Number of walls: Enter a number between 2 to 6 (This will change with future versions) for the walls that you have. Let's assume that you have 3 different walls as shown below. Enter number "3" to the number of walls and click "+" on the right of the number of walls. Below you will see a 3 walls will appear.

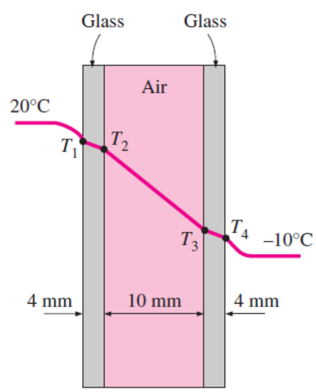

Fig2-6. A System with 3 Different Walls

ii. Environment Temperature: Enter environment temperature. For example in Fig2-6 is -10 °C. You can change the unit as Fahrenheit, Kelvin or Centigrade.

iii. Heat Transfer Coefficient: Enter heat transfer coefficient of the environment. Such as 10 W/m²K. (Cannot enter minus values.)

iv. Inner Temperature: Enter the inner temperature. For Example in Fig2-6 20 °C.

v. Now details for the glass and air will be entered to the Wall-1, Wall-2 and Wall-3. For Wall-1 in the thickness section enter 4 mm. (Unit can be change as mm, cm o m)

vi. For thermal conductivity you can either select from materials or directly enter thermal conductivity value. Materials that you've created in the materials database section will automatically be shown here.

vii. Do the v-vi steps for the rest of the walls and click "solve"

f. Results:
   i. After the software finished solving, there will be a graphic in the iteration section. You can see that it will have a mesh element number and confidence level. Mesh elements will be increased with the increased thickness. Confidence level shows how close you are to the theoretical result.
   ii. In the temperature tab, with the color red you will see a T_Surface temperature value. This will be the surface temperature at the surface that is on the environment side.
   iii. If you'd like to see what is the temperature at a certain thickness you can enter a dimension value on "Enter X Point" and click "Calculate". This will calculate the temperature at the X point.

g. Example:

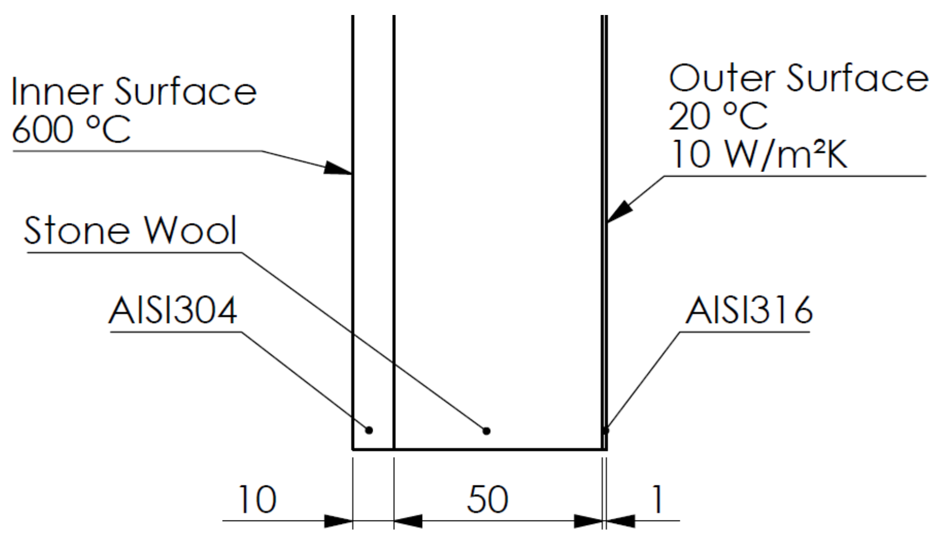

Fig 2-7. Example 2.1

Let's assume that we have an equipment with 10 mm sheet thickness, 50 mm insulation with Stone Wool and 1 mm of insulation sheet. Enter all the variables as shown below.

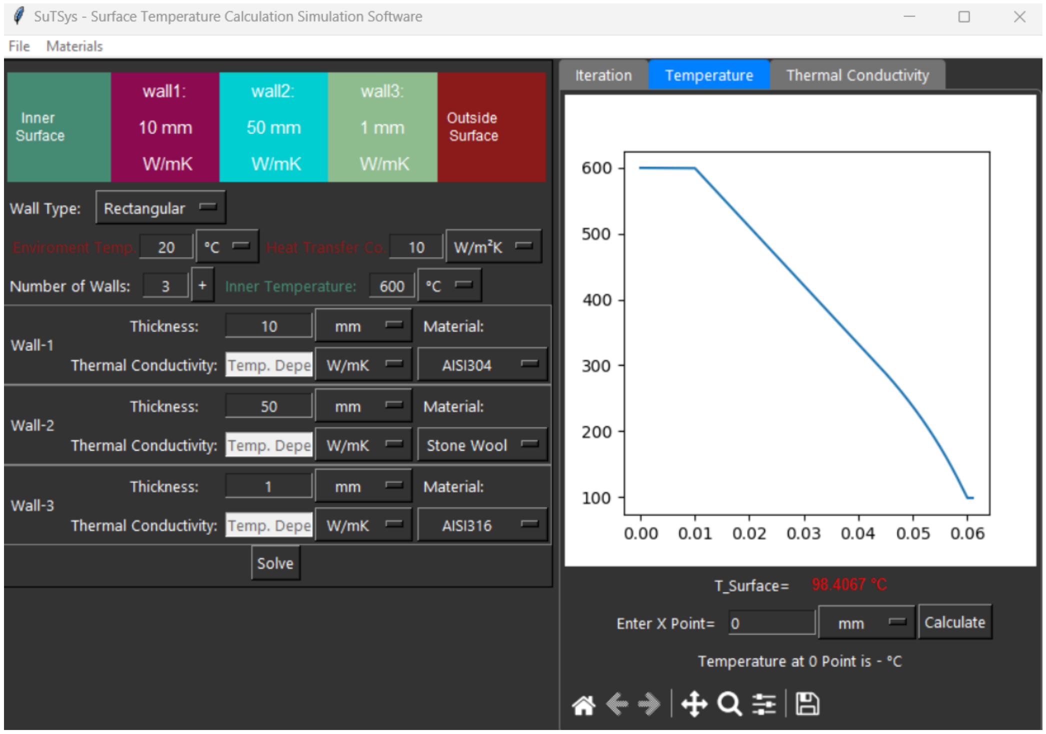

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Fig2-8. Example 2-1 Variables Entered and Solved

After the solve you should see something like this. Now you can change any variable according to your design and find that surface temperature.

3. Heat Transfer Coefficient
    a. What is Heat Transfer Coefficient:
    In thermodynamics, the heat transfer coefficient or film coefficient, or film effectiveness, is the proportionality constant between the heat flux and the thermodynamic driving force for the flow of heat (i.e., the temperature difference, ΔT). It is used in calculating the heat transfer, typically by convection or phase transition between a fluid and a solid. The heat transfer coefficient has SI units in watts per square meter per kelvin (W/m2/K). (Source: Wikipedia)

    To put in a simple manner, it’s the interaction between the surface and the fluid.

There is a lot of debate on what should be the perfect heat transfer coefficient but it changes significantly according to where your surface is geologically or is there any air flowing around the surface or is there any other fluid or what is the flow velocity?

Now let’s take a look at some of the heat transfer coefficients;

b. Heat Transfer Coefficients vs Flow Type:

Flow type	**(W/m^2 K)**
Forced convection; low speed flow of air over a surface	10
Forced convection; moderate speed flow of air over a surface	100
Forced convection; moderate speed cross- flow of air over a cylinder	200
Forced convection; moderate flow of water in a pipe	3000
Forced Convection; molten metals	2000 to 45000
Forced convection; boiling water in a pipe	50,000
Forced Convection - water and liquids	50 to 10000
Free Convection - gases and dry vapors	5 to 37
Free Convection - water and liquids	50 to 3000
Air	10 to 100
Free convection; vertical plate in air with 30°C temperature difference	5
Boiling Water	3.000 to 100.000
Water fowing in tubes	500 to 1200
Condensing Water Vapor	5.0 - 100.0
Water in free convection	100 to 1200
Oil in free convection	50 to 350
Gas flow on tubes and between tubes	10 to 350

Fig3-1. Flow Type vs Heat Transfer Coefficients

In Fig3-1 you see heat transfer coefficient changes a lot. Let's say your environment is a free convection with air. It says here it's 5-37 W/m²K.

In the Fig2-8 If we were to enter 5 W/m²K for the heat transfer coefficient surface temperature is 163,9278 °C and for the 37 W/m²K surface temperature is 42,8753 °C. There is a big gap between two temperatures.

c. Heat Transfer Coefficient Estimation
   i. There is a formula where you can calculate the heat transfer coefficient from velocity of the air;

$$h_{CW} = 12.12 - 1.16v + 11.6v^{1/2}$$

(https://www.engineeringtoolbox.com/convective-heat-transfer-d_430.html) It's an empirical equation and can be used for velocities 2 to 20 m/s.

   ii. According to Ghahfarokhi, Kallaste, Belahcen and Vaimann heat transfer coefficient with the wind speed is;

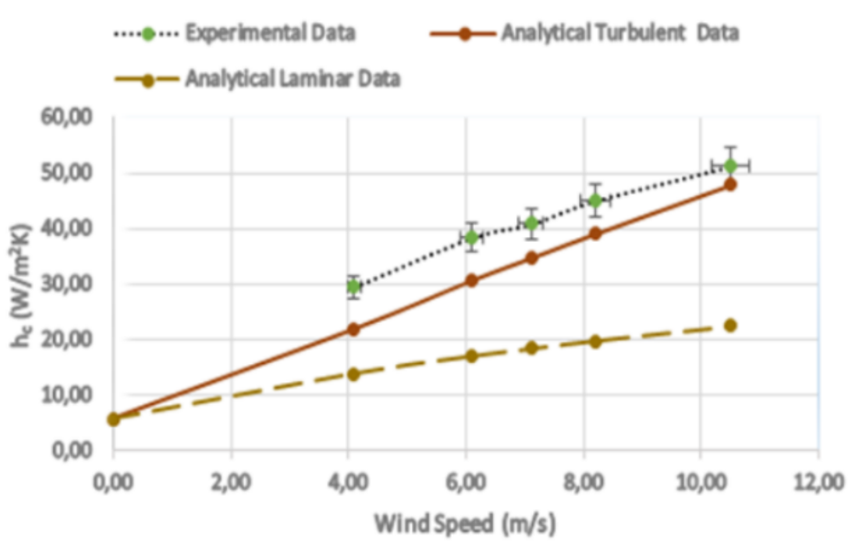

Fig3-2. Heat Transfer Coefficient vs Wind Speed

iii. According to Yener, Yener and Mutlu heat transfer coefficient for the still air is:

	Copper	Steel
$h_C = c_C m_C / \tau A_C$	13.14 W/(m^2K)	25.32/(m^2K)

Fig3-3. Heat Transfer Coefficient for Still Air