FLYING TOUCHDOWN CODE USER'S MANUAL

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INTRODUCTION

The Flying Touchdown Code computes the slider temperature profile, disk temperature profile and the slider fly height for a flying TFC slider over a rotating AlMg PMR disk [1]. Simulations can be performed over a range of TFC powers starting from 0 mW (TFC heater is not powered) all the way down to contact and beyond. To accurately predict the fly height and heat transfer in the head-disk interface (HDI) at near-contact, we incorporate the effects of disk temperature rise, asperity-based adhesion & contact force models, air & phonon conduction heat transfer and friction heating in our model.

The flying touchdown code is based on the CML TFC Code [2]. We use a modified version of the CML Air static simulation program (quick code) [3] to solve the to solve for the air bearing pressure distribution and the steady-state fly height. CML Air determines an equilibrium flying state (fly height, pitch, roll) of a slider for a given suspension load using a Quasi-Newton method. The air bearing pressure is computed by solving the generalized Reynolds equation with the Fukui–Kaneko slip correction. In the modified CML Air quick code, the equilibrium flying state of the slider is then determined by balancing the forces and torques on the slider due to adhesion and contact forces determined using the Sub-Boundary Lubrication model [4, 5], the suspension load and the air bearing pressure.

The slider temperature profile and thermal protrusion is determined using a thermo-mechanical finite element (ANSYS) model, similar to the CML TFC code. The heat transfer coefficient due to pressurized air cooling is obtained using the temperature jump theory and the modified mean free path of air due to boundary scattering [6]. The heat transfer coefficient due to wave-based phonon conduction is determined as a function of the spacing, the temperatures and material properties of the head and the disk [7, 8]. The net heat transfer coefficient in the HDI due to air & phonon conduction is integrated into the slider ANSYS model to simulate the head temperature profile and head thermal protrusion due to TFC heating.

The temperature profile of the rotating disk due to heat transfer from the head is determined using the analytical solution of the classic "stationary heat source acting on the surface of a moving semi-infinite medium" problem [9]. The net heat generation rate per unit area due to friction is determined as: $q_{fric} = \mu p U$. Here μ is the coefficient of friction, p is the net normal pressure due to the contact and adhesion forces and U is the linear disk speed. For further details, please read Ref. [1].

The Flying Touchdown code runs on a windows-platform computer with MATLAB and certain ANSYS product (modules for electric, thermal and structural analysis) installed.

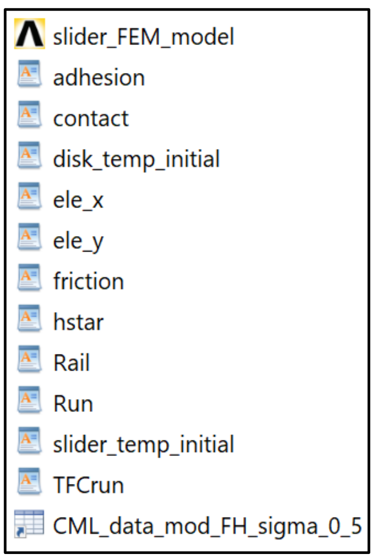
MODEL 1

1.1 Introduction

Model 1 determines the slider temperature profile, disk temperature profile and the slider fly height for a flying TFC slider over a rotating AlMg PMR disk for a range of TFC Powers. Model 1 works upto a minimum fly height of about 1.4 nm. Below this fly height, the slider loses stability and Model 1 does not work. I would suggest running model 1 starting for TFC Power = 0 all the way to the TFC power at which the minimum fly height is around 1.4 nm. Below this fly height, you need to use Model 2a and 2b. For the example simulation using the given parameters, Model 1 runs from TFC Power = 0 to 75 mW. At TFC Power = 75 mW the minimum fly height is 1.375 nm.

1.2 Input Files

You will require the following input files:



- slider_FEM_model.db (ANSYS FEM model of TFC slider)
- ele_x.dat, ele_y.dat (These files contain the x, y coordinates of each node of each ABS surface element of the ANSYS FEM model)
- adhesion.dat, contact.dat, friction.dat, hstar.dat (These files contain the look-up table for adhesion force, contact force, friction force per unit area as a function of the head-disk spacing)
- disk_temp_initial.dat, slider_temp_initial.dat (Initial guess for the temperature profiles on the slider and disk surfaces – assumed to be uniform and equal to 25 ^{o}C)
- Rail.dat (This file contains the ABS rail profile of the slider. Please refer to the *CML Air User's Manual* for further details about this file)
- Run.dat (This file contains parameters required to run CML Air. Please refer to the *CML Air User's Manual* for further details about this file)

- TFCrun.dat (This file contains parameters required for the slider ANSYS FEM model. Please see the CML TFC Code for further details about this file)
- CML_data_mod_FH_sigma_0_5.mat (this file contains a lookup table to convert the regular fly height to a modified fly height, which considers the asperities' contributions to the head disk clearance as defined in Ref. [10])

slider_FEM_model.db, ele_x.dat, ele_y.dat

The provided ele_x.dat and ele_y.dat files to you contain the x, y coordinates of each node of each ABS surface element of the provided ANSYS FEM model (slider_FEM_model.db). If you plan to create your own slider FEM model, you would need to generate the ele_x.dat and ele_y.dat files for the new ANSYS model by running this macro in ANSYS APDL: `*USE, ele_x_y_generate.mac`. Prior to running this macro, please enter the path of the location of all these files in the `RESUME` command (currently set to `C:\Users\siddhesh_sakhalkar\Desktop\Siddhesh Codes\Flying touchdown\Model 1`).

```
RESUME,'slider_FEM_model','db','C:\Users\siddhesh_sakhalkar
\Desktop\Siddhesh Codes\Flying touchdown\Model 1',0,0 ! change
path
```

slider_temp_initial.dat, disk_temp_inital.dat

Since our initial guess for the temperature profile on the slider ABS surface and the top surface of the disk is 25 ^{o}C, both these files contain a matrix of size `surf_ele_num x 3` with value 25, where `surf_ele_num` is the number of number of triangular surface elements on the ABS surface of the slider ANSYS model. For the given slider FEM model, `surf_ele_num = 1505`. If you plan to create your own slider FEM model, note that `surf_ele_num` can be easily determined as the size of the ele_x.dat or ele_y.dat matrix.

Please note that we use an identical mesh for the slider ABS surface and the top surface to the disk.

Run.dat

Enter the initial attitude (`hm, pitch, roll`), desired slider radial location (`radii`), skew (`skews`) and disk RPM (`RPMs`). Although
run.dat allows multiple radii, altitudes and RPMs, only the last calculated flying-attitude will be used for the TFC simulation.

```
***************Intial Attitude***************
hm(m)          pitch(rad)     roll(rad)
+9.0000e-09    +4.5000e-05    +0.0000e+00
***************Runs***************
irad           irpm           ialt          sort
 1             1              1               0
radii(m)
   2.7000E-002
skews(deg)
   9.4300E-001
RPMs
   5.4000E+003
```

Please enter the desired suspension load (`f0`) and torque (`xfs`)

```
***************Load Parameters***************
f0(kg)          xf0(m)          yf0(m)          psa             rsa
usestiff
3.7000E-003     0.0000E+000     0.0000E+000     0.0000E+000
0.0000E+000     0
xfs(µNM)        yfs(µNM)        emax            skp             skr
0.6500E+000     0.0000E+000     5.0000E-004     1.7450E-005
1.7450E-005
```

I would recommend not changing the "Partial Contact" parameters such as `stdasp, dnsasp, rdsasp`. If you do change these parameters, note that the adhesion/contact force input files and the CML_data_mod_FH_sigma_0_5.mat input file need to be updated accordingly. Currently, the adhesion/contact forces and the CML_data_mod_FH_sigma_0_5.mat look-up table are computed for `stdasp = 0.5 nm, dnsasp = 5e15 m^-2, rdsasp = 20 nm`.

Please note that `icmodel` must be set to 0 and the other parameters in the "Partial Contact" section are NOT used in the modified CML Air quick code. Instead adhesion and contact forces are computed using adhesion.dat, contact.dat and hstar.dat input files.

```
***************Partial Contact***************
icmodel         stdasp(m)       dnsasp(m^-2)    ConstantA
ConstantB
 0              5.0000E-010     5.0000E+015     1.0000E-019
1.0000E-076
rdsasp(m)       eyoung(pa)      yldstr(pa)      elecpot(v)
2.0000E-008     1.1159E+011     1.0000E+012     0.0000E+000
frcoe           pratio
 0.3             0.3
```

Please refer to the CML Air manual for further details about the parameters in the Run.dat file.

Rail.dat

Create the desired ABS rail profile and generate the Rail.dat file, as described in the *CML Air User's Manual*. If you plan to create your own slider FEM model, please note that the overall size (length and width) of the air bearing design should match with the size of the FE model built in ANSYS.

adhesion.dat, contact.dat, friction.dat, hstar.dat

The files adhesion.dat, contact.dat, friction.dat contain the corresponding force per unit area, specified in Pa. hstar.dat contains the head-disk spacing at which the force is calculated where the head-disk spacing is defined as the distance between the slider ABS and the mean plane of **surface** heights on the **disk** solid surface [10]), specified in nm (see *Note).

Currently, the adhesion/contact forces and the CML_data_mod_FH_sigma_0_5.mat look-up table are computed for `stdasp = 0.5 nm, dnsasp = 5e15 m^-2, rdsasp = 20 nm` and for $\delta\gamma$ = adhesion energy per unit area = 0.106 N/m [1, 4]. If you change the roughness parameters: `stdasp, dnsasp, rdsasp`, the adhesion/contact force input files and the CML_data_mod_FH_sigma_0_5.mat input file need to be updated accordingly.

If you only want to change $\delta\gamma$, then just multiply each entry in the adhesion.dat file by the corresponding proportionality factor (since adhesion force is directly proportional to $\delta\gamma$ and $\delta\gamma$ does not impact the contact force/friction force/the modified fly height look-up table). For example, if you want to set $\delta\gamma$ = 0.06 N/m, multiply each entry in the adhesion.dat file by 0.06/0.106 (please see Ref. [1] for further details).

TFCrun.dat

If you plan to create and new slider FEM model, please note that you must enter the name of the FEM model here:

```
db file name
*************************************
slider_FEM_model
```

Mapping - xmin, xmax, ymin, ymax: these four parameters define an area on the air bearing surface on which you apply the TFC protrusion calculated from ANSYS to modify the shape of the ABS.
Mapping - nx, ny: these two parameters define the density of the grid in the mapping area.
Please refer to the CML TFC Code User's Manual for details about these parameters. These are the default values for these parameters in the given TFCrun.dat file:

```
mapping
*************************************
xmin        xmax
0.6         1
ymin        ymax
0.25        0.75
nx          ny
401         401
```

Enter the desired back cooling and side cooling heat transfer coefficients.

```
cooling
*************************************
back     side          (W/(m.m.k))
2000    100
```

Please note that the "heater power (mW)", "loads" parameters, "convergence" parameters and the "air parameters" in the TFCrun.dat file are NOT used by this code. Instead the air parameters, the heater power and convergence parameters are set in the main_control.m file. Please refer the CML TFC code for further details about the parameters in the TFCrun.dat file

1.3 Program/Execution Files

quick	Application
ele_x_y_generate	MAC File
GetDimen	MAC File
ModRefTemp	MAC File
SolDeformMag	MAC File
SolFHMag	MAC File
SwitchElemKoptEh	MAC File
disk_temp_compute	MATLAB Code
get_htc	MATLAB Code
get_modfh	MATLAB Code
get_modpress	MATLAB Code
initialize_broyden_linear	MATLAB Code
maincontrol	MATLAB Code
map_CML_ANSYS_avg	MATLAB Code
plotter	MATLAB Code
run_modify	MATLAB Code
usergeom_write	MATLAB Code

maincontrol.m

Set the desired TFC Power range (`TFCPower`) and add the slider radial position (`rr`) and disk RPM (`RPM`). Please make sure that the slider radius and disk RPM values are consistent with those entered in the Run.dat file.

```
%% INPUT PARAMETERS
TFCPower = [0:5:75];
RPM = 5400; % disk RPM
rr = 27e-3; % radial position of slider
```

We have five phonon conduction input parameters: `k1_phon, k2_phon, k3_phon, k4_phon, b_phon`.

```
% Phonon parameters
% We model the phonon conduction htc using the following formula:
% log(htc_phon) = k1_phon*(log(T_disk+273.15)-log(273.15+25)) + k2_phon*(log(dT)-log(400)) + k3_phon*log(h_in_orig) + b_phon
% T_disk = disk temperature in deg C
% dT = slider-disk temperature difference in deg C
% h = spacing in nm
k1_phon = 0.99;
k2_phon = -0.83;
k3_phon = -1.99;
b_phon = 11.4;
```

Further, enter the desired air properties like thermal conductivity (`k_bulk`), mean free path (`lambda0_bulk`), thermal accommodation coefficient (`sigma`), specific heat ratio (`gamma`) and Prandtl number (`Pr`).

```
% Air parameters
k_bulk = 0.0261; % Air thermal conductivity
lambda0_bulk = 67.1e-9; % Air Mean Free Path
sigma = 0.6; % Thermal Accomodation Coefficient
gamma = 1.4015; % Ratio of Specific Heat Capacity for Air
Pr = 0.71; % Prandtl Number for Air
```

`max_htc` is an upper limit to the HDI heat transfer coefficient that is applied in the model to account for the presence of the interface thermal conductance (or Kapitza conductance).

```
max_htc = 1.5e7; % Interface thermal conductance for the HDI (applied as an upper limit for the HDI htc)
```

Further, if you plan to create your own slider FEM model, please note that `surf_ele_num` must contain the number of triangular surface elements on the ABS surface of the slider ANSYS model. Also, the slider mapping parameters: `xmin, xmax, ymin, ymax, length, width, nx` and `ny` from the TFCrun.dat file must be re-entered here, if you make any changes from the default mapping parameters. Additionally, `length_slider` must contain the overall slider of the slider **in mm** and `width_slider` must contain the overall width of the slider **in mm.**

```
% Slider FEM model parameters
surf_ele_num = 1505; % number of surface elements on ABS surface of slider ANSYS model
xmin = 0.6;
xmax = 1;
ymin = 0.25;
ymax = 0.75;
length_slider = 0.8435; % in mm
width_slider = 0.7; % in mm
nx = 401;
ny = 401;
```

Finally, the roughness parameters are also specified here (`sigma_z, eta, R`) and they must be consistent with those specified in the Run.dat file (`stdasp, dnsasp, rdsasp`).

```
%% ROUGHNESS PARAMETERS
R = 0.020e-6; % asperity radius of curvature
eta = 5000e12; % asperity areal density
sigma_z = 0.5e-9; % std deviation of surface heights
```

Enter the path of your ANSYS executable (currently set to `C:\Program Files\ANSYS Inc\v140\ansys\bin\winx64\ansys140.exe`) and the path of the location of all the files required to run this code (currently set to `C:\Users\siddhesh_sakhalkar\Desktop\Siddhesh Codes\Flying touchdown\Model 1`) in the system commands on lines 86, 111 and 124 of the maincontrol.m file.

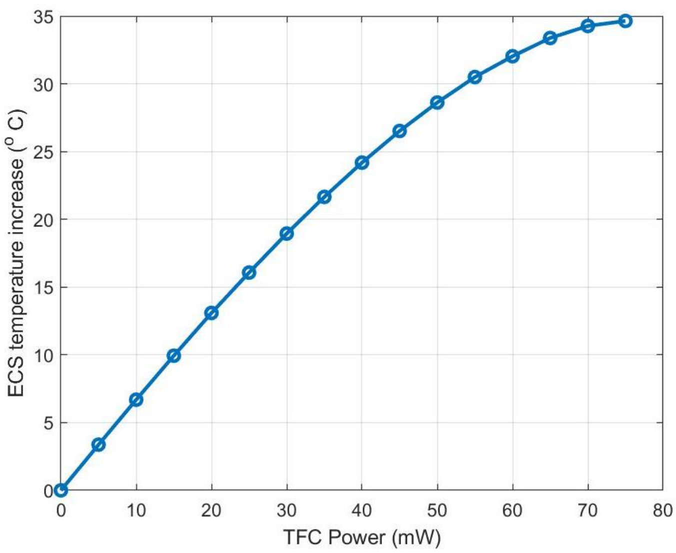
Run the maincontrol.m file using MATLAB.

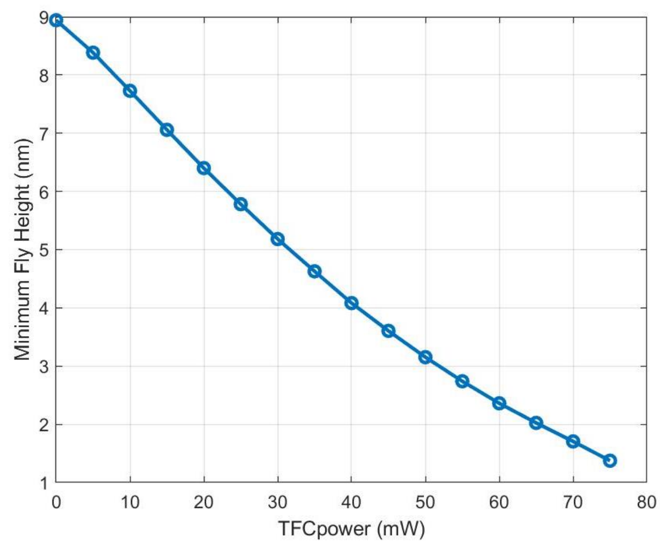
plotter.m

Run the plotter.m file to plot the ECS temperature increase, disk temperature increase and minimum fly height vs TFC Power. This file also plots the slider ABS surface temperature profile and the disk surface temperature profiles at the desired TFC power.

1.4 Example Simulation Result

Here is the ECS temperature increase and minimum fly height vs TFC power for the given parameters.





The ECS temperature and the disk surface temperature at the ECS location is stored in the arrays `ECS_final_temp` and `disk_final_temp` respectively in units of deg C.

The minimum fly height in meters is stored in the array `min_FH`, where the fly height is defined as the distance between the slider ABS and the mean surface of **asperity** heights on the **lubricant** surface (see *Note) [1]. Hence, the fly height becomes negative when the slider TFC protrusion penetrates into the disk lubricant.

*Note

`t` = lube thickness
`d` = distance between the slider ABS and the mean surface of asperity heights on the disk solid surface
`ys` = separation between mean plane of asperity heights and mean plane of surface heights on the disk solid surface [10]

fly height stored in the `min_FH` array = **`d - t`** [1]
head-disk spacing stored in hstar.dat file = **`d + ys`**

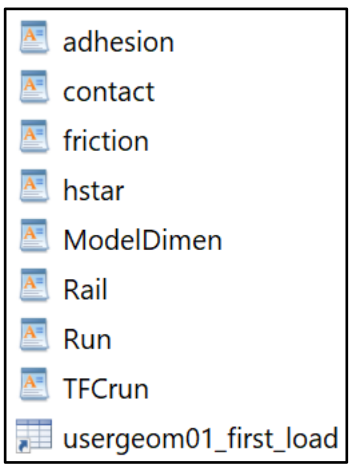
MODEL 2a

2a.1 Introduction

Since the slider loses stability below ~ 1.4 nm fly height, Model 1 can no longer be used. In the example simulation, Model 1 works well from TFC Power 0 to 75 mW. In Model 2a, we set the slider protrusion profile (i.e usergeom01.dat file) at TFC power of 70 mW (for the example simulation) as a baseline and proportionally alter this profile for higher TFC protrusions. This helps us generate the steady state flying attitude of the slider (using modified CML Air quick code) for different peak TFC protrusion levels.

2a.2 Input Files

You will require the following input files:



- adhesion.dat, contact.dat, friction.dat, hstar.dat
- Rail.dat
- Run.dat
- TFCrun.dat
- ModelDimen.dat
- usergeom01_first_load.mat

adhesion.dat, contact.dat, friction.dat, hstar.dat, Rail.dat, TFCrun.dat

Use the same files you used during Model 1.

Run.dat

The only change you need to make from the Model 1 Run.dat file is to choose the initial guess for the flying attitude of the slider (`hm, roll, pitch`). I would recommend choosing the steady state flying attitude of the baseline TFC power (i.e. 70 mW in the case of the example simulation) or something close to it as the initial guess for the flying attitude. For the example simulation, (`hm, roll, pitch`) for TFC Power of 70 mW can be found at `run_save{1,15}(end,2:4)` in the units of (nm, micro-rad, micro-rad) the result workspace of Model 1.

```
***************Intial Attitude***************
hm(m)           pitch(rad)      roll(rad)
+1.3100E-08     +3.8000E-05     +0.0000E+00
```

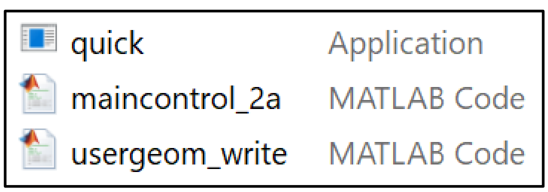
ModelDimen.dat

This file contains the dimensions of the slider FEM model. This file is generated as an output file during Model 1. Just copy the file from the output of Model 1 into the directory containing Model 2a.

usergeom01_first_load.mat

This file contains the TFC protrusion profile of the baseline TFC Power and can be generated using the result of Model 1. For the example simulation, we choose the TFC protrusion profile at TFC Power of 70 mW as the baseline for Model 2a. Hence, we store the "`Usergeom01{1,15}`" matrix from the result of Model 1 as the "usergeom01_first_load.mat" file. Basically, this file contains the TFC protrusion profile at the TFC Power of 70 mW.

2a.3 Program/Execution Files



maincontrol_2a.m

Set the desired range of peak TFC protrusion levels

```
%% Input Paramters
usergeom_peak = [11.7:0.3:14.1];
```

For the example simulation, the peak TFC Protrusion at TFC Power = 70 mW is 11.6327 nm. Hence, we choose a range of 11.7 to 14.1 for the peak TFC protrusion.

The slider mapping parameters: `xmin, xmax, ymin, ymax, length, width, nx` and `ny` from the TFCrun.dat file must be re-entered here, if you make any changes from the default mapping parameters. Additionally, `length_slider` must contain the overall slider of the slider **in mm** and `width_slider` must contain the overall width of the slider **in mm**. These values must be consistent with those entered during Model 1.

```
% Slider FEM model parameters
xmin = 0.6;
xmax = 1;
ymin = 0.25;
ymax = 0.75;
length_slider = 0.8435; % in mm
width_slider = 0.7; % in mm
nx = 401;
ny = 401;
```

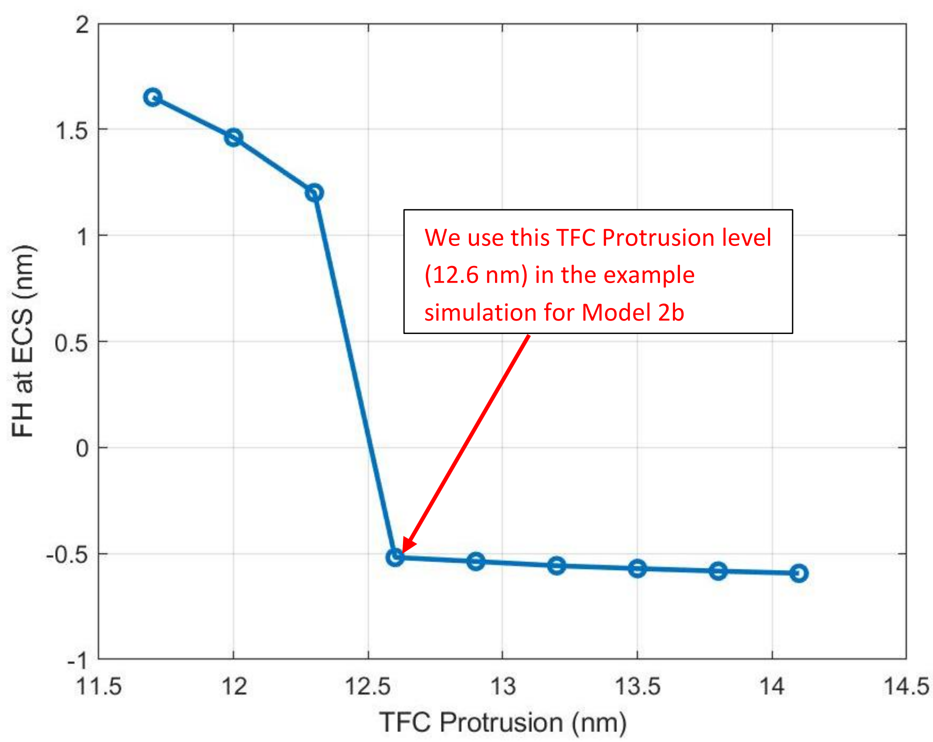
Finally, the roughness parameters are also specified here (`sigma_z, eta, R`) and they must be consistent with those specified in the Run.dat file (`stdasp, dnsasp, rdsasp`).

```
%% ROUGHNESS PARAMETERS
R = 0.020e-6; % asperity radius of curvature
eta = 5000e12; % asperity areal density
sigma_z = 0.5e-9; % std deviation of surface heights
```

Run the maincontrol_2a.m file using MATLAB.

2a.4 Example Simulation Result

Here is a plot of Fly height at ECS vs peak TFC Protrusion for the example simulation.



Please note that for some TFC Protrusion levels (particularly at and beyond contact) the modified CML Air may not converge. This is because achieving convergence in CML Air with the highly non-linear adhesion force is challenging. I would recommend trying to adjust the initial guess for the flying attitude of the slider in the Run.dat file if you are having convergence issues.

The minimum fly height in meters and the fly height at the ECS location in nm are stored in the arrays `min_FH` and `FH_ECS`, where the fly height is defined as the distance between the slider ABS and the mean surface of **asperity** heights on the **lubricant** surface (i.e. fly height = `d - t`, see *Note) [1]. Hence, the fly height becomes negative when the slider TFC protrusion penetrates into the disk lubricant.

MODEL 2b

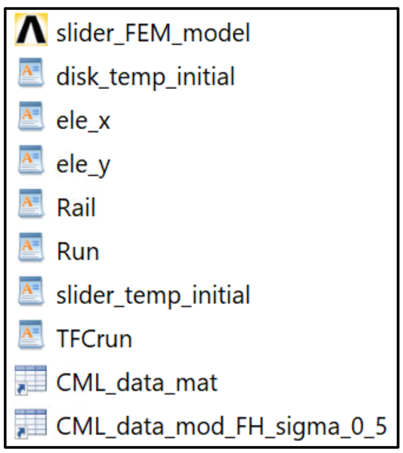
2b.1 Introduction

Once the steady state flying attitude of the slider is computed for different peak TFC protrusion levels using Model 2a, we **back-calculate the TFC Power** corresponding to each peak TFC protrusion level in Model 2a using Model 2b. With the TFC Power known, we can also determine the slider temperature profile and the disk temperature profile.

For example, consider the peak TFC Protrusion level of 12.6 nm from the example simulation result of Model 2a.

2b.2 Input Files

You will require the following input files:



- slider_FEM_model.db
- ele_x.dat, ele_y.dat
- Rail.dat
- Run.dat
- TFCrun.dat
- CML_data_mod_FH_sigma_0_5.mat
- CML_data_mat.mat (generated using generate_CML_data.m)
- disk_temp_initial.dat, slider_temp_initial.dat

slider_FEM_model.db, ele_x.dat, ele_y.dat, rail.dat, run.dat, TFCrun.dat and CML_data_mod_FH_sigma_0_5.mat

Use the same files that you used during Model 1.

generate_CML_data.m

Select the index number of the peak TFC protrusion array (i.e. "`usergeom_peak`" array) for which you intend to perform the simulation using Model 2b. For the example simulation, we intend to perform the simulation using Model 2b for peak TFC Protrusion level of 12.6 nm, which is located at index number 4 in the "`usergeom_peak`" array. Hence we set `ii` to 4 in the **generate_CML_data.m** file. Run this file. It will then save the `CML_data_mat.mat`, which is required as an input file for Model 2b.

```
ii =4; % Select index of "usergeom_peak" for which you intend to save the CML Air data
```

disk_temp_initial.dat, slider_temp_initial.dat

These files contain the initial guess for temperature profiles on the slider and disk surfaces – I would recommend using the slider and disk temperature profiles determined at the last TFC Power data point using Model 1 (i.e. disk_temp_initial.dat, slider_temp_initial.dat files at TFC Power = 75 mW in the case of the example simulation) as the initial guess for Model 2b.

2b.3 Program/Execution Files

ele_x_y_generate	MAC File
GetDimen	MAC File
ModRefTemp	MAC File
SolDeformMag	MAC File
SolFHMag	MAC File
SwitchElemKoptEh	MAC File
disk_temp_compute	MATLAB Code
generate_CML_data	MATLAB Code
get_htc	MATLAB Code
get_modfh	MATLAB Code
get_modpress	MATLAB Code
getQ	MATLAB Code
maincontrol_2b	MATLAB Code
map_CML_ANSYS_avg	MATLAB Code
map_CML_ANSYS_htc	MATLAB Code
usergeom_read	MATLAB Code

maincontrol_2b.m

Set the desired guess for TFC Power (`TFCPower`) and add the slider radial position (`rr`) and disk RPM (`RPM`). Please make sure that the slider radius and disk RPM values are consistent with those entered in the Run.dat file during Model 2a and Model 1. Add the friction coefficient (`mu`).

```
%% Input Parameters
TFCPower = 102;
RPM = 5400; % disk RPM
rr = 27e-3; % radial position of slider
mu = 0.7; % Friction coefficient
```

We have five phonon conduction input parameters: `k1_phon`, `k2_phon`, `k3_phon`, `k4_phon`, `b_phon`. These must be consistent with those values entered during Model 1.

```
% Phonon parameters
% We model the phonon conduction htc using the following formula:
% log(htc_phon) = k1_phon*(log(T_disk+273.15)-log(273.15+25)) + k2_phon*(log(dT)-log(400)) + k3_phon*log(h_in_orig) + b_phon
% T_disk = disk temperature in deg C
% dT = slider-disk temperature difference in deg C
% h = spacing in nm
k1_phon = 0.99;
k2_phon = -0.83;
k3_phon = -1.99;
b_phon = 11.4;
```

Further, enter the desired air properties like thermal conductivity (`k_bulk`), mean free path (`lambda0_bulk`), thermal accommodation coefficient (`sigma`), specific heat ratio (`gamma`) and Prandtl number (`Pr`). These must be consistent with those values entered during Model 1.

```
% Air parameters
k_bulk = 0.0261; % Air thermal conductivity
lambda0_bulk = 67.1e-9; % Air Mean Free Path
sigma = 0.6; % Thermal Accomodation Coefficient
gamma = 1.4015; % Ratio of Specific Heat Capacity for Air
Pr = 0.71; % Prandtl Number for Air
```

`max_htc` is an upper limit to the HDI heat transfer coefficient that is applied in the model to account for the presence of the interface thermal conductance (or Kapitza conductance).

```
max_htc = 1.5e7; % Interface thermal conductance for the HDI (applied as an upper limit for the HDI htc)
```

Further, if you plan to create your own slider FEM model, please note that `surf_ele_num` must contain the number of triangular surface elements on the ABS surface of the slider ANSYS model. Also, the slider mapping parameters: `nx` and `ny` from the TFCrun.dat file must be re-entered here, if you make any changes from the default mapping parameters. These must be consistent with those values entered during Model 1.

```
% Slider FEM parameters
surf_ele_num = 1505; % number of surface elements on ABS surface of slider ANSYS model
nx = 401;
ny = 401;
```

Finally, the roughness parameters are also specified here (`sigma_z, eta, R`) and they must be consistent with those specified in the Run.dat file (`stdasp, dnsasp, rdsasp`).

```
%% ROUGHNESS PARAMETERS
R = 0.020e-6; % asperity radius of curvature
eta = 5000e12; % asperity areal density
sigma_z = 0.5e-9; % std deviation of surface heights
```

Enter the path of your ansys executable (currently set to `C:\Program Files\ANSYS Inc\v140\ansys\bin\winx64\ansys140.exe`) and the path of the location of all the files required to run this code (currently set to `C:\Users\siddhesh_sakhalkar\Desktop\Siddhesh Codes\Flying touchdown\Model 2b`) in the system commands on line 103 of the maincontrol.m file.

2b.4 Example Simulation Result

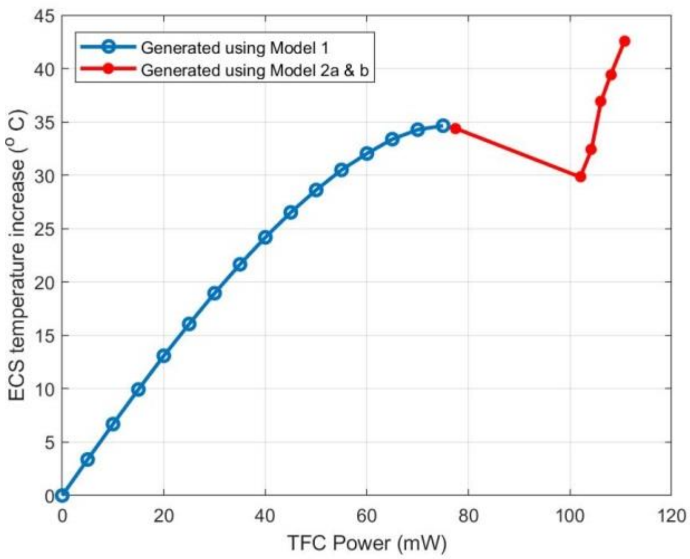
Run the maincontrol_2b.m file using MATLAB. The code will output the peak TFC Protrusion for the inputted guess for TFC Power (as shown below). Keep adjusting the inputted guess for TFC Power and re-running the maincontrol_2b.m code till the outputted peak TFC Protrusion matches the peak TFC Protrusion that was used during Model 2a. In the case of the example simulation, the outputted peak TFC Protrusion matches the peak TFC Protrusion that was used during Model 2a (i.e. 12.6 nm) at a TFC Power of 102 mW.

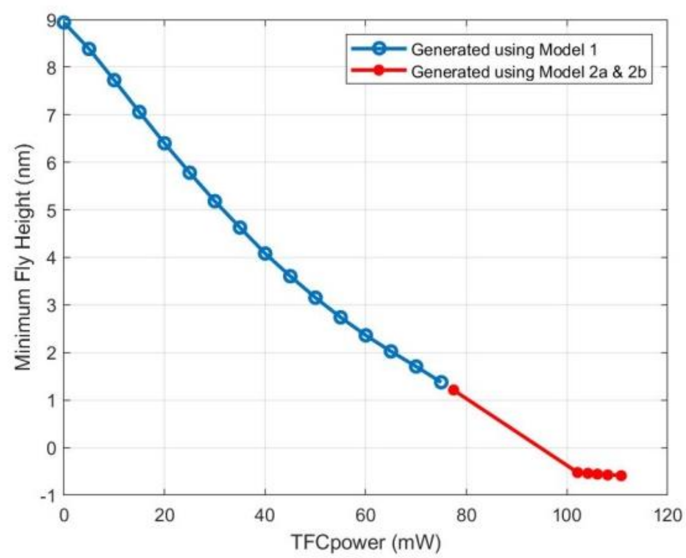
```
Usergeom peak is 12.6017 nm

ECS_final_temp =

   54.8392


disk_final_temp =

   48.3348


min_FH =

  -5.1644e-10
```

The ECS temperature and the disk surface temperature at the ECS location is stored in the variables `ECS_final_temp` and `disk_final_temp` respectively in units of deg C.

The minimum fly height in meters is stored in the variable `min_FH` (see *Note).

On repeating this procedure for the TFC protrusion levels of 12.3 nm (77.5 mW), 12.6 nm (102 mW), 12.9 nm (104.2 mW), 13.2 nm (106.1 mW), 13.5 nm (108 mW) and 13.8 nm (110.7 mW), we get the following ECS temperature and minimum fly height curves for the example simulation:





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