UNIVERSITÄT DUISBURG ESSEN

Offen im Denken

Computer Based Engineering Mathematics Lab

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Project 2: Regression Analysis

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Description

- First Model Function:

Function one: $k_f=x_6e^{x1T}.\ \varphi'^{x2+x5T}.\ \varphi^{x3}.e^{x44}$

This function is not linear with respect to [x] and we must linearize it.

$\ln k_f = \ln x_6+x_1T+\ln\varphi'(x_2+x_5T) + \ln\varphi.x_3+x_4\varphi = x_1T+x_2\ln\varphi'+x_3\ln\varphi+x_4\varphi+x_5T\ln\varphi+\ln x_6$

The last term ln x_6 can simply be replaced by a constant for the calculations.

$=>\ln k_f = x_1T+x_2\ln\varphi'+x_3\ln\varphi+x_4\varphi+x_5T\ln\varphi+x_6$

We now define the vector, $b_i=\ln k_{f1i}{}^T = \begin{bmatrix} \ln k_{fi1} \\ \cdot \\ \cdot \\ \ln k_{fin} \end{bmatrix}$, the vector x= $[x_1\ \ x_2\ \ x_3\ \ x_4\ \ x_5\ \ x_6]$

The matrix A= $\begin{bmatrix} T_1\ ln\varphi'_1 & \ln\varphi_1 & \varphi_1 & \ln\varphi_1 & 1 \\ & & . & & \\ & & . & & \\ & & . & & \\ T_n\ ln\varphi'_n & \ln\varphi_n & \varphi_n & \ln\varphi_n & 1 \end{bmatrix}$

Where i and n are indicating how many measurements, we have. Then to find our x vector we simply need to solve: $A^T.A.x=A^Tb$

- Second Model Function:

Function 2: We do the same procedure: $k_f=x_{10}e^{x1T}.\ \varphi'^{x2+x5T+x6}.\ \varphi^{x3+x1T+x8\phi'}\ e^{x4\phi+x9\phi'}$

$\ln k_f=x_1T+x_2\ln\varphi'+x_3\ln\varphi+x_4\varphi+x_5T\ln\varphi'+x_6\ln\varphi'.\ \varphi+x_7\ln\varphi T+x_8\ln\varphi.\ \varphi'+x_9\varphi'+\ln x_{10}$

$$b=\begin{bmatrix}\ln k_{fi1}\\ \cdot\\ \cdot\\ \ln k_{fin}\end{bmatrix}$$

$$A=\begin{bmatrix}T_1 & ln\varphi'_1 & \ln\varphi_1 & \varphi_1 & T_1\ln\varphi'_1 & \ln\varphi'_1\varphi_1 & \ln\varphi_1 T_1 & \ln\varphi_1\varphi'_1 & \varphi'_1 & 1\\ & & & & & \cdot & & & & \\ & & & & & \cdot & & & & \\ & & & & & \cdot & & & & \\ T_n & {}_{\ln}\varphi'_n & \ln\varphi_n & \varphi_n & T_n\ln\varphi'_n & \ln\varphi'_n\varphi_n & \ln\varphi_n T_n & \ln\varphi_n\varphi'_n & \varphi'_n & 1\end{bmatrix}$$

$A^T.A.x=A^Tb$

- Calculation of R^2 :

To calculate R^2 in both cases we simply use the formula:

$$R^2=\frac{\sum_{i=1}^{n}(f(x,t_i)-y^{-})^2}{\sum_{i=1}^{n}(y_i-y^{-})^2}$$

Where $b(x_, t_i)$ is our predicted value y_i is the measured value y^{-} is the mean of the measured values where,

$$y^{-}=\frac{1}{n}\sum_{i=1}^{n} y_i$$

Getting our vectors of the parameters and R^2 :

For the first model

x06=6x1	x15=6x1	x60=6x1
-0.0013	-0.0009	-0.0021
0.0623	0.0520	0.0114
0.1520	0.0987	0.2918
-0.1681	-0.0476	-0.6639
-0.0001	-0.0001	0.0001
7.1509	6.6426	7.7565

R^2_06 = 0.6145

R^2_15 = 0.4425

R^2_60 = 0.8981

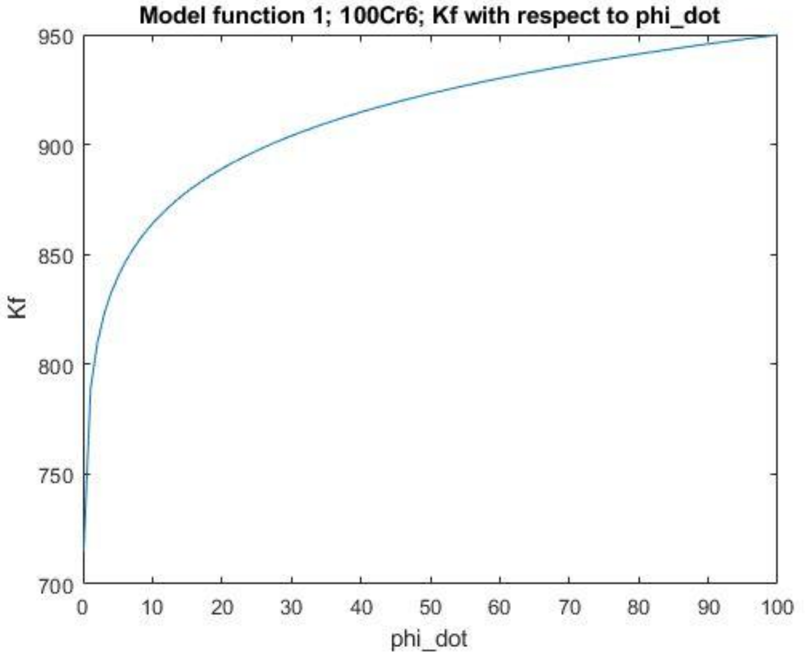
For the Second model

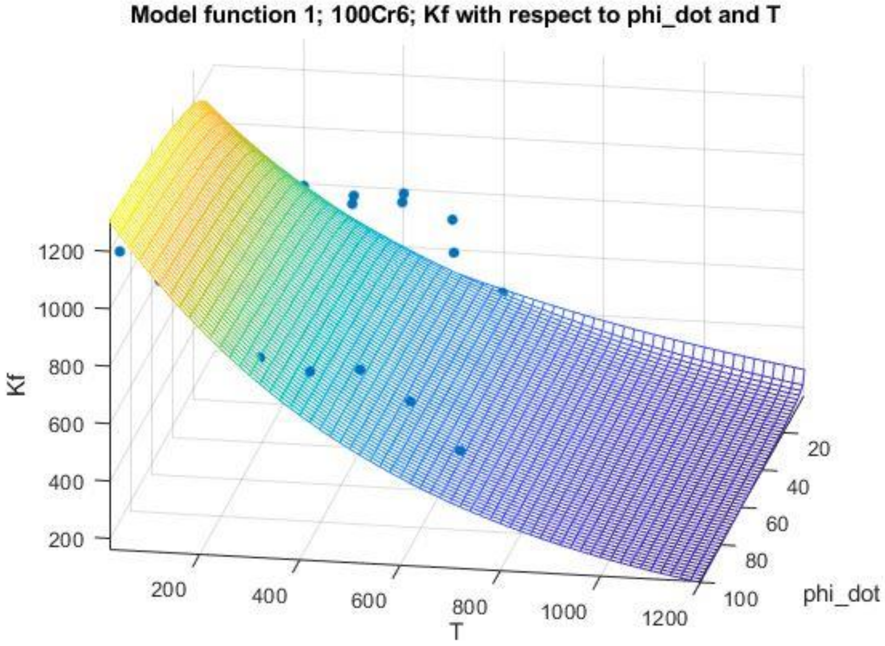
z06=10x1	z15=10x1	z60=10x1
-0.0016	-0.0015	-0.0022
0.0820	0.0679	-0.0457
0.2586	0.3055	0.3557
-0.0297	0.0651	-0.5538
-0.0001	-0.0001	0.0001
-0.0521	-0.0119	0.0085
-0.0003	-0.0004	-0.0002
0.0008	0.0005	-0.0000
0.0010	-0.0003	0.0036
7.2278	6.8724	7.6979

R^2_06 = 0.6255

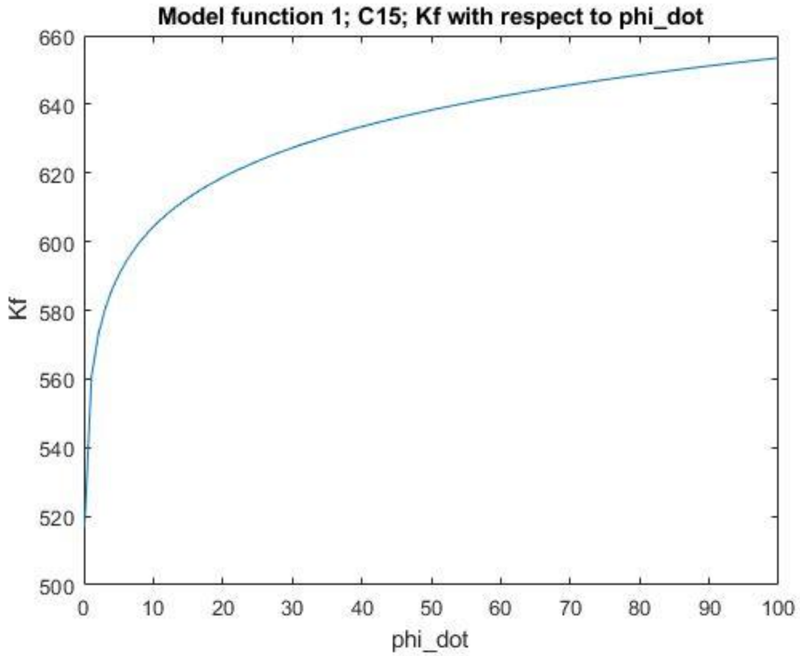
R^2_15 = 0.4754

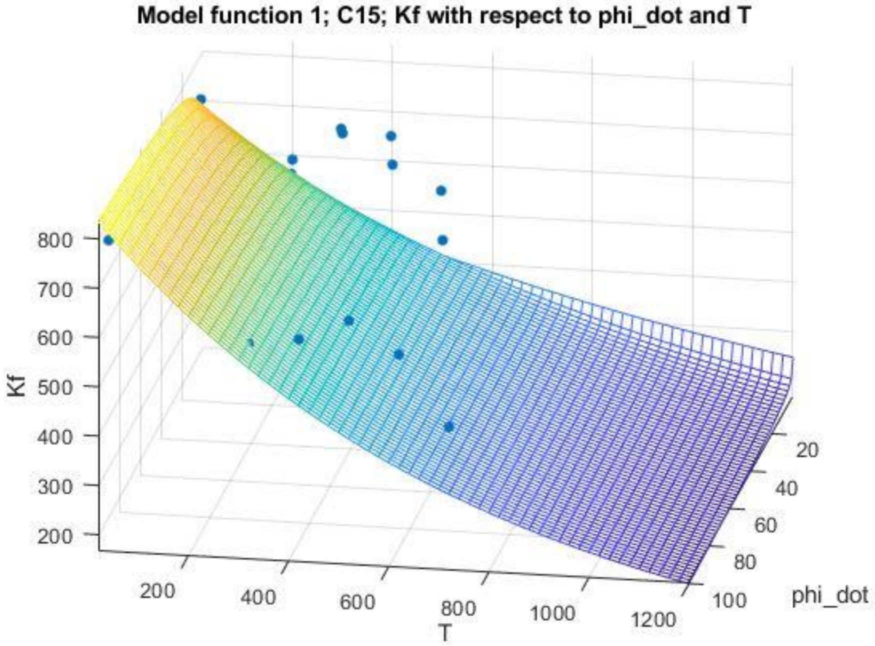
R^2_60 = 0.9082



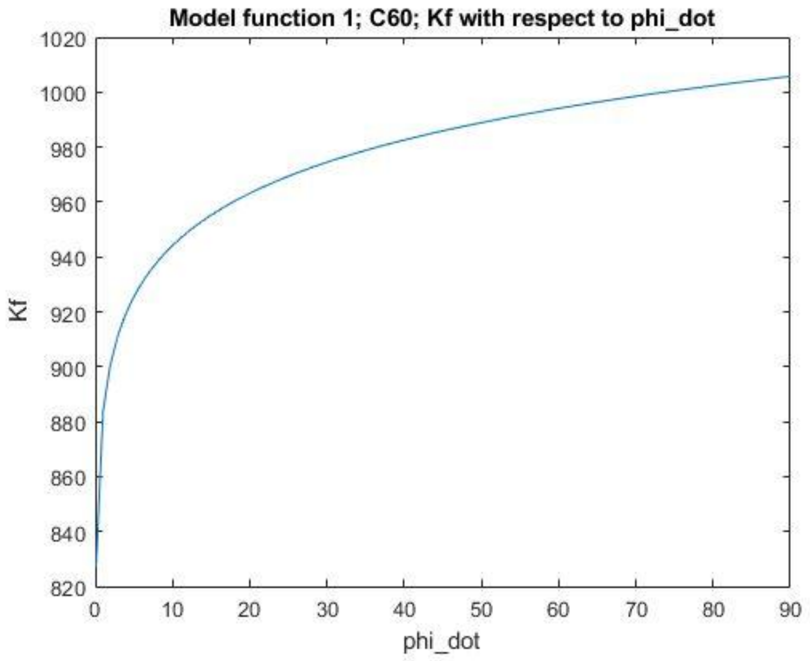


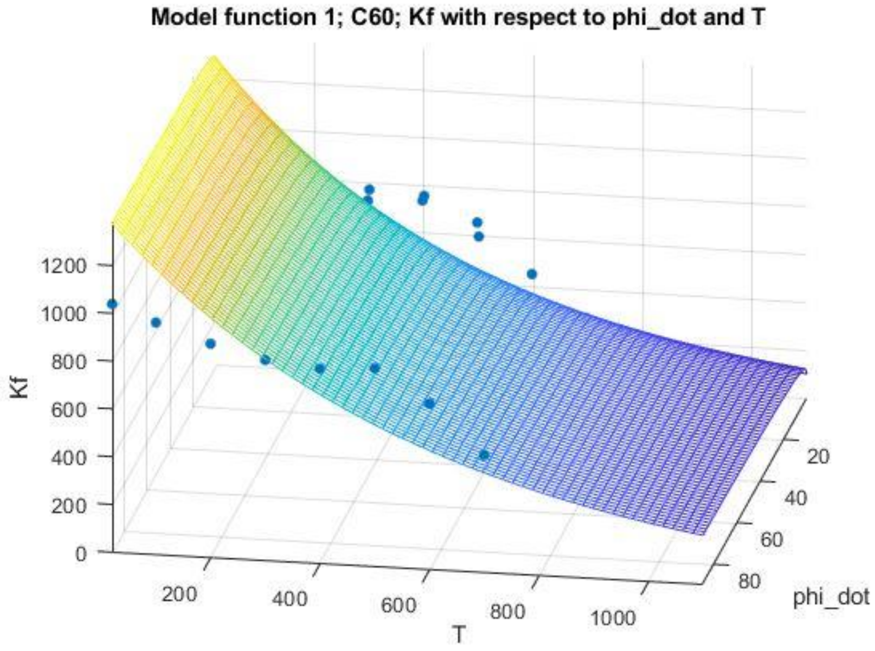
Best fitting curve for 100Cr6 using model function 1: y=1275.255681*e^(-0.001285*T)*phi_dot^(0.062255+-0.000105T)*phi^0.152007*e^(-0.168144phi)



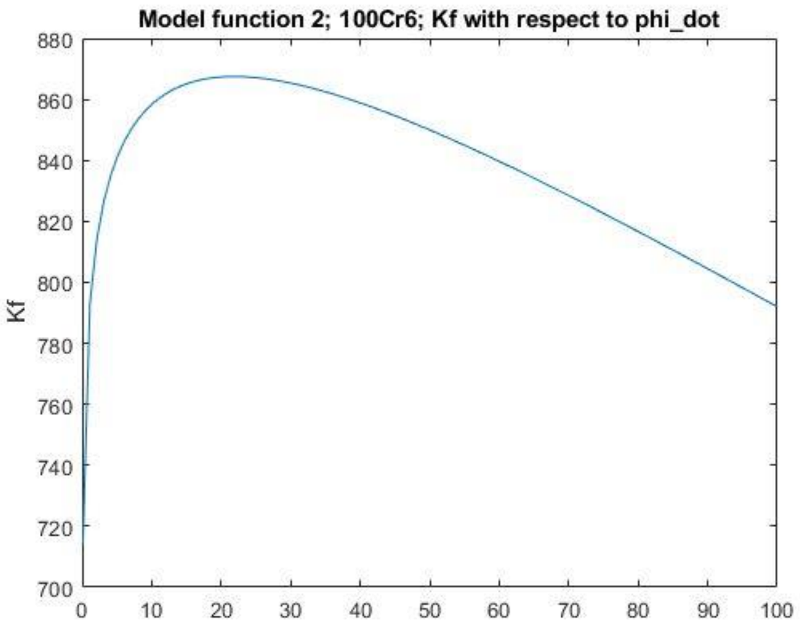


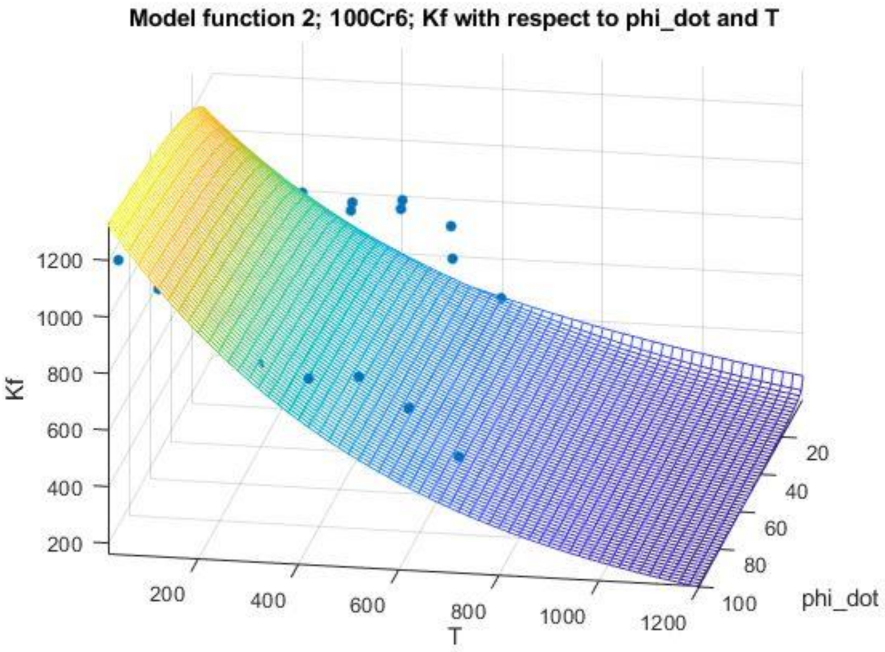
Best fitting curve for C15 using model function 1:
y=767.098096*e^(-0.000945*T)*phi_dot^(0.052005+-0.000090T)*phi^0.098706*e^(-0.047643phi)



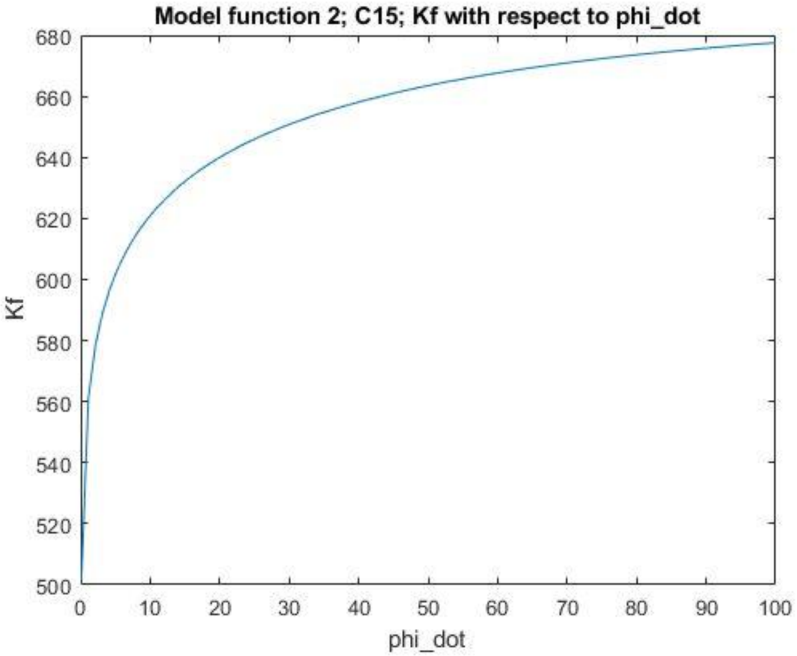


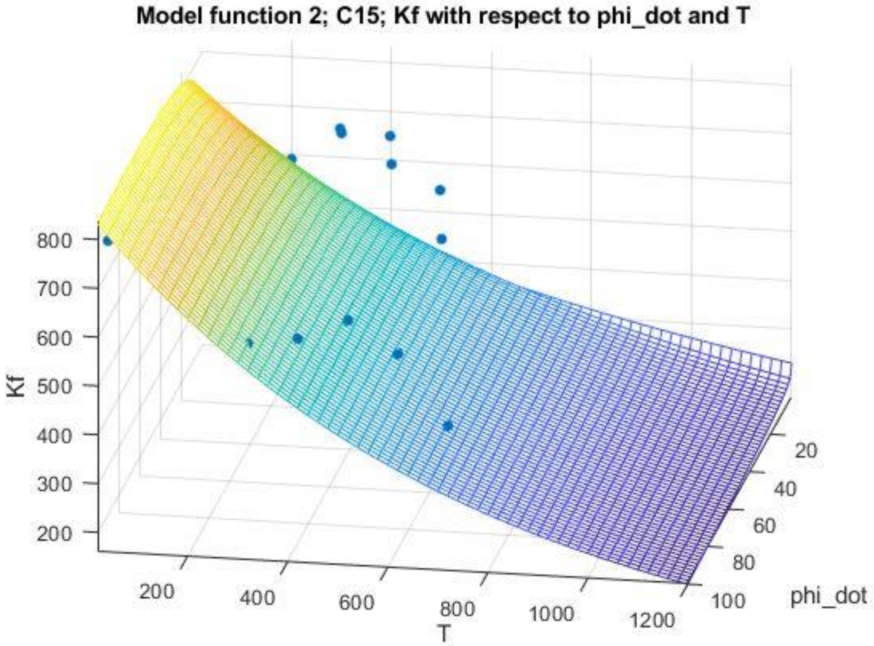
Best fitting curve for C60 using model function 1:
y=2336.604239*e^(-0.002137*T)*phi_dot^(0.011358+0.000087T)*phi^0.291779*e^(-0.663931phi)



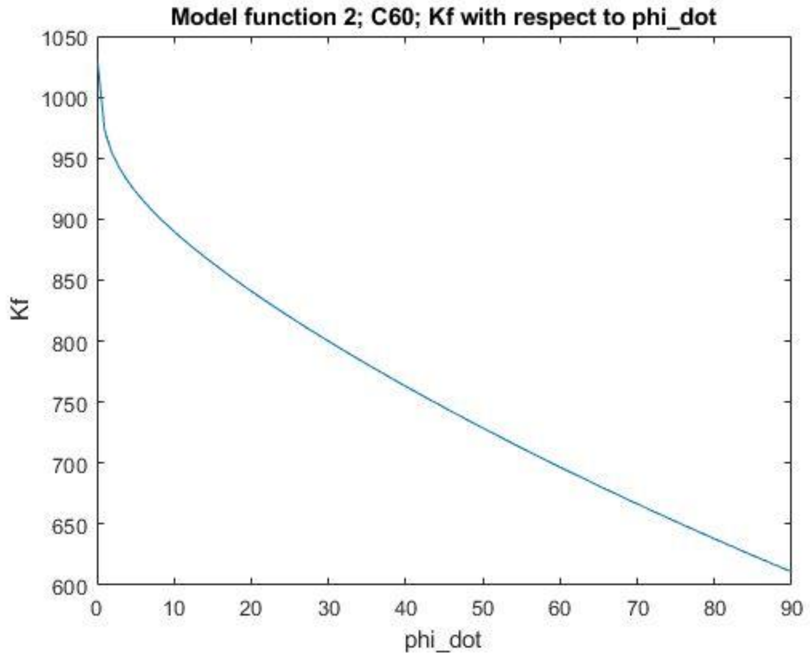


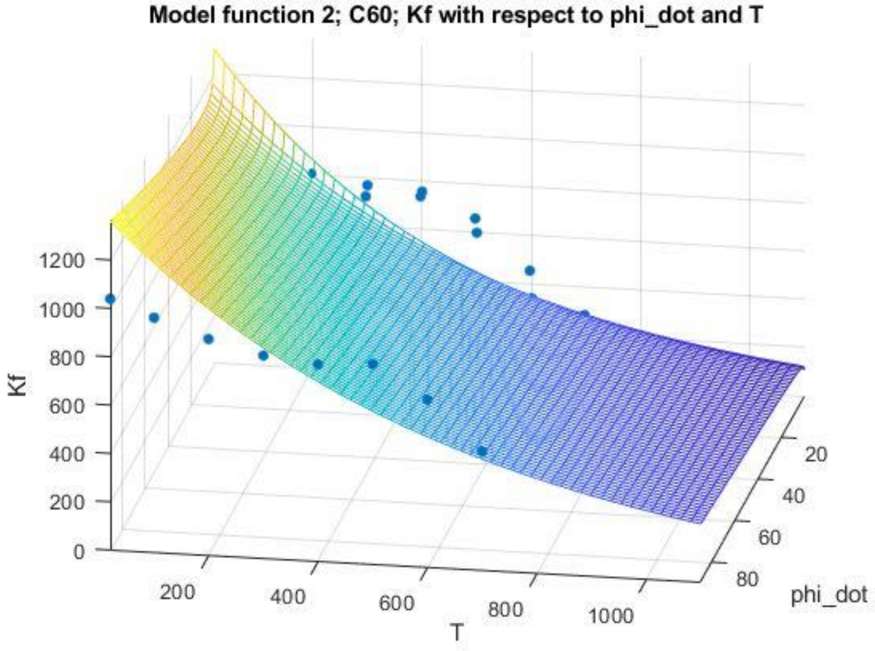
Best fitting curve for 100Cr6 using model function 2:
y=1377.226561*e^(-0.001593*T)*phi_dot^(0.082002+-0.000105T+-0.052111phi)*phi^(0.258644+-0.000258T+0.000830phi_dot)*e^(-0.029658phi+0.000957phi_dot)



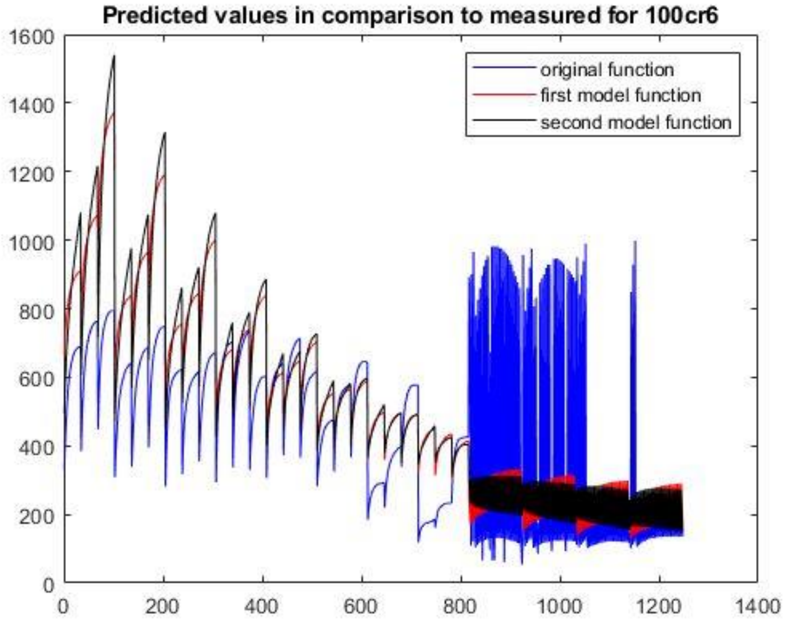


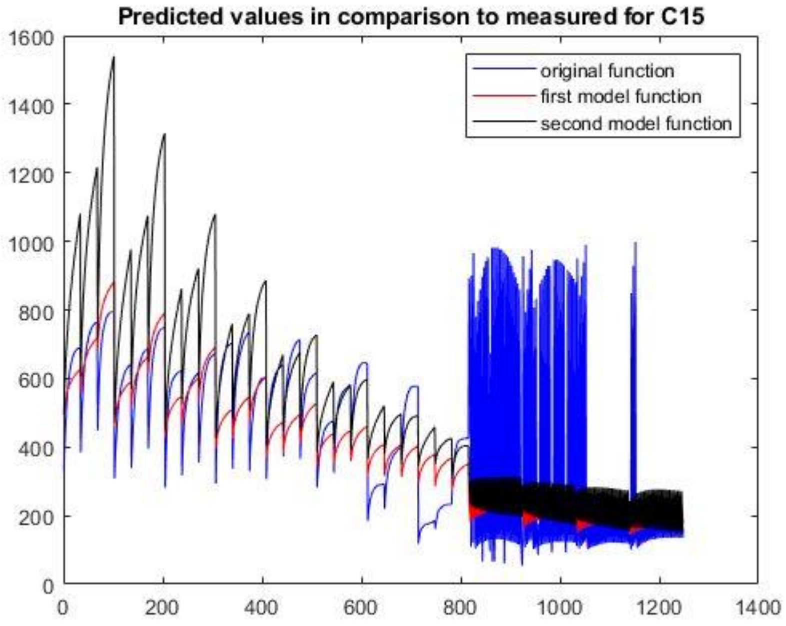
Best fitting curve for C15 using model function 2: y=965.231734*e^(-0.001481*T)*phi_dot^(0.067929+-0.000086T+-0.011947phi)*phi^(0.305504+-0.000428T+0.000504phi_dot)*e^(0.065144phi+-0.000311phi_dot)

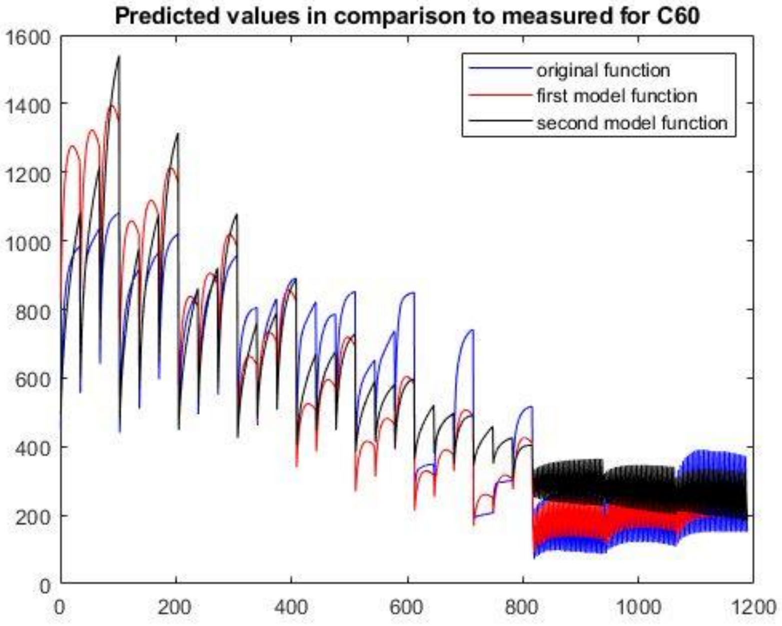




Best fitting curve for C60 using model function 2: y=2203.671363*e^(-0.002240*T)*phi_dot^(-0.045741+0.000101T+0.008467phi)*phi^(0.355744+-0.000174T+-0.000021phi_dot)*e^(-0.553828phi+0.003597phi_dot)







Predicted Values Vs Measured Ones For Data Sheet

Comparison Between Two Models

- We know from the script that the **R^2** measured always between 0 and 1, i.e. : 0<= **R^2** <=1. The closer **R^2** is to one, the better the approximation of the measured data by the calculated fitting curve.
- We have already seen that the model 2 has a better **R^2** but model one still fits some parts of the curve better.

Matlab Codes For Model Functions

```
%Model Function 1
function x = func1(C1)
A=[C1(:,4) C1(:,1) C1(:,2) C1(:,3) C1(:,1).*C1(:,4)
ones(size(C1(:,1)))];
b=C1(:,5);
x=A\b;
end
```

```
%Model Function 2
function z = func2(mdata)
A=[mdata(:,5) mdata(:,1) mdata(:,3) mdata(:,4)
mdata(:,1).*mdata(:,5) mdata(:,1).*mdata(:,4)
mdata(:,5).*mdata(:,3) mdata(:,2).*mdata(:,3)
mdata(:,2) ones(size(mdata(:,1)))];
b=mdata(:,6);
z=A\b;
end
```

Matlab Codes For R^2

```
%Model Function 1
function R_2 = R_square_1(in,x)
f=[in(:,4) in(:,1) in(:,2) in(:,3) in(:,1).*in(:,4)
ones(size(in(:,1)))];
y=f*x;
y_av=mean(in(:,5));
sf=sum((y-y_av).^2);
mf=sum((in(:,5)-y_av).^2);
R_2=sf/mf;
end
```

```
%Model Function 2
function R2 = R_square_2(mdata,z)
f=[mdata(:,5) mdata(:,1) mdata(:,3) mdata(:,4)
mdata(:,1).*mdata(:,5) mdata(:,1).*mdata(:,4)
mdata(:,5).*mdata(:,3) mdata(:,2).*mdata(:,3)
mdata(:,2) ones(size(mdata(:,1)))];
y=f*z;
y_av=mean(mdata(:,6));
sf=sum((y-y_av).^2);
mf=sum((mdata(:,6)-y_av).^2);
R2=sf/mf;
end
```