KC Design Spreadsheet

Material Properties

[Brass, Nylon, Steel, Aluminium]

```
potential_materials = [ 'Brass', 'Nylon' 'Steel', 'Aluminium' ];
yield_stress = [ 135E6, 45E6, 435E6, 276E6 ];        % [Pa]
elastic_modulus = [ 105E9, 2.6E9, 200E9, 69E9 ];    % [Pa]
poisson_ratio = [ 0.346, 0.39, 0.26, 0.33 ];
ultimate_strength = [ 345E6, 82.7E6, 670E6, 310E6 ];
```

Some Input Parameters

```
%Choose a material: 1 = brass; 2 = nylon; 3 = steel; 4 = aluminium
ball_material_choice = 1;
groove_material_choice = 4;

% Ball material properties
yield_stress_ball = yield_stress( ball_material_choice );                % [Pa]
elastic_modulus_ball = elastic_modulus( ball_material_choice );          % [Pa]
poisson_ratio_ball = poisson_ratio( ball_material_choice );
ultimate_strength_ball = ultimate_strength( ball_material_choice );      % [Pa]

% Groove material properties
yield_stress_groove  = yield_stress( groove_material_choice );           % [Pa]
elastic_modulus_groove = elastic_modulus( groove_material_choice ); % [Pa]
poisson_ratio_groove = poisson_ratio( groove_material_choice );
ultimate_strength_groove = ultimate_strength( groove_material_choice ); % [Pa]

Dball = 12.7E-3; % [m], diameter of the "ball".
rminor_ball = 6.35E-3; % [m], minor radius of the "ball": half of the diameter if the "ball" i
rmajor_ball = 6.35E-3; % [m], major radius of the "ball": half of the diameter if the "ball" i
r_groove = inf;          % [m], groove radius: very large if the groove is straight and negativ
D_coupling = 55.88E-3;   % [m], the diamater of the overall circle of the "balls".
F_preload = -25;         % [N], preload force from screw.
groove_angle = 90;       % [deg], tool angle: angle for V-groove
phi = 0;                 % [deg], the angle between the planes of principal curvature of the tw
surface_finish = 2E-6;   % [m]
```

Contact Ellipse Calculation

```
% Minimum yield strength.
min_yield_strength = min( yield_stress_ball, yield_stress_groove );

% Equivalent radius.
Req = 1 / ( 1 / rmajor_ball + 1 / rminor_ball + 2 / r_groove );
```

```
% Equivalent modulus.
Eeq = 1 / ( ( 1 - poisson_ratio_ball.^2 ) / elastic_modulus_ball + ( 1 - poisson_ratio_groove

theta = acos( Req * sqrt( ( 1 / rmajor_ball - 1 / rminor_ball ).^2 ));

% Elliptic integrals
alpha = 1.939 * exp( -5.26 * theta) + 1.78 * exp( -1.09 * theta ) + 0.723 / theta + 0.221;
beta = 35.228 * exp( -0.98 * theta) - 32.424 * exp( -1.0475 * theta ) + 1.486 * theta - 2.634
lambda = -0.214 * exp( -4.95 * theta ) - 0.179 * theta.^2 + 0.555 * theta + 0.319;

% Major contact area elliptical semi-axis
F = ( F_preload / 6 ) * sin( groove_angle / 2 );
c = alpha * ( 3 * abs( F ) * Req / ( 2 * Eeq )).^( 1/3 );
% Minor contact area elliptical semi-axis
d = beta * ( 3 * abs( F ) * Req / ( 2 * Eeq )).^( 1/3 );
```

Contact Pressure

```
q = 3 * abs( F ) / ( 2 * pi * c * d );
disp('Contact Pressure = '+ string( round( q, 3, 'significant' )) + ' Pascals')
```

```
Contact Pressure = 333000000 Pascals
```

```
comparison_value = 1.5 * min( yield_stress_ball, yield_stress_groove );
if q > comparison_value
    meets_criteria = 'True';
    fprintf( 'This configuration meets the criteria that the contact pressure be at least twi
else
    meets_criteria = 'False';
    fprintf( 'This configuration does not meet the criteria that the contact pressure be at le
end
```

```
This configuration meets the criteria that the contact pressure be at least twice the minimum yield stress of the
```

Contact Deflection

```
delta = lambda * ( 2 * F .^2 / ( 3 * Req * Eeq.^2 )).^( 1/3 );
disp('Deflection = '+ string( round( delta, 3, 'significant' )) + ' meters')
```

```
Deflection = 7.95e-07 meters
```

Stress State

State of stress for a circular contact of radius a as a function of depth z below the surface

```
z = 2 * c;
sigma_z = q .* ( -1 + z.^3 / ( d.^2 + z.^2 ).^1.5 );
sigma_theta =  q ./ 2 .* ( -( 1 + 2 .* poisson_ratio_groove ) + 2 .* ( 1 + poisson_ratio_groo
tau = ( sigma_theta - sigma_z ) ./ 2;
```

Stiffness

```
stiffness = abs( F ) / delta;
disp('Stiffness = ' + string( round( stiffness, 3, 'significant' )) + ' Newtons per meter')
```

```
Stiffness = 4460000 Newtons per meter
```

Angular Stiffness

```
angular_stiffness = stiffness * ( D_coupling / 2 )^2;
disp('Angular Stiffness = ' + string( round( angular_stiffness, 3, 'significant' )) + ' Newto
```

```
Angular Stiffness = 3480 Newton meters
```

Repeatability

```
repeatability = surface_finish;                                                      % [m]
disp('Repeatability = ' + string( round( repeatability*1000, 3, 'significant' )) + ' millimete
```

```
Repeatability = 0.002 millimeters
```

```
angular_repeatability = rad2deg( asin( surface_finish / ( D_coupling / 2 )));    % [deg]
disp('Angular Repeatability = ' + string( round( angular_repeatability, 3, 'significant' )) +
```

```
Angular Repeatability = 0.0041 degrees
```

Accuracy

```
accuracy = 3 * repeatability;
disp('Accuracy = ' + string( round( accuracy*1000, 3, 'significant' )) + ' millimeters')
```

```
Accuracy = 0.006 millimeters
```

```
angular_accuracy = 3 * angular_repeatability;
disp('Angular Accuracy = ' + string( round( angular_accuracy, 3, 'significant' )) + ' degrees
```

```
Angular Accuracy = 0.0123 degrees
```