Excel Add-in for Pinch Analysis

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Contents

The Excel Add-In for Pinch Analysis offers the following functions:

1 FUNCTION TARGETS

```
Function Targets(T_supply As Range, _
                 T_target As Range, _
                 Duty As Range, _
                 DTmin As Double) As Variant
```

Calculates from these inputs:

- supply temperatures (T_supply) and
- target temperatures (T_target) and
- associated heat duties to be transferred (Duty), as well as
- set minimum delta_T (DTmin),

the Pinch basic data:

- Pinch temperature hot streams (TP-Hot) and
- Pinch temperature cold streams (TP-Cold),
- minimum heating demand (QHmin) and
- minimum cooling demand (QCmin).

This function is an array formula(1). The output is given in an array of 2 columns and 4 rows.

Example:

input in cell A8 for array A8:B11: {=targets(A3:A6,B3:B6,C3:C6,D3)}

	A	B	C	D
1	T_supply	T_target	Duty	DTmin
2	[°C]	[°C]	kW	[°C]
3	60	100	80	10
4	30	120	81	
5	130	40	90	
6	180	80	50	
7				
8	TP-Hot =	70	[°C]	
9	TP-Cold =	60	[°C]	
10	QHmin =	24	kW	
11	QCmin =	3	kW	

If more than one Pinch Point was found, the function returns ‘multiple Pinches’ in the output cells for TP-Hot and TP-Cold.

(1) An array formula performs an operation on multiple values instead of a single value. The final result of an array formula can be either one item or an array of items, depending on how the formula is constructed. To work correctly, array formulas need to be entered with control + shift + enter, after first selecting the output array. When the formula is entered this way, the formula is wrapped in curly braces {} in the formula bar. Do not enter curly braces manually, or the formula won't work!

2 FUNCTION GRAND COMPOSITE CURVE

```
Function GCC(T_supply As Range, _
             T_target As Range, _
             Duty As Range, _
             DTmin As Double) As Variant
```

Calculates from these inputs:

- supply temperatures (T_supply) and
- target temperatures (T_target) and
- associated heat duties to be transferred (Duty), as well as
- set minimum delta_T (DTmin),

the data to plot a Grand-Composite Curve in a T-H diagram:

- enthalpy values (H-GCC) and
- corrsponding temperate values (T-GCC)

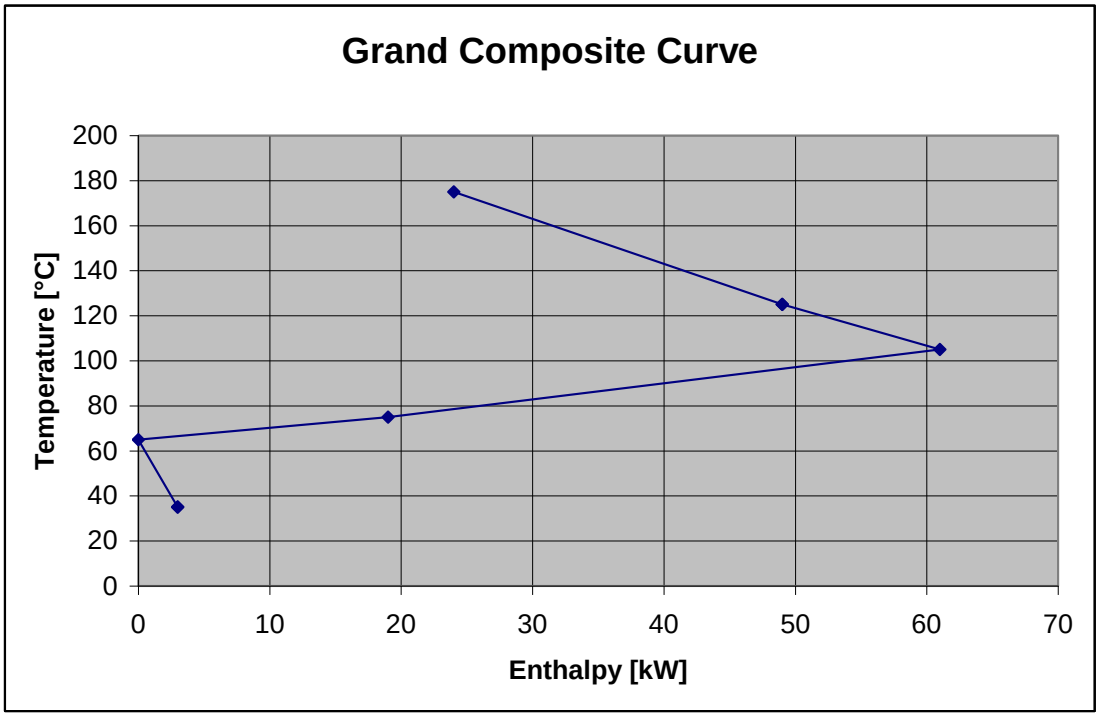
This function is an array formula. The output is given in an array of 2 columns and 2*N+1 rows (N= number of streams).

Example:

input in cell A8 für array A8:B16: {=GCC(A3:A6,B3:B6,C3:C6,D3)}

	A	B	C	D
1	T_supply	T_target	Duty	DTmin
2	[°C]	[°C]	kW	[°C]
3	60	100	80	10
4	30	120	81	
5	130	40	90	
6	180	80	50	
7				
8	H-GCC	T-GCC		
9	3	35		
10	3	35		
11	0	65		
12	19	75		
13	61	105		
14	49	125		
15	49	125		
16	24	175		

Using this data, it is easy to display the Grand-Composite Curve by inserting a X Y (Scatter) diagram:



3 FUNCTION SHIFTED COMPOSITE CURVES

```
Function ShiftedCC(T_supply As Range, _
                   T_target As Range, _
                   Duty As Range, _
                   DTmin As Double) As Variant
```

Calculates from these inputs:

- supply temperatures (T_supply) and
- target temperatures (T_target) and
- associated heat duties to be transferred (Duty), as well as
- set minimum delta_T (DTmin),

the data to plot a Shifted Composite Curve in a T-H diagram:

- enthalpy values (H-CC),
- corresponding temperature of the cold stream curve (T-CC-Cold) and
- corresponding temperature of the hot stream curve (T-CC-Hot)

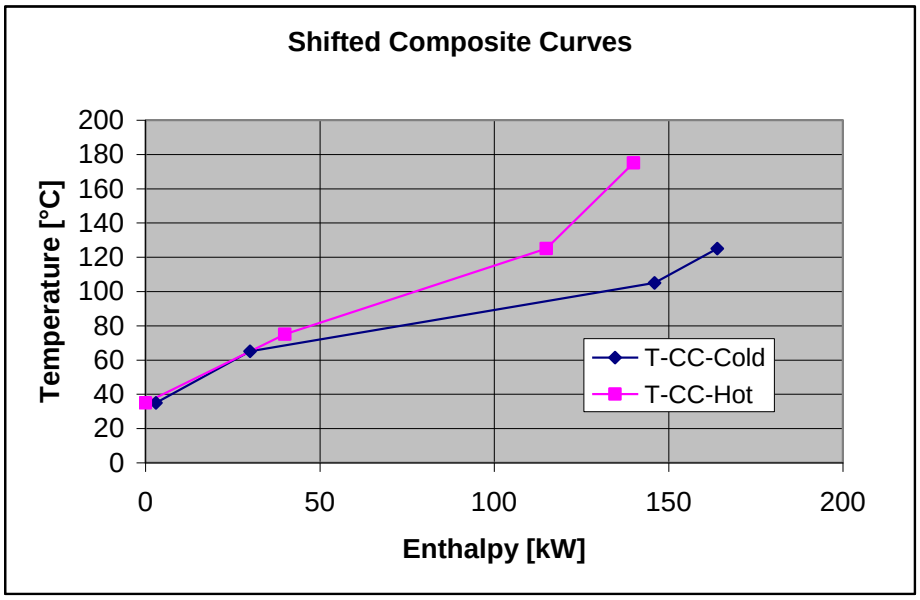
This function is an array formula. The output is given in an array of 3 columns and 2*N+1 rows (N= number of streams).

Example:

input in cell A8 for array A8:B16: {=GCC(A3:A6,B3:B6,C3:C6,D3)}

	A	B	C	D
1	T_supply	T_target	Duty	DTmin
2	[°C]	[°C]	kW	[°C]
3	60	100	80	10
4	30	120	81	
5	130	40	90	
6	180	80	50	
7				
8	H-CC	T-CC-Cold	T-CC-Hot	
9	3	35		
10	30	65		
11	146	105		
12	164	125		
13	0		35	
14	40		75	
15	115		125	
16	140		175	

Using this data, it is easy to display the Shifted Composite Curves by inserting a X Y (Scatter) diagram:



4 FUNCTION UTILITY TARGET

```
Function UtiTarget(T_supply As Range, _
                   T_target As Range, _
                   Duty As Range, _
                   DTmin As Double, _
                   TUS As Double, _
                   TUT As Double) As Variant
```

Calculates from these inputs:

- supply temperatures (T_supply) and
- target temperatures (T_target) and
- associated heat duties to be transferred (Duty) and
- set minimum delta_T (DTmin), as well as
- supply temperature utility and
- target temperature utility,

the maximum heat duty that can be supplied to or can be extracted from the process by this utility. The result is always a positive number.

This function is not an array formula.

Example:

Input (in Cell C7): = UtiTarget(A3:A6,B3:B6,C3:C6,D3,A7,B7)
Input (in Cell C8): = UtiTarget(A3:A6,B3:B6,C3:C6,D3,A8,B8)
Input (in Cell C9): = UtiTarget(A3:A6,B3:B6,C3:C6,D3,A9,B9)
Input (in Cell C10): = UtiTarget(A3:A6,B3:B6,C3:C6,D3,A10,B10)

	A	B	C	D
1	T_supply	T_target	Duty	DTmin
2	[°C]	[°C]	[kW]	[°C]
3	60	100	80	10
4	30	120	81	
5	130	40	90	
6	180	80	50	
7	56	60	0.4	
8	20	30	2.6	
9	80	70	19	
10	121	120	5	

5 FUNCTION COUNT PINCHES

```
Function CountPi(T_supply As Range, _
                 T_target As Range, _
                 Duty As Range, _
                 DTmin As Double, _
                 Optional Approach As Double = 0.001) As Variant
```

Calculates from these inputs:

- supply temperatures (T_supply) and
- target temperatures (T_target) and
- associated heat duties to be transferred (Duty) and
- set minimum delta_T (DTmin), as well as
- an approach temperature (optional parameter, default is 0.001)

the number of Pinch Points and points, that are to be considered as near Pinch Points because delta T between hot and cold Shifted Composite Curve is less than the approach temperature.

This function is not an array formula.

Example:

Input (in Cell A7): = CountPi(A3:A6,B3:B6,C3:C6,D3)

	A	B	C	D
1	T_supply	T_target	Duty	DTmin
2	[°C]	[°C]	[kW]	[°C]
3	60	100	80	10
4	30	120	81	
5	130	40	90	
6	180	80	50	
7	1			

6 FUNCTION LIST PINCHES

```
Function ListPi(T_supply As Range, _
                T_target As Range, _
                Duty As Range, _
                DTmin As Double, _
                Optional Approach As Double = 0.001) As Variant
```

Calculates from these inputs:

- supply temperatures (T_supply) and
- target temperatures (T_target) and
- associated heat duties to be transferred (Duty) and
- set minimum delta_T (DTmin), as well as
- an approach temperature (optional parameter, default is 0.001)

the middle temperatures of all Pinch Points and points, that are to be considered as near Pinch Points because delta T between hot and cold Shifted Composite Curve is less than the approach temperature. The actual temperatures of the Pinch Point of the hot streams can be calculated by adding ½ * DTmin and respectively the temperatures of the cold streams by reducing the found temperatues by ½ * DTmin.

This function is an array formula. The output array is one column wide and has as many rows as the number of Pinch Points and near Pinch Points combined (calculated by CountPi).

Example:

Input (in Cell A11 for array A11:A14): {= ListPi(A3:A10,B3:B10,C3:C10,D3)}

	A	B	C	D
1	T_supply	T_target	Duty	DTmin
2	[°C]	[°C]	[kW]	[°C]
3	60	100	80	10
4	30	120	81	
5	130	40	90	
6	180	80	50	
7	56	60	0,4	
8	20	30	2,6	
9	80	70	19	
10	121	120	5	
11	25			
12	61			
13	75			
14	175			

7 FUNCTION NUMBER OF UNITS

```
Function NUnits(T_supply As Range, _
                T_target As Range, _
                Duty As Range, _
                DTmin As Double, _
                Optional Approach As Double = 0.001) As Variant
```

This function first validates, whether the give stream data is balanced, i.e. as many hot and cold streams have been added to the problem that the remaining heating and cooling demand is zero (almost, can deviate by „Approach“).

Calculates from these inputs:

- supply temperatures (T_supply) and
- target temperatures (T_target) and
- associated heat duties to be transferred (Duty) and
- set minimum delta_T (DTmin), as well as
- an approach temperature (optional parameter, default is 0.001)

the minimum number of heat transfer units.

This function is not an array formula.

Example:

Input (in Cell A11): = NUnits(A3:A10,B3:B10,C3:C10,D3,D5)

	A	B	C	D
1	T_supply	T_target	Duty	DTmin
2	[°C]	[°C]	[kW]	[°C]
3	60	100	80	10
4	30	120	81	
5	130	40	90	0,01
6	180	80	50	
7	56	60	0,4	
8	20	30	2,6	
9	80	70	19	
10	121	120	5	
11	10			

8 FUNCTION HEAT TRANSFER AREA

```
Function AreaT(T_supply As Range, _
               T_target As Range, _
               Duty As Range, _
               htc As Range, _
               DTmin As Double) As Variant
```

Calculates from these inputs:

- supply temperatures (T_supply) and
- target temperatures (T_target) and
- associated heat duties to be transferred (Duty) and
- heat transfer coefficients, as well as
- set minimum delta_T (DTmin)

the area target needed for the heat transfer.

This function is not an array formula.

Example:

Input (in Cell D21): = AreaT(E7:E17,F7:F17,D7:D17,G7:G17,B19)

	A	B	C	D	E	F	G	H
1	**LinnhoffAhmad_CACE14-7_Tab1**							
2								
3			Specific					
4			heat x mass	Enthalpy	Supply	Target	Heat transfer	
5		Stream	flow (CP)	change	temperatur	temperatur	coefficient	
6			[MW°C^{-1}]	[MW]	[°C]	[°C]	[MW m^{-2}°C^{-1}]	
7	1	hot	0,10	-28,60	327	41	5,00E-04	
8	2	hot	0,16	-9,60	220	160	4,00E-04	
9	3	hot	0,06	-9,60	220	60	1,40E-04	
10	4	hot	0,40	-46,00	160	45	3,00E-04	
11	5	cold	0,10	20,00	100	300	3,50E-04	
12	6	cold	0,07	9,03	35	164	7,00E-04	
13	7	cold	0,35	18,55	85	138	5,00E-04	
14	8	cold	0,06	6,60	60	170	1,40E-04	
15	9	cold	0,20	32,00	140	300	6,00E-04	
16	HU	hot		-24,48	330	250	5,00E-04	
17	CU	cold		32,1	15	30	5,00E-04	
18								
19	dTmin	25	°C					
20								
21			Area	17407	[m2]			
22								