



# APEX<sup>®</sup> Suite

## - Digital H-Ex Twin





# APEX<sup>®</sup> Suite - Digital H-Ex Twin

**APEX<sup>®</sup> Suite - Digital H-Ex Twin** is a package of proprietary programs which allow the user to access a digital replica of heat exchanger (e.g. an Air Preheater – APH) designed and supplied by *APEX Heat Transfer<sup>®</sup>*.

**APEX<sup>®</sup> Suite - Digital H-Ex Twin** is dedicated to Plant Operators, Assets Managers, Process Engineers and all those professionals who run, maintain, or design process units utilizing our proprietary heat exchangers, and who will benefit from being able to simulate the digital replica of their heat exchanger under diverse operating conditions.

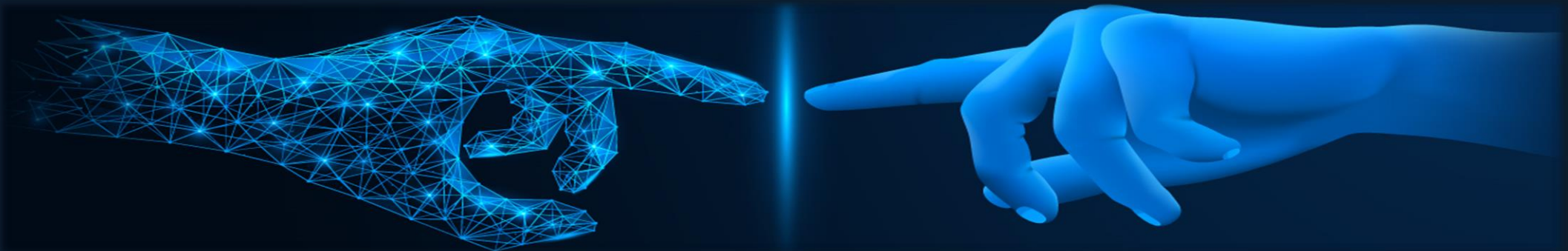
**APEX<sup>®</sup> Suite - Digital H-Ex Twin** comprises of the following programs:

- **APEX<sup>®</sup> Termic** – proprietary heat exchanger design program
- **APEX<sup>®</sup> Combust** – process stream design program
- **APEX<sup>®</sup> DewPoint** – dew point calculator
- **APEX<sup>®</sup> FurnaceEfficiency** – furnace efficiency calculator

**APEX<sup>®</sup> Suite - Digital H-Ex Twin** programs are available to the user under our Premium Software Platform, which can be accessed online with use of popular web browsers.

For comprehensive design or assessment of complete process unit, **APEX<sup>®</sup> Suite - Digital H-Ex Twin** can be easily integrated with such simulation programs as:

- AspenTech
- AspenPlus
- AspenTechHYSYS
- ChemStations ChemCAD
- AVEVA/SimSciPro/II
- BR&E ProMax
- PetroSim
- ProSimPlus
- ProSim
- Honeywell UnisimDesign
- AmsterCHEM COCO Simulator
- Daniel WagnerDWSim



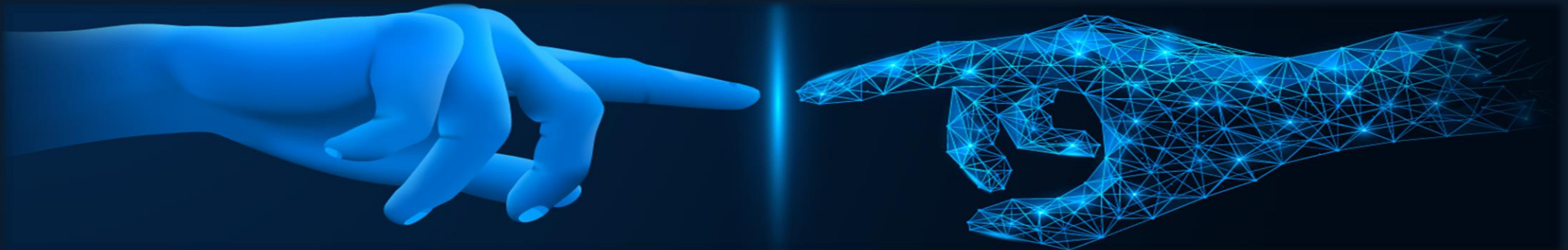




# APEX<sup>®</sup> Suite - Digital H-Ex Twin

## Benefits of Using Digital H-Ex Twin

- Simulate overall performance of the heat exchanger (e.g. metal temperature, pressure drop, flue gas and combustion air outlet temperature) when changing fuel or firing duty, and check how it affects the process unit.
  - Plan ahead efficiency of process unit and fuel savings, NOx and CO2 emissions dependent on the APH performance simulated in foreseen operating cases.
  - Calculate, verify and plan combustion air stream bypass or recirculation to prevent:
    - cold-end corrosion;
    - excess NOx emissions; and
    - decrease in process unit efficiency or integrity.
  - Calculate expected condensation and corrosion rates when operating below the acid dew point, facilitating proactive measures to uphold system integrity and performance.
  - Design or redesign the process unit based on performance of the heat exchanger across a diverse range of operating cases.
- Verify influence of the heat exchanger's performance on process unit; radiant and convection duty, flux rates and coil temperatures; NOx emissions; fuel efficiency; CO2 emissions; catalyst operating temperature and efficiency.
  - Verify influence of the pressure drop across the heat exchanger on the process unit under varying operational conditions.
  - Ensure that temperature of the heat exchanger remains within its metallurgical limits and avoids falling below the acid dew point across range of operating cases.
  - Calculate acid dew point for variable fuels and flue gases.
  - Check the temperature distribution of streams at the outlet of the heat exchanger to ensure the proper functioning of downstream equipment.
  - Avoid costly downtime required for unplanned maintenance or repairs by ensuring proper operation of the heat exchanger within its design parameters.
  - Perform troubleshooting, verify the performance of the heat exchanger by comparing simulation results with measurements in field.





# APEX<sup>®</sup> Suite - Digital H-Ex Twin

## Digital replica in simulations

### User defined inputs:

- Firing fuel and flue gas stream by combustion of defined fuel.
- Chemical composition of process streams.
- Inlet pressure of process streams.
- Inlet temperature of process streams (constant value or as a function of time).
- Inlet flow rate of process streams (constant value or as a function of time).
- Fouling factors.
- Heat loss.
- Stream flow rate and temperature in by-pass or recirculation.

### Simulation results:

- Temperature of streams at the outlet of the heat exchanger (minimum, maximum, average and, in case of stream by-pass or recirculation, mixed value).
- Graphs of temperature distribution of streams at the outlet of the heat exchanger.
- Pressure drop across the heat exchanger.
- Metal temperature across the heat exchanger (minimum and maximum value).
- Duty (heat transferred) and thermal effectiveness of the heat exchanger.
- Warning of insufficient flow turbulence inside the heat exchanger for effective heat transfer.
- Acid dew point at the inlet and the outlet of the heat exchanger.
- Graph of the acid dew point distribution at the outlet of the heat exchanger.
- Water dew point.
- Condensation calculations (e.g. condensation rate, concentration of acid, condensate volume, corrosion rate).





# APEX® Suite - Digital H-Ex Twin

## APEX® Termic

This program allows to simulate the performance of CORPEX®, V-FLEX®, CORTEX® and C-PEX® heat exchangers across a wide range of operating conditions. The user can input various parameters, including inlet temperatures, flow rates, pressure, fouling factors, chemical composition of streams, heat loss, and considerations for stream's by-pass or recirculation.

This comprehensive input capability allows for a detailed analysis of heat exchanger behavior under diverse operating scenarios.

The user is enabled to assess how changes in the process may impact the heat exchanger's performance in terms of:

- Stream outlet temperature,
- Pressure drop,
- Metal temperature,
- Dew point,
- Thermal effectiveness,
- Heat transferred, and more.

APEX® Termic Ver. 2023.3 - October 2023

Exit Open Save Project Data Help

DESIGN Add Case Delete Case Run Stop AutoCalc 1P 2D Geometry Options Process Options Time Functions Printout Graphs

**Geometrical Data** Nr. of Passes: 4 S.U.: SI hr

Units	Pass 1	Pass 2	Pass 3	Pass 4	Total
1. Flow Type	X	X	Z-Cc	X	-
2. H.T. Area	m2	-	-	-	9894.2
3. Width (C-dir)	mm	1 600.0	1 720.0	1 720.0	1 720.0
4. Height (H-dir)	mm	1 320.0	1 570.0	3 820.0	8280.
5. Length (L-dir)	mm	10 250.	10 250.	10 250.	10 250.
6. Appr. Weight	kg	-	-	-	-138 693.

**Performance Data** S.U.: Metric

Units	Pass 1	Pass 2	Pass 3	Pass 4	Total
1. Fluid	AIR-DESIGN	AIR-DESIGN	AIR-DESIGN	AIR-DESIGN	-
2. Flow Rate THR.	kg/h	186 100.	186 100.	186 100.	186 100.
3. Bypass	%	0.	0.	0.	0.
4. Re No.	-	-	-	-	-
5. Temp. IN	°C	-10.	-	-	-
6. Temp. OUT	°C	-	-	-	339.2
7. Temp. MIX	°C	0.0	0.0	0.0	339.2
8. Pin	mm W.C. g	275.3	-	-	-
9. Pout	mm W.C. g	-	-	-	180.0
10. ΔPstatic + R.D.	mm W.C.	-	-	-	95.3
11. Fouling	kcal/(m2.h.C)	4299.300000-	4299.300000-	4299.300000-	4299.300000-
12. H.T. Coeff.	kcal/(m2.h.C)	-	-	-	-
13. Fluid	FG	FG	FG	FG	-
14. Flow Rate THR.	kg/h	194 600.	194 600.	194 600.	194 600.
15. Bypass	%	0.	0.	0.	0.
16. Re No.	-	-	-	-	-
17. Temp. IN	°C	-	-	-	392.2
18. Temp. Out	°C	90.2	-	-	-
19. Pin	mm W.C. g	-	-	-	-60.2
20. Pout	mm W.C. g	-245.5	-	-	-
21. ΔPstatic + R.D.	mm W.C.	-	-	-	185.3
22. Fouling	kcal/(m2.h.C)	2149.7	2149.7	2149.7	2149.7
23. H.T. Coeff.	kcal/(m2.h.C)	-	-	-	-
24. Heat Loss	%	0.5	0.5	0.5	0.5
25. Heat Transf'd	kcal/h	-	-	-	-15 952 313.1
26. U - H.T. Coeff.	kcal/(m2.h.C)	-	-	-	23.4
27. F-factor	-	-	-	-	0.9302
28. LMTD	°C	-	-	-	74.1
29. Min. Metal Temp.	°C	55.6	96.5	156.0	335.9
30. Max. Metal Temp.	°C	105.9	203.3	340.8	369.3
31. Thermal Effect.	%	-	-	-	86.8342

**2D Calculation**

Error Limit: 0.0001 Max. Rel. Error: 0.00009880  
 Calc. Time step: [checked] Time step: 15 s  
 Transient State: [unchecked] Nr. of steps: 360  
 Cell C-Dim.: 100. mm Total Nr. Cells: 1376

Nr. Cells	Pass1	Pass2	Pass3	Pass4
C-Dir	16	16	16	16
H-Dir	16	16	38	16
Total	256	256	608	256

**Fluids Data** Combust Heat Balance vol% wt%

Parameters	Units	AIR-DESIGN	FG
Flow Rate	kg/h	186100.000	194600.000
Pressure	mm W.C. g	0.000	0.000
Enth.Corr.	-	1.000	1.000
O2	vol%	20.785	4.062
N2	vol%	77.200	71.156
H2O	vol%	1.025	16.583
CO2	vol%	0.030	7.316
SO2	ppm vol	0.000	2.612
Ar	vol%	0.960	0.883
CO	vol%	0.000	0.000
NO2	vol%	0.000	0.000
NH3	vol%	0.000	0.000
M <sub>mol</sub>	kg/kmol	28.859	27.793
WDP	°C	7.862	56.370
ADPclean	°C	-273.150	106.892
ADPdirty	°C	-273.150	112.611
Tamb	°C	25.000	25.000
Patm	mm W.C. abs	10332.275	10332.275
RH	%	60.000	60.000
Elevation	m	0.000	0.000

**Acid Condensation**

Parameters	Units	Pass1 / Side2
ADP In.	°C	106.5
ADP Out.	°C	92.
Film Cond. Av.Mass Fract.	wt%	49.64
Max. Corr. Rate C.S.	mm/year	0.0372
Max. Corr. Prod. Rate C.S.	mm/year	0.2848
Condensate Mass Rate @Tout	kg/h	0.0834
Condensate Volume Rate @Tout	l/day	1.3809
Film Cond. Max.Film Thickness	mm	0.0005
Mist Cond. Av.Mass Fract.	wt%	64.29
Mist Cond. Mass Rate Out.	kg/h	0.0868

**Errors & Warnings**

ID	Remarks
862	Fluid Temperature ≠ WDP for Side1 Pass1
863	Fluid Temperature ≠ ADP for Side2 Pass1



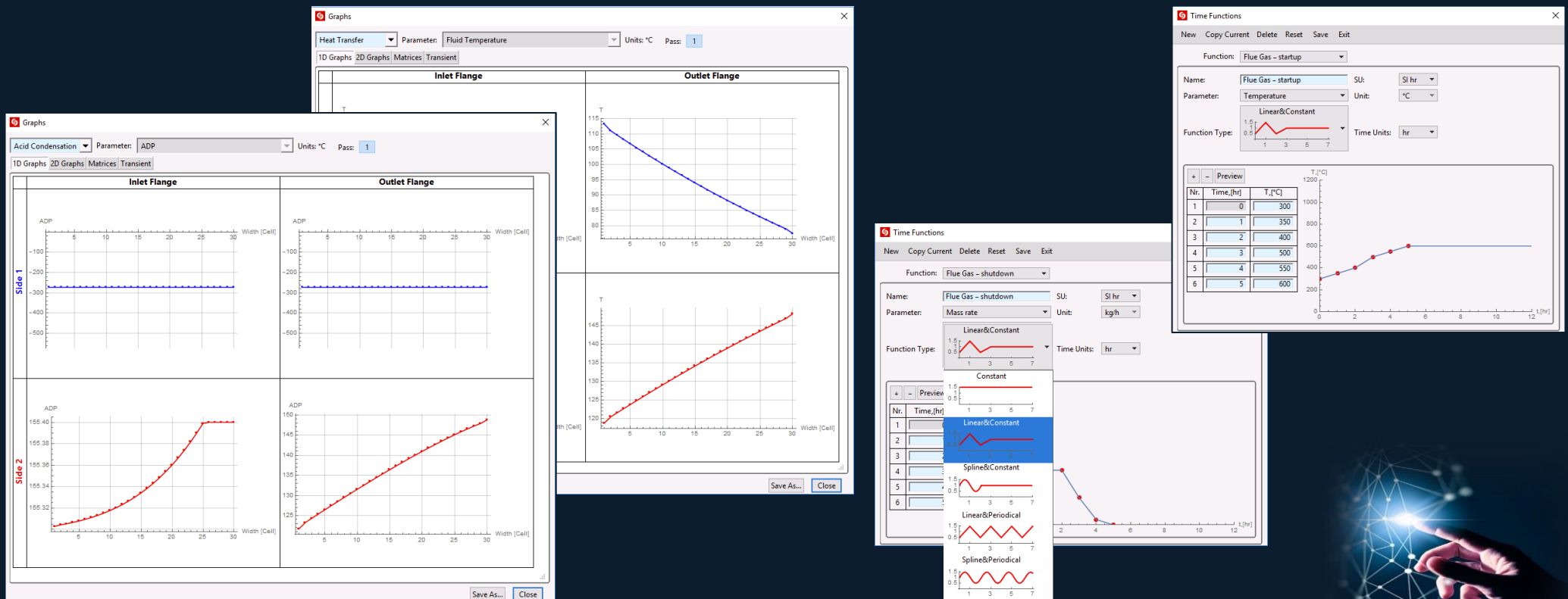


# APEX<sup>®</sup> Suite - Digital H-Ex Twin

## APEX<sup>®</sup> Termic

The program provides graphical display of the streams' temperature distribution and the Acid Dew Point distribution at the outlet of the heat exchanger. The user can assess how the conditions at the outlet of the heat exchanger may affect their downstream equipment.

APEX<sup>®</sup> Termic allows the user to perform time-dependent simulations, such as furnace startup or shutdown, which may be essential in troubleshooting the process unit operation, or to assess how such operating cases impact performance or integrity of the heat exchanger.





# APEX<sup>®</sup> Suite - Digital H-Ex Twin

## APEX<sup>®</sup> Combust

This program utilizes chemical composition, pressure, and flow rate to define the process streams used as heat transfer mediums in the heat exchanger (e.g. APH). It allows also to define and combust the fuel to derive the flue gas stream. The user can assess how changes of the fuel or flue gas composition may affect the operation and integrity of the heat exchanger.

The main interface shows the 'Streams' tab with a list of streams. The selected stream is 'Typical Gas from Oil Firing'. Below the list is an 'Errors & Warnings' table:

ID	Remarks
863	Fluid Temperature $\leq$ ADP for Side2 Pass1

The 'Create New Stream' dialog box includes the following fields:

- Name: Typical Gas from Oil Firing
- Input Units: System of Units (SI hr), Input Composition Unit (kmol), Input Flow Rate Unit (kg/h)
- Atmospheric Conditions: Temperature (25 °C), Relative Humidity (60 %), Elevation (0 m)

The 'Combust Current' dialog box includes the following fields:

- Combustion Stream Name: Enter the stream name
- Burner Properties: Fuel Temperature (25 °C), Combustion Air Temperature (15 °C), Flame Temperature (1000 °C)
- Stream Properties: Excess Air Ratio (10 %), Stream Pressure Gauge (0 Pa g)
- Atmospheric conditions: Elevation (0 m), Temperature (25 °C), Relative Humidity (60 %)

The 'Modify Current Gas Fuel' dialog box shows the gas fuel composition for a total of 100.00000 kmol:

Gas Fuel Type	Gas Fuel Name	Composition	Flow Rate
H2:		0.00000	kmol
CO:		0.00000	kmol
CO2:		0.40000	kmol
CH4:		94.00000	kmol
C2H2:		0.00000	kmol
C2H4:		0.00000	kmol
C2H6:		3.00000	kmol
C3H6:		0.00000	kmol
C3H8:		0.40000	kmol
C4H8:		0.00000	kmol
C4H10:		0.20000	kmol
C5H10:		0.00000	kmol
C5H12:		0.00000	kmol
C6H6(B):		0.00000	kmol
C7H8(T):		0.00000	kmol
C8H10(X):		0.00000	kmol
H2S:		0.00000	kmol
N2:		2.00000	kmol
O2:		0.00000	kmol
Ar:		0.00000	kmol
SO2:		0.00000	kmol
H2O:		0.00000	kmol
NH3:		0.00000	kmol







# APEX<sup>®</sup> Suite - Digital H-Ex Twin

## APEX<sup>®</sup> FurnaceEfficiency

The user can utilize the Air Preheater's performance data to calculate the overall efficiency of the furnace, fuel savings and CO<sub>2</sub> emissions.

## APEX<sup>®</sup> DewPoint

The user can calculate the dew point temperature of Sulfuric, Hydrochloric, and Hydrofluoric acid, as well as water. It allows to assess whether the dew point can lead to corrosion issues in the cold-end of heat exchanger.

**Furnace Efficiency Calculator**

Case Name: Design System of Units: SI hr

**FD Fan**

Stream name: Air-Standard  
 Ambient Air temp (T<sub>amb</sub>): 15 °C  
 Atmospheric Pressure (P<sub>atm</sub>): 101325 Pa abs  
 Ga. Press. at FD fan outlet (P<sub>FDout</sub>): 5000 Pa g  
 FD Fan Air outlet temp: 20.3239 °C  
 FD Fan Power: 130.342 kW

**Steam Air Preheater (SAPH)**

Stream name: Air-Standard  
 SAPH Air inlet temp (T<sub>ASAPHin</sub>): 20.3239 °C  
 SAPH Air outlet temp (T<sub>ASAPHout</sub>): 20.3239 °C  
 Qdot SAPH: 0 kW

**FG Air Preheater (APH)**

Air Stream name: Air-Standard  
 Air Mass flow rate (Mdot<sub>air</sub>): 88684.6 kg/h  
 APH Air inlet temp (T<sub>APHin</sub>): 20.3239 °C  
 APH Air outlet temp (T<sub>APHout</sub>): 265.0434 °C

FG Stream name: Gas-Firing  
 FG Mass flow rate (Mdot<sub>fg</sub>): 93352.2 kg/h  
 APH FG inlet temp (T<sub>gAPHin</sub>): 300 °C  
 APH FG outlet temp (T<sub>gAPHout</sub>): 88.4362 °C  
 Heat Loss APH: 1 %  
 Qdot abs APH: 6161.55 kW

**Fired Heater (Furnace)**

Fuel Mass flow rate (Mdot<sub>fuel</sub>): 4667.61 kg/h  
 Air/Fuel mass Ratio: 19  
 Fuel LHV (25°C): 40500 kJ/kg  
 Fuel inlet temp (T<sub>fuelin</sub>): 50 °C  
 Fuel avg cp: 0 kJ/(kg.K)  
 Atomizing Steam Ratio: 0 kg/kg fuel  
 Atomizing Steam inlet temp (T<sub>AS</sub>): 100 °C  
 Heat Loss Furnace: 1 %  
 Qdot abs Process: 50000 kW

Atomizing Steam Mass flow rate (Mdot<sub>AS</sub>): 0 kg/h  
 Qdot fired: 52510.6 kW  
 Qdot preheat steam: 0 kW  
 Qdot atomizing steam: 0 kW  
 Theoretical AFT: 1753.97 °C  
 Fuel Efficiency (LHV): 95.219 %  
 Thermal Efficiency (LHV): 94.841 %

**ID Fan**

Stream name: Gas-Firing  
 Ga. Press. at ID fan inlet (P<sub>IDin</sub>): -2000 Pa g  
 ID Fan FG outlet temp: 91.192 °C  
 ID Fan Power: 78.768 kW

**Stack**

Stream name: Gas-Firing  
 Stack inlet temp (T<sub>stackin</sub>): 91.192 °C  
 Qdot stack: 2157.51 kW

**Process Flow Diagram:**

```

    graph LR
      MdotAir[Mdotair] --> FD[Fan]
      FD --> SAPH[Steam-Air Preheater SAPH]
      SAPH --> ID[ID Fan]
      ID --> Stack[Stack]
      SAPH --> APH[FG-Air Preheater APH]
      APH --> Furnace[Furnace Fired Heater]
      MdotFuel[Mdotfuel] --> Furnace
      MdotAS[MdotAS] --> Furnace
      Furnace --> APH
      Furnace --> ID
      ID --> Stack
      Stack --> MdotFG[MdotFG]
      ProcessIn[Process flows in] --> Furnace
      Furnace --> ProcessOut[Process flows out]
  
```

**Dew Point Calculator**

H<sub>2</sub>SO<sub>4</sub> | HCl | HF

SO<sub>2</sub> → SO<sub>3</sub> Conversion

Verhoff and Banchero

H<sub>2</sub>SO<sub>4</sub>: 10.0004 ppmv  
 Conversion: 3.933 %  
 ADP: 142.725 °C  
 WDP: 56.894 °C  
 Conc. of condensate: 77.645 wt. %

O<sub>2</sub>: 1.7 vol %  
 H<sub>2</sub>O: 17 vol %  
 SO<sub>2</sub>: 254.27212 ppmv

Plot range: x min: 0.0002 ppmv, x max: 200 ppmv  
 Gas Pressure: 101325 Pa abs

**Dew Point Curve**  
 p H<sub>2</sub>O + p H<sub>2</sub>SO<sub>4</sub> = 0.17001 ata

**Boiling Point Curve**  
 p H<sub>2</sub>O + p H<sub>2</sub>SO<sub>4</sub> = 0.17001 ata

- Note 1: This calculator is based on the assumption that the APH flue gas inlet temperature is known.
- Note 2: For an APH, please provide either flue gas outlet or air outlet temperature.
- Note 3: Atomizing steam ratio to be used only in case of streams from combustion of liquid fuel.
- Note 4: The graphs show the effect of adding an APH to the system, assuming the flue gas inlet temperature is the same with and without the APH.





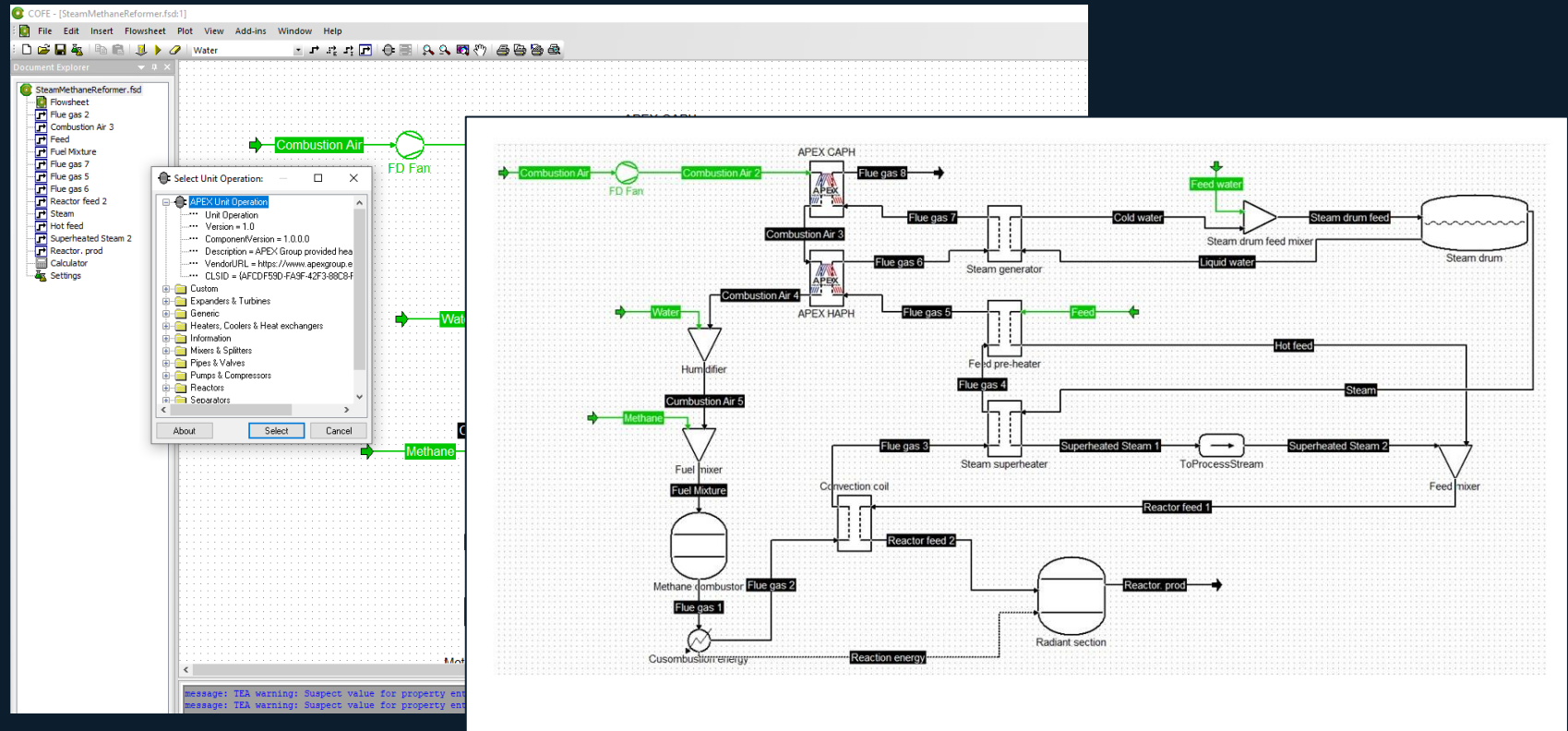


# APEX<sup>®</sup> Suite - Digital H-Ex Twin

## Integration with 3<sup>rd</sup> party process simulation software

APEX<sup>®</sup> Suite – Digital H-Ex Twin can easily be integrated with process simulation software such as HYSYS, UniSimDesign, PetroSim and many others.

This integration allows the user to run simulations of the complete process unit under variable operating conditions. Such simulations enable the process industries to optimize their operations in terms of, for example, energy consumption and emissions, system integrity and maintenance planning, production yields and margins. This capability allows a comprehensive assets management, assessment of the process unit design and output, and planning a strategized optimization of its operational performance to meet rigorous environmental or economical goals.





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