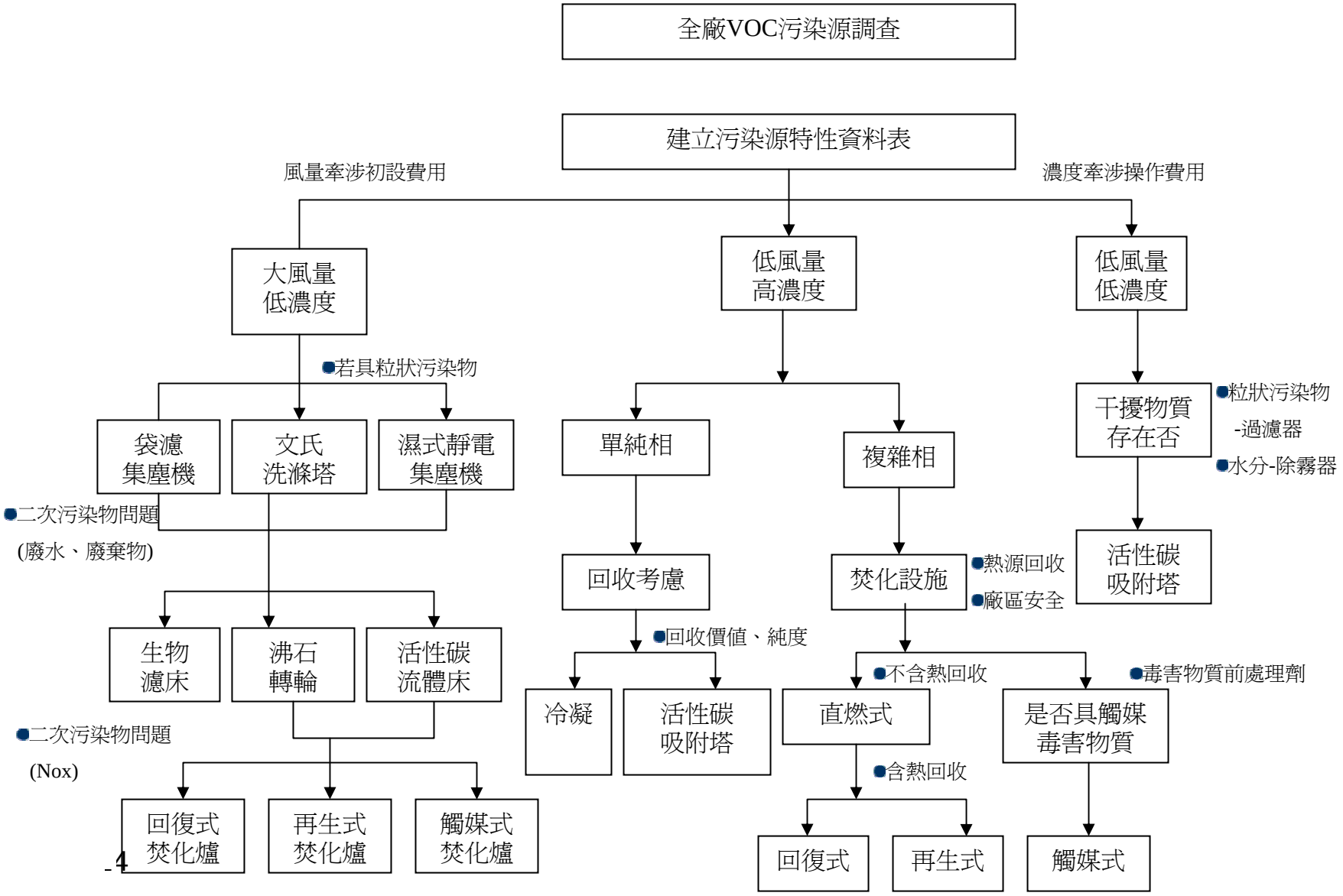
VOC處理與廢熱回收簡介

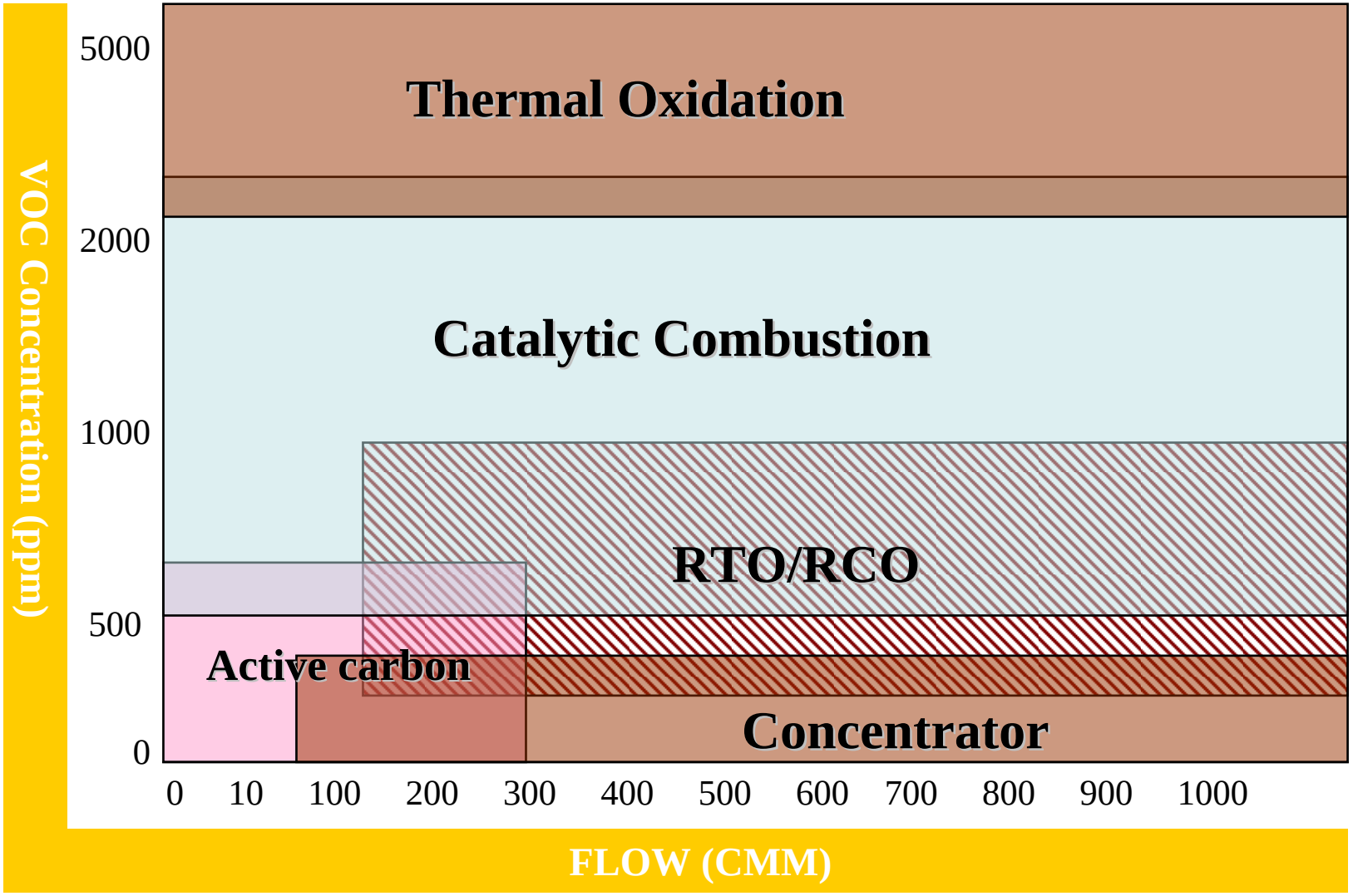
環保觸媒

- 汽機車觸媒(Catalytic converter)
- 脫硝觸媒(SCR de-NOx catalyst)
- 有機廢氣氧化觸媒(VOC catalyst)
  - **VOC catalyst**
  - High temperature combustion catalyst
- 濕式氧化觸媒(Wet oxidation catalyst)
- 光觸媒(Photo oxidation catalyst)
- 戴奧辛分解觸媒(De-dioxin catalyst)

選擇VOC處理技術

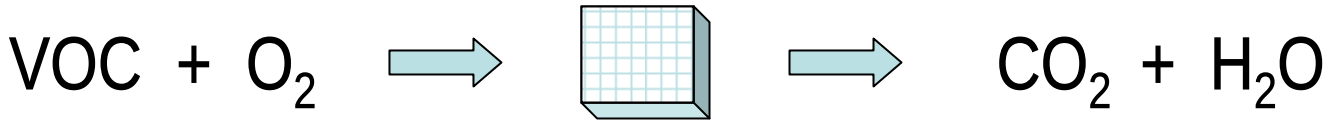

全廠VOC污染源調查
建立污染源特性資料表
風量牽涉初設費用
濃度牽涉操作費用
大風量
低濃度
低風量
高濃度
低風量
低濃度
若具粒狀污染物
袋濾
集塵機
文氏
洗滌塔
濕式靜電
集塵機
單純相
複雜相
干擾物質
存在否
粒狀污染物
-過濾器
水分-除霧器
二次污染物問題
(廢水、廢棄物)
回收考慮
焚化設施
熱源回收
廠區安全
活性碳
吸附塔
生物
濾床
沸石
轉輪
活性碳
流體床
回收價值、純度
不含熱回收
毒害物質前處理劑
冷凝
活性碳
吸附塔
直燃式
是否具觸媒
毒害物質
二次污染物問題
(Nox)
含熱回收
回復式
焚化爐
再生式
焚化爐
觸媒式
焚化爐
回復式
再生式
觸媒式

揮發性有機氣體處理技術圖譜

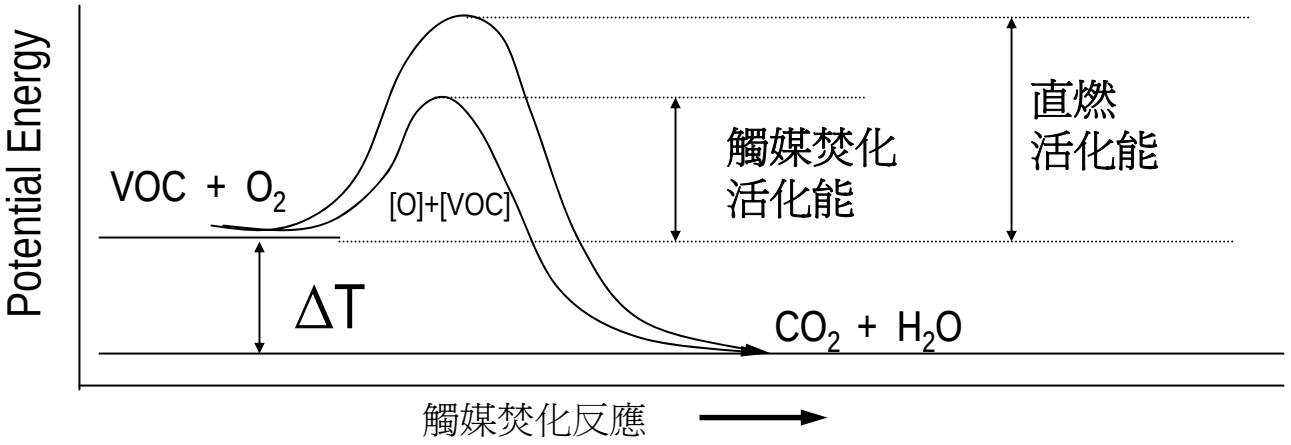


基本原理

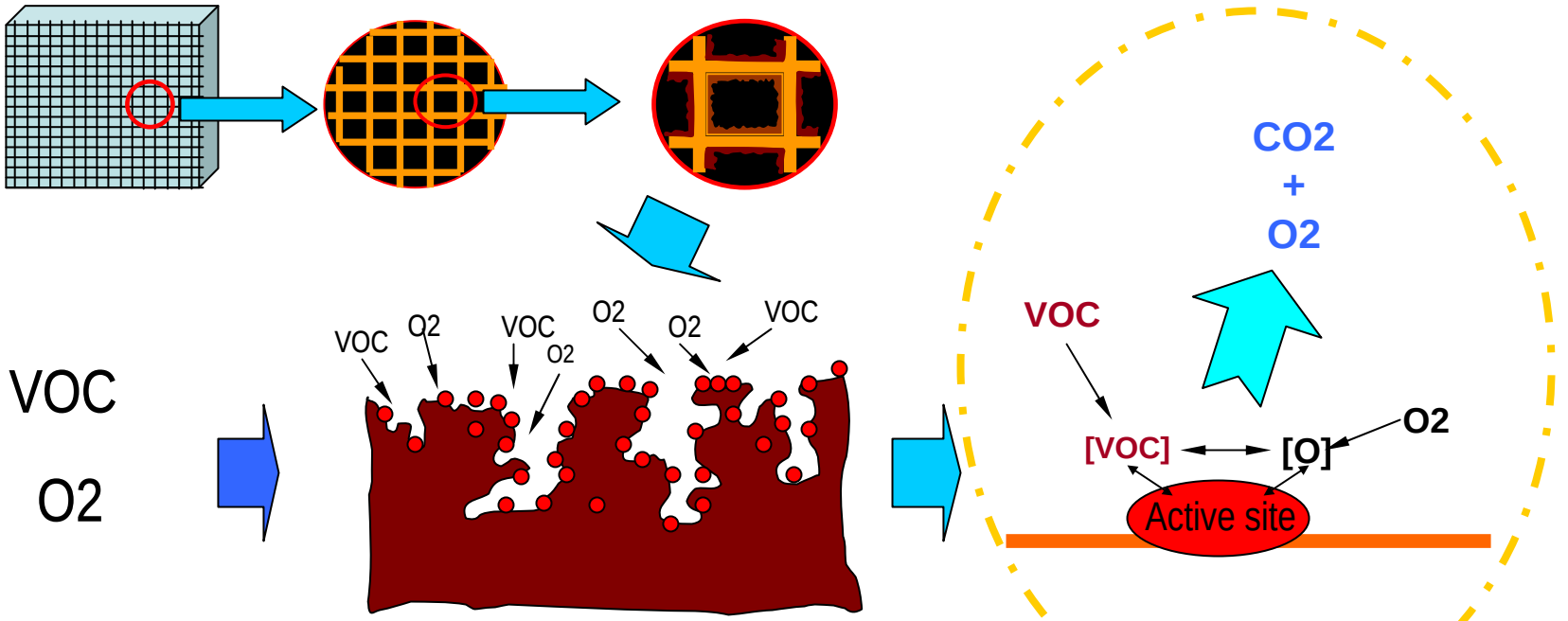
觸媒焚化爲燃燒反應的一種,其主要基本原理是利用觸媒降低其燃燒反應的活化能,進而降低其反應溫度,以達到節約能源的目的.



碳氫化合物 空氣 觸媒 二氧化碳 水
(有害) (無害)



觸媒反應機構



O_2 + active site ⟶ 2[O]

VOC + active site ⟶ [VOC]

[O] + [VOC] ⟶ $CO_2 + O_2$

觸媒種類與形式

- 觸媒種類:貴重金屬(Pt,Pd,Rh 等) 或稀土金屬(Cr, Co, Cu, Fe, W 等)
- 觸媒形式:

觸媒型式	特點	適合場合
纏繞金屬片(發泡金屬)	風阻大易阻塞 觸媒coating效果較差	低風量廢熱處理不含酸性氣體成份
金屬蜂巢	風阻小耐碰撞 使用效果佳國內已能量產供應	高風量廢熱處理不含酸性氣體成份外型／尺寸變化彈性大
陶磁蜂巢	風阻小效果佳但易碎裂	高風量廢熱處理大型工廠可耐酸性氣體
顆粒	風阻很大但製作成本便宜	低風量儀器排氣處理

VOC 觸媒樣品

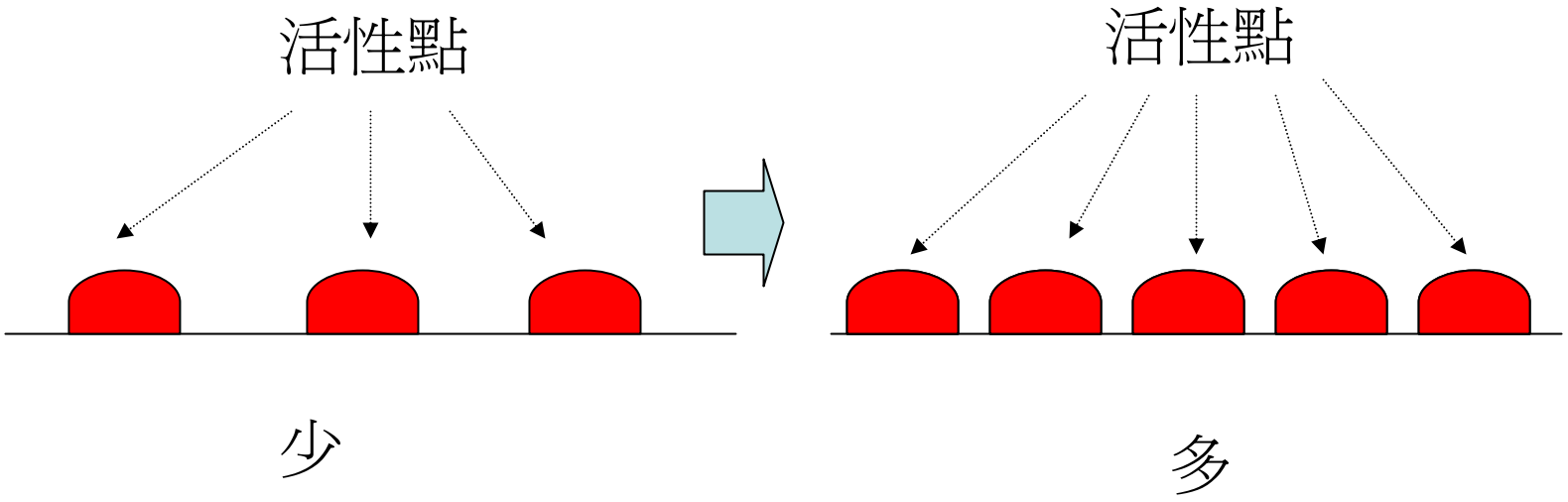
影響觸媒好壞關鍵

- 觸媒總量
- 製作技術
- 觸媒組成

影響觸媒好壞關鍵(1/3)

1.觸媒總量：

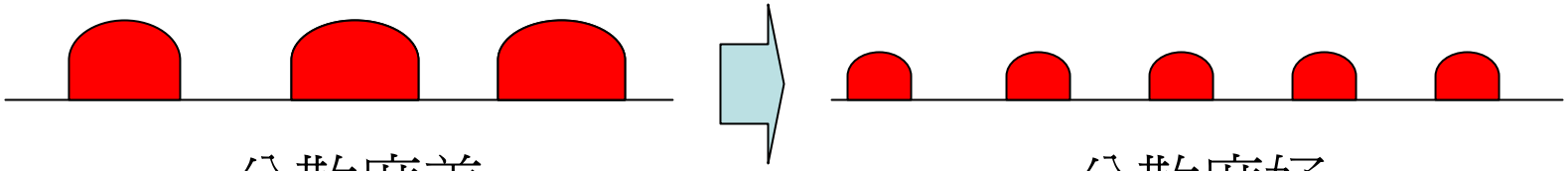
- 活性金屬Pt , Pd 等 總含量



影響觸媒好壞關鍵(2/3)

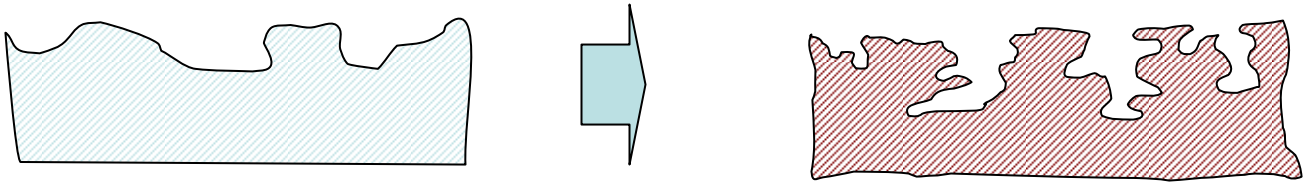
2.製作技術:

- 觸媒金屬分散度



分散度差　　分散度好

- Al_2O_3 support 表面積大小



小表面積　　大表面積

影響觸媒好壞關鍵(3/3)

3.觸媒組成:Pt/Pd比例

①Pt活性較高

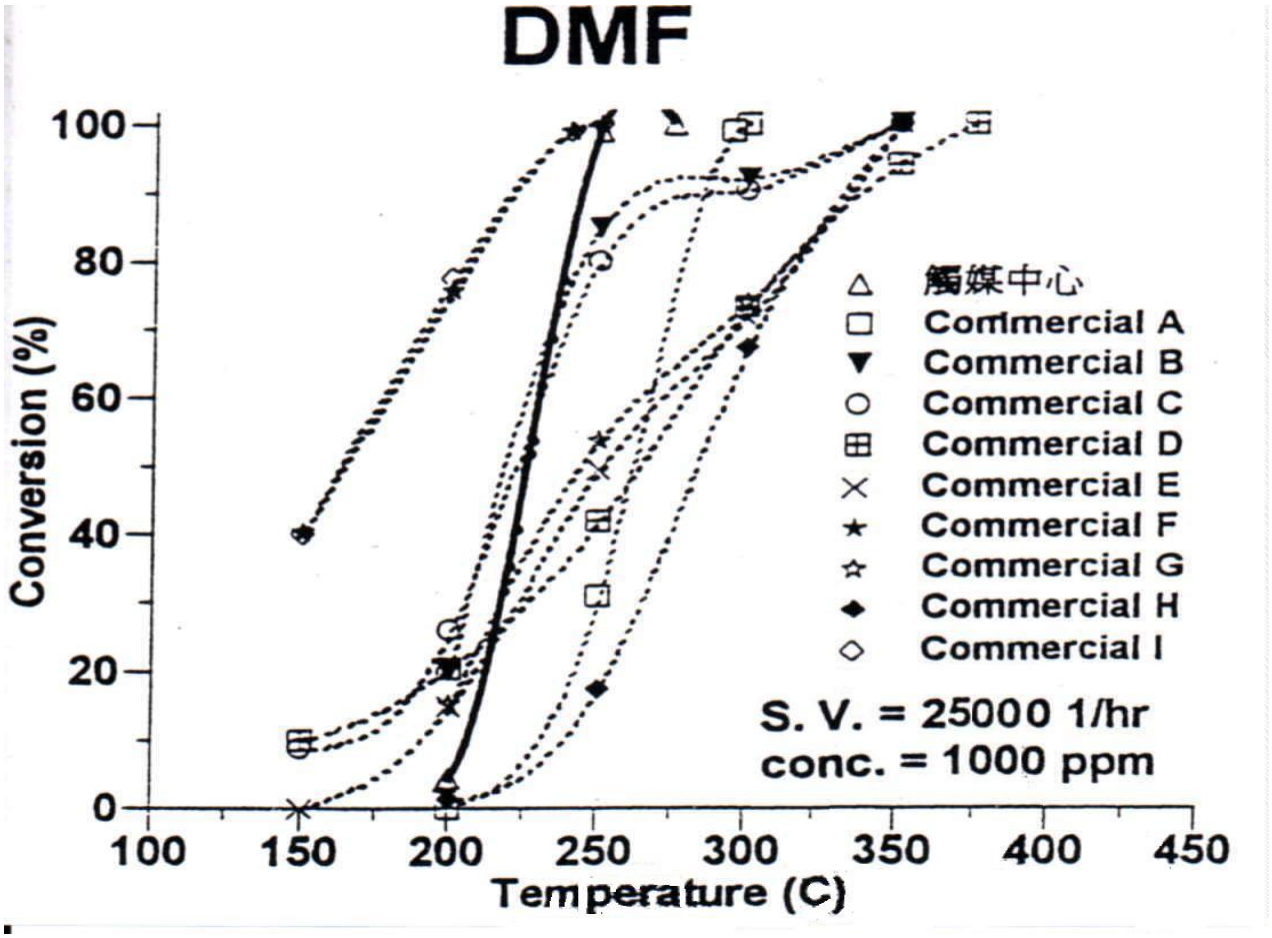
②Pd抗高溫燒結能力較佳

③原料成本

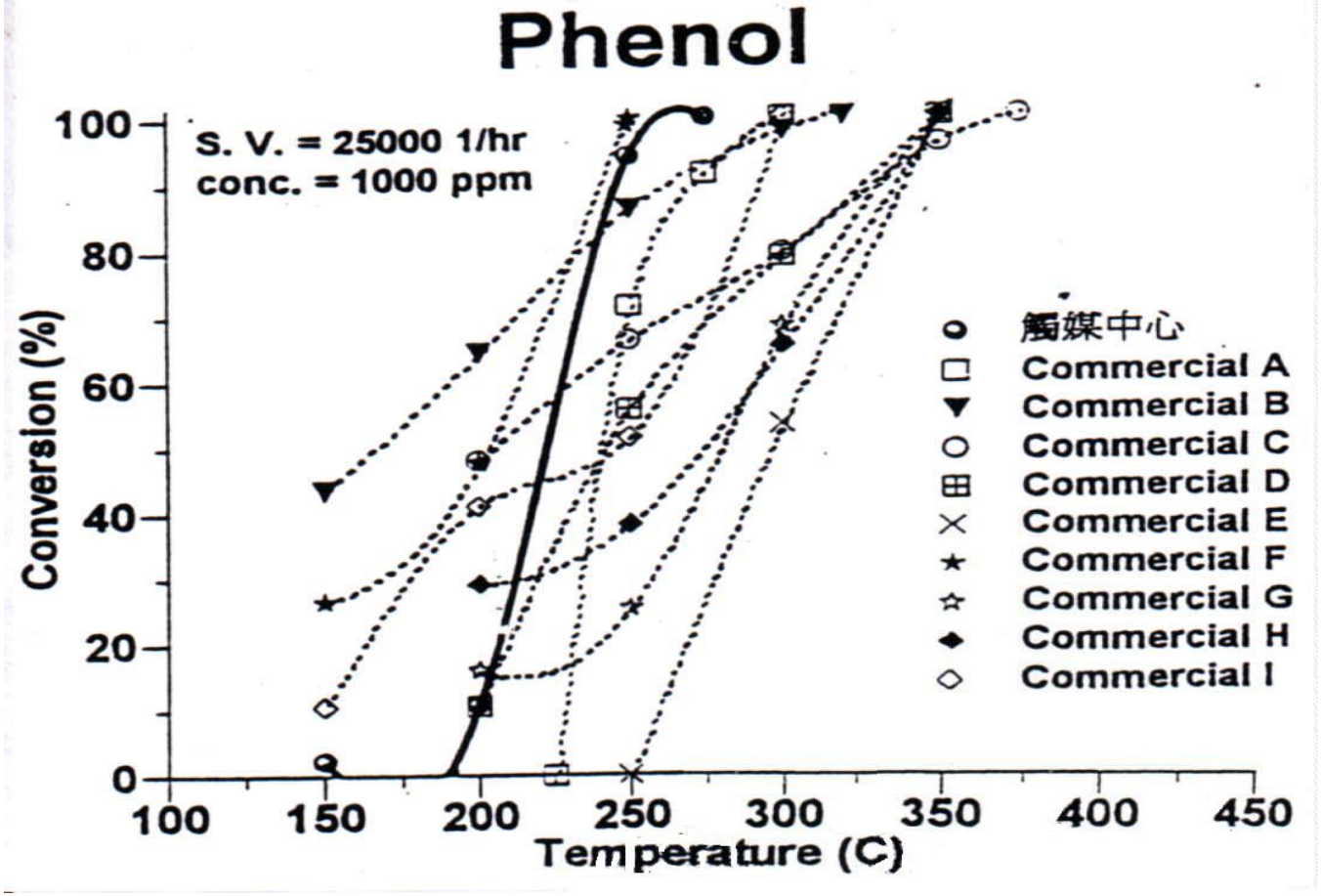
④其他改質成份

例如:Ba ， Ce ， Rh等

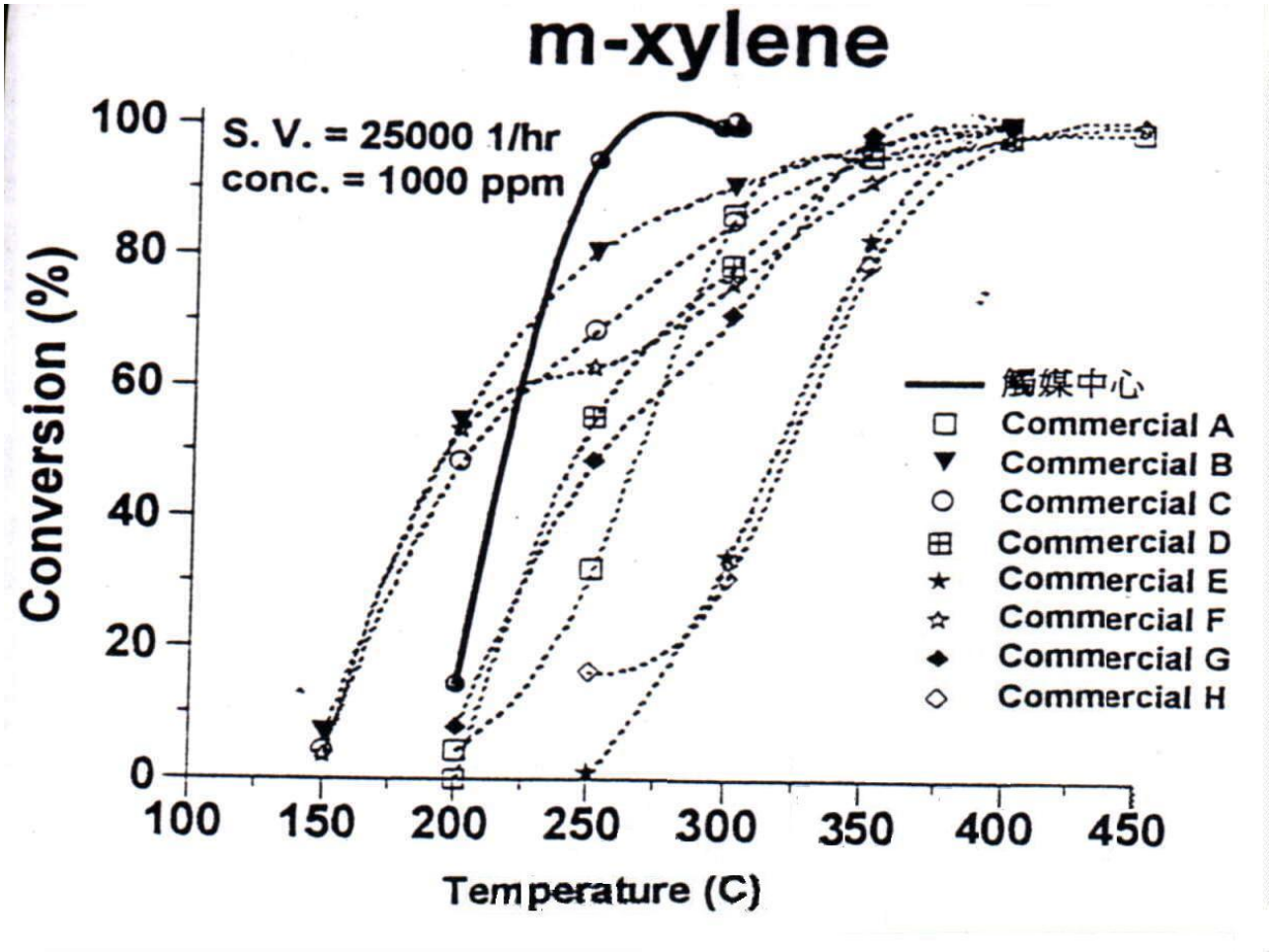
不同溶劑觸媒焚化效果之比較



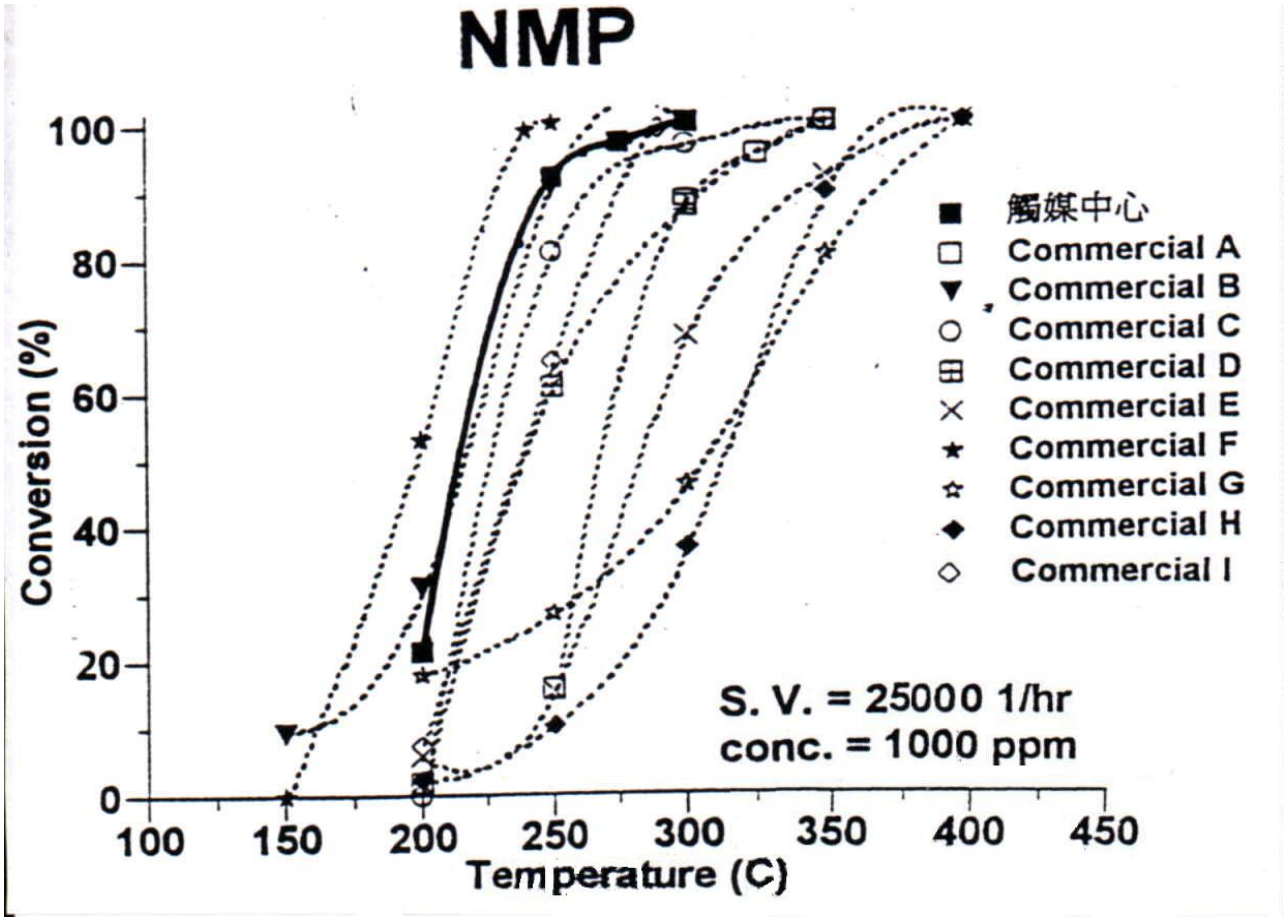
不同溶劑觸媒焚化效果之比較



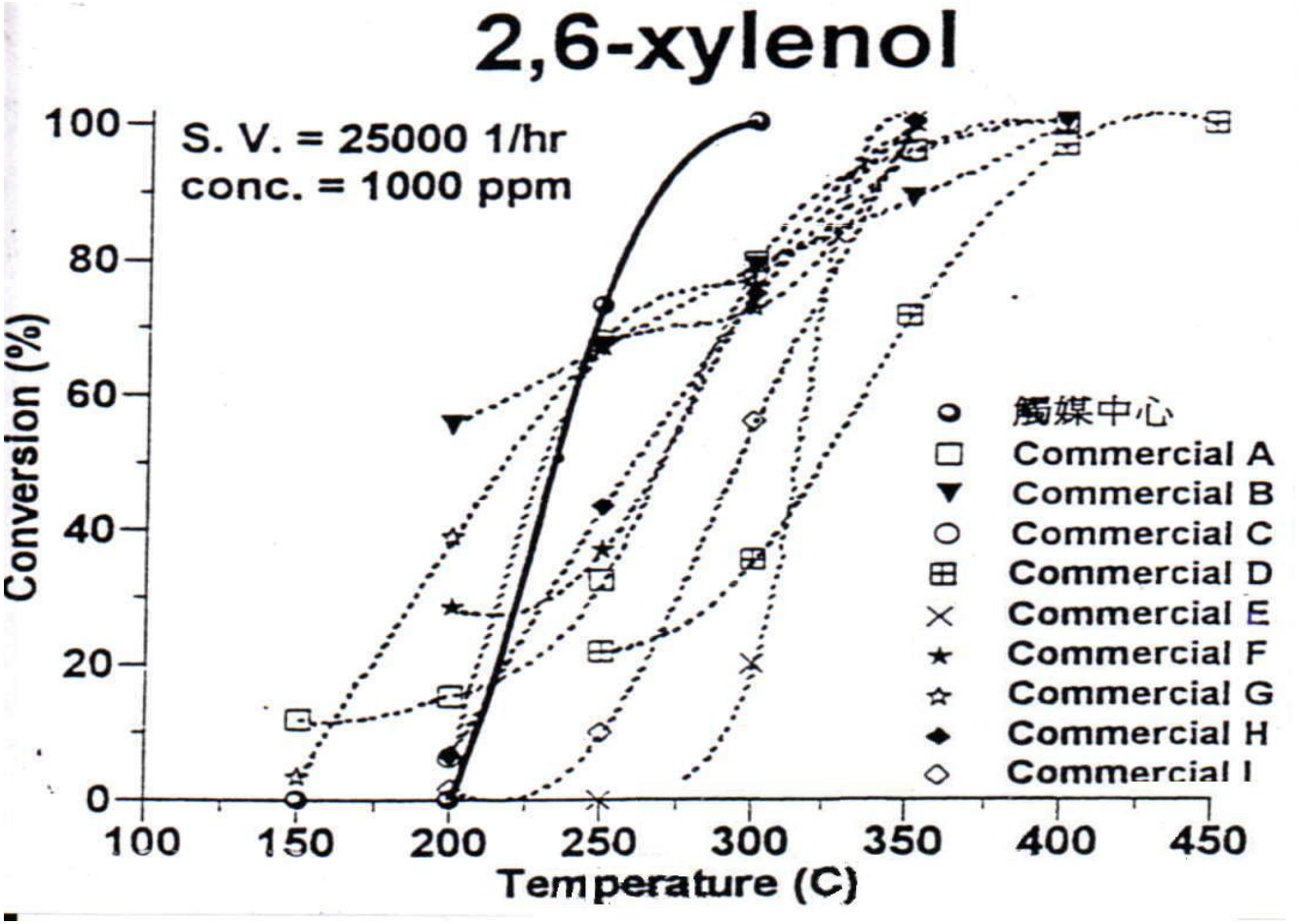
不同溶劑觸媒焚化效果之比較



不同溶劑觸媒焚化效果之比較

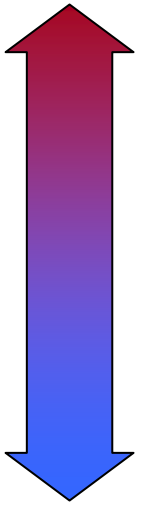


不同溶劑觸媒焚化效果之比較



不同**VOC**焚化相對難易

VOC種類	焚化難易
Chlorinated Hydrocarbon	困難
Oligmer	
Alkanes	
Ketones	
Aromatics	
Aldehydes	
Alcohols	容易

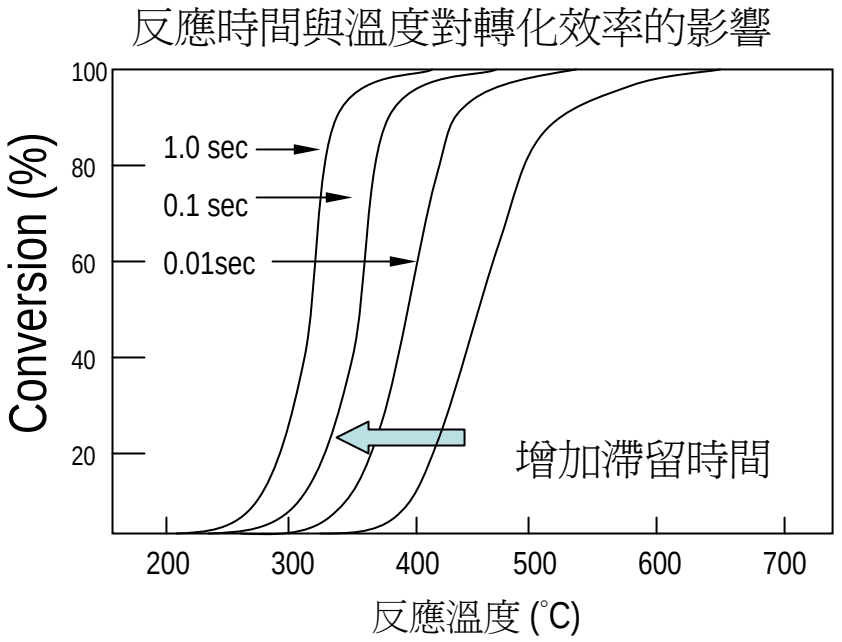


影響焚化效率因素

3T : 溫度(Temperature),

滯留時間(Time),

混合(Turbulence)



- 觸媒體積與氣體流量的關係

$$\text{空間速度(Space Velocity)} = \frac{\text{空氣流量(Ncmm)}}{\text{觸媒體積}(m^3)}$$

評估觸媒性能(1/2)

1.實驗室評估:

①活性比較－燃燒溫度

－最大操作風量

－最大操作濃度

②成份分析－觸媒金屬含量/組成

③壽　　命－以加速老化試驗

預估相對壽命長短

評估觸媒性能(2/2)

2.現場實際使用－觀察升溫， △T

－判煙，氣味

－長期使用經驗

－專業抽樣檢測

觸媒失活原因

1.表面積碳：焦油　積碳　粉塵

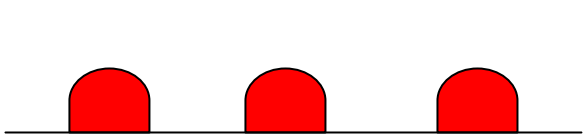
2.使用溫度過高: 觸媒金屬燒結

SUPPORT燒結

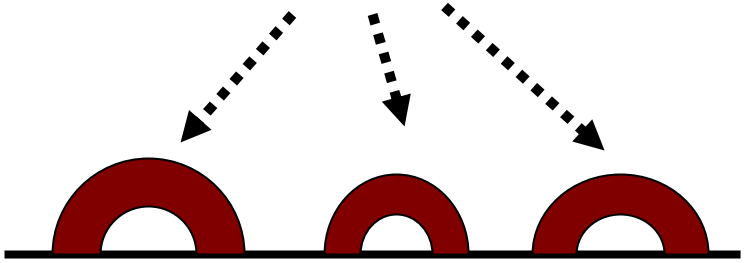
3.觸媒中毒: Si P S Cl Br 重金屬

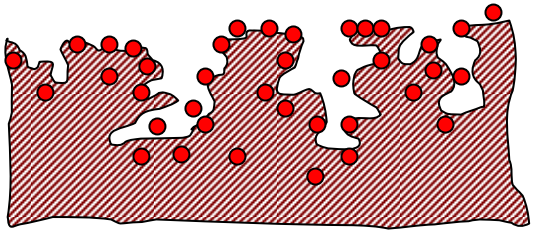
造成觸媒失活原因 - 表面遮蔽

-積碳,焦油,粉塵

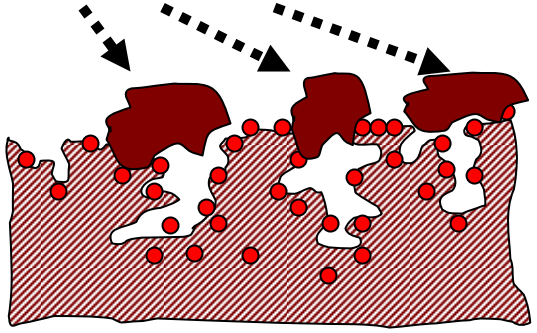


活性點被遮蔽



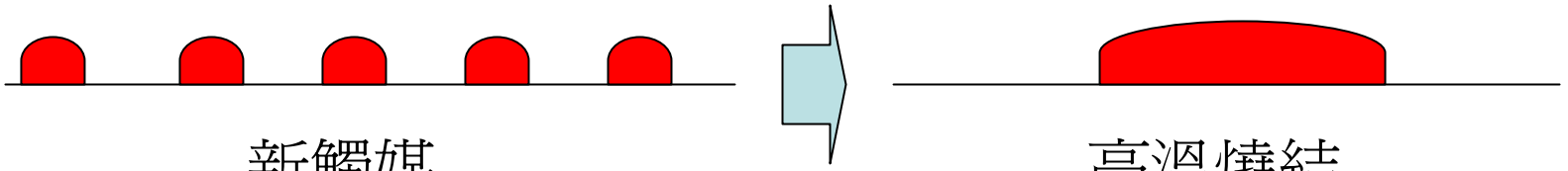


孔洞被堵塞



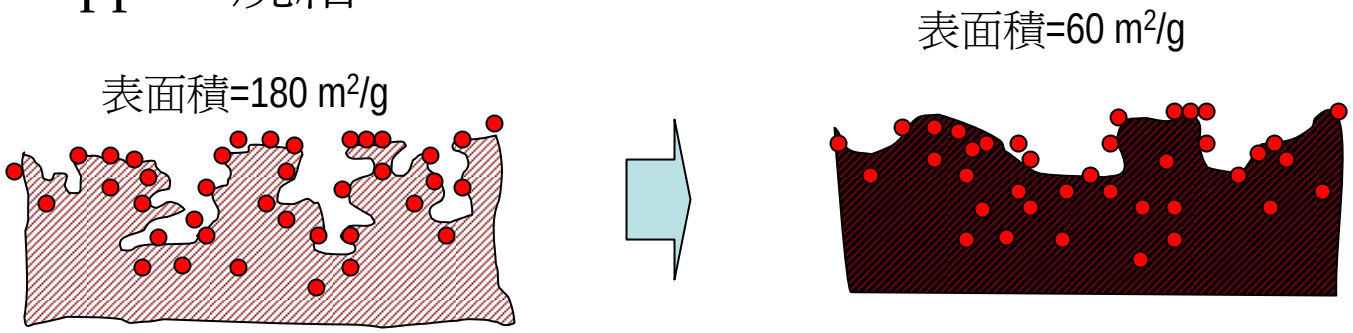
造成觸媒失活原因 – 使用溫度過高

- 觸媒金屬燒結



新觸媒　　高溫燒結

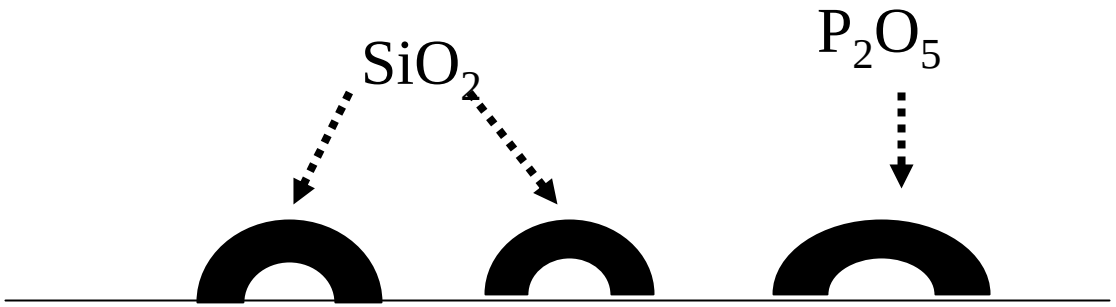
- Support 燒結



新觸媒　　高溫燒結

造成觸媒失活原因 – 觸媒中毒

1. Si P 等將活性點遮蔽:



2. Cl，Br等與活性點發生化學反應:

$$Pt + Cl \rightarrow PtCl_x$$

(催化活性點)　　(沒有催化活性)

觸媒失活對策

失活原因	失活狀態	對策	再生方式
積碳			
焦油	暫時	調整溫度與濃度	加熱燒積碳
粉塵	暫時	觸媒前加裝濾塵裝置	高壓空氣吹或水洗
高溫			
觸媒金屬燒結	永久	避免不當高溫操作	化學再生
Support燒結	永久	避免不當高溫操作	無法再生
中毒 (觸媒中毒並非一定可以再生，須視情況而定)			
Cl ， Br ， S	暫時	提高操作溫度	高溫空氣再生
Si ， P ， Pb	永久	觸媒前加裝前處理設備	化學再生配合高溫空氣再生
Hg等重金屬	永久	---------	無法再生

正確使用及保養觸媒

1.避免操作溫度過高:

-溫度愈高， 觸媒燒結愈快，壽命愈短

-廢氣濃度勿過高

-絕對勿超過700℃

-大部份情況下，廢氣焚化溫度不應超過550℃

2.廢氣分佈均勻

3.一般保養:

-以水沖洗、烘乾

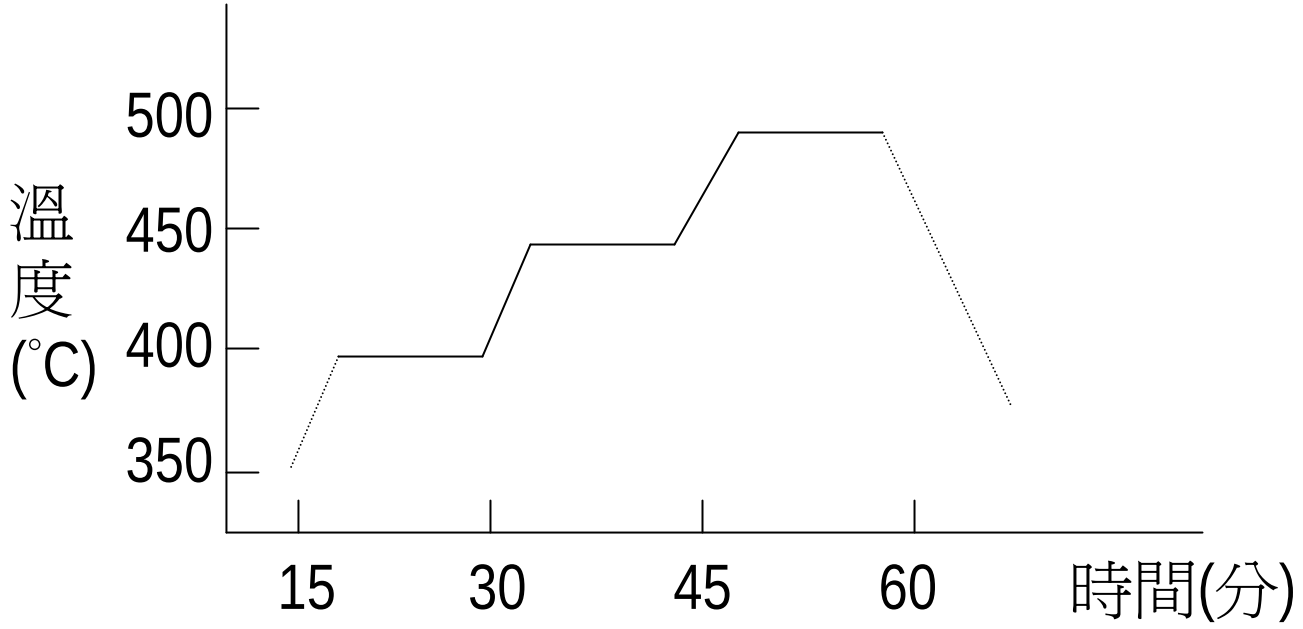
4.專業保養

-再生

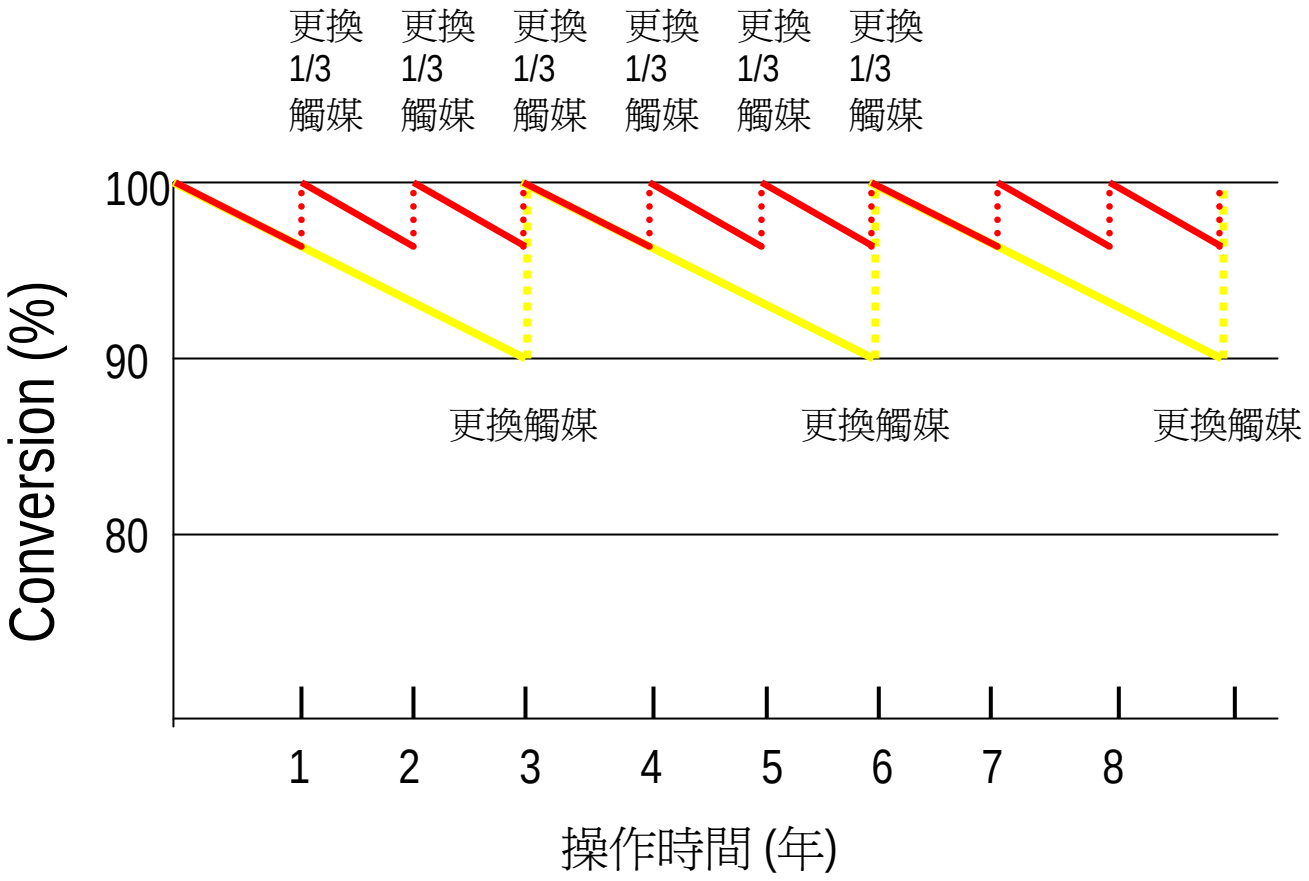
-達正常使用年限或效率不夠即可再生，若觸媒狀況已損毀，則再生效果太差

積碳處理(Bake out)

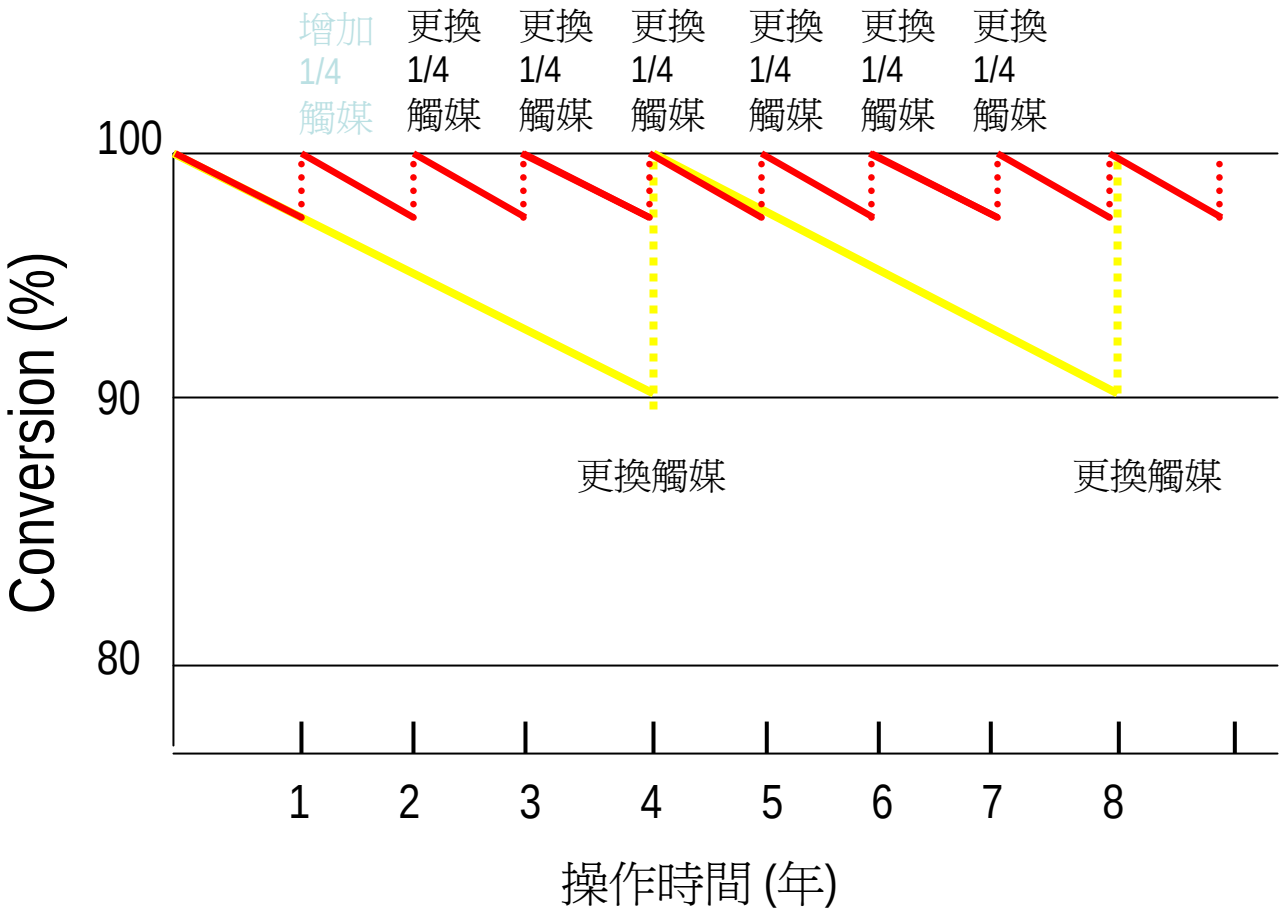
- 連續處理廢氣中含有高沸點成份物質,不可避免有些積碳會累積於觸媒上面,定期進行“積碳處理”將會延長觸媒壽命及增加處理效果.



觸媒更換方式 (一)


更換
1/3
觸媒
更換
1/3
觸媒
更換
1/3
觸媒
更換
1/3
觸媒
更換
1/3
觸媒
更換
1/3
觸媒
100
90
80
Conversion (%)
更換觸媒
更換觸媒
更換觸媒
1
2
3
4
5
6
7
8
操作時間 (年)

觸媒更換方式 (二)


增加
1/4
觸媒
更換
1/4
觸媒
更換
1/4
觸媒
更換
1/4
觸媒
更換
1/4
觸媒
更換
1/4
觸媒
更換
1/4
觸媒
100
90
80
Conversion (%)
更換觸媒
更換觸媒
1
2
3
4
5
6
7
8
操作時間 (年)

主要設備

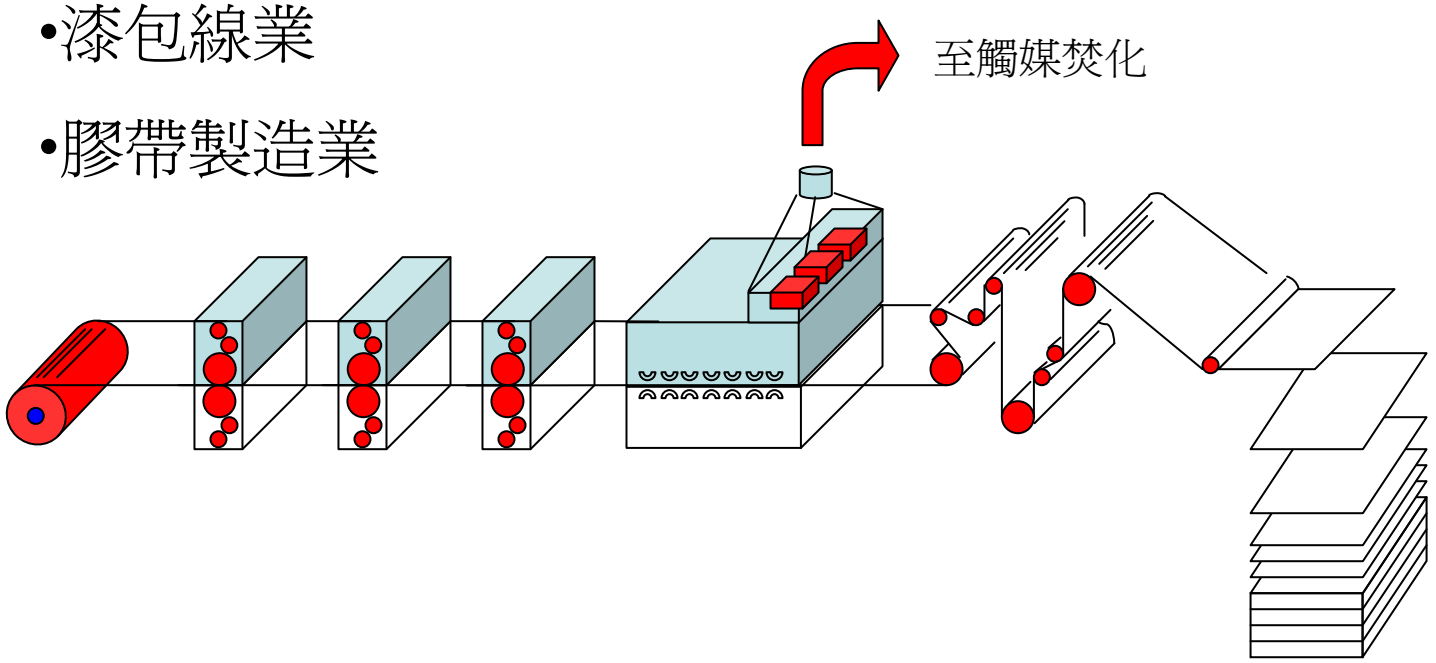
- 加熱器 – 可採電熱式，或是燃燒天然氣或柴油，視使用時之風量與操作/維修需求而定，主要之功能是提供設備暖機及反應時所須之熱量。
- 熱交換器 – 是用來回收VOC燃燒的廢熱，可用來預熱進氣或作其他利用，同樣地，可依廢氣濃度與使用環境作不同取捨，有時回收之熱量足夠預熱進氣時，當暖機後即不須再補充熱源。
- 觸媒 – 爲主要之設備，使反應能於溫度在250-400℃之下進行，觸媒的選擇極爲重要。一般還須考慮觸媒的反應性質、產生壓降、使用壽命及維修換裝之方便性等。
- 送風機 – 主要的功能是將廢氣導入處理設備，最重要是不能影響前端的製程。可視情況須要調整變頻器負載以調整進氣風量。
- 控制部分 – 爲一非常重要單元，必須完全做到安全性的偵測及控制，因此異常現象的警報訊號及自動連動的控制爲必要的要求。

設計處理設備考量因素

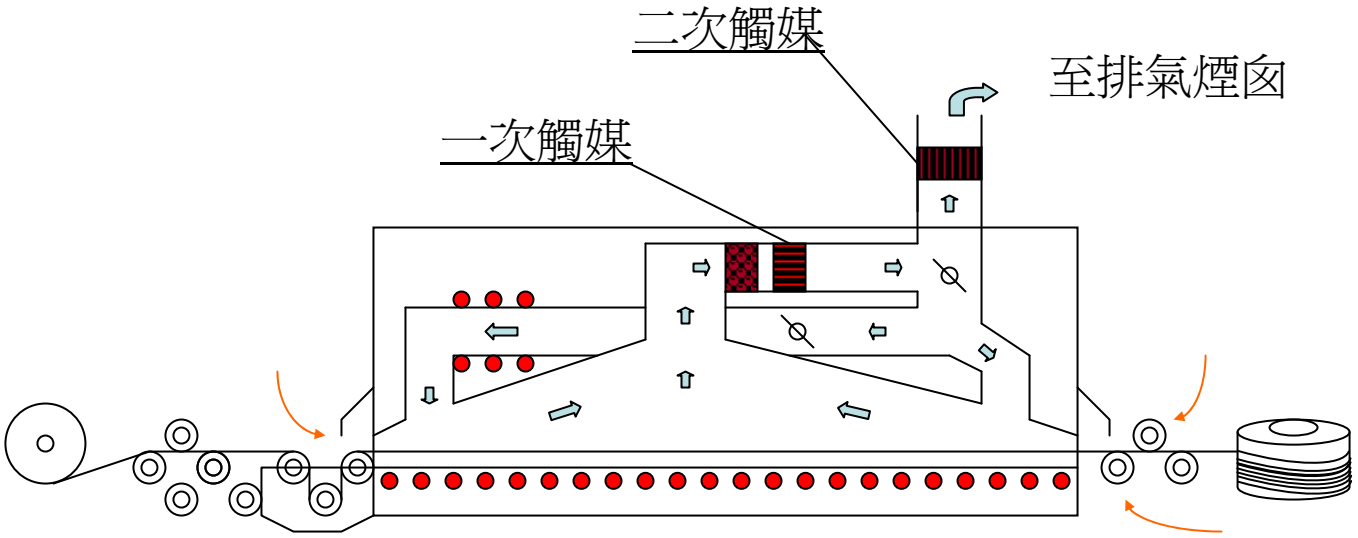
- 環境因素: 設備位置,可運用空間,周圍環境,配合設施
  外觀,..等
- 工程因素: 污染物特性包括處理量,溫度,壓力,組成,濃度
  物理性質及化學性質等
- 特殊因素: 大小重量,壓降,轉化效率,溫度限制,操作及維
  修保養的方便性
- 經濟因素: 投資費用,操作費用,能源回收利用,空污費等

應用範圍

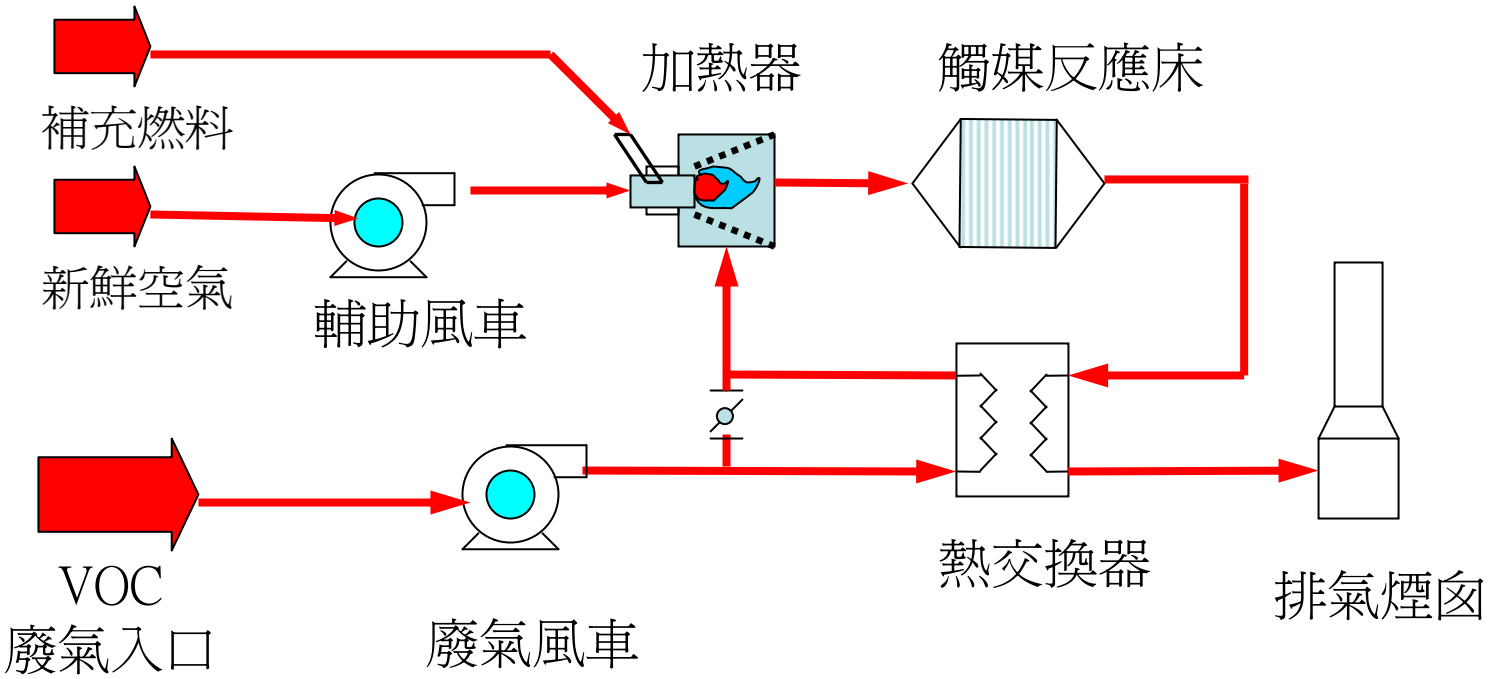
- 平版/凹版印刷業
- 汽/機車塗裝業
- 化學工業
- 漆包線業
- 膠帶製造業



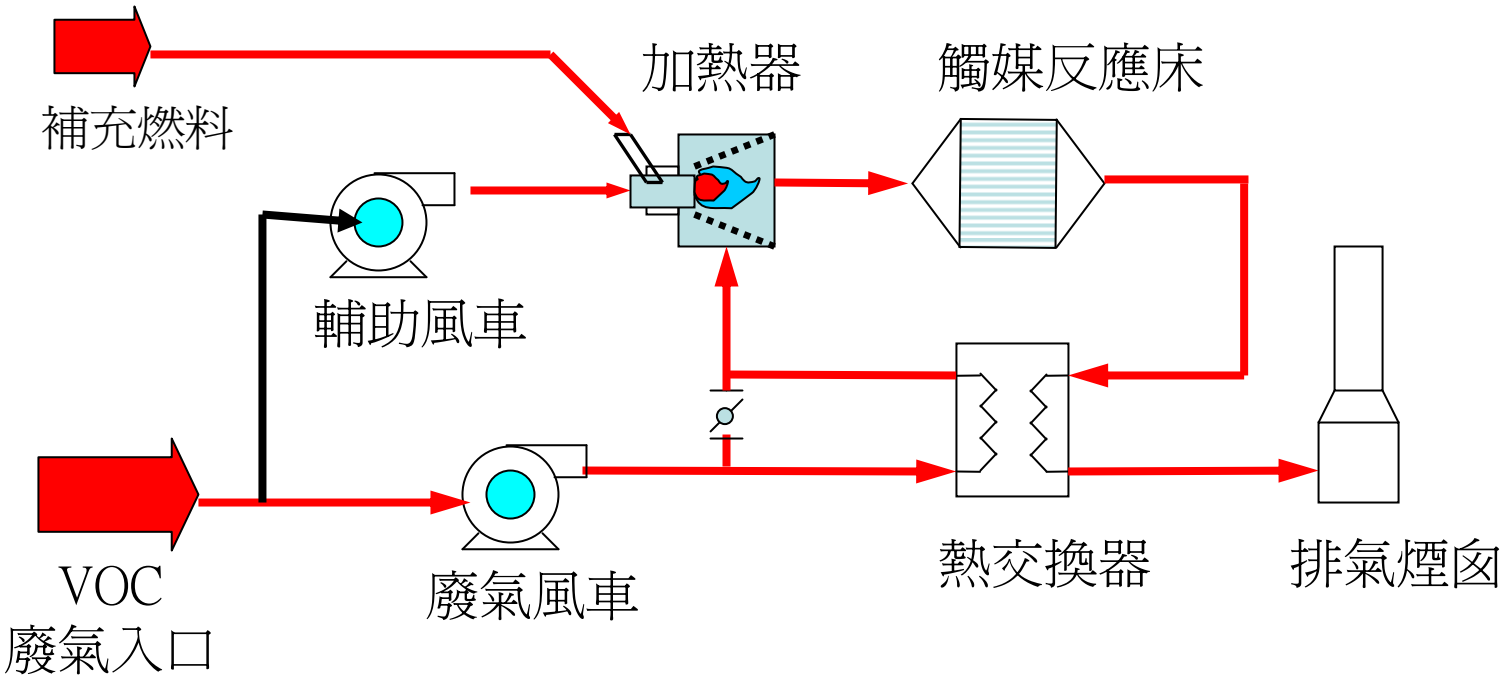
❑ 漆包線業 – 凡立水



觸媒焚化廢氣處理系統基本流程(1)



觸媒焚化廢氣處理系統基本流程(2)



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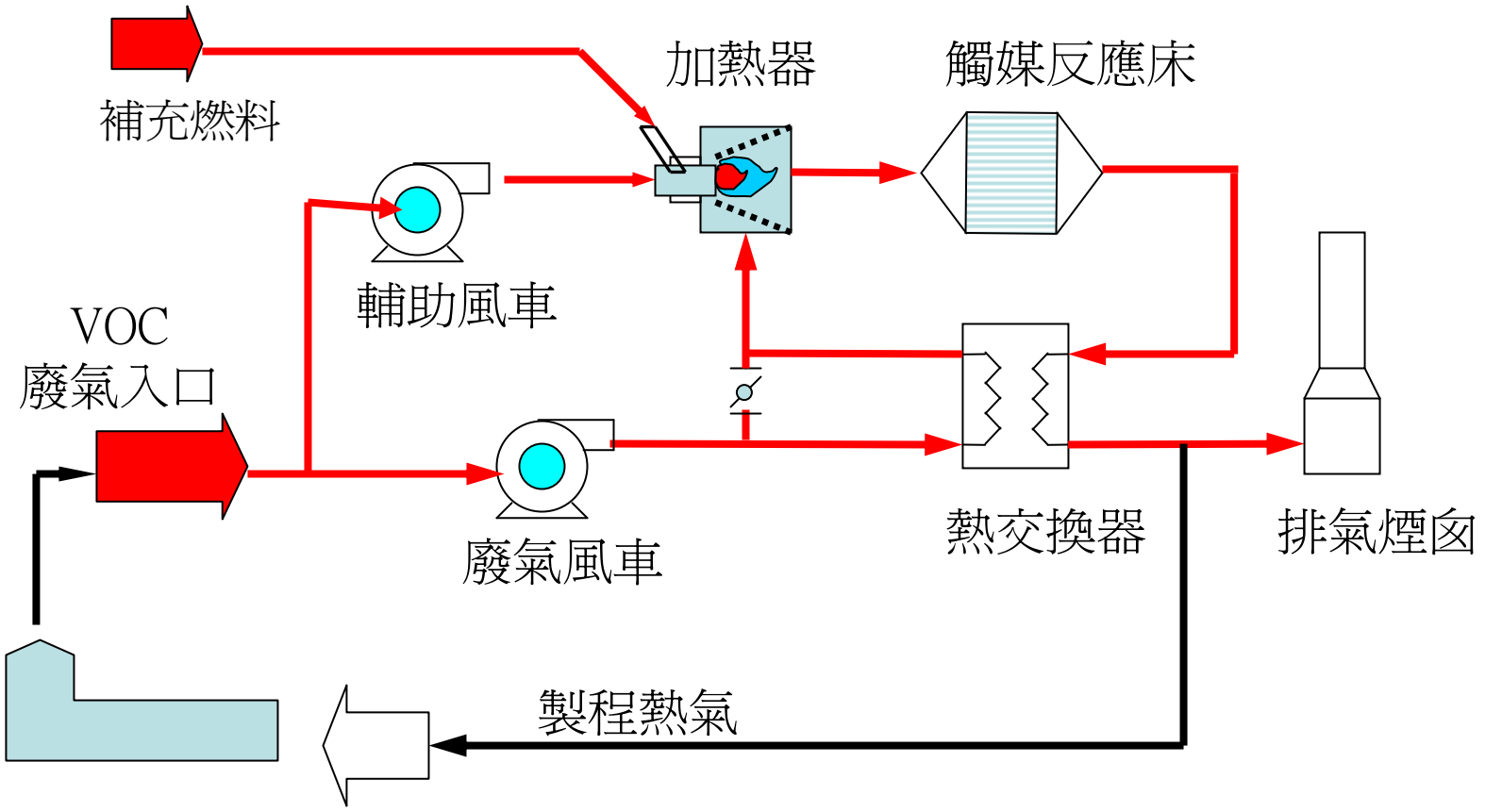
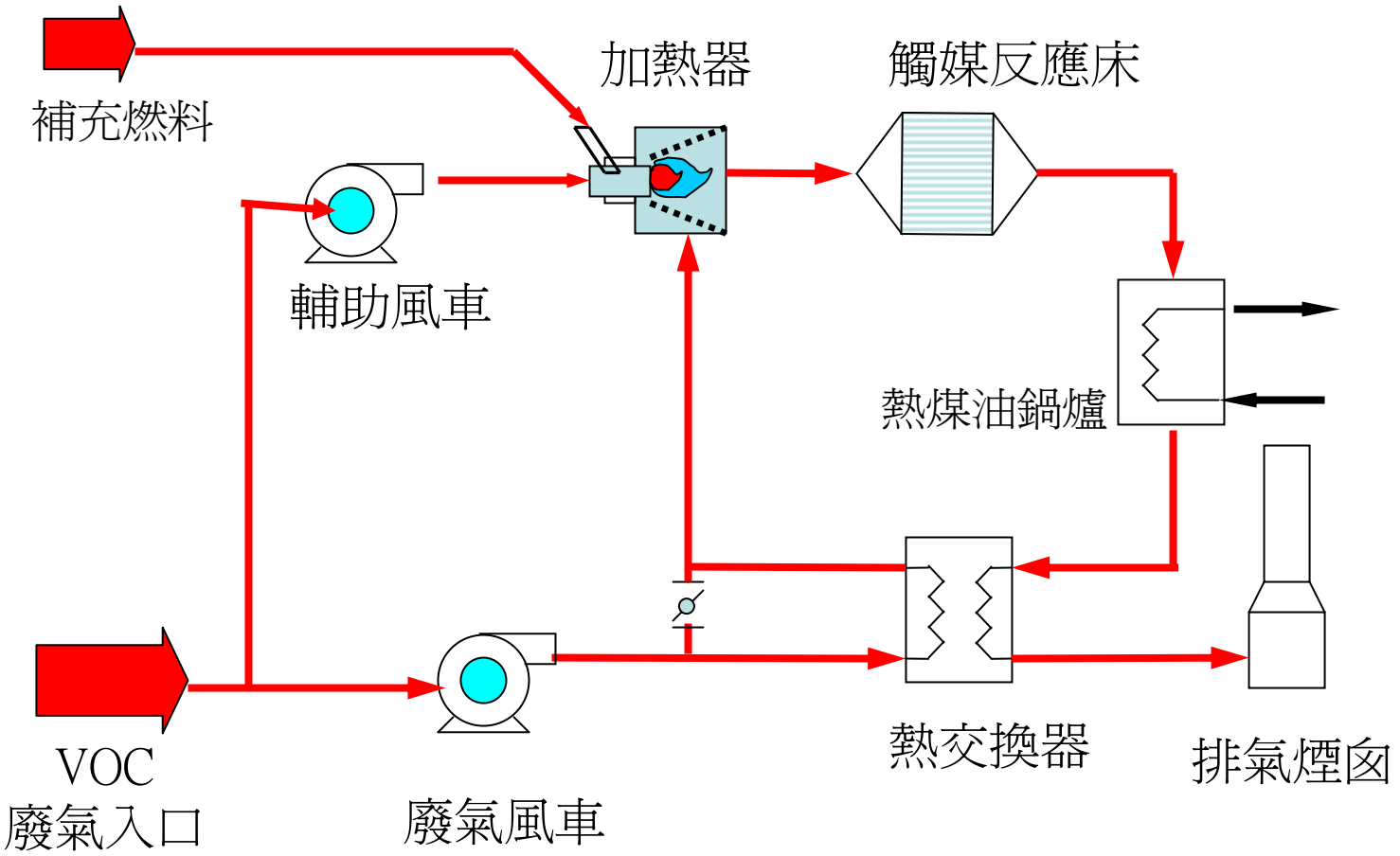
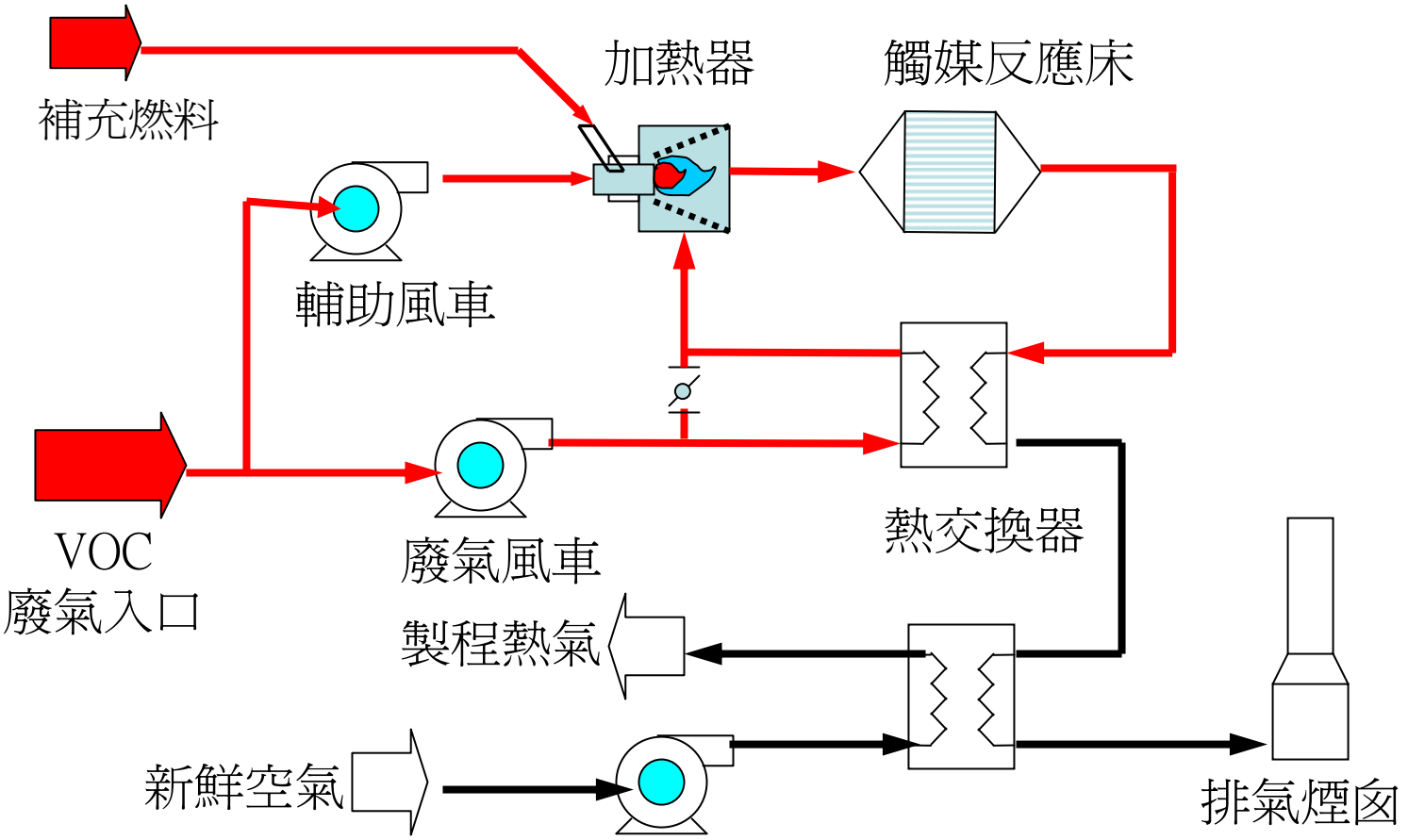


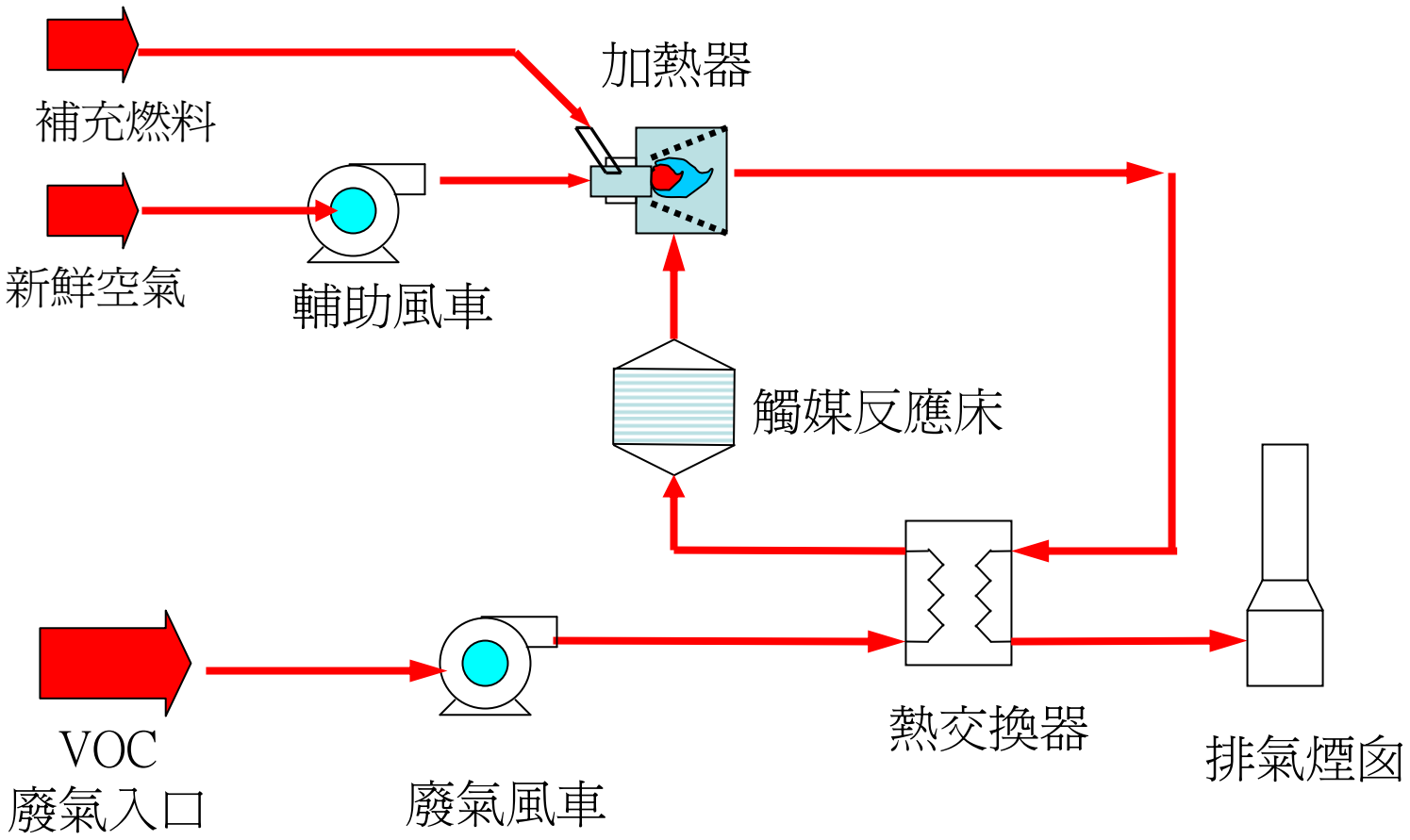
觸媒焚化廢氣處理系統基本流程(4)



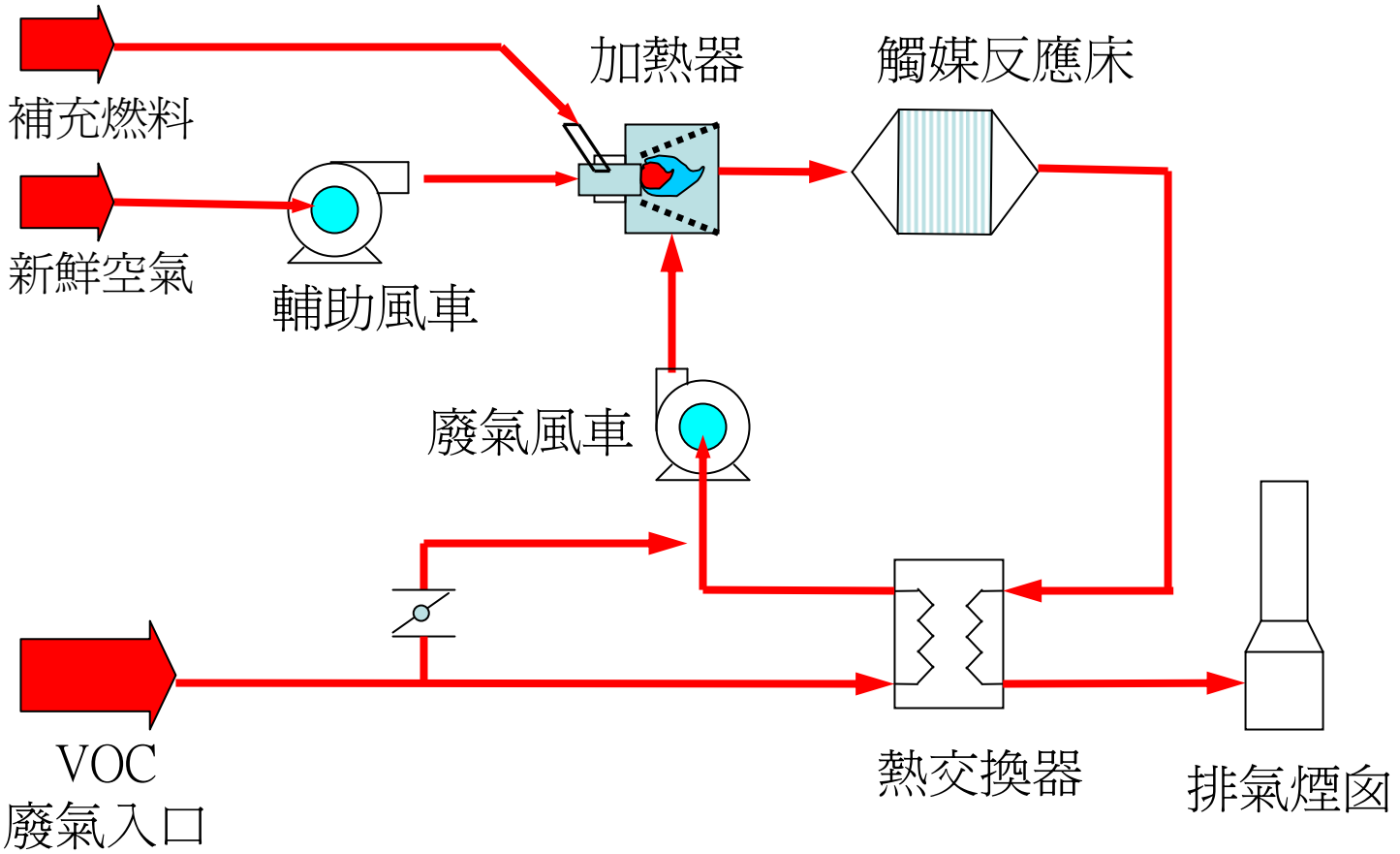
觸媒焚化廢氣處理系統基本流程(5)



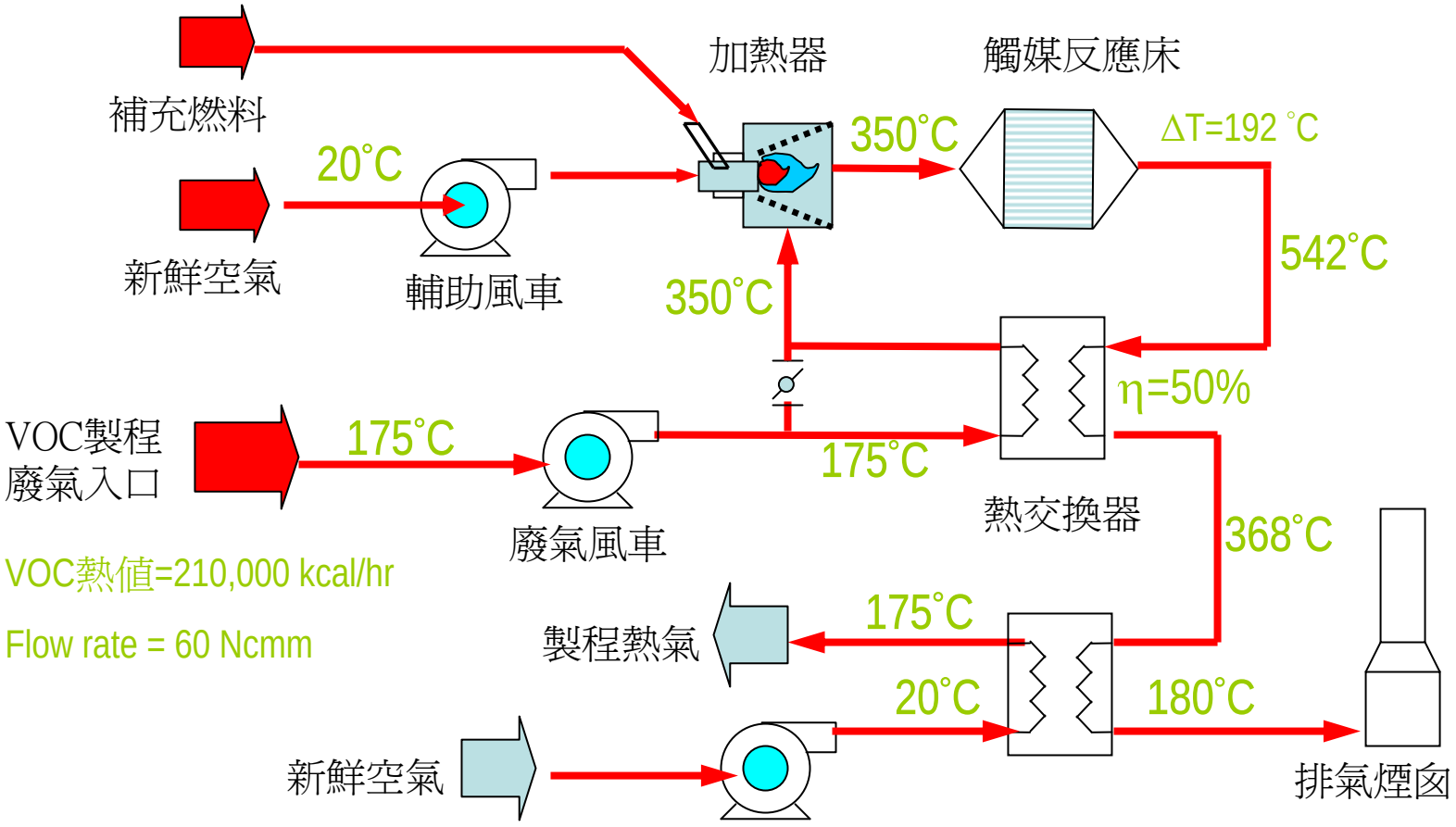
觸媒焚化廢氣處理系統基本流程(6)



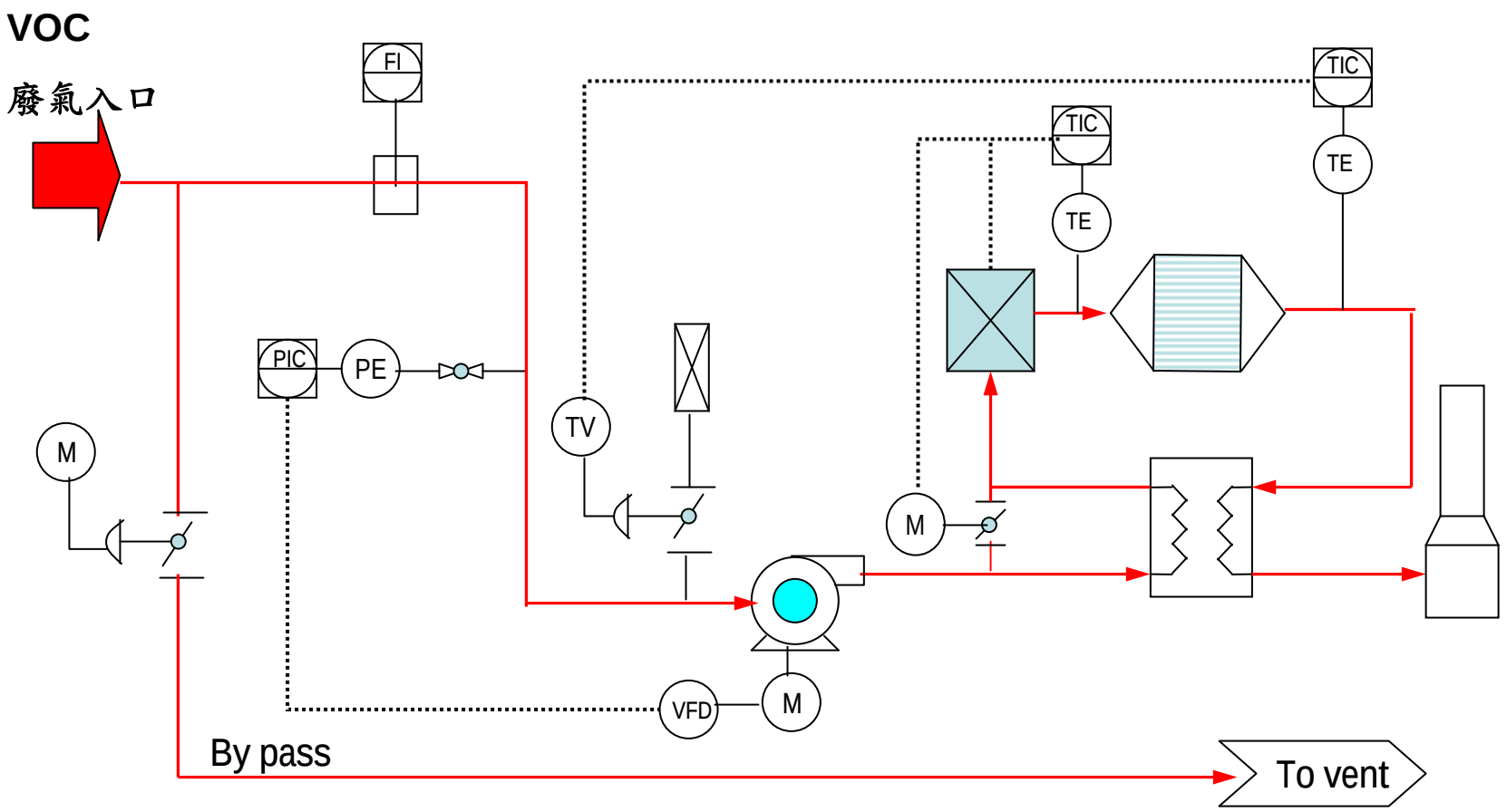
觸媒焚化廢氣處理系統基本流程(7)



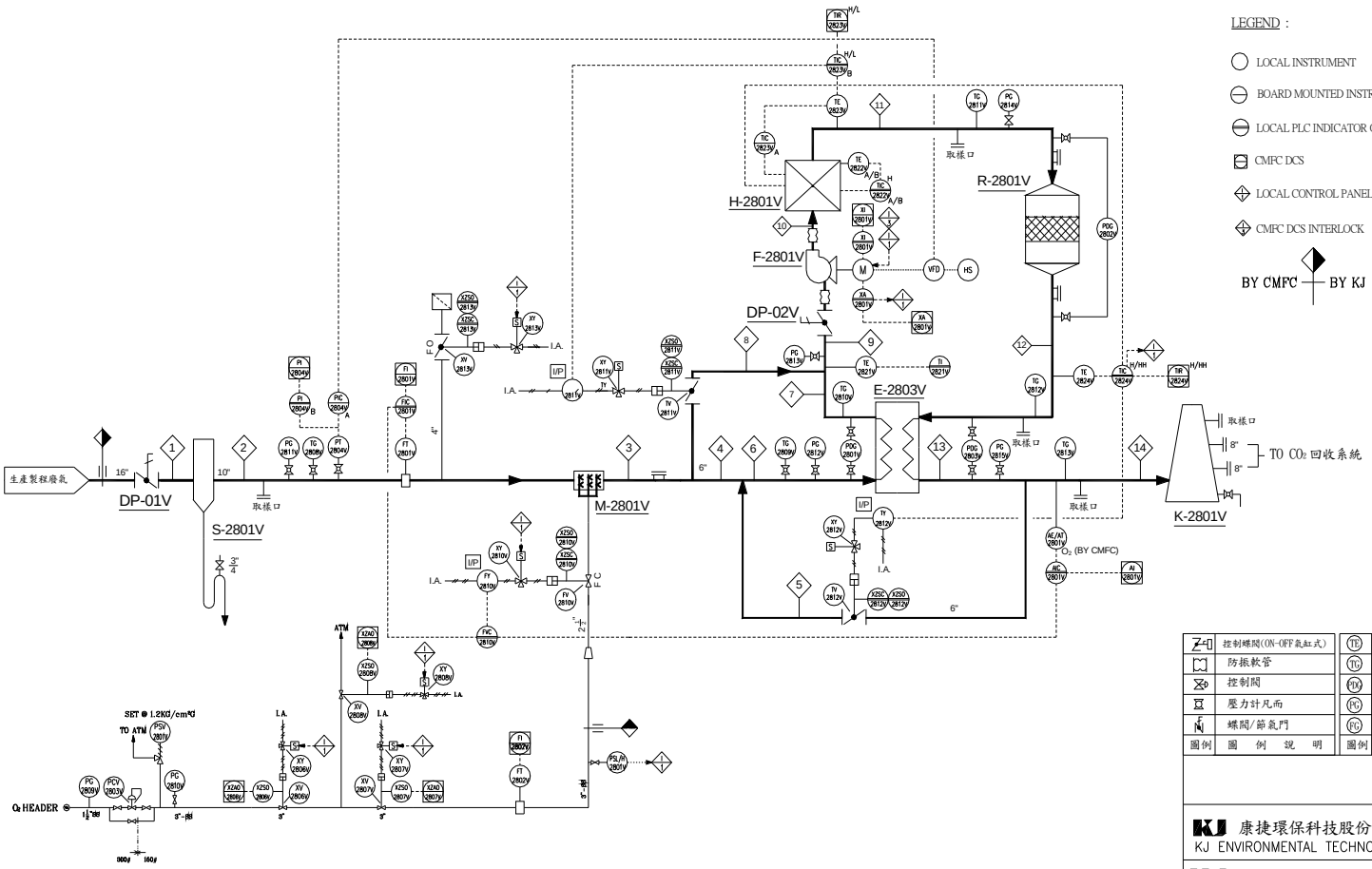
觸媒焚化廢氣處理系統熱平衡



觸媒焚化基本控制系統



S-2801V 氣液分離桶 | M-2801V 氧氣分配器 | E-2803V 熱交換器 | F-2801V 排氣風車 | H-2801V 電熱器 | R-2801V 觸媒反應器 | K-2801V 排氣煙囪



控制蝶閥(ON-OFF氣缸式)	溫阻器
防振軟管	溫度計
控制閥	差壓計
壓力計凡而	壓力計
蝶閥/節氣門	流量計
圖例 圖例說明	圖例 圖例說明

項目 \ 流程編號	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭
流體名稱	VOC 廢氣	VOC 廢氣	VOC 廢氣	VOC 廢氣	乾淨氣體	VOC 廢氣	VOC 廢氣	乾淨氣體	VOC 廢氣	VOC 廢氣	乾淨氣體	乾淨氣體	乾淨氣體	乾淨氣體
壓力(mmH2O)	-380	-400	-410	-410	—	-410	-490	—	-490	290	270	120	20	20
溫度(°C)	70	70	70	70	—	70	350	—	350	350	350	540	260	260
流量(Nm3/min)	67.5	67.5	67.5	67.5	—	67.5	67.5	—	67.5	67.5	67.5	67.5	67.5	67.5
總THC(wt%)NOR.	0.74	0.74	0.74	0.74	—	0.74	0.74	—	0.74	0.74	0.74	0	0	0
O_2 (wt%)	0.06	0.06	4.9	4.9	—	4.9	4.9	—	4.9	4.9	4.9	3	3	3

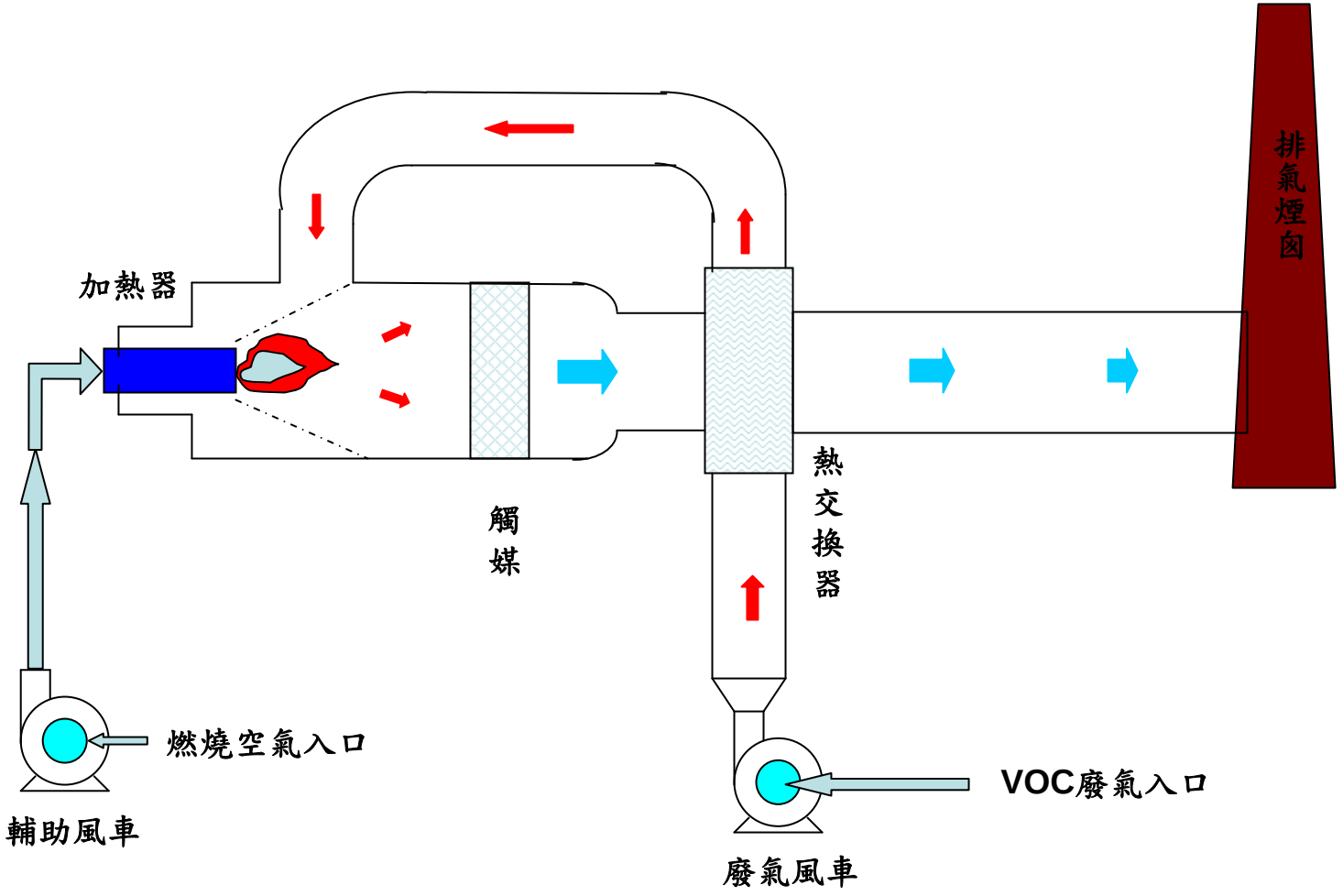
REV	DESCRIPTION	BY	CHK	APPR	DATE
4					
3					
2					
1	FOR APPROVAL	TSO	TIM	LAI	08/05/00
0	FOR APPROVAL	TSO	TIM	LAI	07/27/00

KJ 康捷環保科技股份有限公司
KJ ENVIRONMENTAL TECHNOLOGY CO.,LTD.

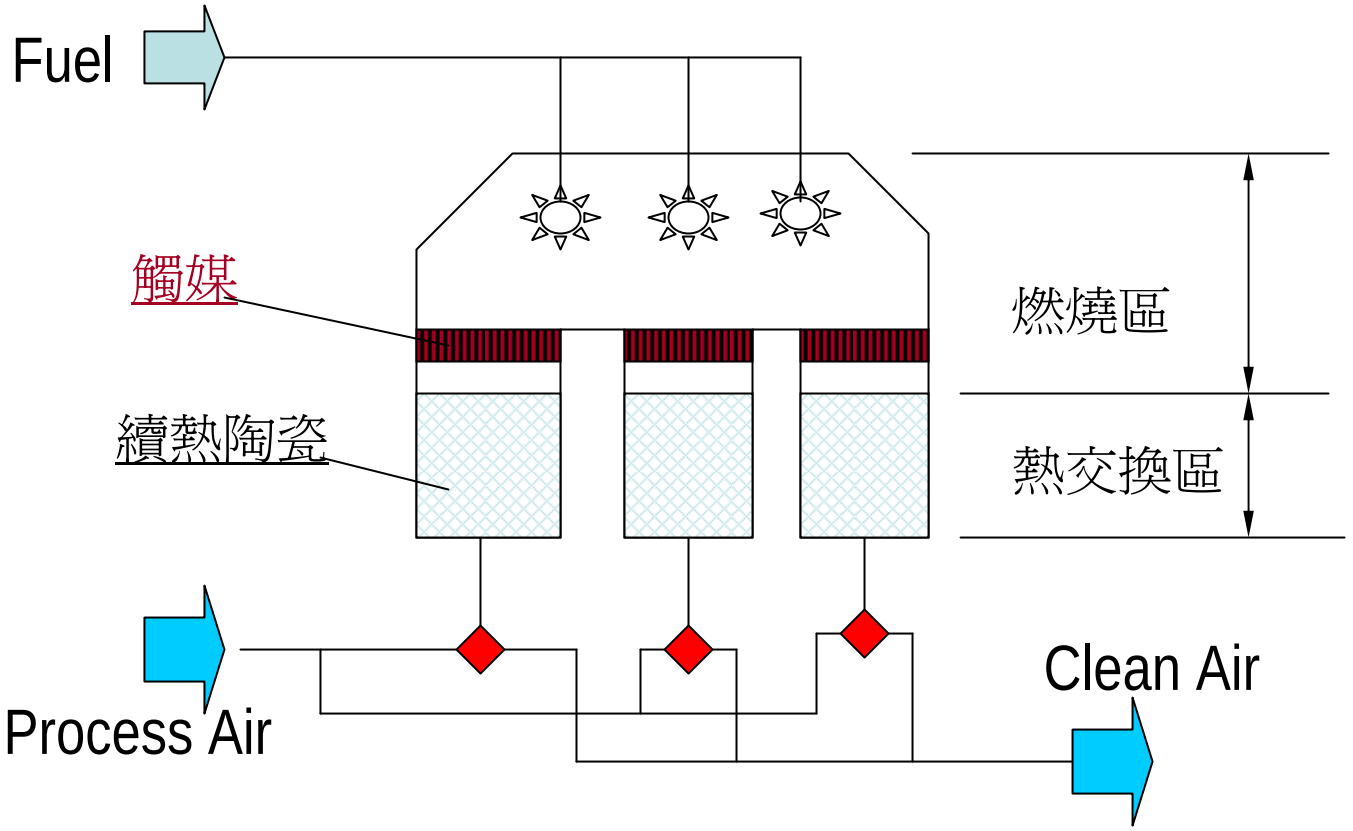
TITLE:

KJ	PROJ. NO.	DWG. NO.
	2KJ033	PID-F002

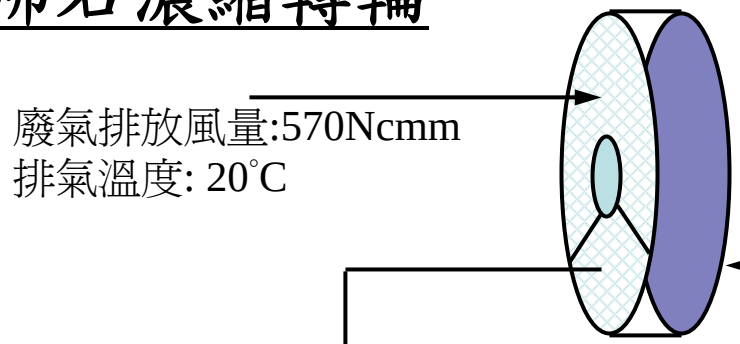
❑ 直燃法 + 觸媒 = 觸媒焚化



- 續熱式焚化 + 觸媒 = 續熱式觸媒焚化
  (RTO) (RCO)



沸石濃縮轉輪



廢氣排放風量:570Ncmm
排氣溫度: 20˚C

脫附空氣風量:57Ncmm
脫附空氣溫度: 176˚C

脫附空氣
溫度: 176˚C

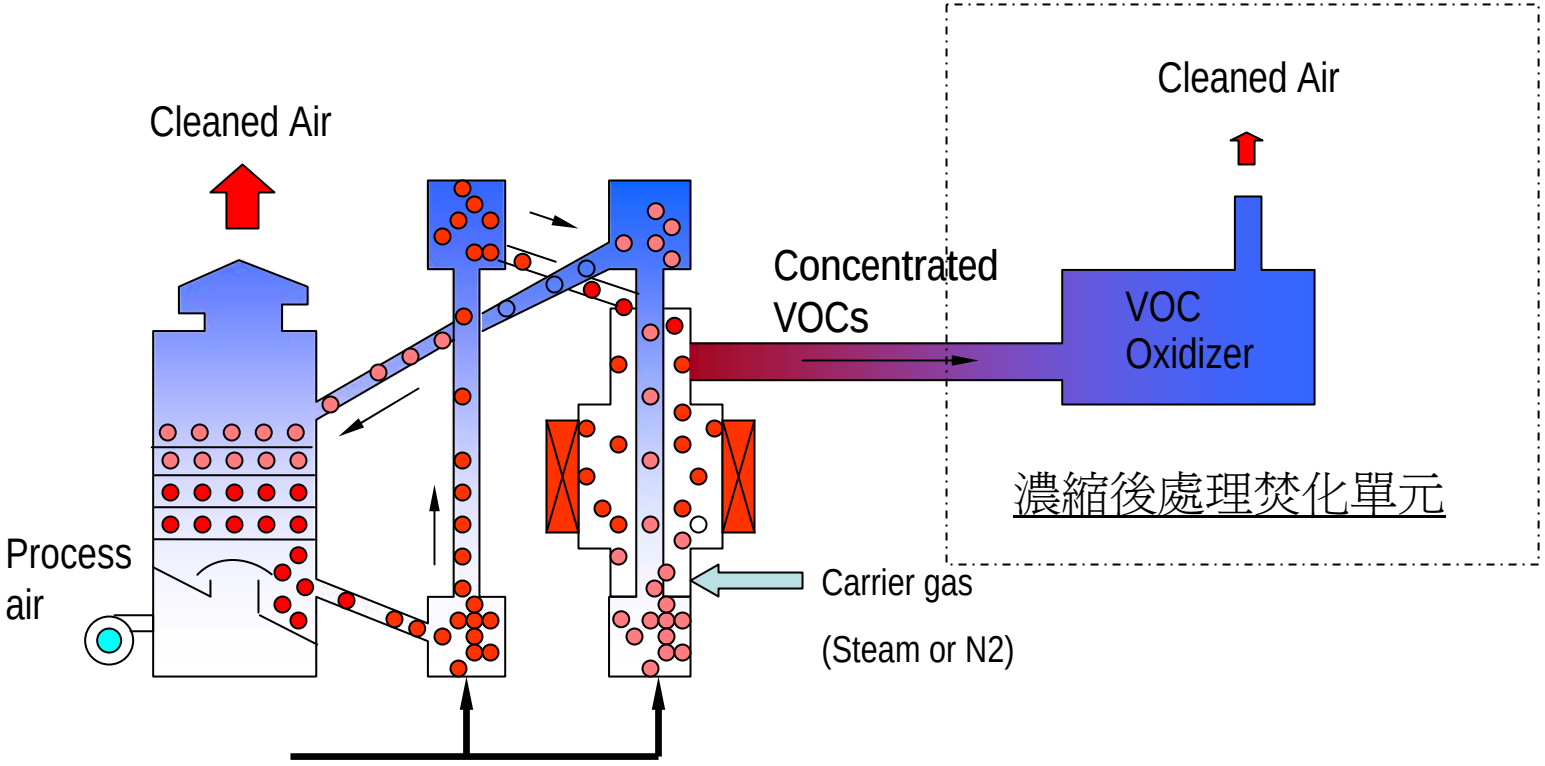
溫度: 350˚C

溫度: 542˚C

排放風量:57Ncmm
排氣溫度: 368˚C

轉輪後處理焚化單元

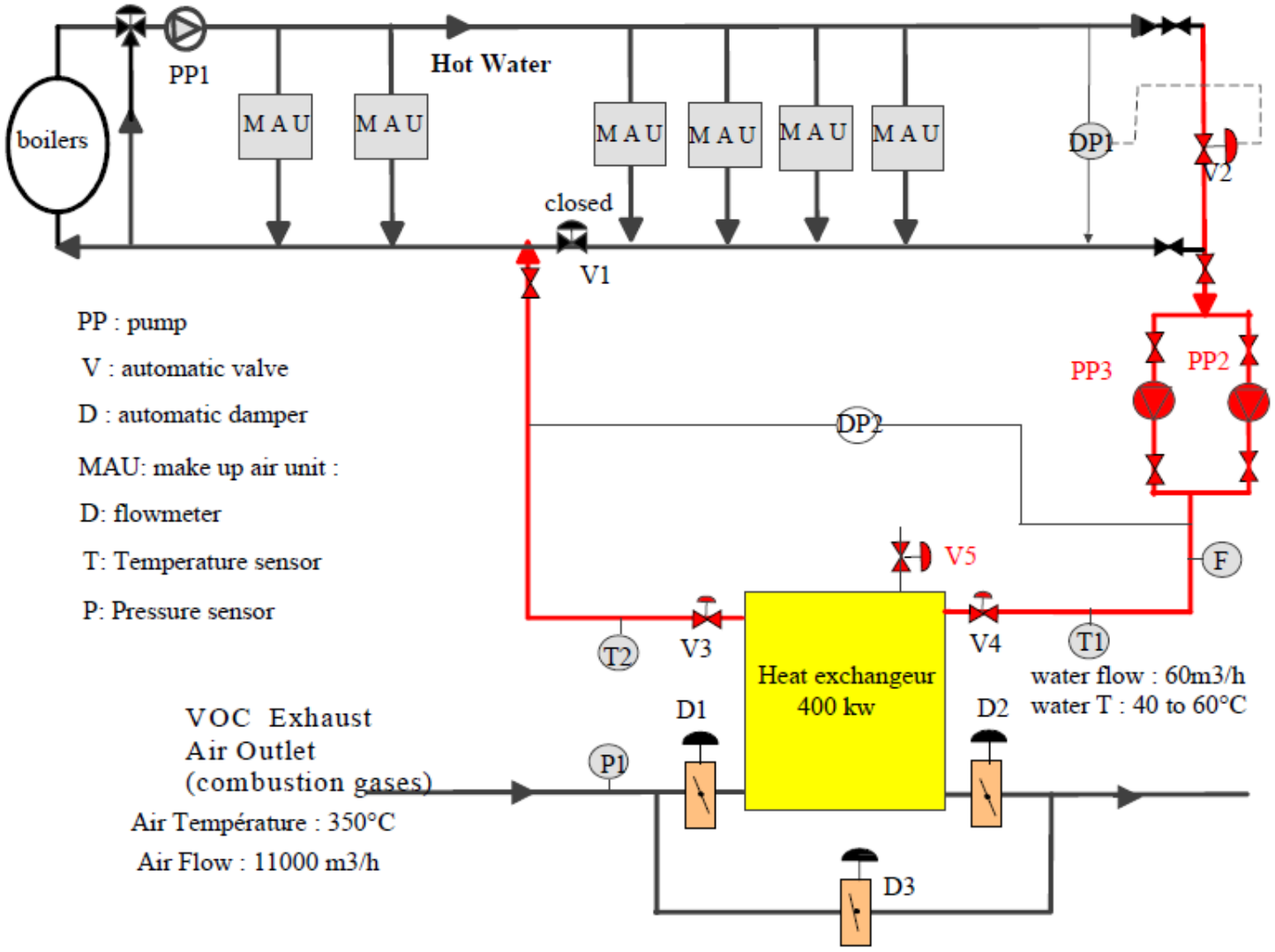
活性碳流體化床濃縮處理系統



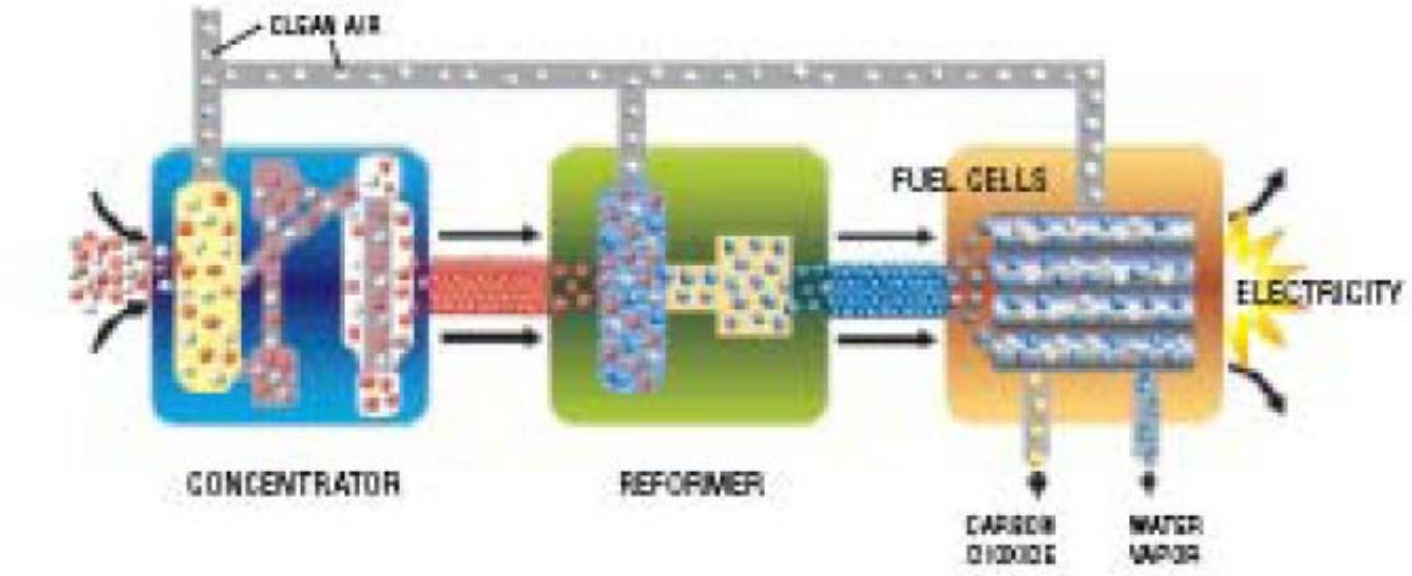
VOC Waste Heat Recovery

- **Semiconductor Background/Strategy:** Recover heat from VOC exhaust abatement combustion system by installation of heat exchanger on combustion gases to transfer energy to the site hot water supply system, reducing hot water system natural gas consumption. by 12,000 MMBtu annually

VOC Heat Recovery System

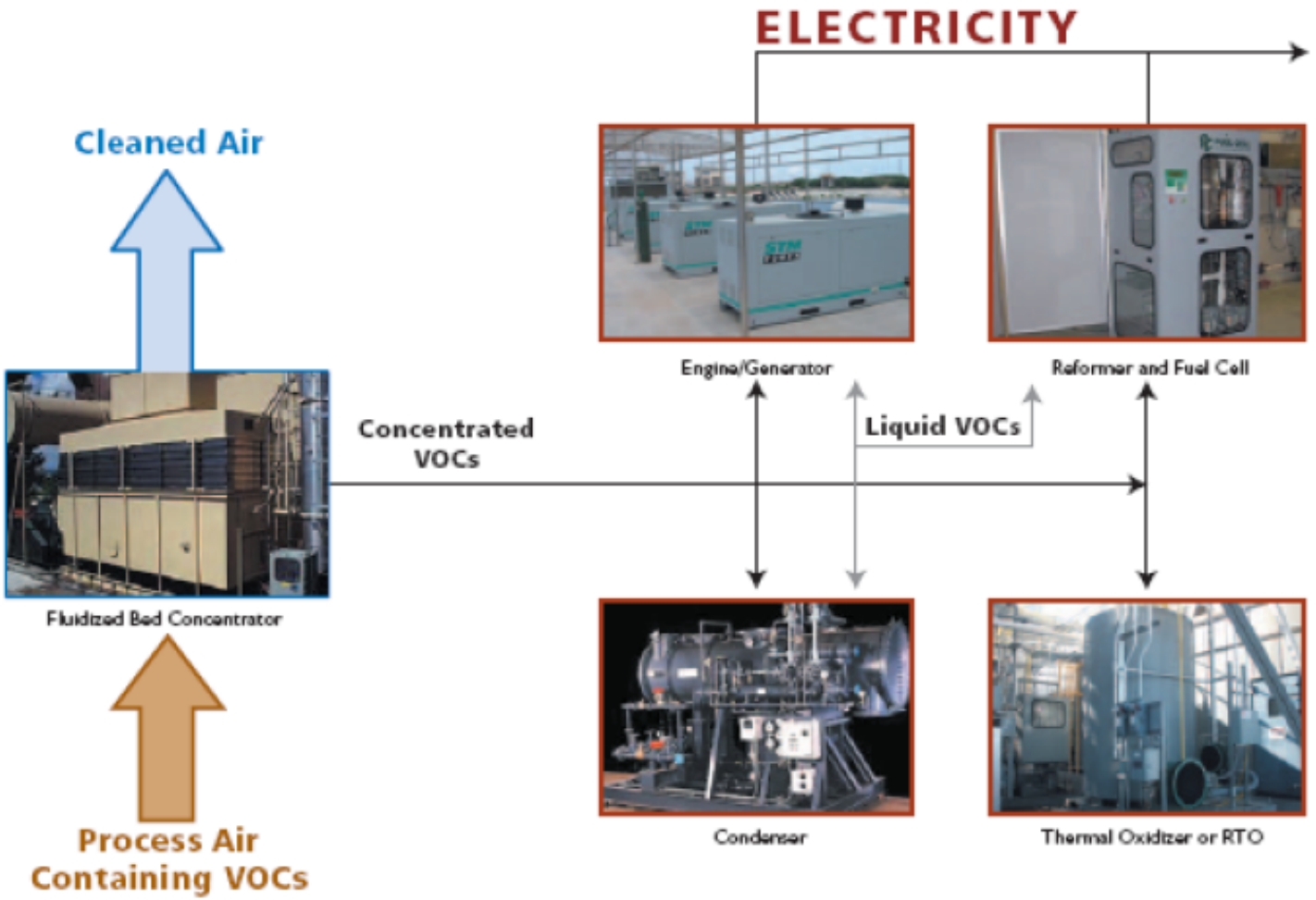


Fumes to Fuel Technology

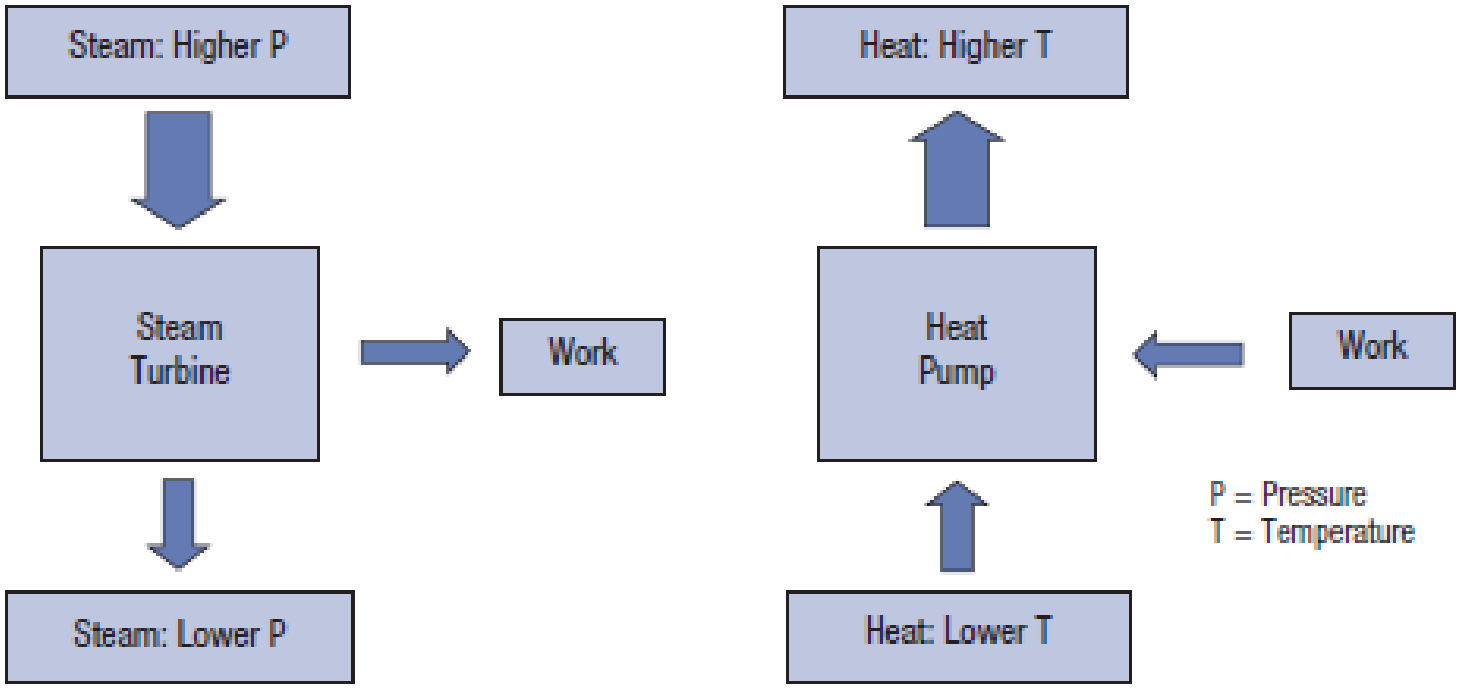


VOC concentrator –applicable to chemical plants & Solid Oxide Fuel Cell

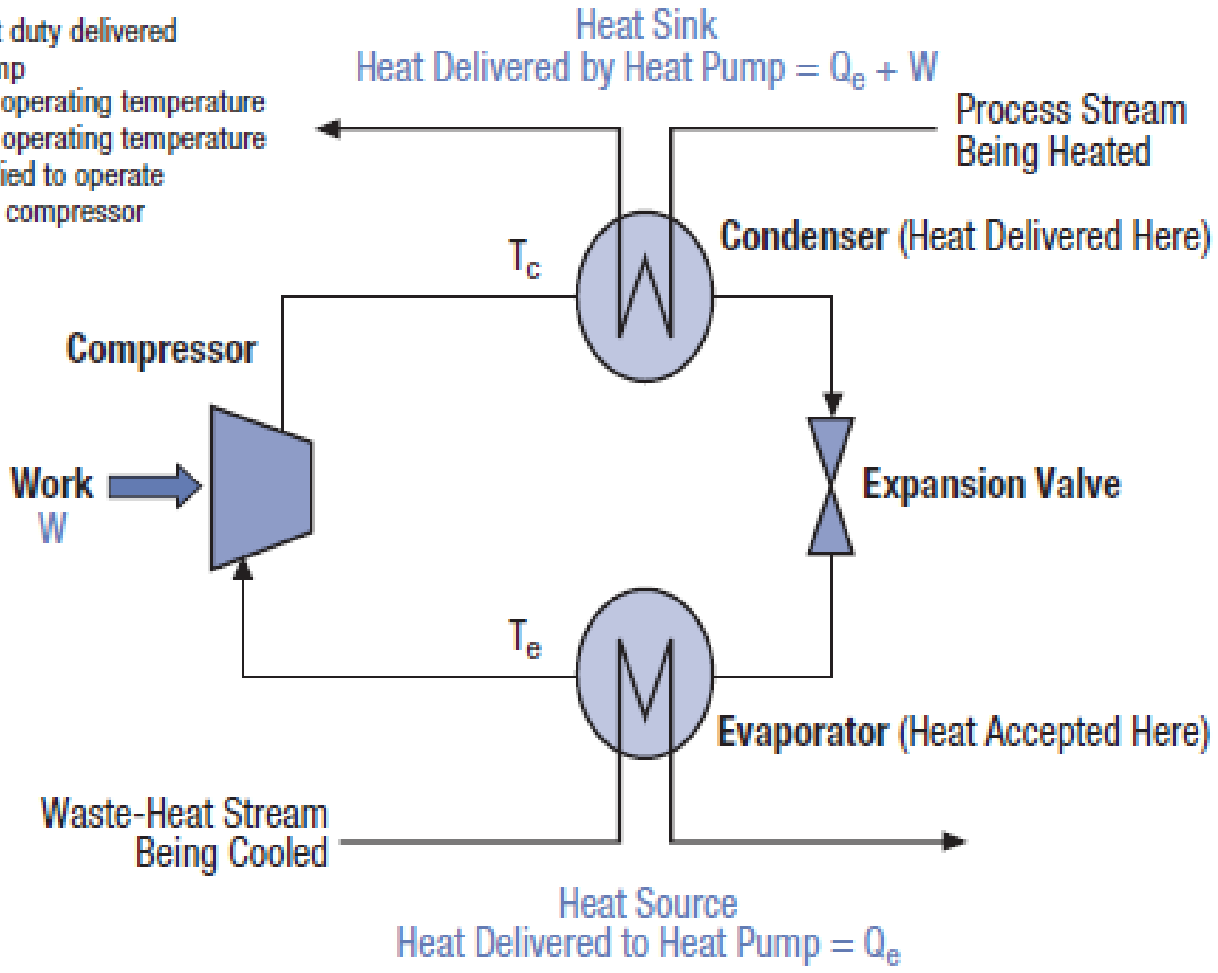
Fumes to Fuel Technology



Heat Pump

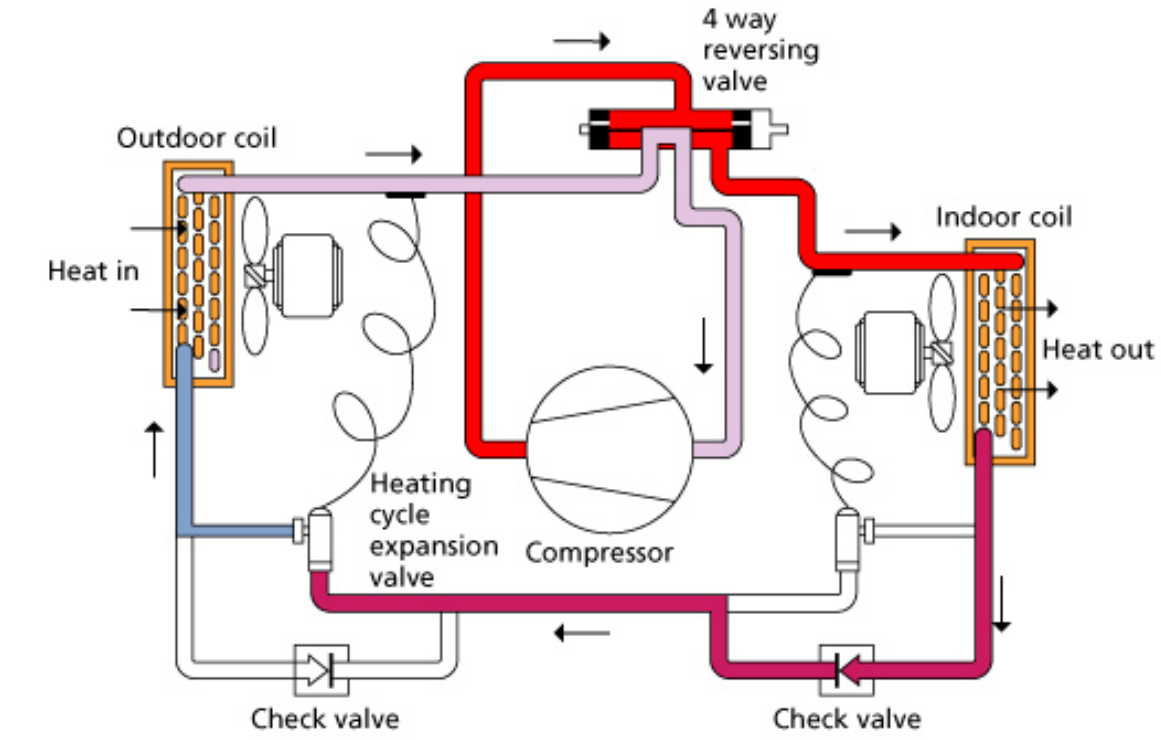

Steam: Higher P
Steam Turbine
Work
Steam: Lower P
Heat: Higher T
Heat Pump
Work
Heat: Lower T
P = Pressure
T = Temperature

Q_e = Waste-heat duty delivered to heat pump
T_c = Condenser operating temperature
T_e = Evaporator operating temperature
W = Work supplied to operate heat-pump compressor

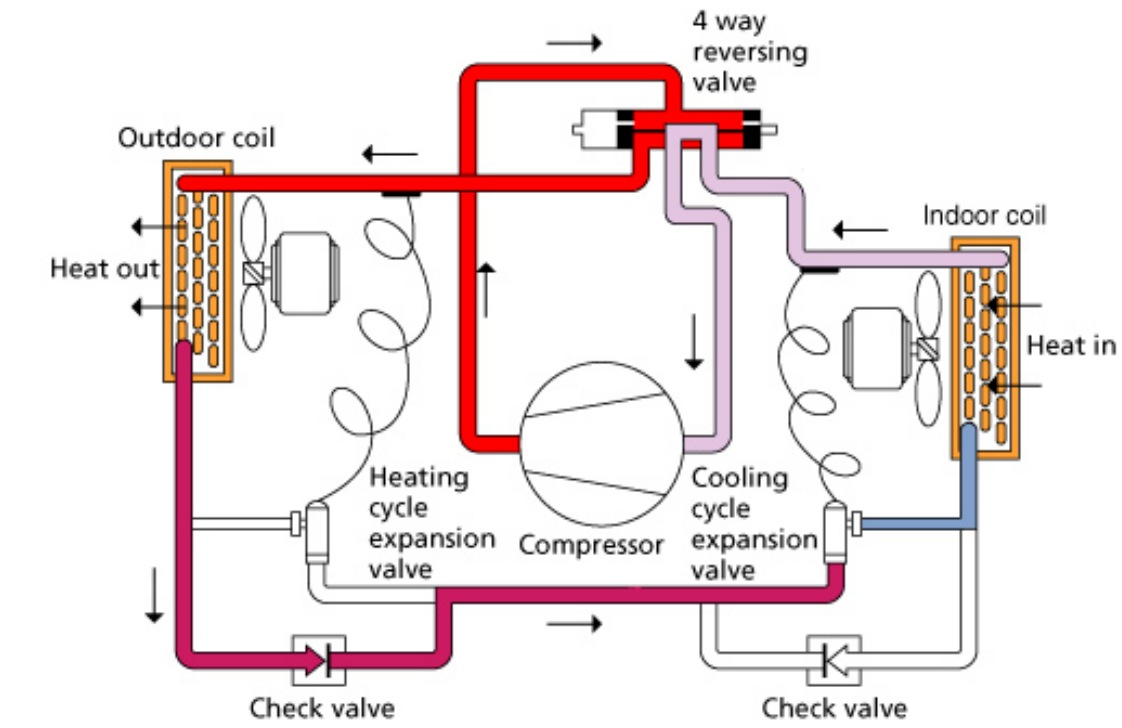


1. Waste-heat stream evaporates heat-pump working fluid at low temperature and pressure
2. Compressor increases pressure of heat-pump working fluid
3. Heat-pump working fluid condenses at high temperature and pressure in the condenser, providing useful heat to a process stream
4. Condensed working fluid is expanded back to the evaporator

REVERSE CYCLE HEAT PUMP – HEATING CYCLE



REVERSE CYCLE HEAT PUMP – COOLING CYCLE



A Simple Example of Process Integration by Pinch Analysis

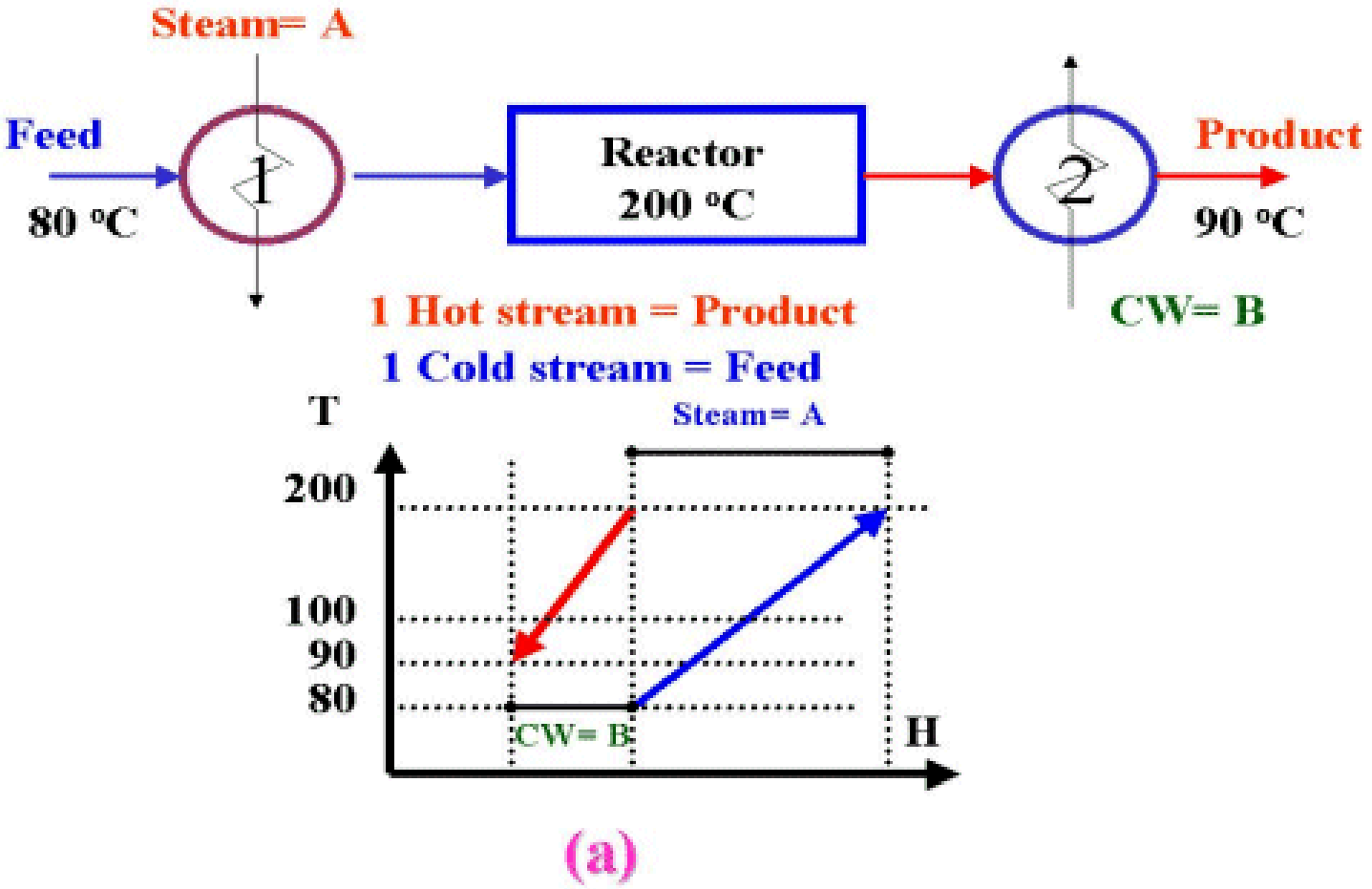
- the following simple process where feed stream to a reactor is heated before inlet to a reactor and the product stream is to be cooled.
- The heating and cooling are done by use of steam (Heat Exchanger -1) and cooling water (Heat Exchanger-2), respectively.

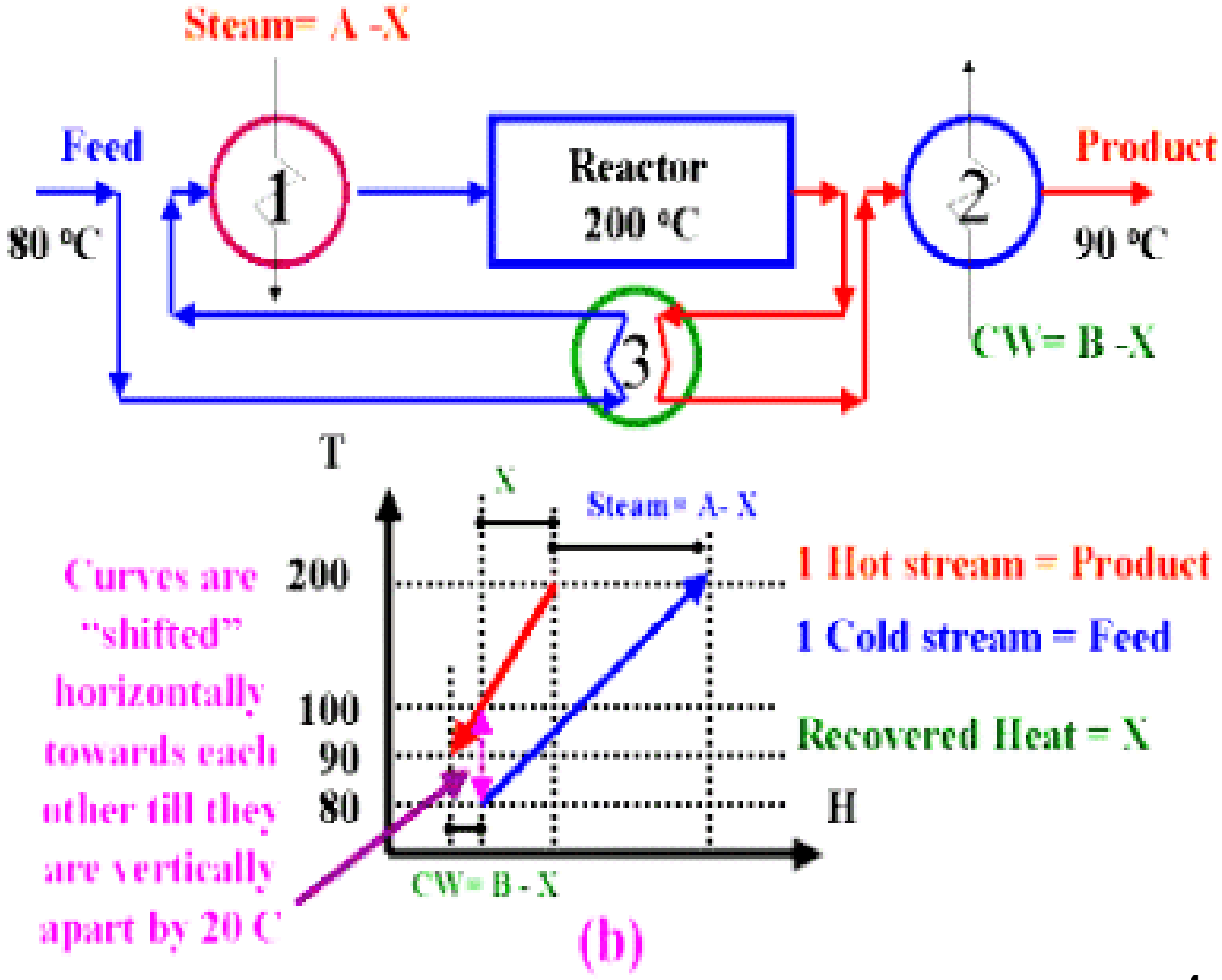
Pinch Analysis

- Pinch Technology provides a consistent methodology for energy saving, from the basic heat and material balance to the total site utility system.
- A Pinch Analysis starts with the heat and material balance for the process.
- After the heat and material balance is established, targets for energy saving can be set prior to the design of the heat exchanger network.
- The Pinch Design Method ensures that these targets are achieved during the network design.

A Simple Example of Process Integration by Pinch Analysis

- From the T-H plot, the X amount corresponds to a DTmin value of 20 ^{o}C.
- Increasing the DTmin value leads to higher utility requirements and lower area requirements.

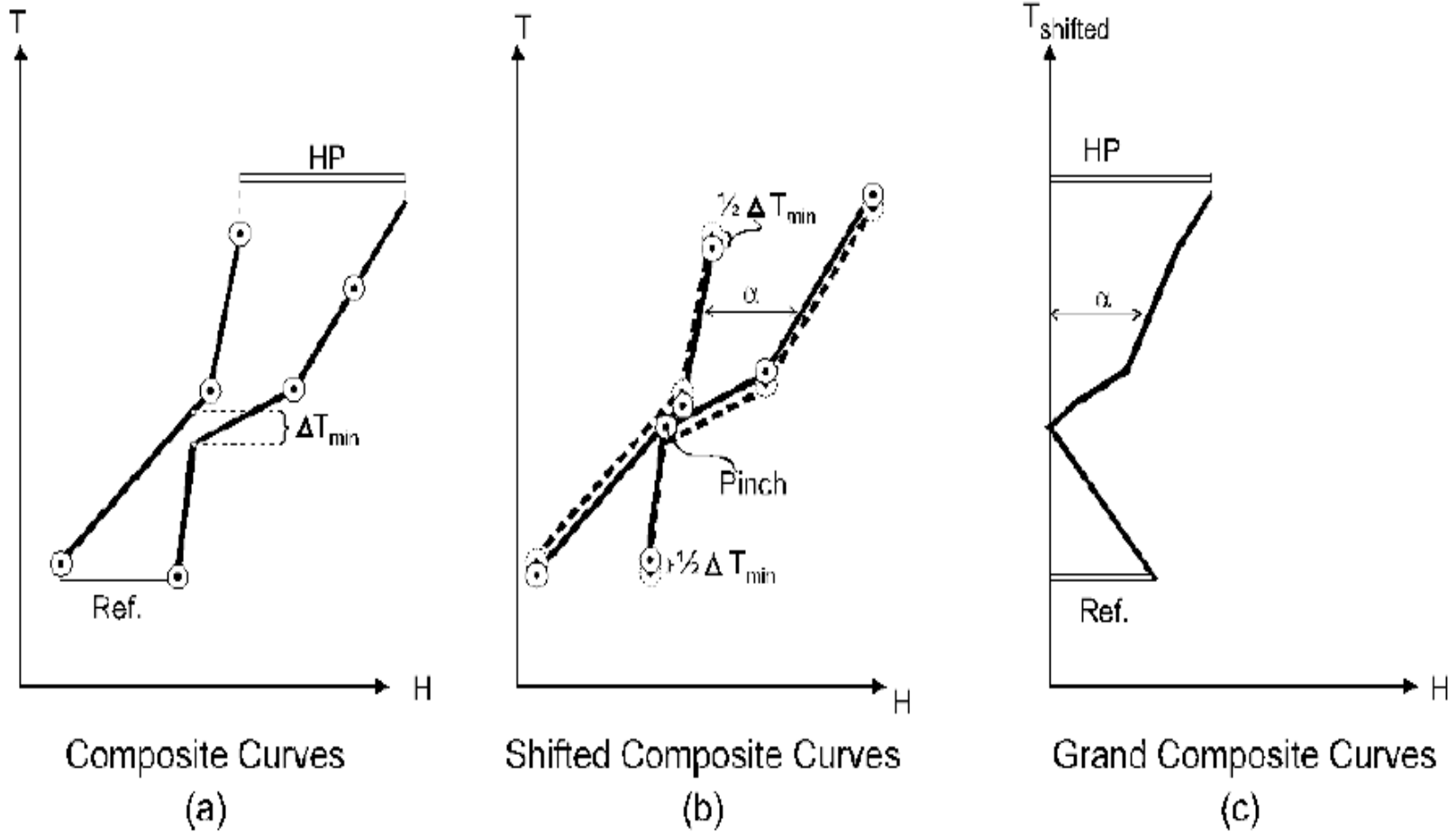

Steam= A
Feed
80 °C
1
Reactor
200 °C
2
Product
90 °C
CW= B
1 Hot stream = Product
1 Cold stream = Feed
T
Steam= A
200
100
90
80
CW= B
H
(a)


Steam= A -X
Feed
80 °C
1
Reactor
200 °C
2
Product
90 °C
3
CW= B -X
T
X
Steam= A- X
Curves are "shifted" horizontally towards each other till they are vertically apart by 20 C
200
100
90
80
H
CW= B - X
1 Hot stream = Product
1 Cold stream = Feed
Recovered Heat = X
(b)

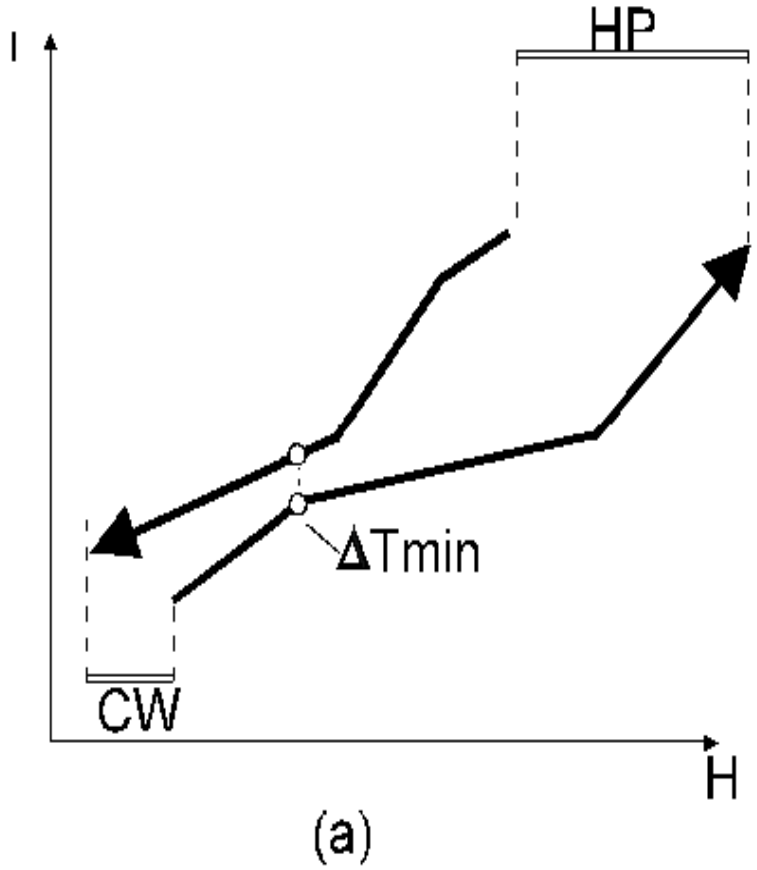
The Grand Composite Curve

- The tool that is used for setting multiple utility targets is called the Grand Composite Curve, the construction of which is illustrated in Figure at next page.
- The "shifted composite curves“ involves increasing the cold composite temperature by ½ DTmin and decreasing the hot composite temperature by ½ DTmin .
- The grand composite curve is then constructed from the enthalpy (horizontal) differences **between the shifted composite curves** at different temperatures (shown by distance a in Figure (b) and (c)).

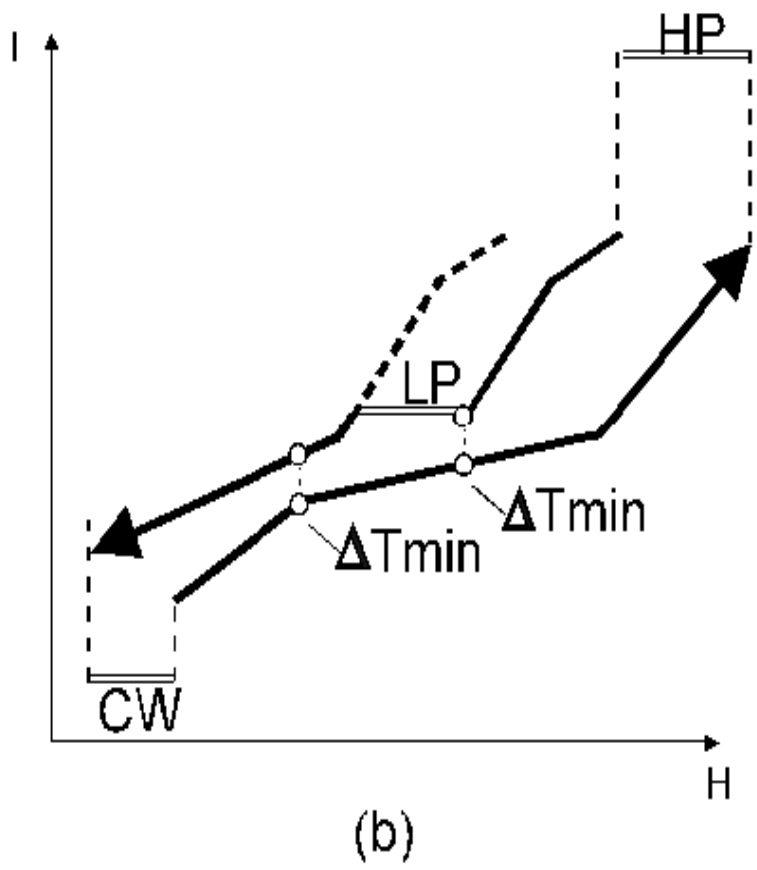
The Grand Composite Curve



Multiple utility targeting with the Grand Composite Curve

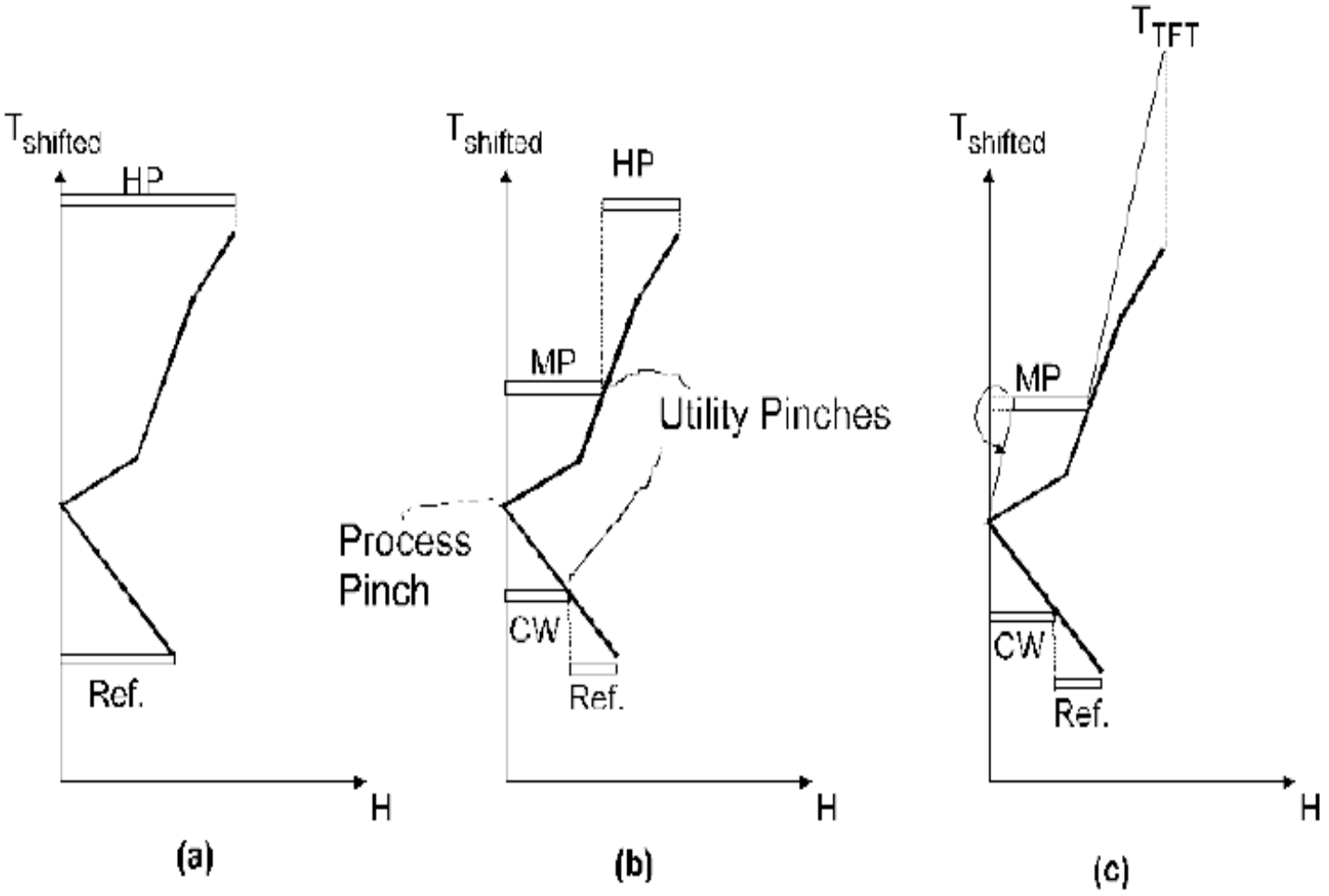


(a)



(b)

Multiple utility targeting with the Grand Composite Curve



Example

- Column integration
- Appropriate integration of heat engines
- Appropriate integration of heat pumps

Benefits and Applications of Pinch Technology

- Since its commercial introduction, documented results reported in the literature show that energy costs have been reduced by 15-40%, capacity debottlenecking achieved by 5-15% for retrofits, and capital cost reduction of 5-10% for new designs.
- Pinch originated in the petrochemical sector and is now being applied to solve a wide range of problems in industries as diverse as iron and steel, food and drink, textiles, paper and cardboard, cement, base chemicals, oil, and petrochemicals, Wherever heating and cooling of process materials takes places there is a potential opportunity.

Benefits and Applications of Pinch Technology

General Process Improvements

- Update or Modify Process Flow Diagrams (PFDs)
- Conduct Process Simulation Studies
- Set Practical Targets
- Debottlenecking
- Determine Opportunities for Combined Heat and Power (CHP) Generation
- Decide what to do with low-grade waste heat

Future Outlook

- The development of Pinch Technology started in the late 1970s and still continues. Besides applications in energy conservation, new developments in Pinch Analysis are being made in the areas of water use minimization, waste minimization, hydrogen management, plastics manufacturing, and others.

Future Outlook

1. Regional Energy Analysis
2. Total Site Analysis
3. Network Pinch
4. Top Level Analysis
5. Optimization of Combined Heat and Power
6. Hydrogen Pinch
7. Water Pinch

電子業VOC廢氣處理

農藥業廢氣處理

漆包線業

- 加裝二次觸媒

電子業烘烤爐廢氣處理

觸媒焚化CCS-2000型

Summary

- 觸媒焚化應用行業範圍很廣,並且可與其他污染防治設備合併使用
- 處理風量範圍很廣從L/min至m^3/min
- 處理設備可依現場條件及需求設計,彈性空間很大
- 廢氣中有機溶劑之濃度,決定釋放出之反應熱,必須注意系統之熱平衡及高溫控制以避免觸媒高溫失活情形發生
- 控制系統之設計一安全,方便操作,容易維修,保養皆須列入設計上之考量
- 觸媒焚化工程設計製作與觸媒生產,均可由國內廠商提供