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Engineering Total Solution CAE: CAD: CAM: PDM: EDA: CONSULTANT



Fluid Dynamics

Structural Mechanics

Electromagnetics

Systems and Multiphysics

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CADMEN Engineering Total Solution CAE: CAD: CAM: PDM: EDA: CONSULTANT

李龍育 Dragon CFD技術副理 虎門科技



虎門科技 CADMEN



- 結構強度分析 ANSYS Mechanical
- 落摔分析 ANSYS LS-DYNA
- · 散熱與熱流場分析
 ANSYS FLUENT、ICEPAK、CFX
- 電磁場分析 ANSYS Emag、Maxwell
- 多物理耦合分析

Provider of Engineering Solutions and Methodology

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總公司:新北市板橋區

• 分公司:台中市文心路





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ANSYS FLUENT於化工產業應用簡介

Fluid Dynamics

Structural Mechanics

Electromagnetics

Systems and Multiphysics

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李龍育 Dragon CFD技術副理 虎門科技

Why to model CFD & reacting flows?

Devices are very complex

 Complex geometry, complex BCs, complex physics (turbulence, multi-phase, chemistry, radiation,...), complex systems, ...

- Tool to gain insight and understanding
- Reduce expensive experiments

Eventually design!

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Filtration • Centrifugal • Granular bed • Pressure • Vacuum • Ulterafine • Chromatography



11, 2013



- Blenders
- Polymerizers
- Hydrogenerators
- Crystallizers
- Fermentators
- Fluidized bed





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CFD Simulation Driven Product Development **ANSYS**[®] •計算流體力學 數位實驗 2.45326 2.10813 1.42329 1.42329 1.45405 4.225500 1.354253 • 設計與偵錯工具 • 深入了解產品問題改良 Velocity Vector 1 7.29 產品性能表現 BETTER FASTER CHEAPER July 11, 2013

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Engineering Challenges

Engineering Challenges

Increase plant yield

- Optimize processes
- Reduce cost
- Control product quality
- Emission and pollution

-Sustainable and green practices

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• Safety

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How can Simulation help

Reactor scale-up

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- Design new equipment and evaluate vendor designs
- Process performance on operating scenarios

-Increase plant yield

 Provide plant support by troubleshooting unit operations
 -Root-cause failure analysis

 Address safety concerns and emission norms

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ANSYS CFD模擬軟體介紹



核心技術

- 移動/變形網格
- 多相流
- 化學反應流
- 紊流
- 熱輻射
- 氣動噪音

擴展分析

- 磁流模組 (MHD)
- 燃料電池模組
- 流固耦合(FSI)
- 最佳化分析
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Physics Model



- Eddy Dissipation
- Premixed Combustion
- Non-Premixed
 Equilibrium
- Partially-Premixed
- Laminar Flamelet
- Laminar Finite-Rate
- EDC

NNSYS[®]

- Composition PDF
 Transport
- Wall Surface & CVD
- Particle Surface
- Spark & Autoignition
- NOx&SOxSoot

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Physics Model

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Gas/Liquid Liquid/Liquid

Gas / Solid

Multiphase Model • DPM

- VOF
- Mixture
- Euler- Euler
- Euler-Granular
- Dense Discrete Phase
- Discrete Element Method
- Cavitation

14



- Bubbly flow Discrete gaseous bubbles in a continuous fluid, e.g. absorbers, evaporators, sparging devices. And can report to a consultant
- Droplet flow Discrete fluid droplets in a continuous gas, e.g. atomizers, combustors
- Slug flow Large bubbles in a continuous liquid •
- Stratified / free-surface flow Immiscible fluids separated by a clearly defined interface, e.g. freesurface flow
- Particle-laden flow Discrete solid particles in a continuous fluid, e.g. cyclone separators, air classifiers, dust collectors, dust-laden environmental flows
- Fluidized beds Fluidized bed reactors
- Slurry flow Particle flow in liquids, solids Liquid / Solid suspension, sedimentation, and hydro-transport





Bubbly, Droplet, or Particle-Laden Flow





Surface Flow

Pneumatic Transport, Hydrotransport, or Slurry Flow

CAD CAD: C	AMPP RIVEDAY CO NSULTA
1.1	
1. S. 1.	
ala di si	
imentation	Fluidized Bed

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Stratified / Free-

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Physics Model **ANSYS**[®]

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Multiphase Model

- DPM
- VOF
- Mixture
- Euler- Euler
- Euler-Granular

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- Dense Discrete Phase
- Discrete Element Method
- Cavitation



VOF Model

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VOF+MDM(Moving Deforming Mesh)



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Sand/Particulate Transport

- Sand is often produced in both onshore and offshore production systems,
- Sand production may be continuous, or sudden
- The sediment consists mud, sand and scale picked up during the transport of the oil
- Sand deposition could lead to corrosion of the pipeline
- Problem of sand deposition and reentrainment can be addressed by Particulate modeling in ANSYS CFD.

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Engineering to the solution

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Internal flow of natural gas containing sand particles.

Selected particle trajectories are colored in grey

The erosive wear hotspots on the piping is colored out in red.

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泥沙沖刷-考慮顆粒侵蝕效應





Oil and Gas Transport Client Case: Umbilical, Risers, Flexible Piping

Challenges

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- Very high reliability requirements
- Transmitting signals and transporting flows over much longer distances
- Tubing exposed to harsh conditions
- Develop reliable piping for variety of offshore applications
- Requires structural reliability while handling thermal stresses and fatigue
- Manufacturing of multi-tubes including the steel wrapped around
- Complex multi-layer, varying material manufacturing channels



Equivalent stress response of the umbilical to a 36 degrees bend

Sample Client Case—Used CAE to:

- Build the core tubing and additional helical tube models in an easy to use environment
- Account for different material proprieties
- Evaluate thermal, flow loading and bending stresses. Account for all applied loads including
 - High bending angles
 - Hydrostatic loads
 - End tension
 - Gravity

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Complex multi-layer umbilical

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Oil and Gas Transport Flow Assurance

Challenges

- Deeper water depths leads to complex tubing design and manufacturing concerns including
 - **Depositions**
 - Wax formation
 - **Thermal management**
 - **Erosion inhibitors**
- Active heating, insulation and bundle design in harsh environment and deep waters





Contours of corrosion inhibitor

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- Ability to optimize thermal and structural behavior of tube bundles used for deep and ultra deep waters
- Can develop technology for fouling, wax and hydrate formation by obtaining detailed thermal management information, including insulation in the analysis
- Thermal uniformity for start up and shut downs
- **Thermal stress and fatigue**

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Some images courtesy of Subsea 7

ANSYSFlow Assurance**Example - Slug-Catcher**

- Gas pipeline from off-shore field to land-based Hannibal terminal
- Slug catcher separates residual liquid from gas at end of pipeline
- Plan to increase pipeline capacity to supply new power station
- Question: Does capacity of slug catcher also have to be increased?

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Estimated cost of modifying slug catcher \$25M

Courtesy of Genesis Oil and Gas

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Slug Catcher High Flow Operation

• Can slug catcher cope with increase in capacity of pipeline? – Yes!

•Liquid carry-over limited to a fine aerosol











Flow rates GENESIS Courtesy of Genesis Oil and Gas

Liquid carry-over

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Case Study: Analyzing Cavitation in the Pipe



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Fluidized bed and Mixing reactor

• Fluidized bed

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Rising bubbles of gas are predicted in a fluidized bed. Bubbles pass through bed surface and enter the gas space above 虎門科技版權所有 個印必克

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Mixing reactor

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固體顆粒處於懸浮狀態時所造成的流體化現象, 藉由固體顆粒與流體分子充分接觸碰撞,以促 進熱傳、質傳或化學反應之效率。

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LES turbulence model predicts the occurrence of vortices behind the blade.

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Equipments Design - Cyclones



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- Optimize inlet design to reduce erosion, increase efficiency and find the range of device's usability
- Geometry and design optimization for various particle loading in 2 phase and 3 phase applications

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TIME = 0.000 sec



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Composite CFD results illustrating the vortex core and flow velocity at various axial planes

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Schematic of complex flow motion in

a cyclone separator

1.5 kg solids per kg air 2.5 kg solids per kg air







- •燃燒器的設計-火焰形狀及溫度分佈的控制
- 燃燒後污染物的清理

 -噴淋注流催化/非催化還原-SCR, SNCR, FGD
 -污染物清理效率很大程度取決於流場的均匀性

 ・清理設備的優化-流道設計的優化

 -減小流道內邊界層分離

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Stagnant region

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Shape Flow Optimization

Design requirement:

- How to get uniform flow across 18 outlet nozzles? Or out of a duct?
- Use mesh morphing and optimizer, both integrated into the FLUENT solver





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Fluid Dynamics

Structural Mechanics

Electromagnetics

Systems and Multiphysics

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ANSYS FLUENT Species Reaction Model

Surface reaction mechanism

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- Decomposition reactions of the precursors in the gaseous phase (氣態體分解反應)
- Adsorption reactions of the reactive products by the surface

(表面反應產物的吸附反應)

- Desorption reactions of the adsorbed species (吸附物種的脫附反應)
- Deposition of the required material (沉積所需的材料)

Heat required for the reactions may be supplied either by heating the reaction chamber wall or the substrate itself





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Surface Reactions Models

Resolved surfaces model
 Surface reaction on resolved wall surfaces

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Growth Rate of Gallium Arsenide in a vertical rotating disc reactor

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- Un-resolved surfaces model
- Surface reactions in porous media



Material & Reaction Set Up

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- Gas, site and bulk species to be defined as type fluid
- Switch on wall surface reactions in the species transport panel
- **Include required species** appropriately
- **Define reactions** - Volumetric

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Wall surface

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Surface Reaction Import





GaAs Deposition

Deposition in a horizontal reactor with tilted susceptor and

rotating substrate

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- Boundary Conditions-
- Operating pressure = 70 Torr
- Inlet; V=0.4m/s, T=298K
- Outlet; pressure = 70 Torr
- Substrate rotational speed = 50 RPM
- Susceptor and substrate at T= 913 K
- and surface reactions

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• 11 gas phase + 25 surface reactions

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GaAs growth on substrate and parasitic deposition on reactor walls

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Example: Aixtron 200 Horizontal Reactor





- Growth profile predicted by CFD is in excellent comparison with that of experiment
- Bending of iso-thickness lines is nicely captured

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Example: Carbon Canister Modeling



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- n-butane vapor and air enter at the inlet
- Mass flow rate = 1e-5 kg/s
 - n-butane mass fraction = 0.675
- n-butane is captured at three porous zones using surface reactions
 - Made up reaction rates
- **Outer walls: adiabatic**
- Fluid and solid temperatures in the porous zones are monitored using non equilibrium thermal



Non Equilibrium Thermal Model

Inputs

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- Interfacial area density
 Surface area to volume ratio
 - Heat transfer coefficient
 - *Note*: Set surface area to volume ratio in reaction tab as well

Solver settings

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- Momentum, species and energy second order
- Time step size: 10s
- Total flow time: ~1500s



Solid Temperature



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Solid and fluid temperature fields in a catalytic converter









Deposition species at wall surface : As, Ga

reaction-1 AsH3+Ga(solid) \rightarrow Ga + As(solid) + H2

reaction-2 $Ga(CH3)3 + As(solid) \rightarrow As + Ga(solid) + CH3$

Reaction-1: 1e6*T0.5 Reaction-2: 1e12*T0.5

V:5[m/s] T:300[k] AsH3:0.4 Ga(CH3)3:0.15

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Operating pressure : 10,000[Pa]

Mixture Density: ideal gas law Cp: mixing Las Thermal Conductivity, Viscosity: Ideal gas mixing law Mass diffusivity, Thermal Diffusion : Kinetic theory

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CVD和表面反應 (Siemens 製法)





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定義加熱器溫度爲2200K

Temperature Field and Liquid Fraction

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E CAD CAM PDM EDA CONSULTANT



1.00e+00 9.50e-01 9.00e-01 8.50e-01 8 00e-01 7.50e-01 7.00e-01 6.50e-01 6.00e-01 5.50e-01 5.00e-01 4.50e-01 4.00e-01 3.50e-01 融化分析 3.00e-01 2.50e-01 2.00e-01 1.50e-01 1.00e-01 5.00e-02 0.00e+00 Contours of Liquid Fraction (mixture) (Time=1.5000e+01) Feb 17, 2011 ANSYS FLUENT 13.0 (2d, pbns, vof, ske, transient) 8.50e-01 8.00e-01 6.00e-01 5.50e-01 5.00e-01 4.50e-01 4.00e-01 3.50e-01 3.00e-01 2.50e-01 2.00e-01 1.50e-01 1.00e-01 5.00e-02 0.00e+00

Contours of Liquid Fraction (mixture) (Time=8.1000e+03)

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選擇性催化還原脫氮 (SCR)

- 通過NO與氨(NH3)的還原反應
 4NO + 4NH₃ + O₂ → 6H₂O + 4N₂
- •通常煙氣温度(200~400℃)下還原反應緩慢 -通過催化劑加速反應
- NH3噴淋- 蒸發- 混合- 反應 - 脫氮效率70%~90%

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烟气

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催化反应

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選擇性催化還原脫氮 (SCR)





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Heat Exchanger 熱交換器CFD分析(操作)

Fluid Dynamics

Structural Mechanics

Electromagnetics

Systems and Multiphysics



Improved

李龍育 Dragon CFD技術副理 虎門科技





利用ANSYS Meshing (AM)執 行熱交換器分析模型之網格 建構,設定全域與局部網格 參數控制,即可執行網格產 生程序,總網格數約100 萬,品質亦在標準內

Details of "Mesh"

Defaults		
Physics Preference	CFD	
Solver Preference	Fluent	
Relevance	80	
Sizing CADMEN		
Use Advanced Size Function	On: Curvature En	
Relevance Center	Medium	
Initial Size Seed	Active Assembly	
Smoothing	Medium	
Transition	Slow	
Span Angle Center	Fine	
Curvature Normal Angle	24.0 "	
Min Size	Default (2.0559e-004 m)	
Max Face Size	Default (2.0559e-002 m)	
Max Size	Default (4.1119e-002 m)	
Growth Rate	Default (1.1280)	
Minimum Edge Length	1.e-002 m	



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顯示調整

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奉 平說正(此条例保持預設)	Service EFF.1_he Fluent [3	d, pbns, ske]	個印法克
1.單位改變	File Mesh Define Solve	e Adapt Surface Display Report Parallel View He ② 【S + Q + ノ @ 八 間 - 二 + General	CADMEN ering Total Solution AM-PDIM-EDA/CONSULTANT
2.求解器型式 3.穩態或暫態求解	Mesh Generation Solution Setup General Models Materials Phases	Mesh Scale Check Report Quality Display	
4.重力考量	Cell Zone Conditions Boundary Conditions Mesh Interfaces Dynamic Mesh Reference Values Solution Solution Methods Solution Controls Monitors Solution Initialization Calculation Activities Run Calculation Results Graphics and Animations Plots Reports	Type Velocity Formulation O Pressure-Based O Absolute O Density-Based Relative Time CAOMEN O Steady English Transient CAE Gravity Units	新 枝 底 横 作 有 御 伊 ぷ 文 CADMEN ering Total Solution AM PDM EDA CONSULTANT
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材料設定

將材質水的密度選爲Boussinesq, 並設定參考密度與熱膨脹係數

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Name Engineering T	Material Type	Engineering Total So
water-liquid CAE, CAB, CAM, PDI/	Fluid	CAE/CAD/CAM/PDIV/EBA/CC
Chemical Formula	Eluent Eluid Ma	terials
h2o <l></l>	water-liquid (h	20<1>)
e	Mixture	
	none	
Properties		
Density (kg/m3)	bouccipeca	Edit
R PROCE	looo	
that Prove	998	AND COMPACT OF AND
Cp (Specific Heat) (j/kg-k)	constant	Edit
CAUI Engineering T	4192	Engineering Total So
TANT CAE CAD CAM PDIV		CAE-CAD-CAM-PDI/-EDA-CC
Thermal Conductivity (w/m-k)	constant	Edit
	0.6	
Thermal Expansion Coefficient (1/k)	constant	Edit
	0.00025	
Chan	ge/Create Delete	Close

材料設定

將材質空氣的密度選為 Boussinesq,並設定參考 密度與熱膨脹係數



💶 Create/Edit Materials





FLUENT 設定 **ANSYS**[®] 邊界設定 💶 Velocity Inlet 設定熱空氣入口條件 Zone Name coldin 1: Mesh **Boundary Conditions** Meshing Momentum Thermal Radiation Species DPM Multiphase UDS Mesh Generation Zone coldin Solution Setup Temperature (k) 293 constant v General conv_wall Models hotin Materials hotout interior-air_zone interior-solid baffle1 💶 Velocity Inlet interior-solid baffle1-solid case oundary Condition interior-solid baffle1-solid pipe interior-solid baffle2 Zone Name Dynamic Mesh interior-solid baffle2-solid case coldin **Reference Values** interior-solid baffle2-solid pipe interior-solid baffle3 Solution interior-solid_baffle3-solid_case Thermal Radiation Species DPM Multiphase UDS Momentum Solution Methods interior-solid_baffle3-solid_pipe Solution Controls interior-solid baffle4 Velocity Specification Method Magnitude, Normal to Boundary Monitors Y interior-solid baffle4-solid case Solution Initialization interior-solid baffle4-solid nine Reference Frame Absolute Y Calculation Activities < Run Calculation Velocity Magnitude (m/s) 0.05 constant v Туре Results Supersonic/Initial Gauge Pressure (pascal) velocity-inlet v Graphics and Animations constant

Turbulence

Specification Method	Intensity and Hydraulic Diameter
虎門科	Turbulent Intensity (%)
	Hydraulic Diameter (m) 0.07

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Edit...

Parameters...

Display Mesh...

Highlight Zone

Copy...

Operating Conditions...

Plots

Reports

July 11, 2013

Profiles...

Engineering Total Solution

Engineering Total Solution CAE: CAD/ CAM/ PDM/ EDA/ CONSULTAIL

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邊界設定

設定熱空氣出口條件

ABIVIEN	CALIMEN	CADIVIEN CADIVIE	
Meshing Solution	Boundary Conditions al Solution	1: Mesh	
Mesh Generation	Zone CAE/CAD/CAM/PDIM/EDA/CONSULTANT	CAE/CAD/CAM/PDIV/EDA/CONSULTANT CAE/CAD/CAM/PDIV/ED	
Solution Setup			
General	coldout		
Models	conv_wair		
Materials	hotout	Pressure Outlet	
Phases Cell Zone Conditions	interior-air_zone		
Boundary Conditions	interior-solid_baffle1-solid_case	Zone Name	
Mesh Interfaces	interior-solid_baffle1-solid_pipe	coldout	
Dynamic Mesh	interior-solid_battle2 interior-solid_baffle2-solid_case		
Reference Values	interior-solid_baffle2-solid_pipe	Momentum Thermal Radiation Species DPM Multiphase UDS	
Solution	interior-solid_baffle3	Gauge Pressure (pascal)	
Solution Methods	interior-solid_baffle3-solid_case	CADMEN	
Solution Controls	interior-solid_baffle4	Backflow Direction Specification Method Normal to Boundary Engineering Tot	
Solution Initialization	interior-solid_baffle4-solid_case	Deuts (els stat) : alcobal data al sultant CAE CAD CAM PDM EL	
Calculation Activities	<	Augusta Discribución	
Run Calculation		Taxaat Mass Flow Date	
Results	Phase Type	L Target Mass Flow Rate	
Graphics and Animations	mixture 🔽 pressure-outlet 🗙		
Plots		Specification Method Intensity and Hydraulic Diameter	
Reports	Edit Copy Profiles	Backflow Turbulent Intensity (%) 5	
	Parameters Operating Conditions		
	Display Mesh Periodic Conditions	Backflow Hydraulic Diameter (m) 0.07	
手技版推所有	Highlight Zone	K. M. M. M. K. K. M. Marker Control of the Part of the	
国印及克	加印动克	Ant EP 36 32	
		OK Cancel Help	



邊界設定

設定冷水出口條件

1: Mesh ¥ **Boundary Conditions** Meshing Mesh Generation Zone Solution Setup coldin А coldout General conv wall Models hotin Materials. hotout Interior-air zone Cell Zone Conditions interior-solid baffle1 Boundary Conditions interior-solid baffle1-solid case 💶 Pressure Outlet interior-solid baffle1-solid pipe Mesh Interfaces interior-solid baffle2 Dynamic Mesh interior-solid_baffle2-solid_case Zone Name Reference Values interior-solid_baffle2-solid_pipe hotout interior-solid baffle3 Solution interior-solid_baffle3-solid_case Solution Methods interior-solid_baffle3-solid_pipe Momentum Thermal Radiation Species DPM Multiphase UDS Solution Controls interior-solid_baffle4 Monitors interior-solid_baffle4-solid_case Gauge Pressure (pascal) constant Solution Initialization interior-solid haffle4-solid pipe < Calculation Activities Backflow Direction Specification Method Normal to Boundary Run Calculation Results Туре Radial Equilibrium Pressure Distribution pressure-outlet 43 Graphics and Animations Average Pressure Specification Plots. Target Mass Flow Rate Profiles... Reports Edit... Copy... Turbulence Parameters... Operating Conditions... Specification Method Intensity and Hydraulic Diameter Display Mesh... Backflow Turbulent Intensity (%) 🕞 Highlight Zone Backflow Hydraulic Diameter (m) 0.06 Help OK. Cancel Help © 2011 ANSYS, Inc. 68 July 11, 2013

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AE/CAD/CAM/PDI//EDA/CONSULTAT

邊界設定

設定外殼壁面對外熱傳特性



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	Solution Methods
	Pressure-Velocity Coupling
	Scheme
	SIMPLE
	Spatial Discretization
	Gradient
	Green-Gauss Cell Based
IM	Pressure
Tot	Standard Engine
INVER	Momentum CAE?CAD?

First Order Upwind

First Order Upwind

Turbulent Kinetic Energy

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Meshing

Mesh Generation

Solution Setup General

> Models Materials Phases.



Reference Values

Solution Controls Monitors

Cell Zone Conditions

Boundary Conditions Mesh Interfaces Dynamic Mesh

Solution Initialization Calculation Activities Run Calculation

Turbulent Dissipation Rate First Order Upwind

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FLUENT 設定 **ANSYS**[®]

設定熱空氣出口平均溫度監控



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案例-管殼式熱交換器 CFD與結構耦合分析





管束、壳体与管板的应力分布





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ANSYS FLUENT 功能延伸討論與應用範圍

Fluid Dynamics

Structural Mechanics

Electromagnetics

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李龍育 Dragon CFD技術副理 虎門科技

攪拌器應用介紹











虎門科技/李龍育 CFD技術副理





攪拌設備歷史悠久,應用範圍廣泛。但是針對攪拌操作的研究卻遠遠不夠。攪拌 操作所涉及的因素極為複雜:攪拌的物料的物性千差萬別,攪拌的目的也不盡相同, 攪拌設備形式多種多樣,再加上物料在攪拌設備內部流動極其複雜,如何合理正確的 設計以及選擇攪拌器都沒有一個嚴密的理論指導,仍存在很大程度上依賴於經驗設計。

攪拌槽內的流動是三維和高度不穩定的湍流,脈動和隨機紊流給流速測定帶來了 很大的困難。

實驗法:

激光多普勒測速儀(Laser Doppler Velocimetry, LDV) 粒子成像測速儀(Particle Image Velocimetry, PIV) 無論是LDV還是PIV技術,都需要花費大量的時間來進行測量。

- •實機實驗資訊取得不易
- •實驗所能獲取的資訊有限
- •實驗與研發成本高昂
- •製程參數改變,優化時程緩慢

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- •製程參數變更
- •幾何設計變更
- •材料改變
- 複雜流場現象掌握





攪拌設備歷史悠久,應用範圍廣泛。但是針對攪拌操作的研究卻遠遠不夠。攪拌 操作所涉及的因素極為複雜:攪拌的物料的物性千差萬別,攪拌的目的也不盡相同, 攪拌設備形式多種多樣,再加上物料在攪拌設備內部流動極其複雜,如何合理正確的 設計以及選擇攪拌器都沒有一個嚴密的理論指導,仍存在很大程度上依賴於經驗設計。

攪拌槽內的流動是三維和高度不穩定的湍流,脈動和隨機紊流給流速測定帶來了 很大的困難。



Mixing And Agitated Vessels

Single phase

ANSYS[®]

- Velocity field prediction
- Turbulence prediction
- Turbulence

Gas liquid flows

- Bubble size distribution
- Mass transfer

Liquid solid flows

Solid suspension

Reacting flows

- Product selectivity
- Heat transfer
- Mass transfer
- Crystallization

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ANSYS tools can model all above processes individually or in combination

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分析需求模組

- Multiphase : VOF , Mixture , Eulerian
- DPM
- Newtonian or Non-Newtonian
- Moving Substrate
- Unsteady State
- Dynamic Mesh
- Reaction

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Agitation Analysis

Particle Traces Analysis



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Agitation Analysis Optimization of Impeller Position





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Agitation Analysis

High viscosity mixing



Agitation Analysis

Particle Size distribution

- Detailed information about the PSD at different operating conditions is crucial for design and scale up
 - -Product quality

Downstream processing

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 Chemical reactions and mass/heat transfer depend on the local particle size distribution (PSD)

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Agitation Analysis Scale-Up Example Result Velocity Magnitude

Agitation power per unit volume

Pv=Nd^{2/3} =const.



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Agitation Analysis Scale-Up Example

Result : Microscale Mixing Time

Almost same resut : Same reaction time



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 $\tau_{g} = \tau_{E} | 0.0303 +$



Circulating Fluidized Bed

- Circulating fluidized beds (CFBs) consist of a cyclone, downcomer, riser, numerous inlets, and a single outlet (red)
- They contain a circulating mixture of gas and solids
 - Different processes clean or burn the solids
- The Eulerian granular multiphase model in FLUENT is used to simulate the multiphase flow in a typical unit



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Circulating Fluidized Bed

Outlet

Cyclone

Downcomer

Separator

- A fully 3D circulating fluidized bed is modeled.
- 74,000 cell hybrid mesh
- Gas/Solids dilute flow (average solids volume fraction around 7%)
- Have a diameter of 85 μ , and density of 2200 kg/m³



ANSYS Circulating Fluidized Bed

0.002 se

- Path lines (colored by air velocity magnitude) show the motion of air.
- Up the riser

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- Through the connecting channel
- Spinning in the cyclone
- Exiting through the outlet

Some air falls through the downcomer and is recirculated with the solids

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ANSYS Circulating Fluidized Bed

Solids volume fraction on the walls of the unit show

- Maximum concentration at the base of the cyclone, after separation
- High concentration throughout the downcomer
- Weak but uniform concentration in the riser due to upward-angled inlets positioned along the riser walls

Flow field is consistent with expect- ations and reports in the literature

Contours of Solid volume fraction

Courtesy of RWE Energie AG, Niederauben, Germany

Results suggest the FLUENT Eulerian multiphase model is well suited for this application

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Realize Your Product Promise™

Mixing Tank 攪拌槽CFD分析(操作)

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CAE/CAD/CAM/PDM/EDA CONSU

Fluid Dynamics Struct

Structural Mechanics

Electromagnetics

Systems and Multiphysics

雙段攪拌翼&通氣環分析設定

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範例簡介 **ANSYS**[®]

本範例是使用HE-3/CD-6兩種攪拌翼,為常見的雙段型攪拌槽,經由下方通氣環來注入氣體(Bakker A, Smith J.M. and Myers K.J, 1994)。

此雙段型通氣攪拌槽為一般常用於工業界的反應槽,包含生化反應、發酵現象及需要氣體參與反應的情況。

本ANSYS FLUENT教程中有: 尤拉的兩相設定。 multiple reference frame (MRF)&通氣環系統的設定教學。 如何設定和求解。 輸出計算數值及後處理。

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教程簡介 **NNSYS**[®]

本攪拌槽設計為增加氣體與液體接觸情況。 攪拌槽中HE-3及CD-6分別為軸向型及徑向型攪拌翼與擋板及攪拌槽 形成一個複雜的流場,使流場主要在攪拌翼及擋板之間流動。

當氣體經由通氣環注入時,氣泡會被液體包覆並隨著流場流動,但 由於浮力的關係,氣泡會由上方逸散,因此整個攪拌槽在穩態下的 氣含率(gas holdup),就是我們這次所要觀察的重點。

本次模擬教學主要爲設定一個CFD的氣液兩相流模式,以及觀察它的混合效益及氣含率,和攪拌翼在旋轉流體部份的MRF的設定。

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Step.1:讀取檔案 讀取(sparger.msh.gz)的網格檔 File→Import→Mesh



Mesh→Check

2. 檢查網格

Step.2:一般設定

1.保留系統設定

ANSYS FLUENT將在網格上自動進行各種檢查,以及不連續的體積

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接著選擇int-he-3-inner及int-he-3-outer,在Mesh Interface中

點選Create完成。 102 © 2011 ANSYS, Inc. July 11, 2013

設定b。

Create/Edit Mesh Interfaces				
Mesh Interface	Interface Zone 1	Engin	Interface Zone 2	
^a CAD, CAM, PDM, EDA, CO	int-cd-6-inner	CAE/CAD	int-cd-6-outer	
(
	int-cd-6-inner		int-cd-6-inner	
	int-cd-6-outer		int-cd-6-outer	
	int-he-3-outer		int-he-3-inner int-he-3-outer	
Interface Options	Boundary Zone 1	I	Interface Wall Zone 1	
Periodic Boundary Condition Periodic Repeats Coupled Wall	Boundary Zone 2	I	Interface Wall Zone 2	
		I	Interface Interior Zone	
Periodic Boundary Condition	有	J.	門斜枝压横所有	
Type Offset			AND EP 30 ST	
Translational X (m) Rotational	Y (m) 0	Z (m) 0	C C C C C C C C C C C C C C C C C C C	
Auto Compute Offset				
Create	Delete Draw	List Close		



5.設定重力向 Define→Operating Conditions 點選Gravity→在X向中設定-9.81為其重力向

A:FLUENT FLU	ENT [3d, pbi	ns, lam] [ANSYS Ac	ademic
File Mesh Def	ine Solve	Adapt	Surface	Displa
i 💕 🖛 🛃 ·	General			
	Models			
Problem Setup	Materials			
General Models	Phases			
Materials	Cell Zone Conditions			
Phases Cell Zone C	Boundary (Condition	ns	
Boundary C:	Operating	Conditio	ns	

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Step.3: 1.設定Eulerian 2相模組

Define→Models→Multiphase→Eulerian

2.黏度模型選擇『k-ε』

Define \rightarrow Models \rightarrow Viscous \rightarrow k- ε

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MNSYS 選擇流體兩相

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Step 4:流體設定 Define→Materials→Fluid→ Fluid Datebase→Water

本模擬為兩相模擬,包含氣體 液體雙相,Fluent內含空氣, 請將選單下拉,倒數第三項為 Water-liquid

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A:FLUENT FLUENT [3d, pbns, eulerian, ske] [ANSYS A File Mesh Define Solve Adapt Surface Displa General... Problem Setup Materials...



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Name water-liquid		Material Type	Order Materials by
Chemical Formula		ELLIENT Eluid Materials	Chemical Formula
h2o <l></l>		water-liquid (h2o <l>)</l>	FLUENT Database
		Mixture	User-Defined Database
		C none IEIN	ADMEN
Properties	Engine	ering Total Solution	
Density (kg/m3)	constant		
	998.2		
Viscosity (kg/m-s)	constant	Edit	
	0.001003		
能所有 花		"针技版推所有 如印必克	
	Change/Crea	te Delete Close	Help CADMEN





邊界條件設定 **NNSYS**[®]

Step 7:邊界條件設定 Define→Boundary Conditions

通氣環設定: Sparger-inlet在下拉選單中選擇air 流速輸入0.1 Multiphase中輸入1

> CADMEN Engineering Total Solution (AE/CAD: CAM: PDM: EDA: CONSULTAL

流速為空氣流速, Multiphase的設定是 表示從此孔進入的皆為空氣。

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邊界條件設定 **ANSYS**[®]

Step 7:邊界條件設定 Define→Boundary Conditions

壓力出口設定: Tank.top在下拉選單中選擇mixture 設定亂流強度及水力半徑 亂流強度:5% 水力半徑:2m 接著在下拉選單中選擇air,Multiphase 一樣設定成1,使回流的液體為空氣。

💶 Pressure	Outlet	×			
Zone Name	CADMEN	Phase			
tank.top		mixture Total Solution			
Momentum	Thermal Radiation Species DPM Multiphase	AD FCAMPDIMEDAL CONSULTANT			
	Gauge Pressure (pascal)	constant 👻			
Backflow Dire	Backflow Direction Specification Method Normal to Boundary				
Radial Equilibrium Pressure Distribution					
Turbulence					
Specification Method Intensity and Hydraulic Diameter					
Ba K and Epsilon Intensity and Length Scale Intensity and Viscosity Ratio B Intensity and Hydraulic Diameter					
	CADMEN	CADMEN			
Engin CAE/CAD	e ering Total Solution Cancel Help	gineering Total Solution AD: CAM: PDM: EDA: CONSULTANT			



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邊界條件設定 **ANSYS**[®]

Step.7:邊界條件設定 Define→Boundary Conditions

轉軸設定: shaft在下拉選單中選擇mixtur 點選Moving Wall 轉速設定84rpm

shaft.absolute shaft.cd-6 shaft.he-3

皆套用以上設定

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🔽 Wall

South		Engineering	1013 50				
Zone	Name			Phase			
sha	ft.absolute			mixture			
Adja	cent Cell Zone						
fluid	d.tank						
Mo		adiation Constant of					
	inernar mermar P		PM Mulupha				
Wa	all Motion N	lotion				/ /	
	Moving Wall	Relative to Adjace	Adjacent Cell Zone	Speed (rpm)	- 0		
		Absolute		-84	P		
所有		Translational		Rotation-Axis Origin	1.7	Rotation-Axis Direction	1
		 Rotational 		X (m) 0		X 1	
		Components		V (m)		V	
Caluttan				r (m) 0	P		P
COLUMNAL				Z (m) 0		Z O	
a chine a bh				desort From	e		e
Wa	all Roughness						
R	oughness Height (m)	0	constant	•			
		Ŭ					
	Roughness Constant	0.5	constant	•			
						1	
			UK	Cancel Help			
Bieste		15 19 20-1	to the set of	The V	1	· 四朝 北方城	ar to



Step.8:求解器設定 Solve→methods

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將梯度設定Green-Gauss Node Based Momentum

- Volume Fraction
- Turbulent Kinetic Energy

Turbulent Dissipation Rate 皆設定成一階



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Solution Methods	虎門科技版技所有
Pressure-Velocity Coupling	
Scheme	CADMEN
Phase Coupled SIMPLE	CAE CADIC T
Spatial Discretization	
Gradient	^
Green-Gauss Node Based	-
Momentum	
First Order Upwind	•
Volume Fraction	
First Order Upwind	▼
Turbulent Kinetic Energy	(BH 14 32 1
First Order Upwind	€ADMEN
Turbulent Dissipation Rate	Engineering Total Solution
First Order Upwind	TOTE CALL AND CALL AN
Transient Formulation	
	-
Non-Iterative Time Advancement Frozen Flux Formulation Pseudo Transient	
High Order Term Relaxation Opti	ons
Default	龙門斜拉版指所有 加印必克
CADMEN	CADMEN

Trep

Engineering Total Solution



Solution 1: 設定流體區域

Adapt→Region

 $X: 2.4 \sim 2.823382$

 $Y: -10 \sim 10$

Z:-10~10 點選Mark



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CADMEN Engineering Total Solution CAE/CAD, CAM, PDM, EDA, CONSULTANT

虎門斜枝压模所东 翻印马克

CADMEN July 11, 2013



CAE/ CAD/ CAM/ PDIM/ ED A/ CONSULTAN



Solution 1:

環境初始化 Adapt→Region 1門耕技版植所有 個印马克

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將air volume Fraction設定為0

接著選擇Patch

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July 11, 2013

	Methods
	Controls
	Monitors
	Initialization Engineering Total Solut
	Calculation Activities
	Run Calculation
	•
R	eference Frame
	 Relative to Cell Zone Absolute
I	nitial Values
	water Y Velocity (m/s)
ł	0
	water Z Velocity (m/s)
	• Orotal Solution Engineering Total Solut
1	air X Velocity (m/s)
Į,	0
1	air Y Velocity (m/s)
	0
	air Z Velocity (m/s)
	0
ł	air Volume Fraction
	0

設定流體區域 **ANSYS**[®]



ANSYS 設定觀察切面&旋轉切面

先設定切面,但 是因爲切面會在 擋板上,所以將 切面以Z軸旋轉 45°





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ANSYS 流場等位面圖&流場向量圖



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