



## DEVELOPMENT PLANS

### **Looking Toward the Future: Introducing FLOW-3D Version 10.0**

未來展望：**FLOW-3D 10.0** 版簡介

John Ditter - FLOW SCIENCE

Version 10.0 of **FLOW-3D**, scheduled for release early in 2011, will have a range of significant improvements and additions, from a largely rewritten GUI to the addition of fluid-structure interaction model based on a finite-element approach. The ongoing SMP parallelization will extend to most physical and numerical models, providing good scaling up to eight cores. The shallow water model will include turbulent and wind effects, making it more suitable for large scale flows. A flow tracer can be used to highlight fluid coming from different directions to enhance flow visualization. Several additions target casting applications, from a beefed-up solidification shrinkage model to sand core blowing and drying.

The release of **FLOW-3D/MP** version 4.1 includes all the capabilities of the SMP version 9.4. Users can now customize the MPI parallel code. A hybrid, OpenMP/MPI approach has been tested and shows some performance advantages over the individual paradigm.

**FLOW-3D 10.0** 版預計在 2011 年年初發表，這個版本從使用者的操作介面到新增的流固耦合的有限元素分析，將出現令人耳目一新的改善與進展。現行的 SMP 平行運算將延伸到大部分的物理與數值模型，能提供多達八個核心工作站優異的平行效能。淺水波模型將可以納入紊流與風力的影響，以更符合大尺度的流場計算。後處理的流體追蹤可以標明來自不同方向的流體，藉此軟體的可視覺化功能將更加完整。此外在鑄造模擬應用領域，研發人員也針對收縮、吹砂與烘乾等功能進行強化。

即將發表的 **FLOW-3D/MP 4.1** 版本將包括 SMP 9.4 版中的所有功能，使用者也可以針對 MPI 平行程式進行客製化功能編輯。此外，新增的混合 OpenMP/MPI 平行計算方法已經在許多不同的案例測試過，結果顯示此法的確能夠有效提升計算效能。

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## USER PRESENTATIONS

### **Simulation of Fluid Flow in Magnesium Injection of Hot Metal Desulfurization**

鐵水噴鎂脫硫製程的流場模擬

Prof. Huey Jiuan Lin - National United University (林惠娟 研發長 - 聯合大學)

Sulphur is a problematic impurity in the steelmaking industry that contributes to embrittlement of the steel, owing to the formation of continuous intergranular liquid film in the solidified steel. In this study, the injection of gas-magnesium solid mixtures as a means of desulphurising the iron is studied. A mathematical model for the description of the gas-liquid flow behavior in the gas injection process is derived. Effects of various operating parameters on desulfurization are discussed. The active/inactive, dead zones and injection length in the hot iron during injection are assessed by the postprocessor.

鋼鐵內所含的硫為雜質，會在晶界偏析形成的低熔點化合物，因而影響到鋼的機械強度及物性。為了改善此結果，目前已發展出多種脫硫製程，而噴吹法為目前廣泛使用的方法之一。本研究將針對噴鎂脫硫製程，以數值模擬的方式分析噴吹製程參數對熱鐵水之流場之影響，並以後處理方式評估各項脫硫效率指標，包括反應區與非反應區及死區的比率，氣體的噴吹長度等。



## **Application of FLOW-3D in Hydraulic Engineering**

### **FLOW-3D 在水利工程之應用分享**

Dr. Chi-Ming Chen - Sinotech Engineering Services, Ltd. (陳啟明 經理 - 環興科技)

In this presentation, the applications of **FLOW-3D**, by Sinotech Engineering Services Ltd., are shown. The applied cases are introduced to assist examination of the possible weakness in designs.

The 1-D calculation could carry out the acceptable results under simple flow conditions. The regulations or handbooks of hydraulic are mentioned as well. Furthermore, the 2-D flow simulation models are well developed through recent progresses of numerical analysis technologies. The results of 2-D flow simulations under most flow conditions are accepted in design applications. However, the uses of the vertical 2-D flow simulations are limited under certain conditions, such as transiting flow, steep complex geometries. The 3-D flow models are capable to such cases. The results could be used to design. In addition, the **FLOW-3D** could save time and cost on the modification of model experiences.

此次介紹 **FLOW-3D** 於水利工程上之應用，輔助過去因水理狀況複雜而造成分析不易，或用於檢核水工結構設計功能等目的，進而介紹目前已應用於水理分析案例。

早期水理分析皆仰賴一維計算分析，而一般水工結構物設計或相關設計手冊亦大多以此方式進行計算，對於簡單流況下皆可得到滿意之結果。近年由於數值分析技術成熟，二維水理模式已廣泛應用於各領域，對於大多數之水理狀況皆可充分掌握。然而垂直二維水理數值模式在使用上亦有理論上之限制。例如無法模擬壓力流與明渠流相互過渡時之流況，或對於模擬排洪隧道時受限於幾何形狀之限制等。而三維水理計算模式可用於此類複雜水理狀況之流場計算，得出合理之結果，提供設計使用。

此外，藉由水工試驗前或進行中配合三維水理分析修正水工結構物，可有效縮短模型試驗修正之時間及節省試驗成本。

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## **Simulating the turbidity current in a reservoir during typhoon event**

### **颱風期間水庫濁水運移模擬**

Dr. Y. C. Lin - Sinotech Engineering Consultants, Inc. (林英傑 博士 - 中興工程)

The deposition behavior of fine sediment is very important phenomenon, and it is a serious problem of the reservoir sedimentation in Taiwan, especially after a strong typhoon. For example, in 2004, typhoon Aere caused catastrophic rainfall in the Shihmen reservoir watershed and large scale sediment disaster resulted in 27.88 million cubic meter sediment deposit in the Shihmen reservoir. The effective water storage capacity decreases in 11%. To elucidate this phenomenon, field observations and measurements or small-scale laboratory experiments had been implemented to study the transport of suspended sediment. Nevertheless, the field researches are dangerous during the typhoon event, and the small scale experiments are expensive and time consuming. Due to the budget and time constraint, the numerical model has been considered to predict the turbid flow moving in the reservoir. **FLOW-3D®** performs the capacity with three-dimensional flow simulation including non-linear drifting of the suspended phase and bed-load transport model.



This presentation will outline some characteristics of the turbidity current in reservoirs and point out the challenges during the design of this simulation. According to our predictions, **FLOW-3D®** shows good agreement with the field observation and experimental results.

細顆粒沉積物沉降行為在台灣水庫是非常嚴重的問題，特別是在強烈颱風過後，例如民國 93 年艾莉颱風侵襲台灣，在石門水庫集水區造成嚴重土石大量崩坍，石門水庫淤積量增加 2,788 萬立方公尺，使水庫減少約 11% 的有效蓄水容量。為了瞭解沉積物運移的現象，過去有許多研究藉由現地觀察量測以及水工模型試驗去觀察懸浮泥沙運移。在颱風時期現地的研究往往是非常危險，而水工模型試驗則是需要花費大量金錢以及時間，因此受到預算以及時間上的考量，研究員開始考慮使用數值模式去模擬渾水在水庫中移動情形，針對這類型問題 **FLOW-3D®** 軟體表現出在處理三維複雜流場包含非線性懸浮載以及底床載運移問題的能力。

在這次的報告中，將針對渾水在水庫運移的特性作簡介以及討論，針對我們所得到的結果，對於現地觀察以及實驗量測資料 **FLOW-3D®** 表現出非常優異的成果。

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## **Research of Local Bridge Scour in Alluvial River**

橋梁局部冲刷在冲積河川之研究

Prof. Der-Liang Young Mr. Feng-Kun Chen - National Taiwan University

(楊德良 教授、陳峰琨 - 台灣大學)

The recent typhoons Sinlaku (September 2008) and Morakot (August 2009) in Taiwan have exposed significant vulnerabilities of the many bridges crossing Taiwan rivers. Observations of bridge scour failures at various sites indicate a number of specific features that are special to Taiwanese conditions, and outside the range of typical conditions that have been examined in worldwide bridge scour research. Conditions specific to Taiwan include the pulsed nature of rainfall and discharge, rapid rates of erosion, joint bedrock and alluvial controls, and interference between different types of structures built along streams, such as weirs and bridges. The example of Hou-Feng Bridge failure in September 2008 can be used to illustrate some specific issues of concern in Taiwan. Due to the tremendous change of the river sediment, the water surface approaches water supply pipeline. For protecting the pipeline, Taiwan Water Corporation built a concrete structure to cover the pipeline, which causes a sudden drop in water surface. To understand the detailed process, the present work seeks to results by combining 3D numerical simulation and laboratory data. For the local scour problem, 3D modeling of local flow patterns is sought by using the **FLOW-3D** software. To define realistic scenarios and check modeling outcomes, the data from numerical modeling are compared with these from small-scale laboratory experiments (scale factor 1:200).

近幾年的兩個強大颱風，辛樂克和莫拉克顯示了台灣許多跨河川橋梁所存在的一些重大隱憂。藉由觀察這些不同地區所損壞的橋梁的過程中進而察覺到在這些工程被破壞的背後伴隨著台灣特有的地理環境因素，包含自然界的降雨和逕流，高速率的侵蝕以及基岩和沖積河川跟橋梁間所產生的交互作用。在台灣剛好可以用后豐大橋在 2009 年坍塌的慘痛經驗來闡述我們想要關切的主題。存在於大甲溪河床上的自然水管線因為大甲溪底泥沙的變化可能會對其有破壞行為，台灣自來水公司為了保護這些管線使其免於破壞，便在管線周圍建造了混擬土的結構物包護了整條管線，也因此動作，意外造成了大甲溪在后豐大橋前有一個水位落差。為了瞭解這水位的落差是否對后豐大橋產生冲刷的影響，我們的做法就是尋求三維的數值模擬配合實驗室的研究數據。在局部冲刷的過程，三維數值方面我們是採用 **FLOW-3D** 去模擬。之後我們從數值模擬配合小尺度的實驗室實驗去做比較(比例大小 1:200)



### **Development of A Recoil Force Simulator**

#### **後座力產生裝置設計與分析**

Prof. Wei-Long Chen - Chaoyang University of Technology (陳維隆 教授 - 朝陽科技大學)

Fidelity level evaluation of recoil forces for rifle used in game or training simulator still relies on subjective judgments. This study aims to develop a scientific process in quantitatively assessing subjective feeling of personnel to rifle recoil. Quantitative assessment is to serve as a tool for evaluating and improving verisimilitude of the simulator in the future. This study conducted an emulating shock test in which impulsive acceleration and subjective feeling of subjects were recorded. Together with the measurement result of real rifle shooting, this study establishes the physical-psychological relation between rifle recoil and personnel feeling about intensity of shock. Analytical results of emulating shock test show, within 1-50 Hz Butterworth band-pass-filtering, the integration value of compressive acceleration over 25 ms interval provide best agreement with subjective feeling at real rifle shooting. According to the study, a systematic design methodology for recoil generation pneumatic device is proposed for further application.

應用於遊戲及訓練模擬器中射擊後座力的擬真度評估目前仍依靠使用者主觀的判斷。本研究旨在發展科學化的方法，評估人員對步槍射擊後座之主觀感受，提供作為評估模擬器後座力擬真程度的依據，以利後續發展設計一套具備高擬真程度的射擊訓練模擬系統。本研究透過模擬之衝擊實驗，同時量測衝擊加速度與受測人員對衝擊力之主觀判定，配合實彈射擊之測量結果，建立人員對射擊後座衝擊感受之心理-物理量關係。模擬衝擊實驗結果顯示所得壓力方向加速度與時間之積分值，在採用 1~50Hz 頻率加權範圍與 25ms 之積分時間時，與實彈射擊人員所獲得之衝擊感覺最吻合。依據此結果本研究提出後座力產生裝置設計依據作為後續發展。

### **Computational Modeling of Ceramic Foam Filter used in Aluminum Gravity Casting**

#### **電腦模擬鋁合金重力鑄造所使用的陶瓷泡沫濾網**

Prof. Fu-Yuan Hsu - National United University (許富淵 教授 - 聯合大學)

Foam filters are normally used for reducing the velocity of liquid metal in the design of runner system. In this study, various designs of runner systems containing foam filters were explored and their apparent velocities were estimated by both casting experiment and computational modeling. In casting experiment, trajectory method and metal weighing scheme, during the time of pouring, are utilized for measuring apparent velocity and flow rate respectively. In numerical model, porous material such as the foam filter was constructed by the use of Forchheimer's equation. The result of modeling was validated by the same design of casting experiment. Regarding to a high efficiency of a filter design, through which liquid metal flow with a high flow rate and a low velocity produced, an optimized design is recommended.

在流道方案設計中，陶瓷泡沫濾網往往被應用在減低金屬流體速度的零件。在本研究中，多種的流道方案設計裏，搭配不同方向的陶瓷泡沫濾網的擺放，並且使用了實際鑄造和電腦模擬兩種方法去實驗，目的要了解這些設計對於金屬液體的外觀速度的變化。在鑄造實驗中，外觀速度及流體由各流道系統之體積流量，可以分別由拋物線法和金屬流出稱重法量測之。在電腦模擬中，多孔性材質如陶瓷泡沫濾網的模擬，是將 Forchheimer 方程式，建置在數值模組中。電腦模擬的結果，則由相同的流道方案設計之鑄造實驗所驗證其準確性。對於最佳效率的泡沫濾網的使用於流道設計，是使金屬流體經由此濾網，能得到最大的體積流量，以及最小的外觀速度，於本研究中將提出建議。