

行政院原子能委員會
委託研究計畫研究報告

人因系統界面運轉維修負荷評估研究

**Efficiency evaluation of maintenance mental workload on digital
system in nuclear power plant**

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摘 要

工作負荷對於核電廠維修保養人員而言是一項重要的指標，工作負荷維持得當能使核電廠的人為疏失減少並增進系統的安全進而提升人員滿意度。而過去在研究維修保養人員的工作負荷大都著眼於線外分析工作，也就是機器必須處於停機狀態，但是核電廠除非是大修需進行停機處理外，其餘都是處於運轉中狀態，也因此對核電廠進行線上維修保養的工作相形之下更顯得相當重要。

由於核二廠的飼水系統目前處於類比及數位兩種機組在運行，因此本研究藉由核二廠的類比及數位系統進行研究，比較維修保養人員在進行類比及數位系統的線上維修時差異，並發展一心智負荷預測模式。首先，透過核能二廠飼水系統類比及數位化之機組程序書進行流程分析，評估兩系統流程差異性；接著，利用問卷設計找出影響核能電廠機器運轉中維修的心智負荷重要因子，再針對問卷中之項目進行量化評估；最後，以倒傳遞類神經法提出數位化系統的心智負荷預測模型。研究結果顯示，數位系統在程序上雖然操作步驟較類比系統為多，但在操作時間上反而較類比系統為少，其原因在於數位系統雖然步驟較多，但大多屬於確認的動作，時間非常的短暫；另外，在問卷評估結果發現類比的負荷度高於數位的負荷度 24% 的百分比值，顯然數位化系統的使用可以降低人員工作負

荷；而應用 GMDH 演算法的計算結果得到操作時間、錯誤率、操作複雜度三個因子對心智負荷的預測具有顯著影響。未來，核四廠的興建除全面採用數位化系統以減少人員負荷外，更可以應用本研究所得到的結果量測維修保養人員的操作時間、錯誤率及操作複雜度以評估目前人員的負荷程度，以做為排定執班人員及人力調度之參考。

關鍵字：心智負荷、線上維修、核能發電廠、自組性演算法

英文摘要

Maintenance engineers' mental workload plays an important role in Nuclear Power Plants (NPPs) which could reduce human errors, improve system safety, increase productivity, and increase engineers job satisfaction. Researchers often focused on evaluating off-line maintenance engineers' mental workload. However, to evaluate on-line maintenance engineers' mental workload is important especially in digital systems. In order to avoid mental overload or under load of engineers' in digital systems, this project compared analog systems with digital systems of Feed Water Control System (FWCS) at the Second NPP in Taiwan. This study measured mental workload and developed a prediction model. Firstly, the procedure of analog and digital systems was examined. Secondly, a questionnaire for assessing mental workload was developed. A six-point scale was constructed and the five parts (e.g., human, machine, material, method, and environment factors) were selected as mental workload factors in the questionnaire. In addition, GMDH algorithm was conducted to predict mental workload in maintaining digital systems. The results revealed that the maintenance engineers' mental workload in an analog system was higher than that in a digital system. Furthermore, the testing time, number of maintenance

errors and complexity from GMDH algorithm are important elements. Besides, we could suggest to adopt digital system in NPPs and to use this equation to predict the maintenance engineers' mental workload in digital systems.

Keywords: Mental workload, On-line maintenance, Nuclear Power Plant, GMDH

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