Development of Power Controller System based on Model Reference Adaptive Control for a Nuclear Reactor

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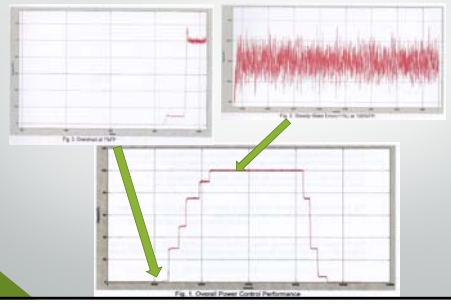
ABSTRACT

- The Reactor TRIGA PUSPATI (RTP)-type TRIGA Mark II was installed in the year 1982. The Power Controller System (PCS) or Automated Power Controller System (APCS) is very important for reactor operation and safety reasons. It is a function of controlled reactivity and reactor power. The existing power controller system is under development and due to slow response, low accuracy and low stability on reactor power control affecting the reactor safety. The nuclear reactor is a nonlinear system in nature, and it is power increases continuously with time. The reactor parameters vary as a function of power, fuel burnup and control rod worth. The output power value given by the power control system is not exactly as real value of reactor power. Therefore, controller system design is very important, an adaptive controller seems to be inevitable. The method chooses is a linear controller by using feedback linearization, i.e Model Reference Adaptive Control. The developed APCS for RTP will be design by using Model Reference Adaptive Control (MRAC). The structured of RTP model to produce the dynamic behaviour of RTP on entire operating power range from 0 to 1MWatt. The dynamic behavior of RTP model is produced by coupling of neutronic and thermal-hydraulics. It will be developed by using software MATLAB/Simulink and hardware module card to handle analog input signal. A new algorithm for APCS is developed to control the movement of control rods with uniformity and orderly for RTP. Before APCS test to real plant, simulation results shall be obtained from RTP model on reactor power, reactivity, period, control rod positions, fuel and coolant temperatures. Those data are comparable with the real data for validation. After completing the RTP model, APCS will be tested to real plant on power control system performance by using real signal from RTP including fail-safe operation, system reliable, fast response, stability and accuracy. The new algorithm shall be a satisfied performance in power control.

INTRODUCTION

- The **Reactor TRIGA PUSPATI (RTP) – type reactor TRIGA Mark II** was installed in the year 1982.
- The Power Controller System (PCS) or Automated Power Controller System (APCS) is **very important in reactor operating and safety reasons**.
- It is a function of controlled reactivity and reactor power.
- A new control algorithm for APCS is develop to control the movement of control rods with uniformity and orderly for PUSPATI TRIGA Reactor (RTP).
- A **Model Reference Adaptive Control (MRAC)** method is use to compare power demand and simulation/real signal reactor power.
- A structure of RTP model is develop to produce the dynamic behaviour of RTP on entire operating power range (1MWatt) including neutronics and thermal-hydraulics concepts.
- The simulation results will be obtained from APCS on reactor power, reactivity, period, control rod positions, fuel and coolant temperatures are comparable with the real data for validation.
- The end product , new APCS will be satify performance in power tracking, produce a fast response, accuracy, high reliability, stability and safe operation of the reactor.

BACKGROUND

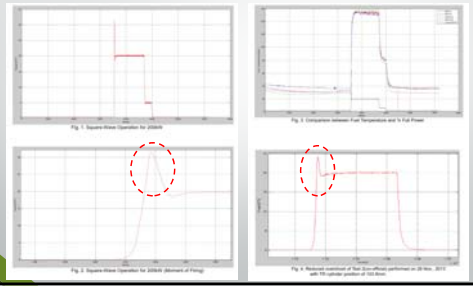


BACKGROUND

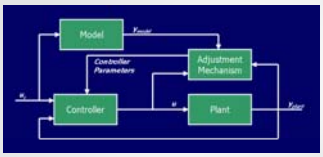
Normal Operation

BACKGROUND

Square-Wave Operation

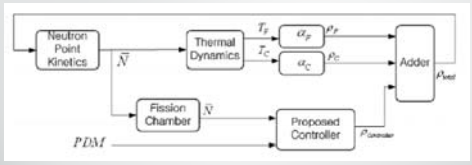


METHODS



- MRAC is to create a **closed loop controller** with parameters that can be updated to change the response of the system.
- The output of the system is **compared to a desired response from a reference model**.
- The control parameters are **update** based on this error.
- The goal is for the parameters to converge to **ideal values** that cause the plant response to match the response of the reference model.

METHODS

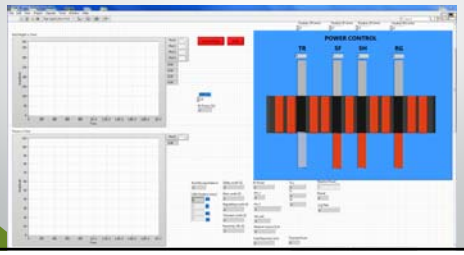


Simulation Structure

RESULTS

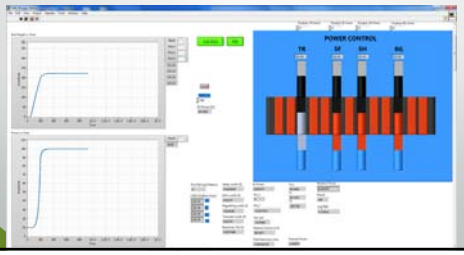
RESULTS

LABVIEW



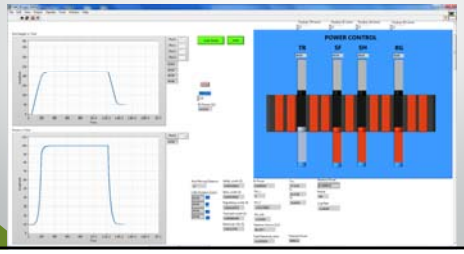
RESULTS

LABVIEW



RESULTS

LABVIEW

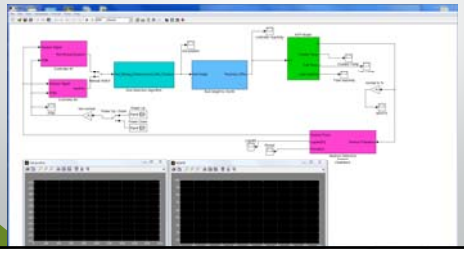


RESULTS

LABVIEW

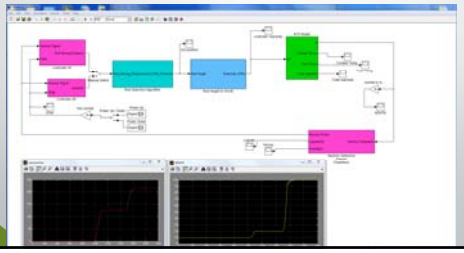
RESULTS

MATLAB/SIMULINK



RESULTS

MATLAB/SIMULINK

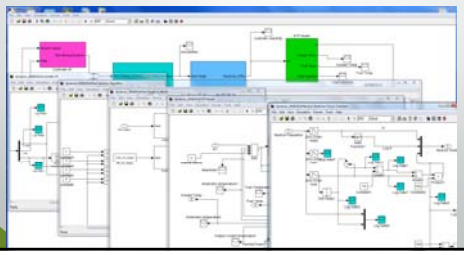


RESULTS

MATLAB

RESULTS

SIMULINK



DISCUSSION

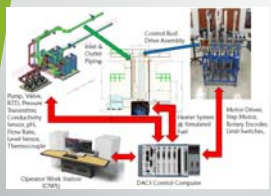
	Simulation Data	Real Data (March 2014)	Error
Reactor power	100% (1MW)	100% (1MW)	0
Control Rod Positions (mm)	221 mm	273 mm	-52mm
Fuel Temperatures (deg.C)	249 deg.C	338 deg.C	-89 deg.C
Coolant Temperatures (deg.C)	50 deg.C	42 deg.C	+8 deg.C

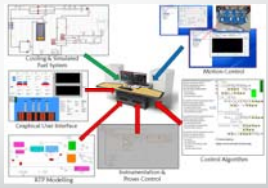
Still need major improvement..

SUMMARY

- The model for simulation of TRIGA Mark II need to be verified and validated using proper reactor model. Previous studies ever carried out by experts the reproduce the dynamic behavior of the TRIGA Mark II reactor, Italy without power controller to be adapted to the reactor TRIGA PUSPATI (RTP), Malaysia.
- The model and power control design need to be proper develop and test using proper engineering tool. Previous studies ever carried out by experts the ability of MATLAB/SIMULINK to be used for modeling and power control system design for research reactor. Investigation and research findings that have been made, has resulted in MATLAB/SIMULINK @ LabVIEW tool to be used as a guide and method to be implemented for this project as reliable tool for dynamic and control analysis.
- The power control system need to be test using software and hardware before install at reactor site. Previous studies ever carried out by researchers the ability of prototype ACSCR to be work as model research reactor in lab scale.

FUTURE WORK





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QUESTIONS & ANSWERS