BACKFITTING IN ROSSENDORF RESEARCH REACTOR CONTROL AND INSTRUMENTATION SYSTEM

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Abstract

The paper generally describes a decentralized Hierarchical Informational System (HIS) which has been developed for backfitting in Rossendorf Research Reactor (RFR) control and instrumentation system. The RFR was put into operation in 1957 and reconstructed from 2 MW up to a thermal power of 10 MW at the end of the sixties. Backfitting is planned by use of an advanced computerized control system for the next years. Main tasks of HIS are: Processmonitoring, online-disturbance analysis, technical diagnosis, direct digital control and use of a special industrial robot for discharging of irradiated materials out of the reactor.
Experiences obtained by HIS during a testperiod will be presented.

1. INTRODUCTION

Experiences have shown, that nuclear reactor control and instrumentation (C & I) equipment once if not twice will have to be replaced during the reactor life-time. Factors influencing this are:

- renew of rapid obsoleting C & I equipment as a result of fast pace of technological development in electronics and computer technique
- backfitting requirements wich arise from major improvements that must be incorporated, changes in operating tasks or due to regulatory requirements following the international trends in safety demands.

In the last years in the field of NPP the amount of applications of digital informational systems increased. But they are mainly used to survey the operation state of the plant. However, these systems based on the so called "centralized concept" were not capable of meeting the requirements of reliability and economy so, that they couldn't be used as control systems.

Relating to this, the use of microcomputer systems seems to be connected with some advantages. And with respect to the increasing capability those informational systems are suitable to realize control of higher order, like optimization, adaption and learning.

To get experiences in designing and developing of computerized control systems, an Hierarchical Informational System (HIS) for surveillance and control of the Rossendorf Research Reactor (RFR) has been developed.

2. REQUIREMENTS AND AUTOMATION TASKS

The RFR is a light water moderated and light water cooled reactor from tank type, which became critical in 1957.
It's thermal power was raised in two steps at first from

2 to 5 MW than from 5 to 10 MW at the end of the sixties /1/. During the first years the reactor was used in general for research work in nuclear and reactor physics, but since a few years the main task of the reactor has become the production of radioactive isotopes. The annual volume of this production may be caracterized by the number of about 40000 packages representing an approximate value of several millions of Dollars. Together with the voluminous production of neutron dotted silicon this needs more than 6000 loading respectively unloading operations by the reactor staff.

At backfitting requirements for RFR C & I system, the following demands have to be taken into consideration:

- automation of loading technique for material to be irradiated. Special aims in connection with steadily increasing production are the decrease of body burden by radioactive radiation and the reduction of the reactor staff.
- preparation for an operating regime with alternating reactor power
- improvement in man-machine communication both during normal and abnormal situation

To meet all requirements mentioned above a lot of automation tasks has to be solved:

- process monitoring, which includes acquisition, preprocessing, monitoring and logging of data
- technical diagnosis, that means elaborating of methods for online disturbance analysis and noise analysis
- process control e.g. in the sense of direct digital control and reactor start-up and shut-down procedures
- use of a special industrial robot for loading operation with material to be irradiated in the reactor

3. GENERAL STRUCTURE OF THE SYSTEM

Because the computerized informational system HIS especially has been developed to meet the backfitting requirements of the RFR, it has some features, which are different from those of systems installed at NPP's. Some of those distinctions are:

- much lower number of process inputs and outputs
- shorter distance between process and computersystem
- solving different problems (research work in reactor physics)

But nevertheless the HIS enables the reactor staff to get experiences with such a system and it also may be considered as a pilot system for developing and testing of methods and programs later used in NPP's. /2/

The tasks discussed in the preceding chapter, in general have autonomous characteristics, but they are very closely linked by the process. Thus a decentralized hierarchical system, shown in fig.1 seems to be the best solution to meet all the requirements mentioned above. The system consists of various basic units which are situated nearby the technological process and linked with the main computer via a serial bus, the so called IFLS interface /3/.
The basic units (urosdat 5000) are connected to the technological process. Each unit consists of a microcomputer Robotron K 1520 and several process I/O modules. It is primary used for data acquisition and preprocessing procedures, but furthermore other tasks can be performed too.
The main computer (Robotron K 1600) generally has two functions:

- operating management problems in the system including the man-machine-communication
- solving of real-time tasks with high demand in processing time and memory

The performance of the whole system essentially will be affected by the exchange of information within the system.
The requirements to the link software realizing the IFLS mainly were deduced as well from experience obtained by earlier computer application in NPP's /4/ as from actuell tasks at the RFR. The following demands were significant for developing of the IFLS program:

- good real-time behaviour of the complete system
- high reliability of data transmission
- simple handling of user programs by the employer
- low demand of memory and operation time

Thus the data are transmitted via the bus by a frame with limited length. Besides the data, a frame contains several information for control and check and is limited by synchron characters. The structure of the frame bases on the ISO-HDLC standard, but IFLS has its own function codes performing the real-time demands of process control better than the HDLC-procedure.

As the result of distributing the control problems on two computer levels, the majority of transmission requests comes from the upper level. For that reason the main computer permanently operates as a masterstation, whereas the basic units only have the slave position on the bus.

The IFLS interface may be realized as well as an electric cable or a fiber optic line.

4. TESTING THE HIS AT THE RFR

To test all the features of the new system a special version of HIS has been installed nearby the RFR some years before backfitting of control and instrumentation system has to be realized. The investigations have to be splitted into:

- test of the system, which means performance and availability of the hardware (K 1620/K 1630, urmadat 5000) and software modules (operating system, IFLS)
- online test of the system at the RFR, whereas the reactor operator has been integrated into solving this task. The following problems had to be solved:
  - process monitoring, including data acquisition and preprocessing on the basic units and monitoring and logging of data by means of the main computer
  - on line disturbance analysis program "SAVP 2" for dialog oriented cause-consequence analysis (realized on K 1620) /5/
  - developing of a special noise analysis monitor for early accident recognition of main aggregats e.g. pumps by means of analyzing the stochastic part of signals, for detection of nuclear boiling and for detection of loose parts in the primary circuit /6/
  - direct digital control of reactor power realized as a cascade of neutron flux, nitrogen activity and primary circuit temperatur regulators. The use of adaptive algorithm is planned.
  - program for optimal reactor shut down
    Fig.2 shows the general solution of xenon-poisoning limitation by means of the shut down control program (realized on urmadat 5000), which is based on the Pontrjagin Maximum Principle /7/. During normal reactor operation, every 6 minutes the shut down control program is calculating as well the reactivity effect of xenon-poisoning from xenon and jodine concentration as the shut down control parameters, which are being stored and displayed as a help for the operator.
  - development, design and installation of a special industrial robot for manipulation and monitoring the complete cycle of loading and unloading of material into the irradiation channels within the core /8/.
    Further steps will be automatic object identification and using of a special communication language.
  - preparation of reactor instrumentation (nuclear and technological sensors) for data acquisition by a process computer e.g. electrical isolation between instrumentation and computer.

5. CONCLUSION

Up to now the decentralized hierarchical system HIS has been tested at the Rossendorf Research Reactor RFR on a large scale. After finishing the investigations spoken about it will be decided, how the system may be used for meeting the backfitting requirements of RFR Control and Instrumentation system.

Simultaneously experiences and results obtained by developing and testing the HIS have been used in the field of designing and projecting of new concepts for NPP Control and Instrumentation systems.

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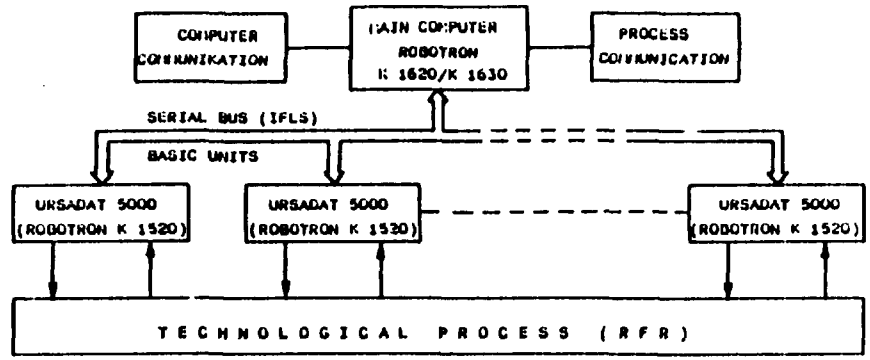

Fig.1 HIERARCHICAL INFORMATIONAL SYSTEM (HIS) GENERAL STRUCTURE

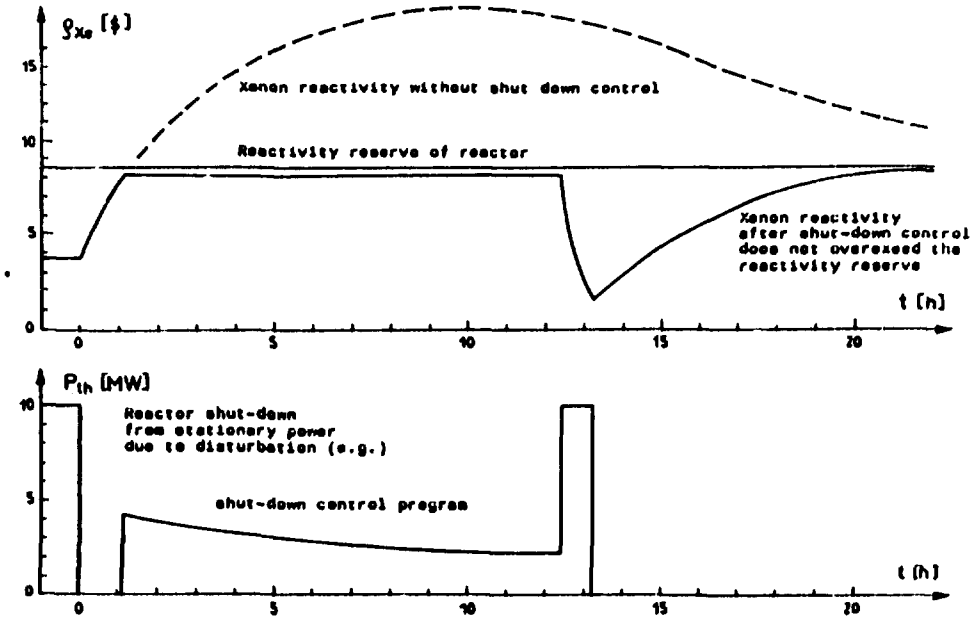

Figure 2 Shut-down control at the Rossendorf Research Reactor