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Publication date:
1982

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
Lind, M. (1982). Multilevel Flow Modelling of Process Plant for Diagnosis and Control. (Risø-M; No. 2357).

RISØ-M-2357

MULTILEVEL FLOW MODELLING OF PROCESS PLANT FOR DIAGNOSIS AND CONTROL

Morten Lind

Abstract. The paper describes the multilevel flow modelling methodology which can be used to construct functional models of energy and material processing systems. The models describe mass and energy flow topology on different levels of abstraction and represent the hierarchical functional structure of complex systems. A model of a nuclear power plant (PWR) is presented in the paper for illustration. Due to the consistency of the method, multilevel flow models provide specifications of plant goals and functions and may be used as a basis for design of computer-based support systems for the plant operator. Plant control requirements can be derived from the models and due to independence of the actual controller implementation the method may be used as a basis for design of control strategies and for the allocation of control tasks to the computer and the plant operator.

INIS Descriptors: AUTOMATION; CONSERVATION LAWS; CONTROL SYSTEMS; ENERGY BALANCE; FLOW MODELS; INDUSTRIAL PLANTS; MASS BALANCE; NUCLEAR POWER PLANTS; PLANNING; REACTOR OPERATION; SPECIFICATIONS; SYSTEMS ANALYSIS

UDC 621.039.56

August 1982
Risø National Laboratory, DK 4000 Roskilde, Denmark

Preprint of paper to be presented at International Meeting on Thermal Nuclear Reactor Safety, August 29 - September 2, 1982, Chicago, Illinois, USA.

ISBN 87-550-0876-3
ISSN 0418-6435

Risø Repro 1982

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INTRODUCTION

The operation of large industrial installations such as nuclear power plants or chemical processing units involves operator decisions which depend critically on proper information about the required plant functions and the associated necessary control constraints. This information is usually only available to the operator in the form of written documents or is given to him as part of the training. Although information about the state of plant functions is essential for the understanding of plant behaviour, existing man-machine interface designs do not support the operator in thinking in functional terms. The introduction of computers in the control rooms of modern processing systems has aggravated this situation because the level of automation has been increased without attempts to make the functional structure of the total plant complex transparent to the operator. The operator is still left with information which essentially is on the level of the individual sensors. These deficiencies of the man-machine interface may not be important during normal operation, but can be serious in accident situations. This has recently been stressed at the TMI accident where the operators did not know - and could not be expected to know - what was going on in the plant. Rasmussen and Lind (1981) have proposed a solution to these problems based on the idea of using a computer-based man-machine interface. The task of the computer should be to integrate measured data into plant state information related to different levels in an abstraction hierarchy (Fig. 1). The levels in the hierarchy, which can be identified by analysing verbal protocols recorded in power plant control rooms, correspond to different representations of plant function and support different problem solving strategies.

In the present paper we will discuss a methodology called multilevel flow modelling (MFM) which can be used to construct functional models of energy and material processing systems and which belong to the level of abstract function. A multilevel flow model is essentially qualitative as it represents func-

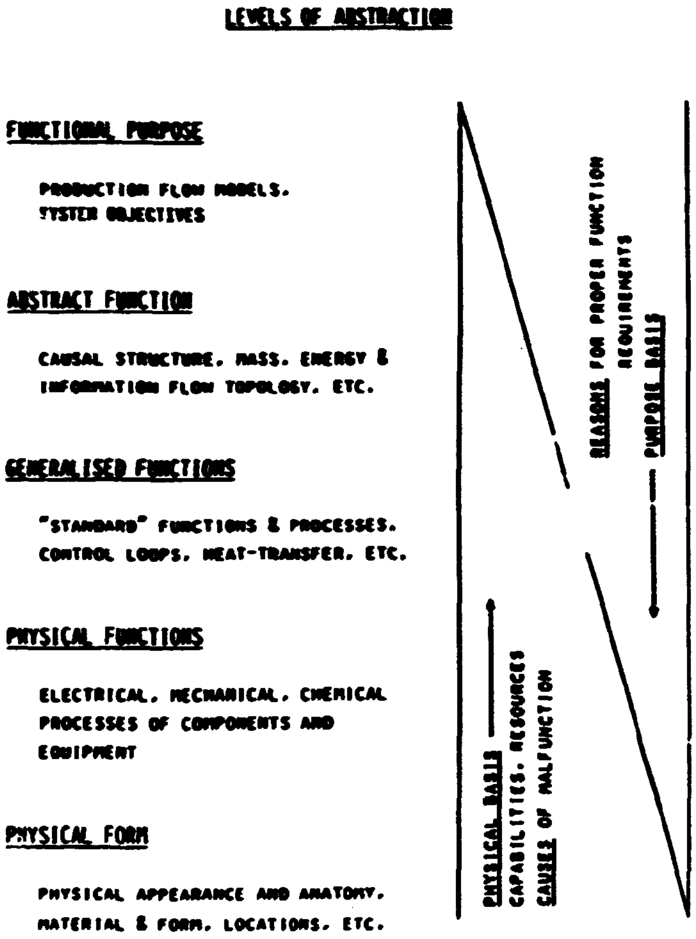


Figure 1. The abstraction hierarchy used for representation of functional properties of a technical system.

tional structure of the process plant considered. The modelling method is based on the identification of mass and energy flow structures on different levels of physical aggregation in the plant. It may be used as a basis for man-machine interface design as it provides a systematic way of identifying plant goals and functions and the plant state information required in control and decision making. Due to the consistency of the MFM method, the models produced can be considered as providing functional specifications of the plant. This property makes MFM models attractive as a basis for design of advanced operator aids such as systems for automated diagnosis (Lind, 1981) or for synthesis of operating instructions (Lind, 1979). Within the broader context of the abstraction hierarchy, MFMs may also provide a basis for design of integrated "cognitive" systems where the computer and the operator cooperate in plant supervision and control (Lind, 1982, and Hollnagel and Woods, 1982). Before describing the multilevel flow modelling method we will discuss how functional specifications appear as a result of the process design and how these relate to the levels of abstraction in Fig. 1. Later it will become clear how MFMs provide a systematic framework for organizing this information into a set of interrelated goal and function hierarchies.

SPECIFICATION OF PLANT GOALS AND FUNCTIONS

The specification of goals and functions of plant subsystems is an integral part of the process design, i.e. the activity where the physical structure of the plant is synthesized. However, the identification of subsystem goals and functions depends on the actual design strategy adopted. The description given below relates to a formalized "systems approach" to the process design. Gregory (1979) characterizes the systems approach as "a managerial procedure --- relying upon the identification of the objectives to be attained, the specification of the functions needed to achieve those objectives, the quantification of performance in terms of output quality and value, the specification of parts of the system needed, their interrelationships, and the optimal configuration to achieve the objectives, given the environment, constraints, and resources". This top-down approach is suitable for the development of radically new designs. Another design strategy is used when new designs are obtained by adaptations or modification of existing designs. From the point of view of such an evolutionary design process, the top-down formalized approach may rather be used as basis for a review of the consistency of design decisions.

The systems approach to process design can be described in terms of the abstraction hierarchy (Fig. 1). During design of the plant, the functions of the system and its physical implementation are developed by iteratively considering the plant at various levels of abstraction and in increasing degree of detail (Fig. 2). During this design process, the physical system is identified. But, as the degree of physical detail increases during the design process, so does the number of degrees of freedom in functional states, and control paths relating desired target states or goals with necessary control actions must be introduced to constrain the possible operational states. Another result of the plant design process is the identification of operating modes, i.e. system configurations and functional states corresponding to different overall safety or production goals. In this way the desired states of functions, equipment and components will be identified during design at different levels of abstraction, and the necessary information or control constraints will be identified in terms related to these levels. Due to the coupling between levels of aggregation and abstraction during design, this leads to a conceptual fragmentation of the functional specifications and the associated control requirements. On the high levels of abstraction we deal with the whole system and specify states of the overall plant production function. As we go down in the hierarchy we become more oriented towards components, i.e. we specify states of pumps and valves.

In order to formalize the functional specifications it is necessary to be able to use the same language on all levels of aggregation. As shown below multilevel flow models can be used as a consistent framework for dealing with functional specifications in a uniform language and can be considered as a formalized abstraction hierarchy. Fig. 2 shows how specifications developed during the design can be translated into information related to an MFM. The flow model can be considered as obtained by a decomposition of the overall plant mass and energy flow structure, where the decomposition is guided by the design information on system purposes and functions.

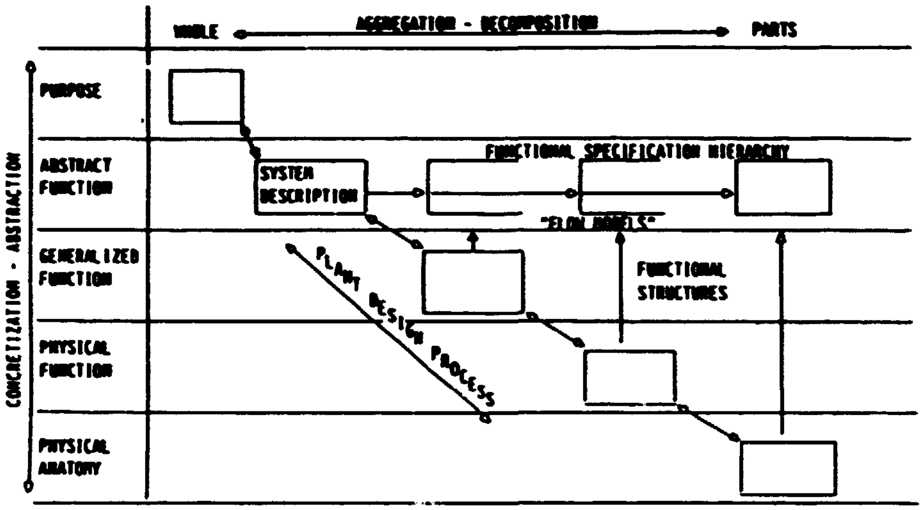


Figure 2. Derivation of goals and functional specifications during the design process.

THE FUNCTIONAL STRUCTURE OF PROCESS PLANTS

In this section I will briefly describe characteristics of the functional structure of process plants. This may give a general indication of the nature of the complexity to be handled when specifying plant functional requirements. The degree of complexity of the plant functional structure is furthermore an indicator of the difficulty of the control tasks involved in operating the plant. Some important characteristics of functional structure in process plants are:

- A component, an equipment or a plant subsystem may have several purposes or goals.

- Plant and subsystem goals may be multiple and partially conflicting.

- A plant function may have several alternative physical implementations.

- The functional structure changes depending on operating mode.

The one to many and many to one mappings describing the relations between plant physical structure and plant functions are consequences of process plants being systems and having subsystems with multiple operating goals and the results of the design for reliable operation. The features of plant functions as described above can be represented in an MFM together with a map of the physical structure as described below.

MULTILEVEL FLOW MODELS FOR FUNCTIONAL SPECIFICATION

The main goal of multilevel flow modelling is to describe the functional structure of process plants in terms of a set of interrelated mass and energy flow structures on different levels of physical aggregation. The basic concepts used are closely related to thermodynamics which is the basis for every consistent approach to modelling physical phenomena in process plants. Flow modelling can be used for providing both <u>descriptive</u> and <u>normative</u> models. A descriptive model represents the actual behaviour of the system, whereas a normative model represents the system in terms of how it is intended to behave (Simon, 1969). This distinction is important for understanding how flow models are used for functional specification and for avoiding pitfalls in applying the methodology for this purpose. The modelling approaches in the two cases are basically different as the normative model requires a top-down function--oriented holistic approach whereas the descriptive modelling is a bottom-up atomistic approach starting with minute details and ending with a level of detail determined by simplifying assumptions.

Flow modelling may be applied for descriptive purposes as the first conceptual step in the development of a conventional simulation model. In this way a flow model describes the qualitative structural aspects of the problem to be analysed. This type of model is useful as an analytical tool for the study of actual plant behaviour and limiting functional properties. Such a model will necessarily only describe one single functional level. When the flow modelling approach is used to provide normative models specifying intended function we obtain multilevel structures representing the plant as a functionally organized system adapted to its environment - as an artificial system (Simon, op.cit.).

BASIC MODELLING CONCEPTS

The flow modelling method is a diagrammatic method aimed at describing qualitative aspects of the function of material and energy processing plants. The result of the modelling is a graph, called a flow structure, or a set of graphs describing the topology of mass and energy flow paths in the plant. Each node in a flow structure represents the function of a plant subsystem, i.e. related basically to a set of interconnected physical components. It is an assumption that subsystem functions belong to a very restricted set of basic so-called flow functions. A flow structure is accordingly a functional network representing the plant on a level of physical detail given by the decomposition into subsystems. It is an important aspect of the methodology that this physical decomposition is motivated by functional considerations. Two distinct functional elements (nodes) in a flow structure may, as a result, correspond to two overlapping plant subsystems, i.e. they may share components.

The basic flow functions used for modelling are storage, transport, distribution, barrier, source/sink and support functions. Furthermore, we will also need the concept of a condition. The individual functions will be explained below and their symbols in flow structured are shown in Fig. 3. The performance parameter mentioned is a plant variable which can be used to evaluate the success of the system to perform its intended function.

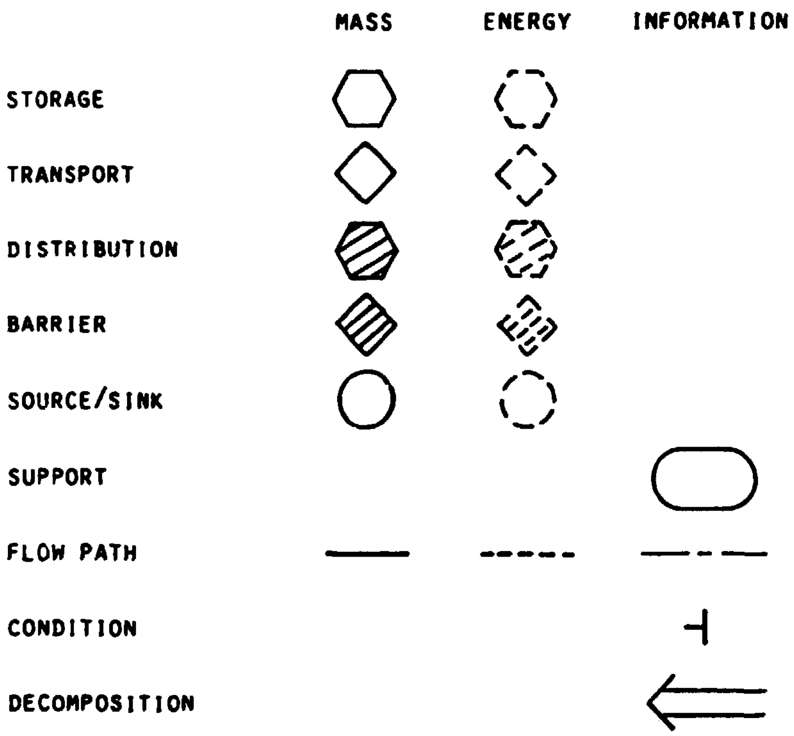


Figure 3. Symbols used in flow modelling.

- The storage function represents the property of a system to act as a buffer or accumulator of mass or energy. We distinguish between mass storage and pure energy storage but note that a mass storage in some cases may imply energy storage too. The storage function is characterized by a performance parameter indicating the level of mass or energy accumulated by the system. In the case of multicomponent processes, a storage function may include the interchange of mass between the different chemical species (chemical reactions). The performance parameter will in this case be a vector indicating the levels of mass accumulated for the individual species.

- A transport function represents the property of a system to provide transfer of materials or energy between two other systems. As for the storage function, we distinguish between mass and pure energy transport. A transport function is characterized by a performance parameter indicating the rate of flow of the mass or energy transferred.

- A distributor function represents the property of a system to provide a balance between the total rates of incoming and outgoing flows. Again we distinguish between material and pure energy distribution. The performance parameter is a vector characterizing the ratios between rates of the individual ingoing/outgoing flows and the total ingoing/-outgoing flows.

- A barrier function represents the property of a system to prevent the transfer of materials or energy between two other systems. We distinguish between material and pure energy barriers.

- A source/sink function represents the property of a system to behave as an infinite reservoir of mass or energy. No physically realizable system has in principle unlimited capability of delivering or receiving mass or energy. However, this representation may in many cases be perfectly adequate.

- A support function represents the property of a system to provide the conditions necessary to allow another system to perform its function. The performance parameter associated with a support function is the variable defined by the condition to be provided. The variable has no fixed type as it depends on the actual case. Any plant variable may be chosen such as e.g. temperature, pressure or flow variables.

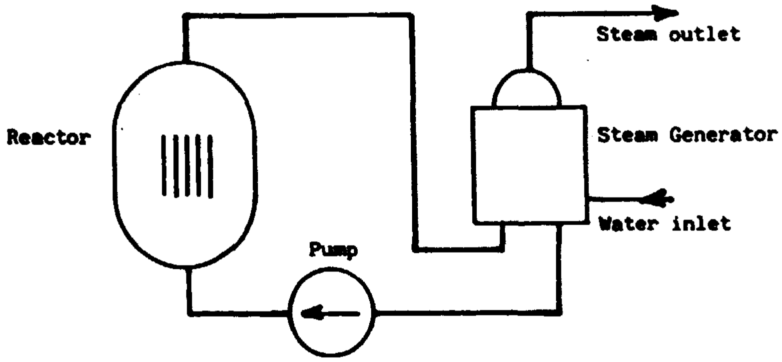
The basic flow functions can be interrelated to create a functional network - a flow structure. The relations are created by links called flow paths as defined in Fig. 3.

A condition can be associated with any of the flow functions described above, except the support, to describe that the system function modelled can only be achieved under certain specified operating circumstances. These may be "natural" physical constraints which should not be violated (cladding integrity) or "artificial" constraints which are determined by the designer's control decisions. A condition is related to a support function which provides the means for reaching these necessary conditions. This relation is indicated by a link in the flow structure called an information flow path. This path has as an attribute a predicate defining the truth function to be satisfied by the performance parameter of the support function. The predicate quantifies the requirements to be met for the conditioned flow function. Several conditions may be related to a given flow function in which case all the associated predicates should be true.

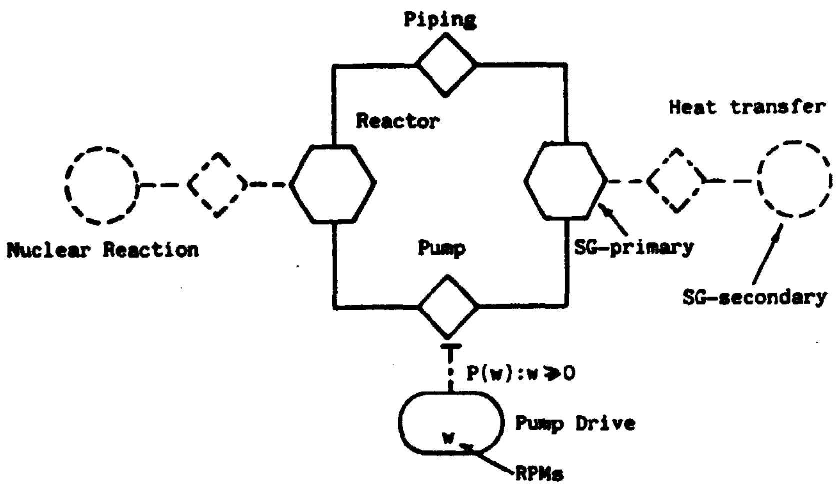
A SIMPLE EXAMPLE

As an illustration of the modelling approach we will describe some models of a simple system as depicted in Fig. 4.

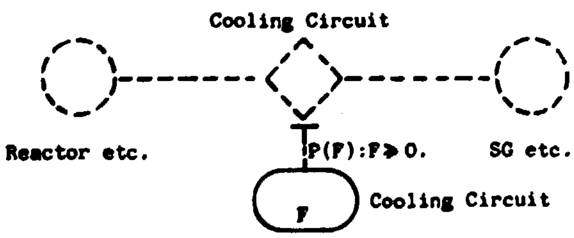
The example chosen is a very simple reactor coolant system comprising a reactor as an energy source, a pump for providing flow and a steam generator. Flow model A describes system function with a high level of detail and specifies the functional degrees of freedom in terms of performance parameters (not indicated in the diagram) for the individual flow functions. Note that the transport node modelling the pumping function is conditioned by the pump drive. The condition for existence of the transport function is given as a predicate P(w) where w is the shaft angular velocity. Flow model B describes the same system at a high level of abstraction as the function of the cooling circuit is specified as an energy transport node. This model describes the intent of the plant



Physical Structure



Flow Structure A



Flow Structure B

Figure 4. A simple example illustrating the use of the flow modelling methodology for describing a system on different levels of abstraction.

designer as it specifies the purpose of the cooling circuit. The energy transport is conditioned by a support function representing the circulation of fluid in the primary. The plant parameter critical to the existence of the energy transport is the rate of flow F in the primary and the condition to be satisfied is given by a predicate P(F) which should be true.

MULTILEVEL FLOW MODELS AND DECOMPOSITION OF FLOW FUNCTIONS

The flow modelling framework described above can be used to describe plant function on any level of aggregation but it is not sufficient for representing the relations between plant functions on different levels. Thus, in the example in Fig. 4 we described two functional aspects of the same system, but we did not model explicitly the relation between the energy transportation aspect of the reactor coolant system and the circulation of fluid in the system. This relation can be represented by introducing a flow modelling concept (see Fig. 3 for the associated symbol) to indicate a functional decomposition of a flow function. The usefulness of this concept becomes clear when it is realized that the decomposed function always can be described in terms of the basic flow functions, i.e. as a flow structure. This recursion is possible because the basic flow functions apply on any level of physical detail and makes it possible to construct multilevel flow models describing how the system is organized into several functional levels. Such a model may cover the whole range of functional aspects related to the process plant as a whole down to aspects dealing with minute details concerning the function of e.g. the auxiliary systems to a lubrication pump. An example of a nuclear power plant model will be discussed later.

As an illustration of the use of functional decomposition in flow modelling consider the example in Fig. 5. This example shows a model of a feedwater system consisting of a feed and a condensate pump and a feedwater tank. Two models are provided, on level 1 the feedwater system is described as a mass transport system, which indeed is the function intended of such a system. On level 2 the transport node on level 1 is decomposed into subfunctions (note that the decomposition is in the direction opposite to the arrow), which in this case can be associated with the components of the system.

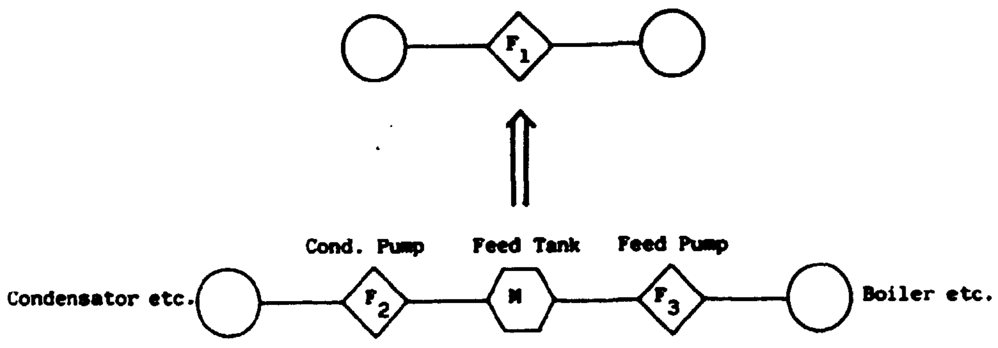


Figure 5. Example illustrating the use of functional decomposition in flow modelling.

This example shows a general aspect of a decomposition that it increases the functional degrees of freedom. From considering only the flow F_1 on level 1 we consider two flows F_2 and F_3 and a mass level M on level 2. This implies that F_2 and F_3 should be coordinated in order to ensure that the model on level 1 is an adequate description of the overall function of the feedwater system. We can accordingly consider the transport node on level 1 as specifying the goal of the function described on level 2 and the double arrow implies that a control mechanism (automated or the operator) is required to constrain the variability on level 2. A possible constraint could be $F_1=F_2=F_3$. This corresponds to the choice of a specific control strategy and F_1 will be the reference for the resulting control loop. The aspects of functional decomposition discussed here in terms of an example are general, i.e. flow functions can be considered as goals when decomposed and the decomposition implies a control constraint. However, when a support function is decomposed, the associated condition is considered as the goal and not the support function itself.

OPERATING MODES AND THE MODELLING OF FUNCTIONAL ALTERNATIVES

In complex processing plants it is often the case that critical functions may be accomplished in several alternative ways. As examples may be mentioned the main and the auxiliary feedwater systems as being alternative systems for the provision of feed flow to the steam generators. Similarly, a condition may be provided by several alternative support systems. These alternatives can also be represented in a multilevel flow model. On the plant level functional alternatives are treated by developing an MFM for each operating mode, i.e. the models are separate. This could also be done on the subsystem level but may lead to the generation of a complex hierarchy of separate models. In order to avoid this, alternatives are only allowed to lead to separate models if they are exclusive. Otherwise they will be considered as belonging to the same operating mode. It is possible to identify three different situations where alternatives should be taken into account.

- A flow function may have several decompositions. However, these alternatives cannot be relevant at the same time otherwise it would reflect an ambiguous design goal and could not be realized. Accordingly, we should only consider the case where the alternatives are exclusive. In this case the alternatives should be represented in separate flow models defining alternative sub-operating modes.

- A flow function may have several conditions. If these conditions should all be satisfied at the same time, there are no problems. But if they are mutually exclusive we are dealing with a situation involving different physical implementations of the same support function. This means that we are dealing with different operating modes which should be modelled separately.

- A condition may be satisfied by several support functions. This case can be treated by combining conditions into a logic network as exemplified in Fig. 6. It is clear that arbitrarily complex logical networks can be constructed by using AND and OR operations on condition predicates.

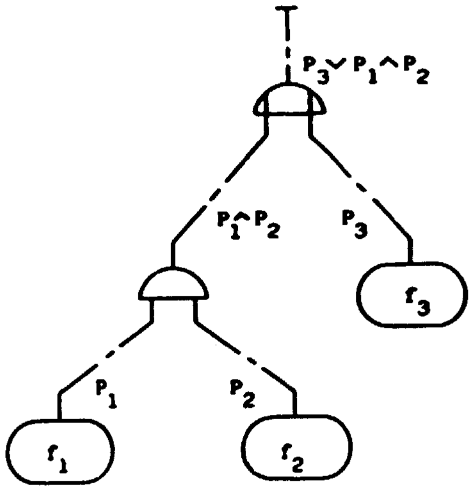


Figure 6. Logical network illustrating how several support functions (f_1, f_2 and f_3) may contribute to the same condition. Condition predicates P_1, P_2 and P_3 are combined using AND and OR operations.

DERIVATION OF CONTROL REQUIREMENTS FROM FUNCTIONAL SPECIFICATIONS

Plant control requirements are clearly closely related to functional specifications, but where the latter describes what should be achieved the specification of control requirements deals with how goals are reached and plant functions established. In the following I will show that MFMs introduced above as a formalism for functional specification can also be used for specification of plant control requirements. The two uses depend on two different interpretations of the information contained on each functional level in the model.

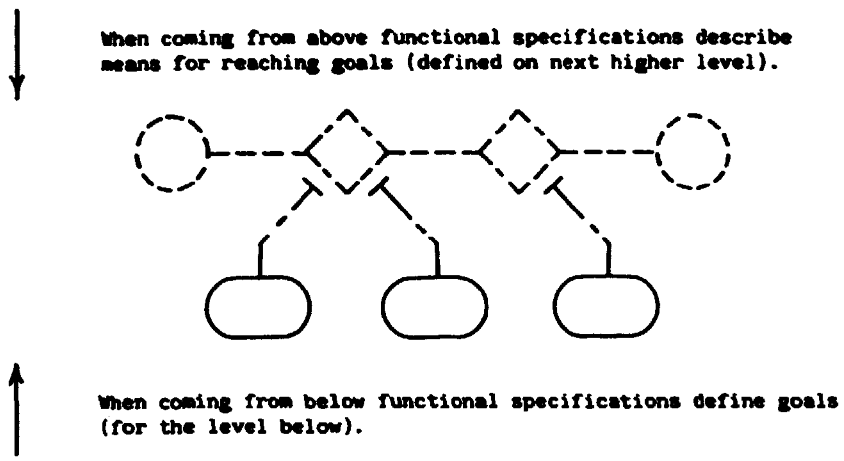


Figure 7. A flow model specifies plant goals and functions but also provides specification of control requirements when taken together with information about actual state of flow functions.

Considering now as an example the flow model shown in Fig. 7. Such a model defines the causal flow of mass and energy in a plant on the particular level selected, and the functional degrees of freedom in changing levels and flows can be readily identified. Each node in the flow model represents from this point of view a subfunction. But as discussed earlier nodes could also be considered as goals of subsystems on the next lower functional level. Conditions correspond similarly also to goals for subsystems the functions of which are defined on the next lower level. A flow model on one level induces accordingly a set of control requirements on the next lower level, i.e. a set of target states to be reached by proper manipulation of the controllable mass and energy variables (degrees of freedom) on the next lower level. This applies by recursion to all the levels in an MFM and we can conclude that we have two different interpretations of the information provided in the model, one for the specification of plant system goals and functions and the other for specification of control requirements. This situation is illustrated in Fig. 7 and it should be noted that the two interpretations correspond to the two ways an operator could use the information in an MFM during diagnosis or control (Rasmussen and Lind, 1981). The possibility of applying two interpretations is the property which makes MFMs useful for transfer of information from plant design into control design (Rasmussen and Lind, 1982), and from the whole design phase into operator training and plant operation.

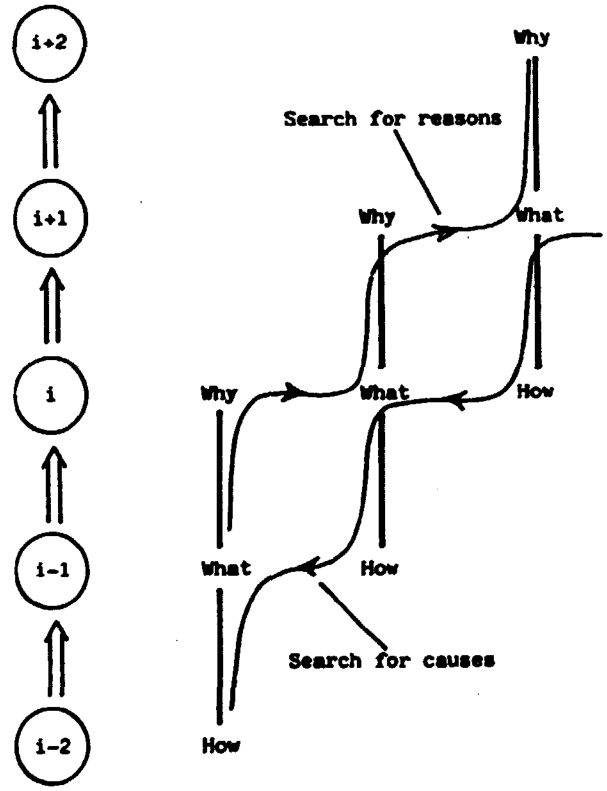


Figure 8. Illustration of the use of why, what and how questions for searching through an MFM. Each circle corresponds to a flow structure. The search routes depicted correspond to a search for reasons and causes. More complex search patterns are possible depending on the use of model information.

This point can be further elaborated by considering three consecutive levels i-1, i and i+1 in a sequence of levels in an MFM as illustrated in Fig. 8. Assuming that level i describes the function of a particular plant subsystem under investigation in a given model application, then level i+1 will describe why this function is required. Similarly, level i-1 will describe how the plant function on level i is established and level i will relate to what is going on in the plant subsystems considered. The triple of why, what and hows can be shifted upwards or downwards (see Fig. 8) as the subsystem considered changes and provides a systematic functionally motivated strategy for searching through model information. This may be important for the use of MFMs in training as it provides a way of organizing plant knowledge into a coherent structure. The why, what and hows may also be important for an operator in diagnosis if supported by an information display designed on the basis of an MFM plant model (Goodstein, 1982, Rasmussen and Lind, 1981). In constructing an MFM model it is also necessary to consider the triple as it guides the modeller in the choice of plant aspect to address at a given instant in the modelling (enforces the systems approach).

A MULTILEVEL FLOW MODEL OF A PWR

In order to illustrate the modelling method I will now show an example of a nuclear power plant (PWR) model. The model (Fig. 9) is not complete in any sense but illustrates the characteristics of a multilevel flow model. The presentation of a reasonably complete model would be outside the scope of this paper.

The plant is modelled from two points of view, one dealing with the overall safety goal of preventing release of radioactive materials to the environment and the other dealing with the goal of plant energy production. These two goals are described in flow modelling terms and the two goals are decomposed into subgoals with associated plant subfunctions. The safety aspect is described by modelling the flow of radioactive materials through the system. This model includes the safety barriers: cladding, RCS boundary and containment. The availability aspect is described by modelling the RCS and steam generator as an energy transport system. If taken separately, the two plant goals would lead to two goal and function hierarchies, one dealing with the safety issue and the other with the energy

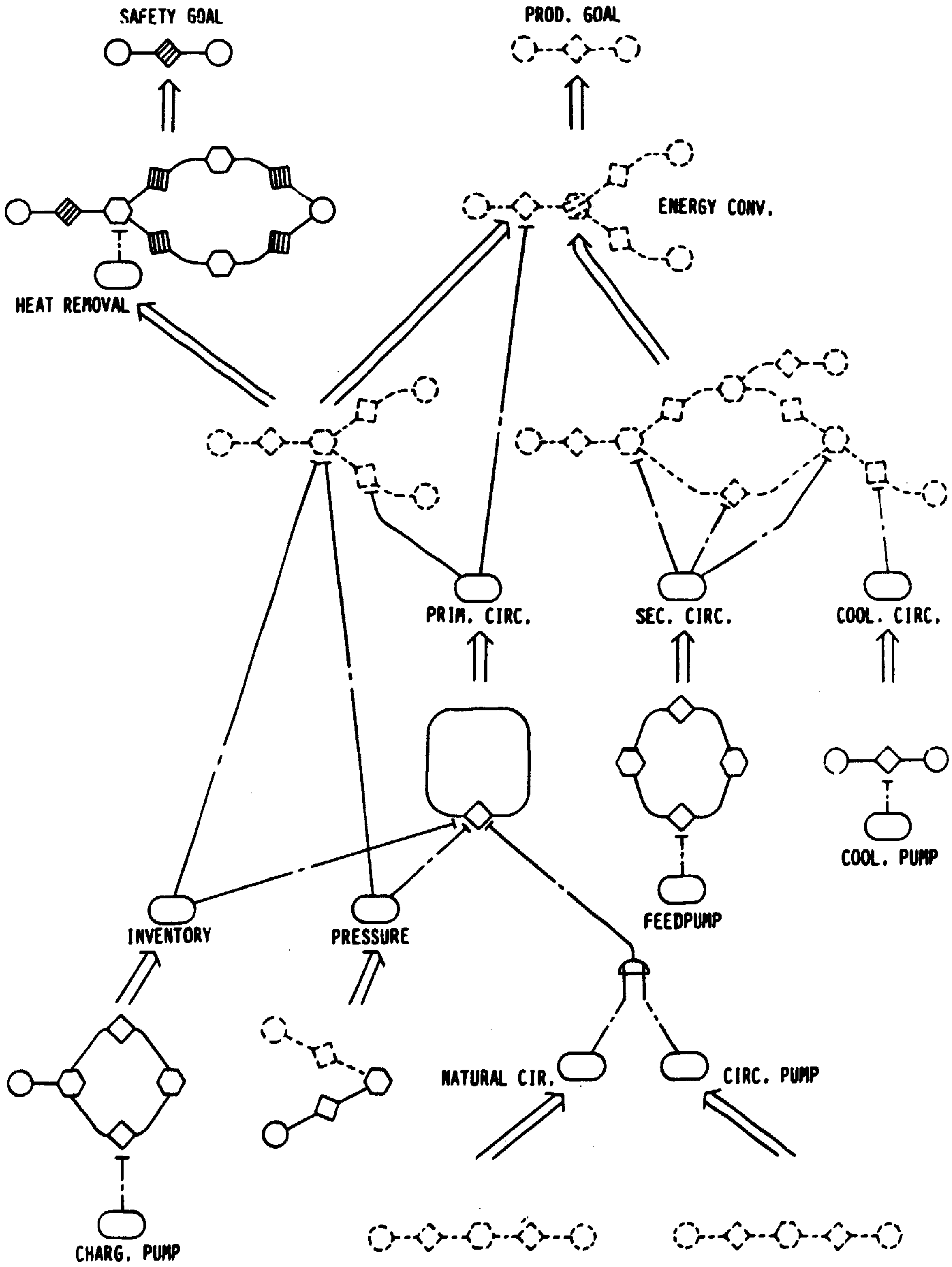


Figure 9. Multilevel flow model of a nuclear power plant (PWR).

production issue. This would disguise the fact that safety and production functions have a common physical basis by being functional aspects of the same system. These relationships appear directly in the PWR model (Fig. 9) as the two functional hierarchies merge together on the lower levels which represent the function of physical components.

APPLICATIONS OF MULTILEVEL FLOW MODELS

Several applications of multilevel flow models have been considered (Lind, 1979, 1981, 1982a and 1982b). They may be used as a system analytical tool in plant design to provide a basis for planning of overall control strategies (Rasmussen and Lind, 1982) and as a consistent basis for identification of critical events in risk analysis (Rasmussen and Pedersen, 1982). Furthermore, they may be used as a basis for design of man-machine interfaces by providing a structure to the plant information which should be displayed to the operator. This structure reflects the plant designer's intentions. In more advanced computer-based operator support systems a set of flow models may provide the knowledge base necessary in assisting the operator in diagnosis of plant malfunctions. Flow models may also be considered as a basis for operator training.

ACKNOWLEDGEMENTS

This work is part of the joint Scandinavian NKA/LIT project on Human Reliability supported by the Nordic Council of Ministers.

The support of Westinghouse Electric Corporation, Pittsburgh, USA in providing me with technical information for the PWR modelling is greatly appreciated.

REFERENCES

L. P. GOODSTEIN, "Computer Based Operating Aids". To be presented at Design 1982 in Birmingham, September, 1982.

S. A. GREGORY, "Design Strategies and Tactics". Paper presented at ICE Symposium: Current Design Thinking, September 12-14, 1979, Aston University, England.

E. HOLLNAGEL and D. D. WOODS, "Cognitive Systems Engineering". Risø-M-2330, 1982.

M. LIND, "The Use of Flow Models for Design of Plant Operating Procedures". Risø-M-2341. Paper presented at: IWG/NPPCI Specialists Meeting of Procedures and Systems for Assisting an Operator during Normal and Anomalous Nuclear Power Plant Operation Situations, December 5-7, 1979, Garching, F. R. Germany.

M. LIND, "The Use of Flow Models for Automated Plant Diagnosis". In: Rasmussen, J. and Rouse, W. B. (Eds.), "Human Detection and Diagnosis of System Failures". Plenum Press, New York, 1981.

M. LIND, "Artificial Intelligence Techniques in Process Plant State Identification". Paper presented at: SAIS-82 Workshop on Artificial Intelligence, April 23-25, 1982a, UPMAIL Uppsala University, Sweden.

M. LIND, "Generic Control Tasks in Process Plant Operation". Paper presented at the 2nd European Annual Manual, Bonn, F. R. Germany, 1982b.

J. RASMUSSEN and M. LIND, "Coping with Complexity". Risø-M-2293, 1982. Paper presented at the European Annual Conference on Human Decision and Manual Control, Delft, 1981.

J. RASMUSSEN and M. LIND, "A Model of Human Decision Making in Complex Systems and Its Use for Design of System Control Strategies". Paper presented at the American Control Conference in Arlington, Virginia, June 14-16, 1982.

J. RASMUSSEN and O. M. PEDERSEN, "Formalized Search Strategies for Human Risk Contributions: A Framework for Further Development". Risø-M-2351, 1982.

H. A. SIMON, "The Sciences of the Artificial". The MIT Press, 1969.

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Title and author(s)	Date August 1982
Multilevel flow modelling of process plant for diagnosis and control Morten Lind	Department or group Electronics
	Group's own registration number(s) R-10-82 NKA/LIT-3.2(82)120 ML/bs
pages + tables + illustrations	

Abstract

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