EXPERT RULE-BASED CONTROL TO A FISH GENERATIVE-CULTIVATIVE PLANT

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In recent years, conventional expert systems techniques have been applied on industrial controllers design. Intelligent control and particularly expert rule-based controllers can improve the performance of systems. The dynamics of a fish generative-cultivative plant has been simulated and the performance of an expert PID controller based on preknown knowledge evaluated for setpoint tracking purposes and different load conditions. The closed loop behavior of the system under sea water flow changes which affect on the global transfer function has been improved and the plant can be work in a variety load changes conditions having good performance.

The plant consists of a number of tanks where the small fishes are cultivated, a Heat Exchanger, a Steam Generator, a Programmable Logic Controller and a PID controller embedded in PLC. Water is continuously pumped from the sea to the tanks through the heat exchanger. The temperature of the water supplied to the tanks must be kept within a desired range regardless of sea water temperature. The control objective is to regulate sea water temperature by adjusting the steam pressure in the heating coil. The primary load variable is assumed to be inlet temperature. Since a pneumatic control valve is used, the controller output must be converted to an equivalent pneumatic signal by a current to pressure transducer. The transducer output signal is then used to adjust the steam control valve. The heat exchanger is capable of heating the sea water at the required temperature for the maximum mass flow rate of the sea water. The maximum mass flow rate happens when operate all (n) the tanks.

The three parameters of the PID controller are regulated for the above state of operation of the system and the behavior of the controller is quite satisfactory for any temperature of the inlet sea water and for any temperature set-point. However, there are several reasons because of which the total sea water flow is not constant. Every day several tanks may be out of order because for example they are under a cleaning procedure or the fishes were sold etc. Since the variation of the total sea water flow leads to variation of the parameters of the heat exchanger the situation of the system is changed. The PID controller will not operate satisfactorily for the full range of the sea water flow, due to the fact that exchanger parameters may vary significantly in this range.

The manually regulation of PID parameters is changed on an expert control based on heuristic rules. All the possible combinations between the physical variables and for each linguistic term representing an interval of them, lead to no more than 20-30 rules that constitute the heuristic knowledge of the expert operator. The PLCs until today can not include such heuristic control rules and the special intelligent modules, as a PID module is, are programmed for constant PID parameters.

Although PID controllers with auto tuning capability can save time for process engineers and ensure a better control than ill-tuned standard PID controllers, they can not cope with changes in the dynamic characteristics of the process under control, structural perturbations, and environmental variations. Among the control strategies developed in the last decade the adaptive control and Knowledge based and fuzzy expert control approaches are seen to be the most attractive. In the case of expert fuzzy control systems the experience and process knowledge which enable the control engineer to adjust manually the controller's parameters, involves many logical functions incorporating the heuristic knowledge. In order to incorporate this knowledge we follow two approaches.The previous off-line generation of a Knowledge base and the on-line Knowledge acquisition from an experienced human operator in the view of a learning phase.

1. Initial look-up table. Using the mathematical model of the system covering all the range of values of the water mass flow rate we construct a matrix with the optimum values of the PID parameters which will constitute the initial values in the form of a look-up table. In reality we take care to restrict as much as possible the size of the matrix in order to simplify and reduce the initial searching of the parameters corresponding to the measured inputs.

2. Expert-fuzzy supervision. The process control strategy is expressed linguistically as a set of imprecise conditional statements which form a set of decision rules. Then, a fuzzy expert controller typically takes the form of a set of IF-AND-THEN rules whose antecedents and consequences are membership functions. The membership functions of the fuzzy sets used to formulate the linguistic terms can be defined in many ways and their choice depends on each practical situation. In this approach the classical triangular membership functions, from negative big to positive big, are

used. The expert operator makes the tentative decision based on some important variables and then later he modifies it when more information (response parameters measurements) become available. This procedure used heuristically by the operator is very similar to that followed in a hierarchical structure of rules proposed by others researchers. We introduce a hierarchical structure with two levels as shown in Fig.1. In the first level, all the heuristic rules of the expert operator, are

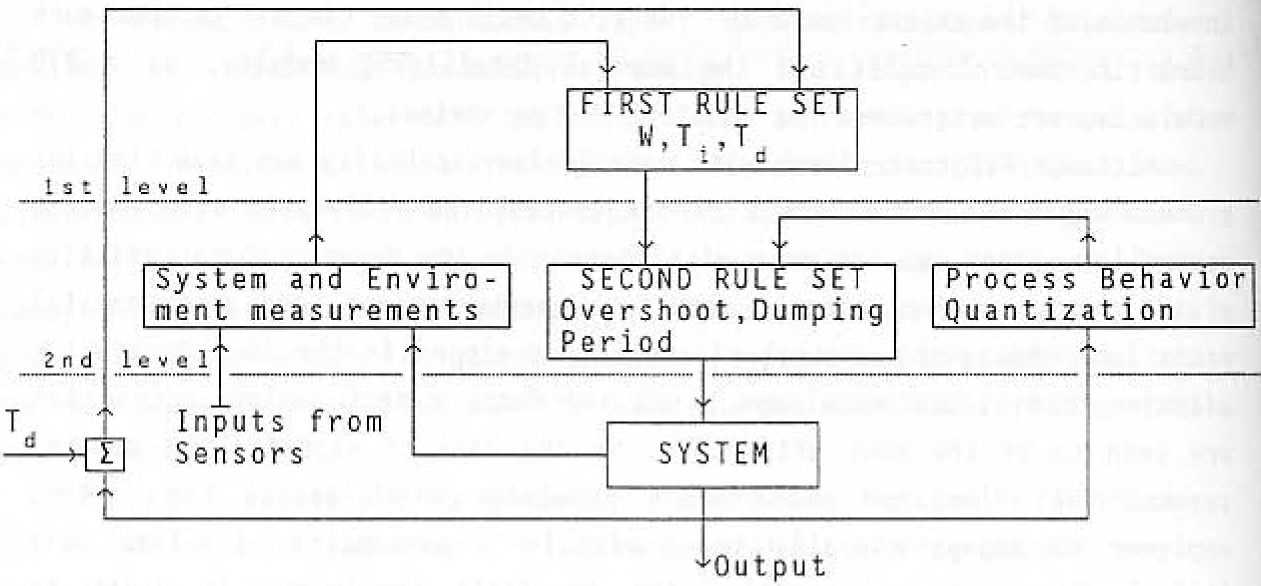

Fig.1. Hierarchical fuzzy structure.

included and refer to the primary system variables as are the water mass flow rate, the temperature of the sea water and the setpoint. The evaluation of these (first set) decision rules leads to fuzzy control actions which must farther be determined. This is done in the second level where the rules contain IF conditions that refer to the process behavior. The overshoot, dumping and period variables characterize the system transient response and are calculated before the execution of the decision tree. The IF-AND-THEN rules of the second set are based upon the following four general heuristics:

1.IF <the dumping is low> THEN {reduce proportional gain AND increase derivative gain}

2.IF <the dumping is high> THEN {increase proportional gain AND reduce derivative gain}

3.IF <the overshoot is high> THEN <increase integral gain>

4.IF <the period is high> THEN {reduce integral AND proportional gain}

We developed 30 rules for computing the incremental values of the PID parameters.