

PROJECT OF AN ELECTRIC-SOLAR SYSTEM OF FOOD DRYING WITH TEMPERATURE FUZZY CONTROL

Djanilton F. Rêgo Andrés O. Salazar André L. Maitelli Sebastião Ribeiro Antônio R. S. Costa.
Departamento de Engenharia Elétrica, Universidade Federal do Rio Grande do Norte.
Campus Universitário, Lagoa Nova, Natal - RN
djanilton@bol.com.br, andres@dca.ufrn.br, maitelli@dca.ufrn.br, seba@ufrnet.br.

Abstract – This paper presents an electric-solar dryer system based on fuzzy logic. The control signal commands a power electronics source for its to supply just the necessary energy to complement the heat absorbed by the solar collector. A supervisory system was developed for the visualization of variables of the process.

KEYWORDS

Fuzzy System, Solar Energy

I. INTRODUCTION

We developed an electric-solar dryer for food drying. The nature of the reasoning fuzzy is attractive for the automation of the conventional drying processes, because the fuzzy logic makes possible to take advantage of the experience of the human operators in the composition of computational inference rules, avoiding the effort of the operator in working with a mathematics, usually for him, incomprehensible, [1-10].

The use of power electronics circuits to accomplish the administration of the electric power is, no doubt, the most rational solution to make the control and to minimize the costs of the process. In the figure 1, the simplified block diagram of the system is shown.

II. AUTOMATION OF THE SYSTEM OF DRYING FOOD

An outline of connections of the supervisory system with the drying plant is shown in the figure 2. As we can see the system it is composed by the following parts: a drying cabin done of aluminum and screens of flexible plastic, where the foods are piled up in

trays; a wind exhaust allows the exit of humid air; a solar collector of plastic in cylindrical format; a computer and a data acquisition board (A/D-D/A); a fan coupled to a engine, allowing the flow control; a heater formed by electric resistances to supply the amount of necessary heat; a power circuit that feeds to the resistances by a bridge of tiristors in anti-parallel, which switching is controlled by a computer interface. The idea is to complement the solar energy captured by the solar collector, in order to control the temperature in the cabin.

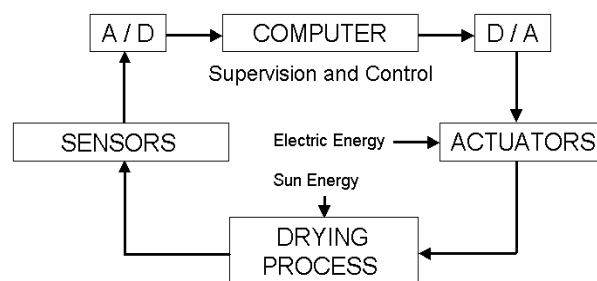


Figure 1 – Block diagram.

The equivalent resistance of the heater is 30 Ohms. The power circuit can vary the tension on the group of resistances from 0 to 220V rms, and, therefore, the power from 0 to 3500W.

III. PROJECT OF THE FUZZY CONTROLLER

In the controller's project we accomplished the following sequence of tasks: definition of the operational characteristics to establish the peculiarities of the system, such as sensors and actuators, besides inherent properties to the logic fuzzy to be used;

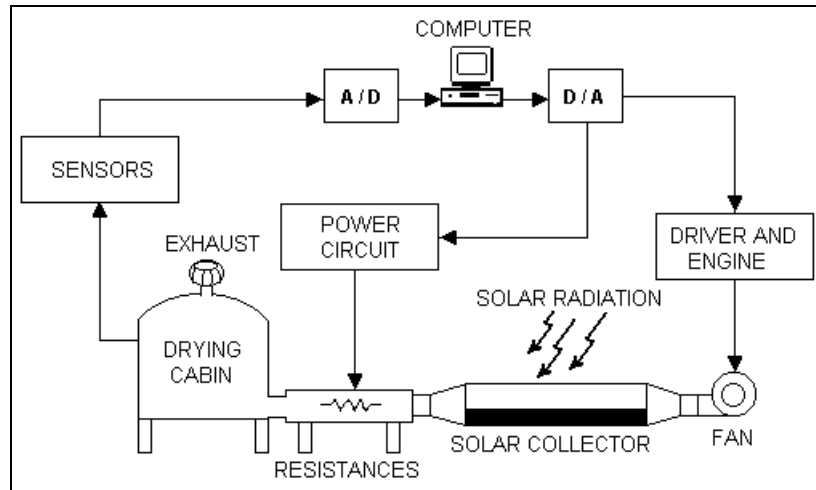


Figure 2– Automation outline.

definition of the linguistic terms of each variable, using a partial overlap of the fuzzy sets to try to guarantee softness; and definition of the rules what relate the behavior of the control action by virtue of the input variables states, [11-16].

In the figure 3, the computational logic of the control algorithm is shown. We used a controller fuzzy-PI, which is defined by a surface of nonlinear control, the inputs they are error (e) and change in error (de), and the output is change in control signal (du).

The knowledge base what generates the surface or control law is composed by a group of rules. These rules map the linguistic descriptions of the error and change in error, which act in a parallel way to supply an action control incremental defined for a linguistic description too. In the table 1, the Fuzzy Association Map is shown (rule base), [17-19].

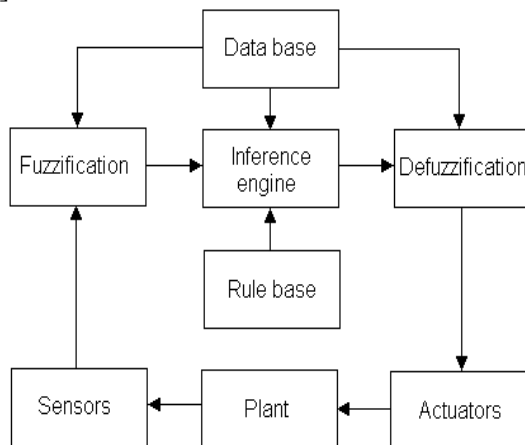


Figure 3 –Fuzzy control algorithm.

Table 1 – Fuzzy Association Matrix

(e = error, de = change in error, NB = Negative Big, NM = Negative Medium, NP = Negative Small, ZE = Zero, PS = Positive Small, PM = Positive Medium, PB = Positive Big).

$e \backslash de$	NB	NP	ZE	PP	PB
NB	NB	NB	NB	NM	NS
NS	NB	NM	NS	ZE	PS
ZE	NM	NS	ZE	PM	PS
PS	NS	ZE	PS	PM	PB
PB	PS	PM	PB	PB	PB

In the figures 4, 5 and 6, we see the normalized membership functions used in the fuzzification and defuzzification stages (data base). the fuzzification was accomplished by the method min-max of Mamdani and the defuzzification was accomplished by the method center of maximum, [20-22].

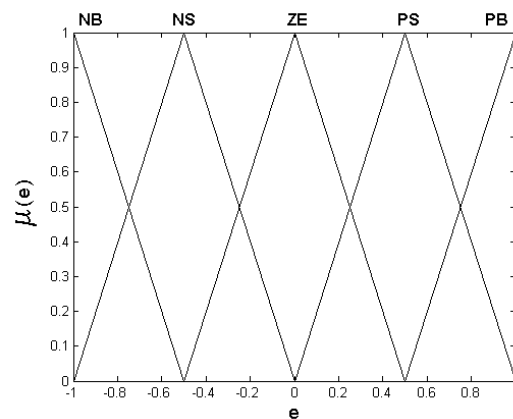


Figure 4 – Membership functions of error (e).

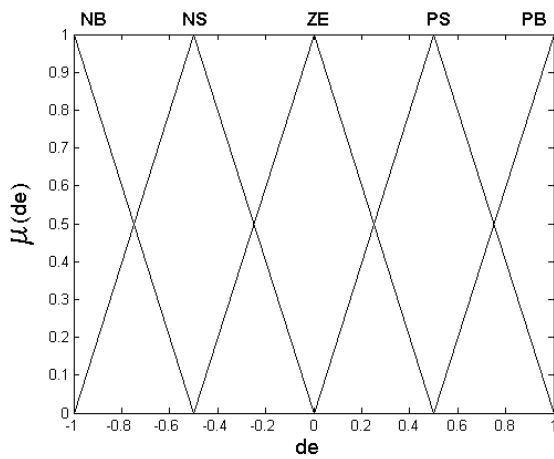


Figure 5 – Membership functions of change in error (de).

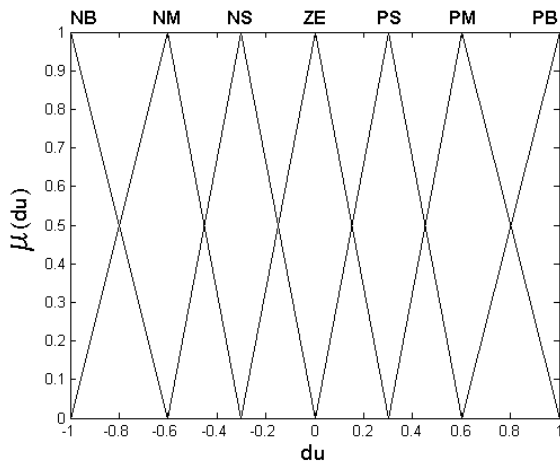


Figure 6 – Membership functions of change in control signal (du).

In the figure 7, the control surface resulting of the process of fuzzy inference is shown.

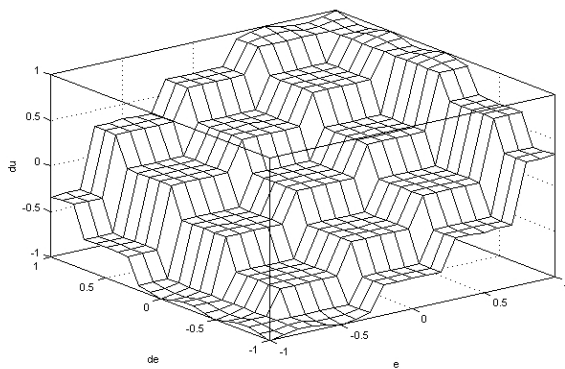


Figure 7 – Control surface.

IV RESULTS

The performance of fuzzy inference systems depends directly on several aspects related to its structure. The number of sets associated to each variable, the shapes of the membership functions, implication functions, operators t-norms and t-conorms, defuzzification method, besides scale factors, these aspects allow controllers fuzzy to have a field of work vast, due to its inherent nonlinearity. That capacity associated your robustness is being pointed out, therefore the controller implemented fuzzy-PI plays an important part in a drying process, reducing the total time of drying in at least 50%, promoting a more uniform secagem and, of course, supplying conditions so that the final product has a better quality.

In the figure 8, the evolution of the medium temperature is shown (T) inside of the drying cabin for a set-point of 60° C. The sampling rate was of 300ms.

VI CONCLUSIONS

In practical terms, the automation of the dryer of foods with the implementation of the supervisory system and the adoption of the fuzzy logic is reaching its technical objectives and it seems to have good acceptance by professionals of the food engineering, because this work is opening new perspectives in the drying and conservation of fruits in tropical areas.

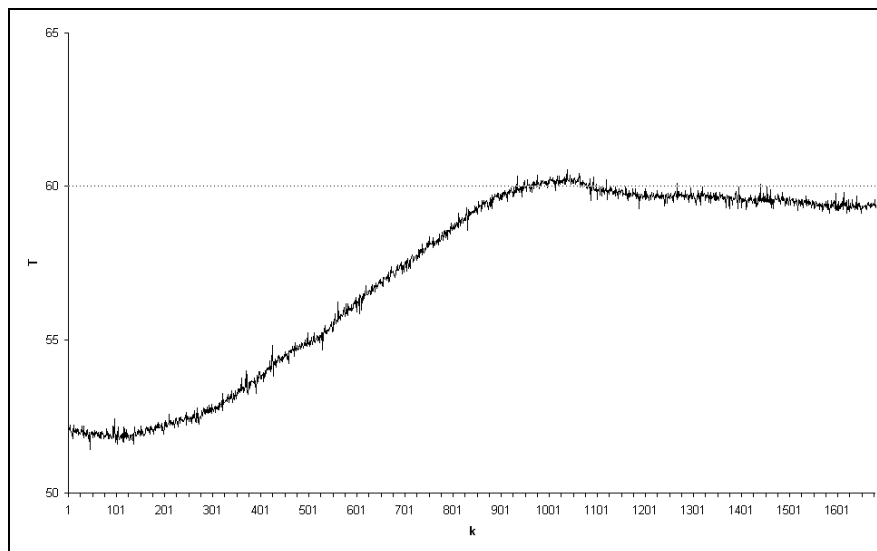


Figure 8 – Medium temperature (T) in function of the sampling instant (k).

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