THE USE OF FUZZY LOGIC IN THE STUDY OF DEEP DRAWING CYLINDRICAL PARTS THINNING

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ABSTRACT: In today's society when competitiveness is one of the main factors that companies should take into account, it is very important that all the factors involved in a manufacturing system should be studied and optimized. The quality of deep drawing parts depends on several factors. It is important to know how these factors will influence the deep drawing process. In this paper it's studied how the thickness of the parts varies, depending on the radius of the punch, the radius of the die and the blank holder force. By using the fuzzy logic toolbox under Matlab it was made with neuro-fuzzy network with three inputs and one output. The model is built on the basis of experimental tests. The model is built on experimental tests. So it can be identified the areas of minimum thickness of deep drawing part.
KEYWORDS: deep drawing, fuzzy logic, thickness

1. INTRODUCTION

The cost of the products and the productivity can be improved by optimizing the deep drawing process. Improving such measures can be done through increased deformability and reduced tool wear and reducing the percentage of waste. To achieve this some process parameters must be controlled, such as blank dimensions, blank holder force, lubrication and form of punch and die. [1] It is estimated that the decisions made in the design stage determine the 70% -80% of the productivity of manufacturing.

The methods used for checking internal and external caracteristic of deep drawing parts have change from year to year. It has been used traditional methods for taking decisions based on practice and experience. Also the designer used artificial intelligence for optimizing the deep drawing process.

The evaluation of the manufacturing aspects is performed by using various approaches as neural networks, fuzzy logic.

In recent years it was particularly interested in the integration of the two approaches, fuzzy systems and neural networks.[5][6] What is sought is to combine the transparency provided by fuzzy systems, neural networks with the property to adapt. There are a number of approaches that combine the two techniques, grouped into four main categories:

- neural models based on fuzzy;
- a training procedure based on fuzzy neural network;
- fuzzy system completed with neural network;
- adapting fuzzy based on usage neural networks

The basic idea of the approaches that fall into this category is to extend the standard model of artificial neuron so as to be able to process information represented by fuzzy sets.

Attention of researchers was concentrated particularly on developing a special type of neural network whose topology is equivalent to the structure of rules "if - then" fuzzy systems. [4]. Thus, the neural network could emulate inference mechanism of a fuzzy system. In other words, the system is transformed into a fuzzy neural network, starting from their structural equivalence. Such neural networks are called neuro-fuzzy systems and have the following advantages:

- have a transparent structure:[2]

- there is a direct correspondence between neuro-fuzzy system weights and fuzzy rules parameters;

- human expert knowledge can be used to initialize the system in order to speed up the procedure neuro-fuzzy training;

− rules extracted can be tracked by a human expert to examine their plausibility and interpret them.

2. EXPERIMENTAL RESULTS

It has been studied the development of major deformation of the workpiece along the x,y-axis, the result shown in table 1.

To achieve experimental tests (Figure 1) it has been designed and made a die for cylindrical deep drawing parts pills stamped with interchangeable.

They were made a total of 56 deep drawing parts (Figure 2).

Figure 1. Deep drawing parts manufacturing

Figure 2. Deep drawing experimental parts

These parts was made using 3 punches with different radius and 3 die with different radius, 2 blank holder forces, and 3 lubrication systems.

Measurement accuracy is very important in the study of the deep drawing process because minimum size of the blank thickness it can be found were the base and wall is meeting in a area very inaccessible with traditional instruments. For the accuracy of measurement is necessary that the number of points in with it made the measurement to be in a large number.

The measurement was made using the coordinate measuring machine, the thickness dimensions can be seen in table.

3. ADAPTIVE NEURO-FUZZY SYSTEM FOR THIKNESS DETERMINATION OF CYLINDRICAL DEEP DRAWING PARTS

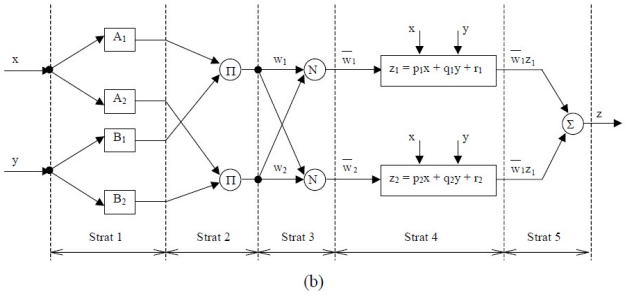
Adaptive Neuro-Fuzzy systems (ANFIS) are adaptive neural network functionally equivalent with Sugeno and Tsukamoto fuzzy system. In contrast to fuzzy system , the neuro-fuzzy systems has the capacity to adapt during a learning process. In this way applying a optimization method, can be adapted the membership functions of the fuzzy sets and the parameters of fuzzy sets. [3]

The function minimized criterion may be of mean square error of the output current neuro-fuzzy system and its desired output.

It is considered a first-order Sugeno fuzzy system which has two inputs, x and y, and an output value z. Fuzzy rule base system is considered to be composed of two rules as:[7]

Rule 1: ***if*** x is A1 ***and*** y is B1 ***then*** z is $z1 = p1 \cdot x + q1 \cdot y + r1$,

Rule 2: ***if*** x is A2 ***and*** y is B2 ***then*** z is $z2 = p2 \cdot x + q2 \cdot y + r2$.



(b)

Figure 3. Sugeno fuzzy system [7]

The Anfis model structure build for modelling the deep drawing thickness has 3 inputs, radius punch, radius die, and the blank holder force. It can be seen in figure 4

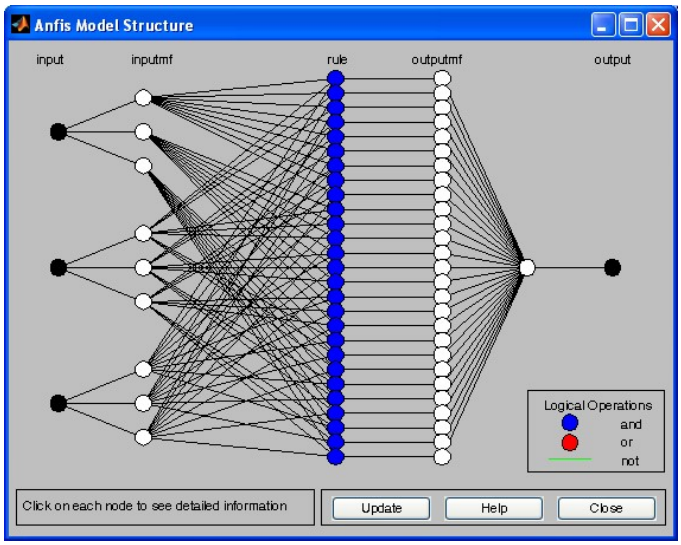


Figure 4. The structure of ANFIS model for the study model

In this way you can build a neural network equivalent to a first order Sugeno fuzzy system. The resulting construct ANFIS is not unique, and can be combined, for example, the layers 3 and 4 into one layer resulting a network with 4 layers.

The measurements of deep drawing parts made in the experimental tests are showed in table

Table 1. Deep drawing parameters

Radius die [mm]\	Punch radius [mm]	Blank holder force [N]	Minimun Thickness [mm]
3	3	20000	0,692121
5	3	20000	0,731037
8	3	20000	0,743075
10	3	20000	0,743888
3	5	20000	0,694247
5	5	20000	0,733851
8	5	20000	0,75547
10	5	20000	0,756101
3	8	20000	0,694477
5	8	20000	0,73686
8	8	20000	0,759215
10	8	20000	0,760182
3	3	30000	0,691149
5	3	30000	0,730931
8	3	30000	0,73801
10	3	30000	0,743888
3	5	30000	0,6953
5	5	30000	0,733811
8	5	30000	0,755583
10	5	30000	0,756026
3	8	30000	0,69333
5	8	30000	0,737141
8	8	30000	0,759254
10	8	30000	0,759937
3	3	40000	0,690656
5	3	40000	0,730324
8	3	40000	0,737548
10	3	40000	0,743888
3	5	40000	0,69491
5	5	40000	0,73361
8	5	40000	0,755578
10	5	40000	0,756
3	8	40000	0,69222
5	8	40000	0,736919
8	8	40000	0,758897
10	8	40000	0,759806

These material thicknesses are obtained depending on 3 parameters, the variation of die radius, of punch radius, and the variation of blank holder force. Because of the complexity of the problem, the other parameters like friction between blank and active element, or mechanical characteristics of the material, are not the subject of this study.

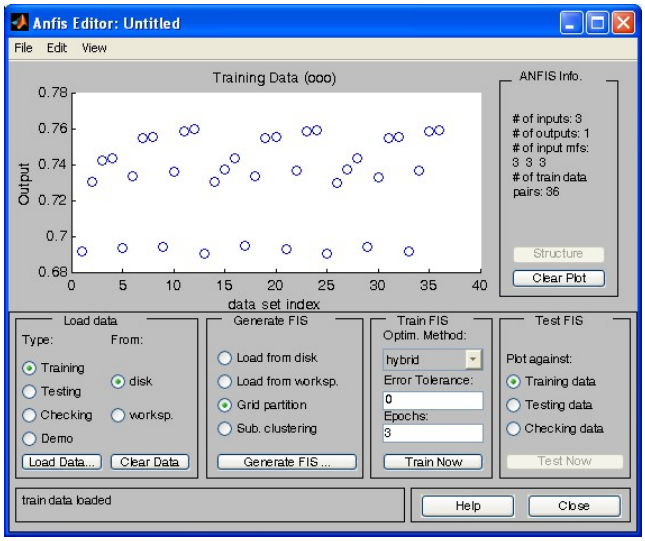


Figure 5. .Training data in ANFIS

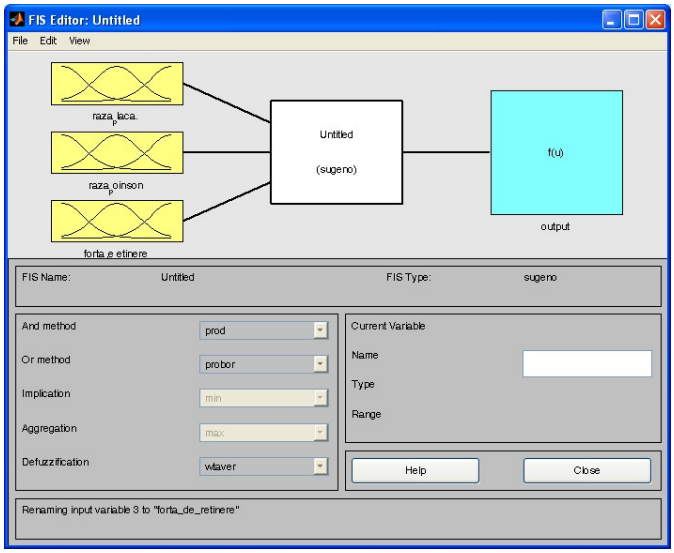


Figure 6. Fuzzy system with 3 inputs and one **output.**

Using fuzzy neural network data will be trained so that we can get the material thickness for any other combination of input parameters.

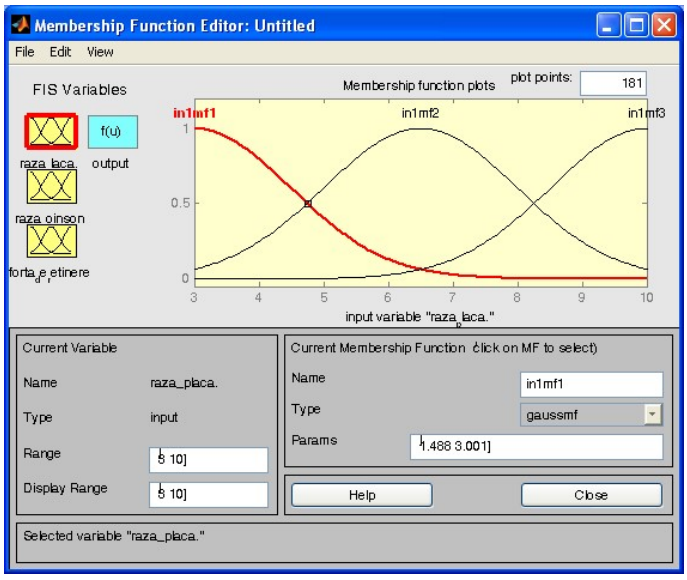


Figure 7. Radius die function membership

In figure 7, figure 8, figure 9 it can be seen the membership functions of each input parameters:

In figure 7, it is showed the membership function for the die with value in the range of 3 and 10 mm. The type of membership function is choosed to be the Gaussmf.

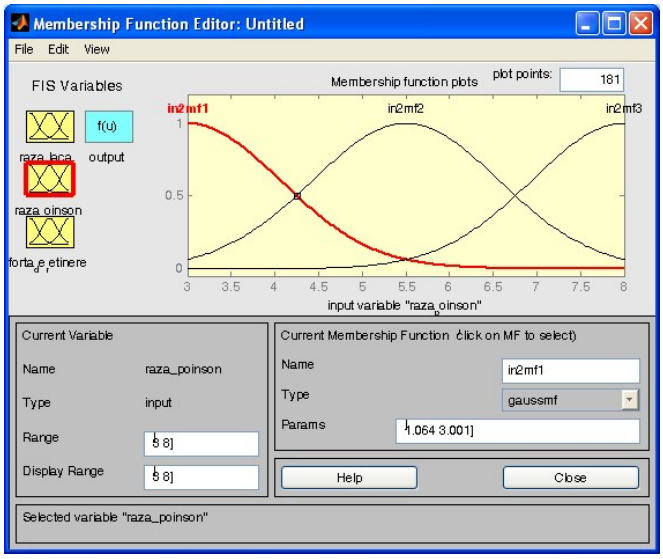


Figure 8. Radius punch function membership

The membership function of the punch is defined with range values between 3 and 8 mm and the function type is defined to be Gaussmf.

In case of blank holder force the range interval is between20 KN and 40 KN.

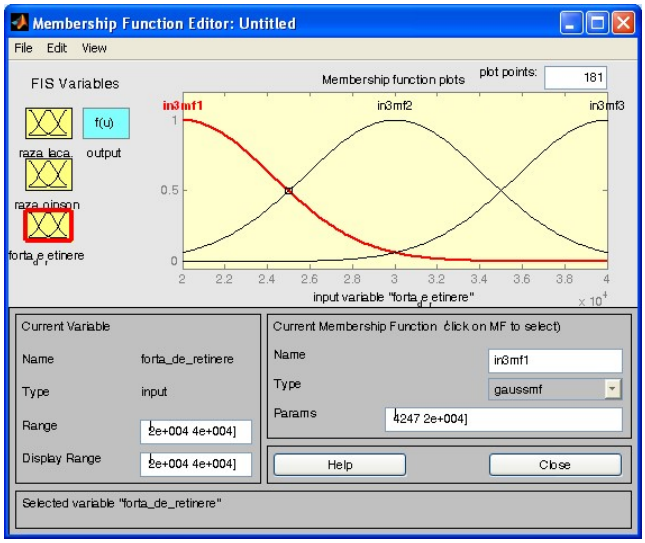


Figure 9. Blank holder force membership

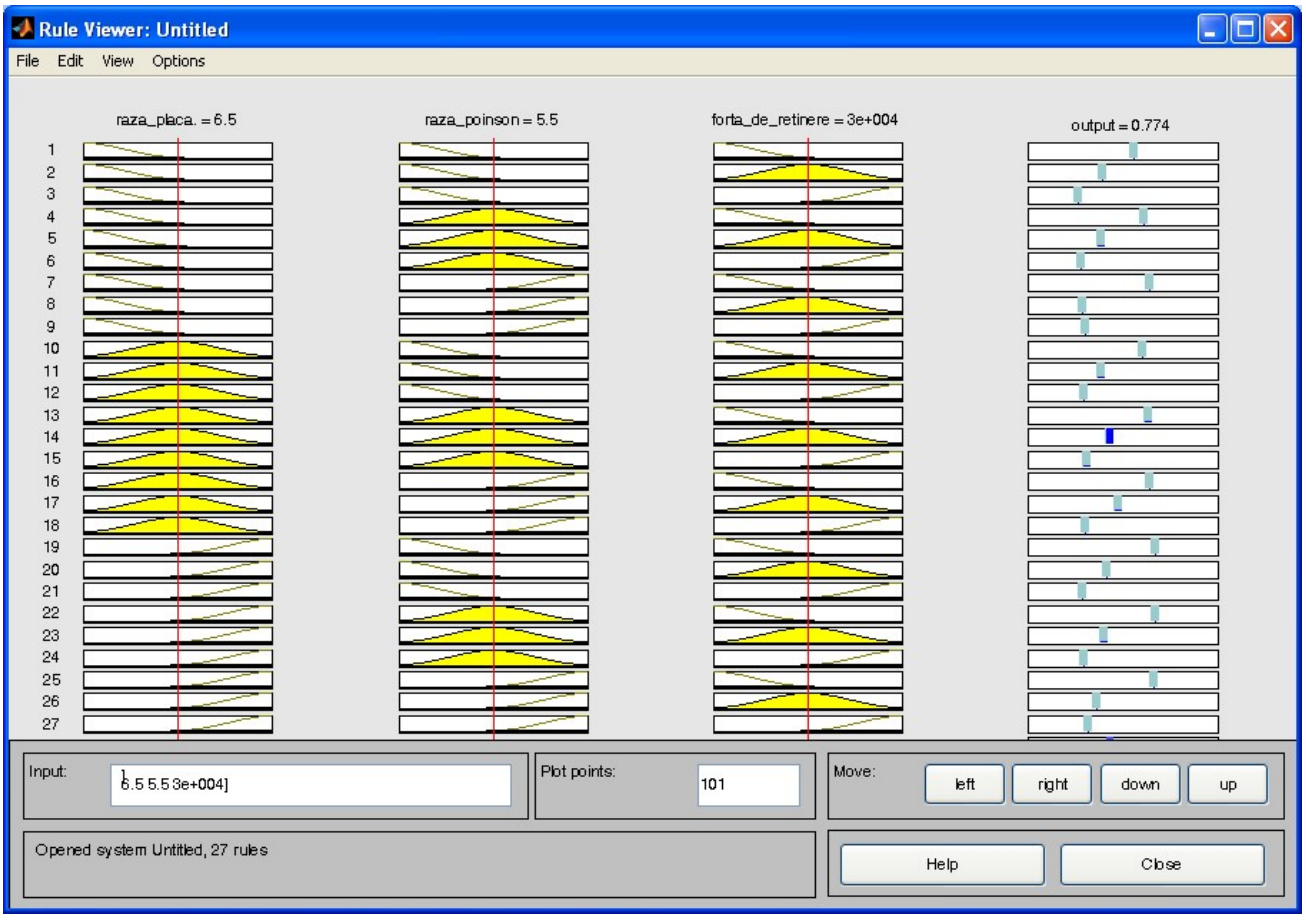


Figure 10. Fuzzy rules

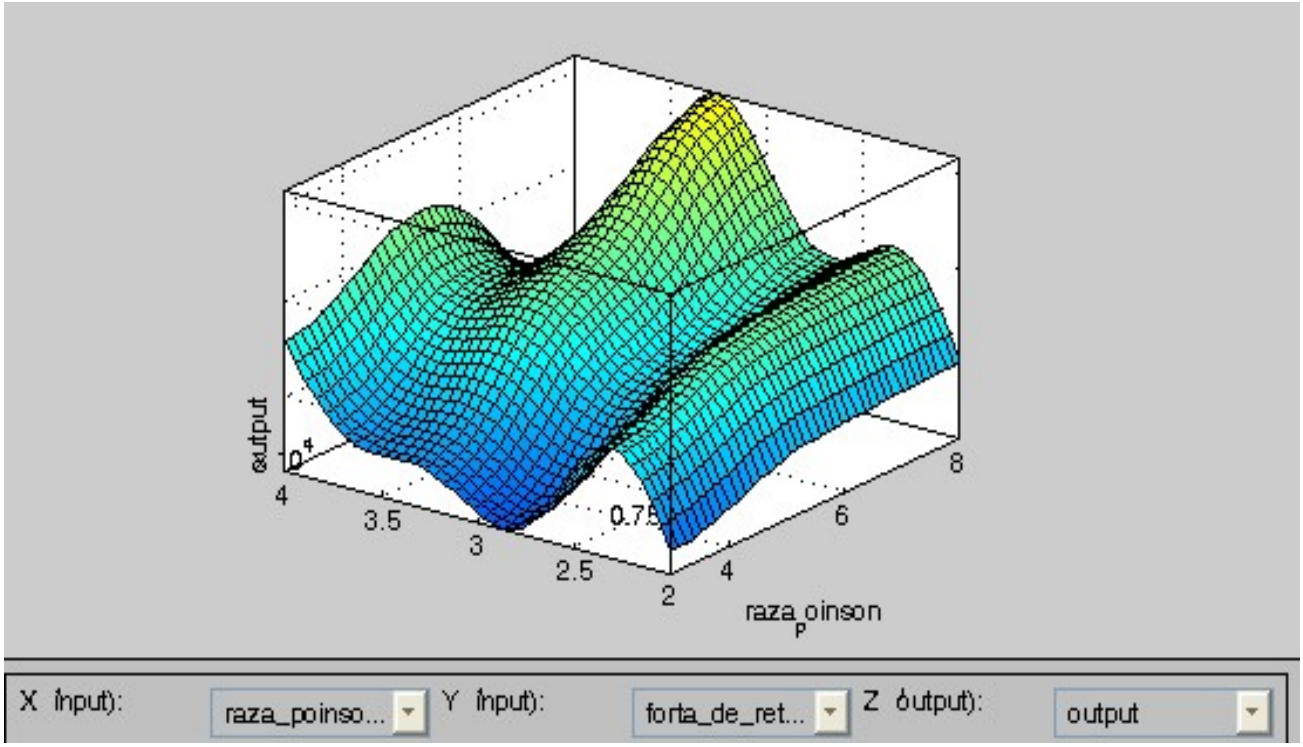


Figure 11. Influence range punch and blank holder force the workpiece thickness

4. CONCLUSIONS

The area were the base and the wall of deep drawing cylindrical parts is meet is the place where can appear more defects.

ANFIS is a powerful tool to determine the different sizes of output if input is at high accuracy measurements. The experimental tests made on deep drawing cylindrical parts can give us a clear idea about the influence of parameters. Making the data training with this experimental results and building the membership functions of each input parameters such as punch radius, die radius and blank holder force, it was obtained the thickness of deep drawing parts

Seeing were it can be found the minimum values of thickness, can lead to better solutions for die design.

5. REFERENCES

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