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# Application of Artificial Neural Network for Analysis of Droplet Size

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**ABSTRACT:** Atomization is the process in which the small size droplets are being formed using piezoelectric effect or using forced air through the orifice. The droplet size has the large effect on the properties of the materials which are being used for the number of application. The surface tension, viscosity, concentration of the precursors plays important role in the atomization process. The geometry of the orifice is also one of the important process parameter which affects the droplet size. Generally the droplet size distribution needs to be narrow. Hence In this work, the droplet size analysis is carried out using Artificial Neural network (ANN).
**Keywords:** Atomization, ANN**,** droplet distribution , process variables, MSE, optimization

## I. INTRODUCTION

Atomization is being used in number of industrial processes such as drying coating milk powder preparation etc. It is always required to have narrow distribution of the droplet as it is going to affect the size of powder. There are number of atomization processes are available such as mechanical atomization, two phase atomization, high pressure atomization, ultrasound atomization. The methodology of conversion of kinetic energy into the droplet size is important [1-4].

Typically, an atomizer is used to dispense something in small, controlled amounts [5]. An atomizer for medical use is probably the most precise type of atomizer, because it is designed to deliver a metered dose of the medication to the patient. When used for perfume, an atomizer creates a light, even spray which covers a reasonably large area. As a general rule of thumb, perfume should not be smelled by anyone except the person wearing it, or people who are in very close physical proximity with that individual. An atomizer helps to dispense a small amount of perfume so that the wearer is not drenched in it. Perfume atomizers are often made from glass and other ornamental materials, so that they are decorative as well as functional. Glass atomizers for perfume are available at some specialty stores [2-5].

In cooking, atomizers are extremely useful for dispensing small amounts of ingredients. Many cooking oils come in atomizers to create a fine spray which will cover a cooking pan, and other ingredients come in atomizers so that cooks can add a dash of flavor to a dish. Bartenders sometimes use atomizers to add a faint flavor to a drink without overpowering it. Many companies sell atomizers designed for the kitchen/medical applications which can be filled by consumers with a substance of choice [6-7]. This paper deals with the atomization process of water. Atomization is the ejection of fine droplets from a liquid film. The size of droplet formed on depends on various parameters such flow rate, surface tension. The current work helps the predicting droplet size of water using ANN.

## II. METHODOLOGY

**Figure 1** shows the formation of droplet through atomization orifice.

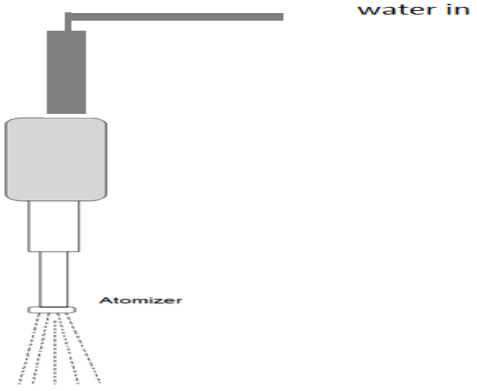


**Fig. 1:** Atomization process for the formation of droplets

The generalize atomization process using high pressure atomization of water is shown in figure 1. Schematic diagram of the proposed neural network is as shown below figure 2. It consists of:
Input neurons = 11, Hidden neurons = 20 (arbitrarily fixed), Output neurons = 1 (dp).

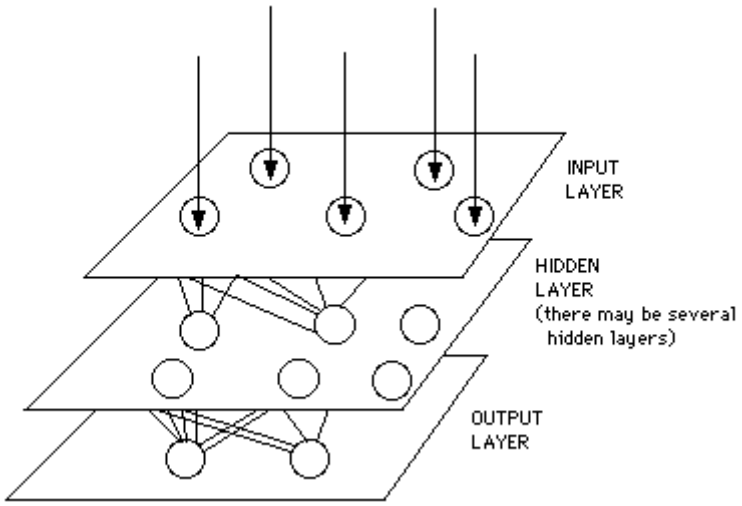


**Fig. 2:** Proposed neural network schematic diagram

The number of hidden layer neurons can be changed later after testing for improved network performance. The performance of the ANN was statistically measured by the mean squared error (MSE) and the coefficient of determination ($R^2$) as follows:

$$MSE = \frac{\sum_{i=1}^{n}\left(X_{pre,i} - X_{exp,i}\right)^2}{n} \qquad R^2 = 1 - \frac{\sum_{i=1}^{n}\left(X_{pre,i} - X_{exp,i}\right)^2}{\sum_{i=1}^{n}\left(X_{exp,i} - \overline{X}\right)^2}$$

where Xpre,i is the predicted output from neural network, Xexp,i is the experimental (target) output, $\overline{X}$ is the average value of experimental output, and n is the total number of data obtained.

## III. RESULTS AND DISCUSSION

In this work, input and output data were normalized (scaled) between 0 and 1, before training network as follows:

$$(Scaled)_{value} = \frac{(Actual)_{value} - minimum_{(Actualvalue)}}{maximum_{(Actualvalue)} - minimum_{(Actualvalue)}}$$

It is necessary to train an ANN before using it for a particular application. Feed forward network training starts by applying the input vector to the input layer having network processing element. During the training, the network learns to create new outputs through a repetitive method. Generated outputs by network are compared to the target. The network is adjusted, based on a comparison of the output and the target, until the network output matches the target. After training, the trained network is tested by testing data to further check if the network achieved good generalization [7-8].

Training of the network is performed with the function of "trainlm" in MATLAB 7.10 (R2010a) that updates weight and bias values according to the Levenberg-Marquardt optimization. It is an algorithm that trains neural networks 10 to 110 times faster than the usual back propagation algorithm. While back propagation is a steepest descent algorithm, the Levenberg-Marquardt algorithm is a variation of Newton's method. Here, for modeling xylitol production, the Levenberg-Marquardt algorithm has been employed which is an approximation to Newton's method. The input is table and the target table, both of which are saved as excel sheets and imported into MATAB GUI. Input data were randomized into three sets: learning, validation and testing. Usually, 40% of data are used for testing and the remaining 60% for training and validation. Here, we have the following random data distribution:

| | | |
|---|---|---|
| Training | 60% | = 300 samples |
| Validation | 20% | = 60 samples |
| Testing | 20% | = 60 samples |

These are presented to the network during training, and the network is adjusted according to its error as shown in figure 3. These are used to measure network generalization, and to halt training when generalization stops improving as shown in figure 3. The regression and validation is carried out as shown in figure 4 and figure 5. These have no effect on training and so provide an independent measure of network performance during and after training. Total number of iterations is five. The details of regression, mean square error are reported in Table 1. Mean Squared Error MSE is the average squared difference between outputs and targets. Lower values are better. Zero means no error. Regression R Values measure the correlation between outputs and targets. An R value of 1 means a close relationship, 0 a random relationship. From figure 5, it can be seen that the predicted results are quite cohesive to the exact experimental results obtained. The predicted output would be of help in evaluating the optimal parameter values and in examining the output response with respect to a change in any of the parameters.

**Table I: The results of training validation and testing of the set of samples of atomization**

| Operation | Samples | Mean Square Error | Regression Value |
|---|---|---|---|
| Training | 5 | 2.18591e-19 | 0.999 |
| Validation | 3 | 6.3788e-6 | 1.00000 |
| Testing | 3 | 3.41359e-6 | 0.989 |

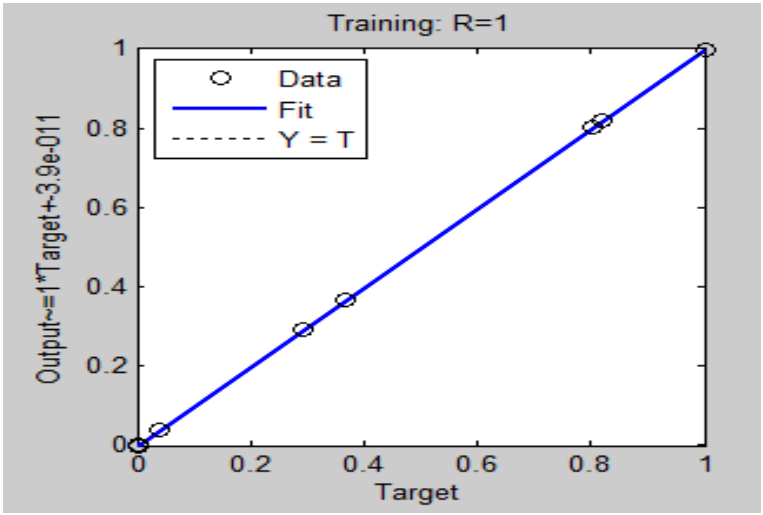


**Fig. 3:** Regression plot for training

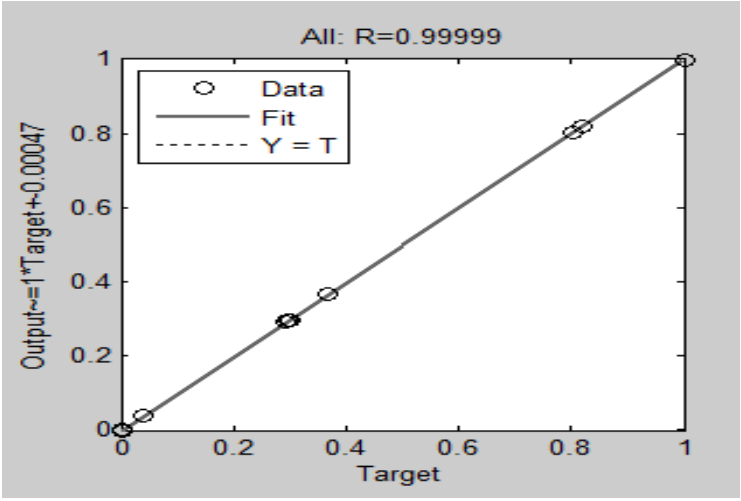


**Fig. 4:** Regression plot for complete fitting

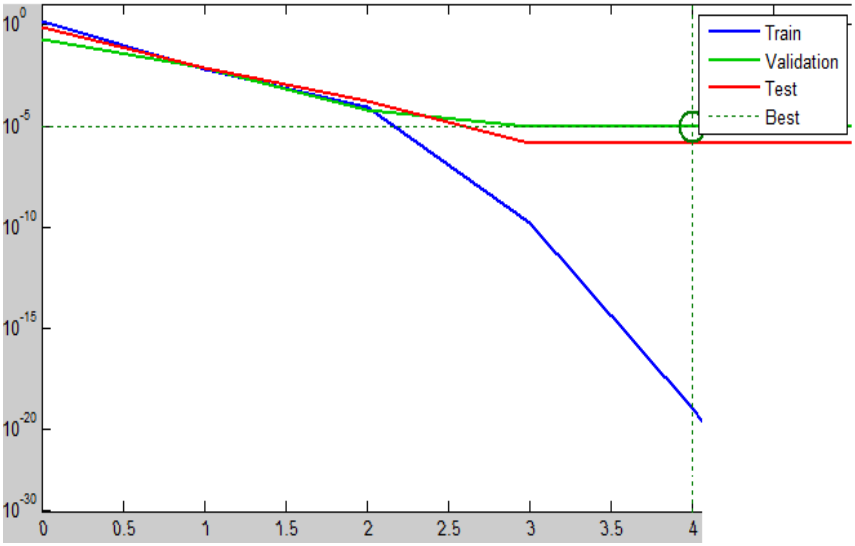


**Fig. 5:** Performance plot for training, validation and testing

## IV. CONCLUSION

It can be seen that the results are quite possible to predict the droplet size. The predicted parameters could be useful for the optimization process in order to get the narrow size droplet distribution. ANN methodology can be used for the finding optimum parameters for combustion process and atomization of jet fuel.

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