Study and modeling of changes in volumetric efficiency of helix conveyors at different rotational speeds and inclination angels by ANFIS and statistical methods

A. Zareei[1]- R. Farrokhi Teimourlou[2]- L. Naderloo[3*]- S. M. H. Komarizade Asl[4]

Introduction

Spiral conveyors effectively carry solid masses as free or partly free flow of materials. They create good throughput and they are the perfect solution to solve the problems of transport, due to their simple structure, high efficiency and low maintenance costs.

This study aims to investigate the performance characteristics of conveyors as function of auger diameter, rotational speed and handling inclination angle. The performance characteristic was investigated according to volumetric efficiency. In another words, the purpose of this study was obtaining a suitable model for volumetric efficiency changes of steep auger to transfer agricultural products. Three different diameters of auger, five levels of rotational speed and three slope angles were used to investigate the effects of changes in these parameters on volumetric efficiency of auger. The used method is novel in this area and the results show that performance by ANFIS models is much better than common statistical models.

Materials and Methods

The experiments were conducted in Department of Mechanical Engineering of Agricultural Machinery in Urmia University. In this study, SAYOS cultivar of wheat was used. This cultivar of wheat had hard seeds and the humidity was 12% (based on wet). Before testing, all foreign material was separated from the wheat such as stone, dust, plant residues and green seeds. Bulk density of wheat was 790 kg m^{-3}. The auger shaft of the spiral conveyor was received its rotational force through belt and electric motor and its rotation leading to transfer the product to the output. In this study, three conveyors at diameters of 13, 17.5, and 22.5 cm, five levels of rotational speed at 100, 200, 300, 400, and 500 rpm and three handling angles of 10, 20, and 30º were tested.

Adaptive Nero-fuzzy inference system (ANFIS) is the combination of fuzzy systems and artificial neural network, so it has both benefits. This system is useful to solve the complex non-linear problems in agricultural engineering applications. ANFIS by linguistic concepts can establish and inference non-linear relationship between inputs and outputs. In this research, generally modeling was performed by using toolbox of ANFIS and coding in MATLAB software. Five important and effective factors in modeling were optimized until the best ANFIS model was obtained. The five factors were: type of fuzzy sets for inputs, number of fuzzy sets for inputs, type of fuzzy set for output, method of optimization and number of epochs. The statistical model was done by using SPSS and in the multivariate regression method. In multivariate linear regression in statistical model, the independent variables were auger blade diameter, rotational speed and the angle of slope of the auger and dependent variable was volumetric efficiency. The factorial test in randomized complete block design was conducted for variance analysis of volumetric efficiency. Mean Comparison of volumetric efficiency in different levels of factors was performed using Duncan' test in 5% level.

Conclusions

In this study, volumetric efficiency of spiral conveyors was investigated as a function of auger blade diameter, auger rotational speed and slope of transfer. The performance was measured in terms of volumetric

1- M.Sc. Graduated Student, Mechanical Engineering of Agricultural Machinery Dept., Urmia University, Urmia, Iran
2- Assistant Professor, Mechanical Engineering of Agricultural Machinery Dept., Urmia University, Urmia, Iran
3- Assistant Professor, Mechanics of Biosystems Engineering, Razi University, Kermanshah, Iran
4- Professor, Mechanical Engineering of Agricultural Machinery Dept, Urmia University, Urmia, Iran
(*- Corresponding Author Email: l.naderloo@razi.ac.ir)

efficiency using ANFIS and statistical models with SPSS. The results showed that:

Volumetric efficiency almost decreased by increasing of rotational speed, for all three conveyors.

Maximum volumetric efficiency in all three spiral conveyors was in the speed range of 100 to 200 rpm.

Volumetric efficiency significantly reduced in all three spiral conveyors by increasing in rotational speed and slope of transferring in spiral conveyors.

Effect of spiral conveyor diameter on the volumetric efficiency in product transferring was irregular and no specific process is appeared.

The correlation coefficient between the actual and predicted values was obtained as 0.98 in ANFIS model and 0.94 in multivariate linear regression with SPSS which showed the ANFIS model was more accurate than statistical model.

Comparison between performances of spiral conveyor to transfer the seeds of wheat, with results by other researchers that has been reported for spiral conveyors with the same slope to transfer of corn kernels, was found that the angle effect on volumetric efficiency is quite significant. Therefore, it proves that performances of spiral conveyor are impressed by characteristics of transition material considerably.

The maximum volumetric efficiency was corresponded in rotational speed of 100 rpm, inclination angle of 10º, and blade diameter of 17.5 cm that it was approximately 29.11%.

Keywords: Angle of transfer, Fuzzy sets, Helix conveyor, Optical digital tachometer