Simulation of Energy Consumption in Jaw Crusher Using Artificial Intelligence Models

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Introduction

- The **size reduction of feed rocks** is an important mechanical operation in the processing of raw materials in several industries such as **mining** and the **cement industry**.
- Any inefficiency in crusher power consumption within these **energy intensive equipment** leads to the loss of billions of kilowatt-hours of electricity per year .
- The use of inefficient crushers may lead to many troubles as the process quality may depend mainly on the quality of crushers to feed the downstream process with product in acceptable reduced size.
- To optimize crushing energy efficiency, **proper modelling** relating the stone strength and jaw crusher parameters to successfully estimate the power consumption is required.
- **ANFIS** is ideal to predict specific energy consumption based on input predictor variables in the process of jaw crushing.
- In this work, power consumption of jaw crusher is predicted to provide specific reduced rock size with the help of **ANFIS** modelling; as one of the computing techniques playing great importance in modelling the input-output parameters relationship.

ANFIS Modelling

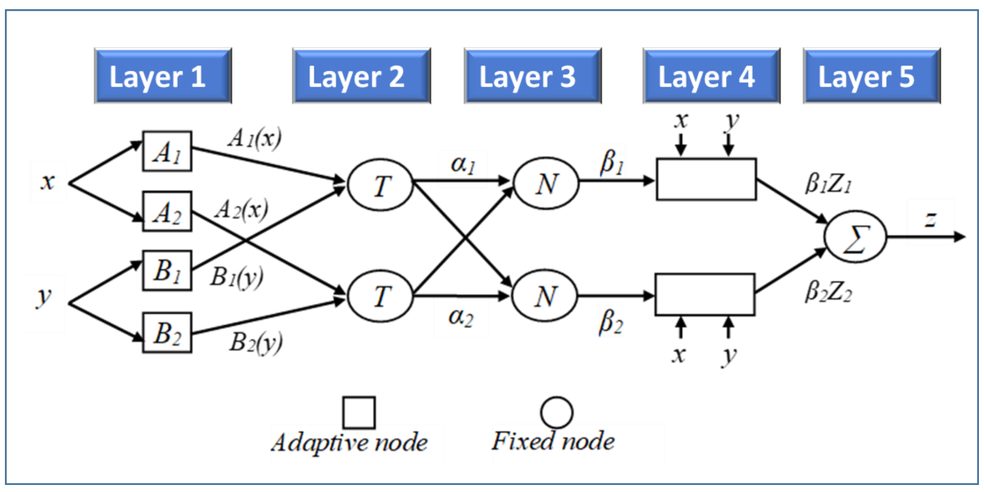

Fig.1 ANFIS architecture for a two input Sugeno fuzzy model.

Layer 1

First parameter membership function $A_i(u) = exp\left[-\frac{1}{2}\left(\frac{u-a_{i1}}{b_{i1}}\right)^2\right]$

Second parameter membership function $B_i(v) = exp\left[-\frac{1}{2}\left(\frac{v-a_{i2}}{b_{i2}}\right)^2\right]$

Layer2

Top neuron $\alpha_1 = A_1(x) \times B_1(y)$

Bottom neuron $\alpha_2 = A_2(x) \times B_2(y)$

Layer 3

Top neuron $\beta_1 = \frac{\alpha_1}{\alpha_1+\alpha_2}$

Bottom neuron $\beta_2 = \frac{\alpha_2}{\alpha_1+\alpha_2}$

Layer 4

Top neuron $\beta_1 z_1 = \beta_1 (a_1 x + b_1 y)$

Bottom neuron $\beta_2 z_2 = \beta_2 (a_2 x + b_2 y)$

Layer 5 $z = \beta_1 z_1 + \beta_2 z_2$ $E_k = (y^k - o^k)^2$

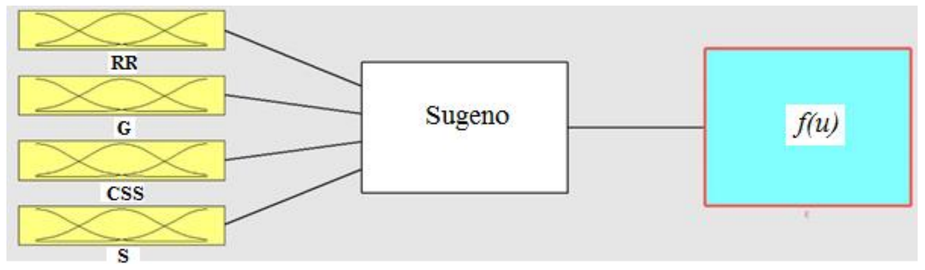

Fig. 2 Fuzzy role architecture of the gaussian membership function

Results and Model Verificacion

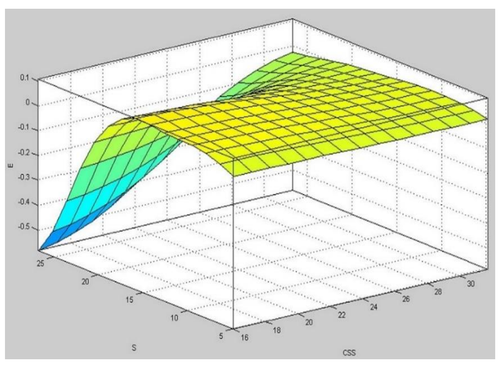

Fig. 3 Energy (E) in relation to change of closed side set (CSS) and Strength (S)

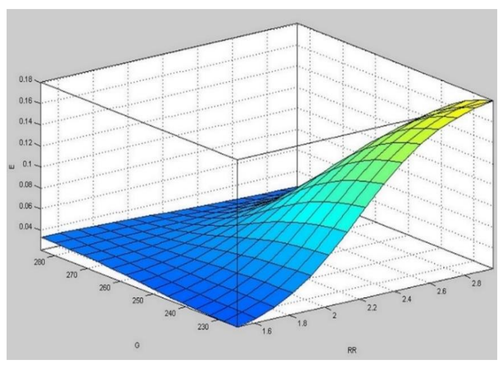

Fig. 4 Energy (E) in relation to change of Gape (G) and Reduction ratio (RR)

$$E_i = \frac{|Em_i - Ep_i|}{Em_i} \times 100$$

Fig. 5 Error bars for the predicted energy with the help of ANFIS model versus the measured energy values for different test data

$$E_{av} = \frac{\sum_{i=1}^{m} E_i}{m}$$

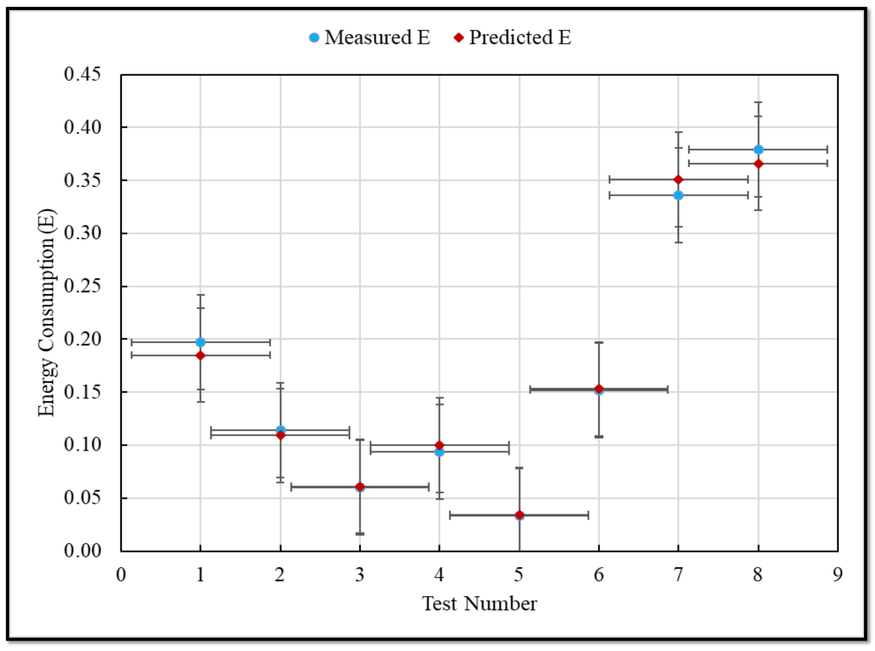

Table 1: The ANFIS predicted powers versus the measured power consumed by jaw crusher

Test No.	PARAMETERS				POWER CONSUMPTION KWH/T		ERROR (%)
	RR	Gape (mm)	CSS (mm)	S (MPa)	Measured E	Predicted E	
1	1.5	284	31.75	21.666	0.197	0.185	6.09
2				8.33	0.114	0.109	4.39
3				6.286	0.06	0.061	1.67
4				8.069	0.094	0.1	6.38
5	2.97	224	16	4.897	0.033	0.034	3.03
6				8.071	0.152	0.153	0.66
7				8.635	0.336	0.351	4.46
8				11.021	0.379	0.366	3.43
					Average Error		3.76

Conclusion

- The closed side set, gap, stone strength, and intended reduction ratio are among the predictor input inputs.
- ANFIS model was created using a set of 32 particular energy consumption values measured under varied crushing settings.
- The adequacy of the proposed model to provide the precise energy usage was next evaluated using another set of 8 collected data.
- ANFIS model with gaussmf has a high level of accuracy (more than 96%) for predicting the specific energy consumption of jaw crushers.