APPLICATION OF NEURAL NETWORKS TO PREDICT MULTICOMPONENT PORCELAIN TILE PROPERTIES

[1,2] F. A. Corbelini de Souza, [1] N. Schwartz da Silva,
[2] R. A. Francisco Machado, [2] D. Hotza

[1] T-Cota Engenharia de Minerais Industriais,

Rua Coronel Izidoro, Brazil

[2] Núcleo de Materiais Cerâmicos e Vidros (CERMAT)

Universidade Federal de Santa Catarina (UFSC) Brazil

1. INTRODUCTION

In an artificial neural network, the coefficients of a multiple-term polynomial are adjusted using a training algorithm. Prior papers documenting the application of artificial neural networks to metal, polymer, composite and ceramic materials have opened up a promising path towards discovering new materials and predicting behaviour patterns. The overall objective of this work is to obtain neural networks for mixture experiments, as well as to assess their performance in predicting porcelain tile properties.

2. METHODS AND RESULTS

The experiments were carried out at the T-cota Engenharia de Minerais Industriais facilities in Tijucas, SC, Brazil, where the industrial porcelain tile manufacturing process stages were reproduced on a pilot-plant scale. The raw materials were identified by codes that referred to the role they played in the mixture: 'F' for flux, 'R' for refractory and 'P' for plastic. Table 1 shows the formulations of the processed porcelain tile mixtures. Table 2 presents the processing parameters for this system.

The following properties were assessed: post-pressing dry bulk density; post-firing bending strength, bulk density, water absorption, and fired linear shrinkage.

MetLab R13 software was employed to create an artificial neural network for each property under study. Relative response errors depending on the number of neurons in the composition networks display the same trend, thereby indicating that a certain generalization exists in the relationship between the formulation and the properties. Mean prediction errors of between 0% and 10% were revealed for dry bulk density, fired linear shrinkage and water absorption (1100 and 1140°C), the smallest error being 0.2% for dry bulk density. Prediction errors of between 10% and 20% were found for mechanical strength and water absorption at 1180°C. The largest prediction error was for dry mechanical strength.

3. CONCLUSIONS

Neural networks are able to model the relationship that exists between the composition and end properties of multicomponent ceramics. Systems that do not naturally exhibit linearity can be dealt with using neural networks. Systems that do exhibit linearity can be treated with the classic linear regression method or with neural networks. When they are treated with neural networks, a smaller standard deviation is seen. Generally, the use of neural networks in mixture experiments has been found to be an efficient way of developing porcelain tile formulations.

Mixture	Composition (% by weight)									
	F1	F2	F3	P1	P2	P3	P4	P5	P6	P7
1	20	40	-	-	15	-	-	-	25	-
2	-	50	-	15	-	2	8	25	-	-
3	-	50	2	-	-	15	8	-	25	-
4	-	50	5	-	15	5	-	15	-	10
5	12	30	5	15	5	-	8	-	25	-
6	10	50	5	-	15	5	8	7	-	-
7	17	30	-	-	15	5	8	15	-	10
8	10	50	5	-	2	-	8	15	-	10
9	20	35	5	15	-	-	-	25	-	-
10	-	50	5	15	-	5	-	-	15	10
11	20	40	5	-	2	-	8	-	25	-
12	12	30	5	-	5	15	8	-	15	10
13	20	40	-	5	-	15	-	-	10	10
14	20	30	5	-	-	15	5	25	-	-
15	20	40	5	15	-	2	8	-	-	10

Table 1. Porcelain tile formulations.

Stage	Parameter		Value
Milling	Water (%)		40
	Solids (%)		60
	Residue	Mesh	325
		Oversize (%)	4.5 to 5.0
Pressing	Moisture content (%)		6.5
	Pressure (kgf/cm^2)		300
Firing	Total time (min)		51
	Time at peak firing temperature (min)		10
	Peak firing temperature (ºC)		1100, 1120, 1140, 1160, 1170, 1180, 1190, 1200

Table 2. Process parameters for porcelain tiles.

REFERENCES

[1] RAO, H.S.; MUKHERJEE, A. Artificial neural networks for predicting the macromechanical behaviour of ceramic-matrix composites. Computational Materials Science, v. 5, p. 307 – 322, 1996.

[2] GUO, D.; LI, L.; NAN, C.; XIA, J.; GUI, Z. Modeling and analysis of the electrical properties of PZT through neural networks. Journal of the European Ceramic Society, v. 23, p. 2177 – 2181, 2003.

[3] SCOTT, D. J.; COVENEY, P. V.; KILNER, J. A.; ROSSINY, J. C. H.; ALFORD, N. M. N. Prediction of the functional properties of ceramic materials from composition using artificial neural networks. Journal of the European Ceramic Society, v. 27, p. 4425 – 4435, 2007.