RA-TeS Software for Response Surface Methodology of the Mixture Experiments

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Abstract
Response surface methodology, or RSM, is a collection of mathematical and statistical techniques useful for the modeling and analysis of problems in which a response of interest is influenced by several variables and the objective is to optimize this response. In mixture experiments, the factors are the components or ingredients of a mixture, and consequently their levels are not independent. For example, if $x_1, x_2, \ldots, x_p$ denote the proportions of p components of a mixture, then

$$0 \leq x_i \leq 1 \qquad i = 1, 2, \ldots, p$$

and

$$x_1 + x_2 + \cdots + x_p = 1 \text{ (i.e., 100 percent)}$$

This paper presents the RA-TeS software for RSM of three-component mixture systems developed at Faculty of Mechanical and Civil Engineering in Kraljevo. The fitted models are analyzed to assess their adequacy and to determine the significance of the model terms. This involves conducting analysis of variance (ANOVA) to test the statistical significance of the factors and their interactions. The optimized levels of the mixture components are determined based on the fitted models and the desired response. Optimization techniques, such as RSM, are employed to find the optimal factor settings that maximize or minimize the response variable.
Overall, Response Surface Methodology for Mixture Experiments provides a systematic approach for studying and optimizing mixture processes. It allows for efficient exploration of the factor space, modeling of the relationship between mixture components and response variables, and identification of optimal factor settings to achieve desired outcomes.

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Graphical abstract:

ФМГ КРАЉЕВО
УНИВЕРЗИТЕТ У КРАГУЈЕВЦУ

Regresion Analysis in Ternary System

RA-TeS

n = **30** α = **0.01**

Data:

	x1	x2	x3	Y
	Ni	Pb	Sb	EP (MS/m)
1	0.30	0.40	0.30	2.49
2	0.30	0.40	0.30	2.45
3	0.30	0.40	0.30	2.45
4	0.20	0.60	0.20	1.56
5	0.20	0.60	0.20	1.51
6	0.20	0.60	0.20	1.49
7	0.16	0.69	0.16	1.96
8	0.16	0.69	0.16	1.98
9	0.16	0.69	0.16	1.97
10	0.30	0.30	0.40	2.66
11	0.30	0.30	0.40	2.62
12	0.30	0.30	0.40	2.63
13	0.10	0.10	0.80	1.37
14	0.10	0.10	0.80	1.38
15	0.10	0.10	0.80	1.30
16	0.05	0.05	0.90	1.78
17	0.05	0.05	0.90	1.69
18	0.05	0.05	0.90	1.83
19	0.12	0.12	0.77	2.35
20	0.12	0.12	0.77	2.34
21	0.12	0.12	0.77	2.48
22	0.08	0.08	0.85	3.68
23	0.08	0.08	0.85	3.72
24	0.08	0.08	0.85	3.69
25	1.00	0.00	0.00	0.45
26	0.00	1.00	0.00	1.31
27	0.00	0.00	1.00	2.50
28				
29				
30				

Model Summary Statistic

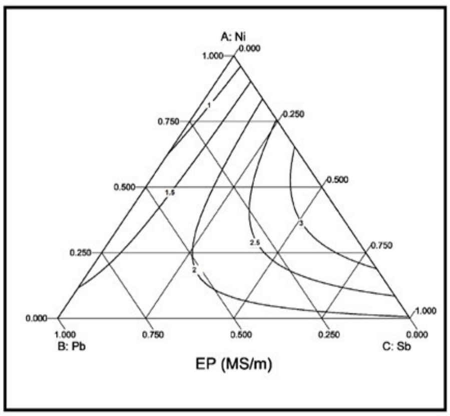
Source	Std. Dev	R-Squared	Adjusted R-Squared	Predicted R-Squared	PRESS	F rp p hqw
Linear	0.7400	0.1591	0.0891	-0.7802	28.0400	
Quadratic	0.6900	0.3565	0.2033		+	
Special Cubic	0.6900	0.3957	0.2144		+	
Cubic	0.7000	0.4088	0.1910		+	Aliased
Special Quartic	0.7200	0.4070	0.1435		+	Suggested
Quartic	0.7200	0.4476	0.1551		+	Aliased

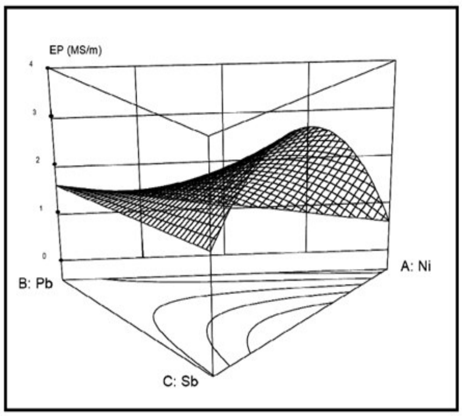
Selected model **5**

ANOVA - The Analysis of Variance

Source of Variation	Sum of Square	Degrees of Freedom	Mean Square	F-Value	p-Value	
Regression (fitted model)	9174	8	0.8	1.54	0.2107	significant
Linear Mixture	5134	2	1.25	2.42	0.1177	
AB	3135	1	0.02	0.039	0.8451	
AC	714:H036	1	4.17E-03	8.04E-03	0.9296	
BC	51B<H036	1	2.59E-03	4.99E-03	0.9445	
A^2BC	51B:H037	1	2.57E-04	4.95E-04	0.9825	
AB^2C	314	1	0.1	0.19	0.6646	
ABC^2	3148	1	0.15	0.28	0.6003	
Residual	<167	18	0.52			
Lack of Fit	<164	2	4.65	2358.6	< 0.0001	not significant
Pure Error	31365	16	1.97E-03			
Cor Total	481:8	26				

TERNARY GRAPH





Model:

EP (MS/m) = +0.45*Ni+1.32*Pb+2.29*Sb+92.81*Ni*Pb+50.35*Ni*Sb-41.35*Pb*Sb-103.78*Ni^2*Pb*Sb-476.14*Ni*Pb^2*Sb-143.10*Ni*Pb*Sb^2

Date: 10-06-23	Noted:	M. Kolarević

Response Surface Designs Report.