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# *A modified SPACE Method for Determining the Product and Market Position of the Industrial Product on an Example of Raw Material Grinding Machines*

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**ABSTRACT**

The *SPACE* (Strategic Position and Action Evaluation) method is an analytical technique used in the companies' strategic management and planning, encompassing the object of analysis through two internal dimensions (financial strength and competitive strength) and two extreme dimensions (environmental stability and industry strength) [3,5,7]. The analysis evaluates the internal and external environment in order to obtain an appropriate idea regarding the business strategy and development directions of a company [2, 6]. By modifying the methodological flows of the *SPACE* method and in accordance with the research problem, as well as by selecting the assessment dimensions and a set of parameters encompassing each of the four selected dimensions, the paper has, on an example of grinding machines, identified its position from the aspect of technical, technological, cost-related and environmental parameters. In the subsequent analysis, in order to strengthen the decision on machine assessment, additional criteria for assessing the machine were introduced, taking into account the three most significant parameters from each group. Apart from the raw material grinding machines, the modified *SPACE* method enables the analysis of machine manufacturer's references or those belonging to the industrial plant for raw material processing, and the obtained assessment data can be used by investors and companies for making decisions on procuring a new machine (facility), as well as reconstructing or modernising the existing one.

**Keywords:** parameters, dimensions, matrix, assessment, decision-making

## Possible Modification of the *SPACE* (Spatial) Matrix

The market differentiation process for products and technologies specifies the course of achieving a favourable market position through the company's business reputation and the brand of the industrial product. Differentiation elements rely on the dimension of product design, essence, quality, shaping, product price and brand [2, 3]. Determining the strategic position of [1]:
1.The grinding machine manufacturers and technology holders from the area of the mining and machinery industry and
2.The grinding machine as an industrial product.

The method for determining the strategic position is actually a modified *SPACE* matrix which could not have been applied in its original form for assessing grinding machines because:

- the vector directions illustrate only two variables in the coordinate system,

- we are determining the strategic position of an industrial branch, i.e. financial strength and competitive advantage of a business, the strength of the company's branch and

- of the stability of the surrounding business environment.

It represents a useful methodological analysis whose result can complement the decision making process regarding machine selection.

# New Dimensions as the Basis for Conducting the Analysis

The *SPACE* matrix is based on 4 dimensions (factors): the environment, advantages or strengths, market or competitive position and the company's financial position [2, 7]. Upon professional methodological modification, the new matrix has four dimensions through which we obtain the corresponding fields. Namely, the modified *SPACE* matrix of an industrial product and its manufacturer is based on four dimensions or variables [1]:

**the first**, competitive advantage or market position, $T_rD$
**the second**, economic dimension, *ED*
**the third,** technological dimension, $T_eD$
**the fourth**, dimension of maintenance and environmental protection, $D_{oe}$

These dimensions illustrate the stability and strategic determination of the position (vector directions) related to several machine manufacturers (or machines) on the basis of set criteria expressed through the values of parameters and dimensions (points) plotted on the coordinates. Based on this, we can recognise the differences in field surface sizes and vector directions, and therefore, the strength of the strategic position. Through preliminary and experimental research, we obtained significant indicators (as seen throughout the example) based upon which we can assess and select the machine manufacturer or the grinding machine, depending on how the analysis parameters are placed on the dimensions (groups). Within each dimension, we review and select the parameters which we can assess and which, by their nature, mostly belong to that dimension and realistically reflect each one.

Considering the importance of this methodological analysis and the method of valuating the machine as an industrial product, as well as defining the competitive position of a machine manufacturer in relation to others, additional research could be directed towards the prominent world manufacturers, creating favourable conditions and a basis for quality application of the method.

In all the methods, we can detect certain steps and gradation, so the strategic position method for machine manufacturers or the machine as an industrial product will have several steps.

# Designing a Parameter List According to the Dimensions

A group of experts, engineers and economists participate in creating the parameter list for all four dimensions, alongside a recommendation that another "freely chosen expert" with a general education profile participates as a member.

The classification of parameters according to importance in each group, as well as the selection of three preferential parameters from each group is determined in the same way. During their work, an expert or a group of experts use the documentation according to the tasks of the analysis (the project task) in consultation with the client, as well as parameters and indicators from the manufacturer's official documentation, professional newsletters, statistical reports, technical documentation and those obtained in other ways. The method enables parameter processing in a graphic and analytic way.

## The approach to Method Development with Research Directions

The procedure in the modified *SPACE* method takes place in four stages:

- specifying the four dimensions of the area with field and direction determinants where the grinding machine's graphic position can be identified in relation to the chosen dimensions,

- drawing the coordinate system with the axes (+x, -x, + y, -y ) and plotting the dimensions: competitive advantage or market position $T_rD$, economic dimension ED, technological dimension $T_eD$, and the fourth dimension of maintenance and environmental protection $D_{oe}$,
- quantifying (valuating) the dimensions and determinants, and
- defining the product position of the grinding machine and determining the strategic direction for making a decision on machine assessment.

The research on method application was conducted in two directions, namely:
a) preliminary research and
b) experimental research

The operational analysis according to preliminary and experimental results is reflected in the following steps [1]:

1. establish a set of parameters (factors), $V_{pNs}$ (min. 5), included in the 4 dimensions,

2. rank the variables from 1 to 10 in the corresponding dimension of the matrix system,

3. calculate the variable values for all dimensions according to the provided formulae,

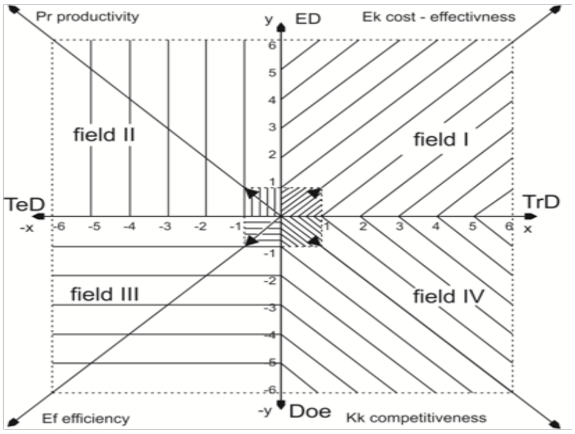
4. add the obtained scores individually for each dimension and calculate average mean values,

5. the average score values for all 4 dimensions have to be plotted on the corresponding axes in the matrix, obtaining 4 points with a position in the x and y axes,

6. by connecting the four points we obtain a corresponding geometrical form with four characteristic fields ($_{max.}$ and $_{min.}$) marked by different crosshatch lines and vector directions of the dimensions,

7. from the intersection point of the x and y matrix axes we draw vector directions with the corresponding points uncovering the strategic positions of machine manufacturers, machines or processing facilities.

The field sizes with vector directions provide the characteristics of positions for the four dimensions, specifying certain advantages among the machine dimensions. Depending on the size (surface area) of the fields I, II, III and IV, according to the demand set by the buyer or investor, a preference for the analysed criteria i.e. dimensions is established, following the selection of a machine or facility[1]. The procedure is conducted in several "samples".




The meaning of abbreviations:
$T_rD$- market dimension
ED- economis dimensuon
$T_eD$- technological dimension
$D_{oe}$- dimension of maintenance
an environmental protection

*Image 1. Matrix of the indicator assessment plan showing ±6 points (ideal fields) and ±1 point (critical fields)*

Characteristics of the fields I, II, III and IV (Image 1.) give priority to one of the valuated dimensions in relation to the other ones (ranking). Those are indicators functioning as logical combinations of the following [1]:

- cost-effectiveness, as a combination of the $T_rD$ and *ED* dimensions,
- productivity, as a combination of *ED* and $T_eD$ dimensions,
- efficiency, as a combination of $T_eD$ and $D_{oe}$ dimensions, and
- competitiveness, as a combination of $T_rD$ and $D_{oe}$ dimensions.

# Examining the Grinding Machine's Position

According to the modified *SPACE* method, the intensity of dimensions is estimated according to the set 6-degree scale where 1 is the lowest and 6 is the highest score for the ($T_rD$) and (*ED*) values, while -6 is the lowest and (-1) the highest score for (*TD*) and ($D_{oe}$).

Within each dimension, we have parameters which have to be reviewed and assessed, and which, by their nature, mostly belong to that dimension of the machine or facility. In order to consider the impact of each parameter, we introduce the so-called weighting coefficients kt so as to, by using the weighted values of parameters, decrease subjectivity of participants during the application of the modified method for machine assessment.

Then, the corrected value of awarded points ($P_{Nke}$) will be relevant for determining the rank of each selected indicator from the dimension $D_n$, which is important in the process of machine assessment.

It is assumed that the sum of all weights for one dimension is 1, and the total indicator for the given dimension is equal to the sum of weighted assessments for each variable. 10 significant parameters have been chosen for each of the dimensions (economic dimension *ED*, technological dimension $T_eD$, competitive advantage or market position $T_rD$, and the dimension of maintenance and environmental protection $D_{oe}$).

A representation of the established table matrices with an overview of valuation results for the four assessment dimensions of the machine as an industrial product [1]:

*Table 1*

| MATRIX DIMENSION | Classification of parameters according to importance | RANK | | |
|---|---|---|---|---|
| **Competitive advantage of the machine and manufacturer, market dimension $T_rD$** | | Description ↓ | Point value $V_{pi}$ | Description ↑ |
| PARAMETER $n_{iN}$ | | | | |
| 1. Market competitiveness and participation in machine production | 1 | small | 1234**5**6 | high |
| 2. Quality of the industrial product | 2 | good | 1234**5**6 | extremely good |
| 3. Technology and experience | 3 | exists | 1234**5**6 | noticeable and strong |
| 4. References | 4 | common | 1**2**3456 | considerable |
| 5. Compatibility and modularity | 5 | difficult to accomplish | 1234**5**6 | possible and feasible |
| 6. User satisfaction with the machine | 6 | good | 12345**6** | commendable |
| 7. Competitive strength development | 7 | weak | 1234**5**6 | strong |
| 8. Effective advancements, success in product designing | 8 | limited | **1**23456 | possible |
| 9. Modernisation | 9 | classic | 1**2**3456 | applied |
| 10. Degree of vertical integration | 10 | limited | 1**2**3456 | functional |
| RESULT | $P_{Nk}$ | **38 points** | | |

*Table 2*

| MATRIX DIMENSION | Classification of parameters according to importance | RANK | | |
|---|---|---|---|---|
| **Economic dimension and criteria *ED*** | | Description ↓ | Point value $V_{pi}$ | Description ↑ |
| PARAMETER $n_{iN}$ | | | | |
| 1. Purchase price of the machine | 1 | high | 1**2**3456 | acceptable |
| 2. Purchase price of the facility | 2 | high | 1234**5**6 | acceptable |
| 3. Cost-effectiveness | 3 | good | 123**4**56 | excellent |
| 4. Energy consumption | 4 | deviates | 12**3**456 | within limits |
| 5. Operating lifetime | 5 | normal | 12345**6** | long |
| 6. Construction works for the installation | 6 | significant | 12**3**456 | minimal |
| 7. Dosing devices | 7 | directly | 12345**6** | indirectly |
| 8. Ratio between the purchase price and maintenance costs | 8 | lower | 12345**6** | higher |
| 9. Procurement convenience | 9 | unfavourable | 12**3**456 | functional |
| 10. Proven product quality on the market | 10 | changeable | 1234**5**6 | proven |
| $P_{Nk}$ | RESULT | | **43 points** | |

*Table 3*

| MATRIX DIMENSION | Classification of parameters according to importance | RANK | | |
|---|---|---|---|---|
| **Technological dimension, criteria *TeD*** | | Description ↓ | Point value $V_{pi}$ | Description ↑ |
| PARAMETER $n_{iN}$ | | | | |
| 1. Grinding capacity according to the raw material characteristics, range of application | 1 | limited | **1**23456 | optimal |
| 2. Size ratio of the inlet and outlet openings | 2 | determined | 12**3**456 | changeable |
| 3. Technological know-how | 3 | low | 1234**5**6 | high |
| 4. Grinding degree | 4 | low | 12**3**456 | high |
| 5. Granulometric composition, product granulation | 5 | deviates | 1234**5**6 | within limits |
| 6. Super-grain, sub-grain and dust particle composition | 6 | deviates, exceeds limits | 1234**5**6 | within limits |
| 7. Productivity | 7 | variable | 12345**6** | optimal |
| 8. Fineness modulus | 8 | unsatisfactory | 12**3**456 | satisfactory |
| 9. Technological innovation | 9 | not applied | 1234**5**6 | visible |
| 10. Protection and regulation degree | 10 | low | 123**4**56 | high |
| $P_{Nk}$ | RESULT | | **39 points** | |

*Table 4*

| MATRIX DIMENSION<br>**Maintenance and environmental protection $D_{oe}$**<br>PARAMETER $n_{iN}$ | Classification of parameters according to importance | RANK<br>Description ↓ | Point value $V_{pi}$ | Description ↑ |
|---|---|---|---|---|
| 1. Plant stability | 1 | low | 12**3**456 | high |
| 2. Plant reliability | 2 | low | 12**3**456 | high |
| 3. Plant efficiency | 3 | low | 12345**6** | high |
| 4. Surveillance and management | 4 | classic | 12**3**456 | networked |
| 5. Convenient and suitable maintenance | 5 | hampered | 12345**6** | facilitated |
| 6. Supplying spare parts, servicing | 6 | with waiting time | 12**3**456 | timely |
| 7. Protection against metal objects | 7 | classic | 12**3**456 | efficient and reliable |
| 8. Cleaning the openings and grinding elements | 8 | frequent | 1**2**3456 | occasional |
| 9. Environmental impacts on the working and living environments (noise, dust, vibrations) | 9 | noticeable | 1**2**3456 | moderate and within limits |
| 10. Industrial product's ergonomic properties | 10 | common | 1**2**3456 | improved |
| RESULT | $P_{Nk}$ | | **33 points** | |

The methodological procedure according to the presented method starts by summarising the points awarded for each parameter per group.

*Table 5*

| Group | Dimension | $P_{Nkp}$ | $V_{pNs}$ | $P_{Nkp}$ max | $P_{Nkp}$ min | Point values $V_{pk}$: 1 | 2 | 3 | 4 | 5 | 6 | $n_{iN}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | The number of the same point occurences $n_{pk}$ | | | | | | |
| 1 | $T_rD$ | 38 | 3.8 (x) | 60 | 10 | 1 | 3 | 0 | 0 | 5 | 1 | 10 |
| 2 | $ED$ | 43 | 4.3 (y) | | | 0 | 1 | 3 | 1 | 2 | 3 | 10 |
| 3 | $TD$ | 39 | 3.9 (-x) | | | 1 | 0 | 3 | 1 | 5 | 0 | 10 |
| 4 | $D_{oe}$ | 33 | 3.3 (-y) | | | 0 | 3 | 5 | 0 | 0 | 2 | 10 |
| N=4 | $\sum_{N=1}^{4} D_N$ | $\sum_{N=1}^{4} P_{Nkp}$ | $\frac{1}{N} V_{pNs}$ | 240 | 40 | $\sum_{N=1}^{4} n_{pkN}$ | | | | | | $\sum_{N=1}^{4} n_{iN}$ |
| | | **153** | **3,825** | | | 2 | 7 | 11 | 2 | 12 | 6 | 40 |
| The number of awarded points for each group is within the limits of maximum and minimum. | | | $\sum_{N=1}^{4} n_{pkN} \cdot n_{pk}$ | | | **2** | **14** | **33** | **8** | **60** | **36** | |

Where:
$n_{pk}$ – the number of the same point occurrences $V_{pk}$, k= 1,2,...,6
$n_{iN}$ – the number of ranked parameters for N groups, i= 1,2,3,...,10
$N$ – the number of dimensions, groups

$P_{Nkp} = \sum_{k=1}^{6} n_{pk} \cdot V_{pk}$ – the number of points awarded by the experts per groups $N$ and per parameters $N_{in}$

$V_{pNs} = \frac{1}{n_{in}} \cdot P_{Nkp}$ – total sum of awarded points per N dimensions

$\frac{1}{N} V_{pNs}$ – arithmetic mean of points awarded for $\sum_{N=1}^{4} D_N$

$\sum_{N=1}^{4} n_{pkN}$ – total sum of the same point occurrences for $\sum_{N=1}^{4} D_N$

$\sum_{N=1}^{4} n_{iN}$ – total number of parameters for $\sum_{N=1}^{4} D_N$

$P_{nkp_{max-min}}$ – the extreme point values set

$P_{nk_{max-min}}$, statistical values of points

**a) calculating the weighing coefficients, $k_t$**

$k_{tk} = \frac{V_{pk}}{\max V_{pk}}$, k=1,2,.....6

General form:
Calculating extreme values and the range of points, as well as distribution (concentration) coefficients:

for: $V_{pk} = 1 \longrightarrow k_{t1} = \frac{1}{6} = 0.166$ ;

for: $V_{pk} = 2 \longrightarrow k_{t2} = \frac{2}{6} = 0.333$ ;

for: $V_{pk} = 3 \longrightarrow k_{t3} = \frac{3}{6} = 0.050$ ;

for: $V_{pk} = 4 \quad > k_{t4} = \frac{4}{6} = 0.666$ ;

for: $V_{pk} = 5 \longrightarrow k_{t5} = \frac{5}{6} = 0.833$ ;

for: $V_{pk} = 6 \longrightarrow k_{t6} = \frac{6}{6} = 0.100$

where: $\max V_{pk}$- maximal point value in a rank

**b) preliminary point and coefficient values**

max $P_{N6p} = n_{p6} \cdot V_{p6} = 10 \cdot 6 = 60$ poena
min $P_{N6p} = n_{p1} \cdot V_{p1} = 10 \cdot 1 = 10$ poena

Corrective preliminary coefficient per dimensions:

$k_{kn(p)} = \frac{P_{Nkp}}{60}$

max $k_{6N(p)} = \frac{P_{N6p}}{60} = \frac{60}{60} = 1.0$

min $k_{1N(p)} = \frac{P_{N1p}}{60} = \frac{10}{60} = 0.166$

**c) experimental point and coefficient values**
For the N group:

$P_{Nke} = \sum_{k=1}^{6} n_{pk} \cdot V_{pk} \cdot k_{tk}$, the corrected experimental value of the awarded points

$K_{kn(e)} = \frac{P_{Nke}}{60}$, experimental distribution coefficient per dimensions

max $P_{N6e} = n_{p6} \cdot V_{p6} \cdot k_{t6} = 10 \cdot 6 \cdot 1.0 = 60$ poena
min $P_{N3e} = n_{p3} \cdot V_{p3} \cdot k_{t3} = 10 \cdot 3 \cdot 0.5 = 15$ points

max $k_{6N(e)} = \frac{P_{N6e}}{60} = \frac{60}{60} = 1.0$

min $k_{r3kp} = \frac{P_{N3e}}{60} = \frac{15}{60} = 0.25$

**d) calculating experimental values of the awarded points in line with the report submitted by the expert or a group of experts**

For the N dimension groups:
N=1 TD $P_{16e}$=1.0•1.0•0,166+3•2•0,333+5.0•5.0•0,833+1.0•6•1.0=28,939 points

$k_{r6e} = \frac{28.939}{60} = 0.482$

»experimental distribution coefficient
N=2 ED $P_{26e}$=1•2•0.333+3•3•0.5+1•4•0.666+2•5•0.833+3•6•1.0=37,160

$k_{r6e} = \frac{37.16}{60} = 0.619$

» experimental distribution coefficient
N=3 TD $P_{36e}$=1•1•0.166+3•3•0.5+1•4•0.666+5•5•0.833=28,105

$k_{r6e} = \frac{28.105}{60} = 0.468$

» experimental distribution coefficient
N=4 $D_{oe}P_{46e}$= 3•2•0.333+5•3•0.5+2•6•1.0= 21,498

$k_{r6e} = \frac{21.498}{60} = 0.358$

**e) setting and marking the limits of experimental coefficients**

$\frac{\max k_{kN(e)} - \min k_{kN(e)}}{V_{p6}} = \frac{1.0 - 0.25}{6} = 0.125$

From the quotient:
we receive the amount of the increase (growth) which is distributed from the number 0.25 to 1.0 as follows:

| $k_{kN(e)}$ | >0.25min | >0.375 | >0.50 | >0.625 | >0.75 | >0.875 (1.0max) |
|---|---|---|---|---|---|---|
| Symbol | ✔ | ✔✔ | ✔✔✔ | ✔✔✔✔ | ✔✔✔✔✔ | ✔✔✔✔✔✔ |

| COMPARATIVE SCORE INDICATORS | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Group | Dimension | PRELIMINARY INDICATORS | | | | | | EXPERIMENTAL INDICATORS | | | | | |
| | | $P_{Nkp}$ | $P_{Nkp}$ max | $P_{Nkp}$ min | $k_{knN(p)}$ | $k_{knN(p)}$ max | $k_{knN(p)}$ min | $P_{Nke}$ | $P_{Nke}$ max | $P_{Nke}$ min | $k_{kN(e)}$ | $k_{kN(e)}$ max | $k_{kN(e)}$ min |
| 1 | TrD | 38 | | | 0.633 | | | 28.939 | | | 0.482 | | |
| 2 | ED | 43 | 60 | 10 | 0.716 | 1.0 | 0.166 | 37.160 | 60 | 15 | 0.619 | 1.0 | 0.25 |
| 3 | TD | 39 | | | 0.65 | | | 28.105 | | | 0.468 | | |
| 4 | $D_{oe}$ | 33 | | | 0.55 | | | 21.498 | | | 0.358 | | |
| N=4 | $\sum_{N=1}^{4} D_N$ | **153** | 240 | 40 | $k_{kN(p)}$ within limits | | | 115.702 | 240 | 60 | $K_{kN(e)}$ within limits | | |

| A COMPARISON OF DIMENSIONS ACCORDING TO EXPERIMENTAL INDICATORS WITH SCORE SYMBOLS | | | | |
|---|---|---|---|---|
| INITIAL | N=1 $T_rD$ | N=2 ED | N=3 TD | N=4 $D_{oe}$ |
| NEW | N=1 ED | N=2 TrD | N=3 TD | N=4 $D_{oe}$ |
| SYMBOL | ✔✔✔ $\uparrow$ | ✔✔ $\uparrow$ | ✔✔ $\uparrow$ | ✔ $\uparrow$ |

**f) setting an additional assessment criterion** $k_{dN(e)}$

| Group | Dimension | $P_i$ ($^nNd$) | $V_{pk}$ max | $V_{pd}$ ($V_{pi}$) | $k_{dN}$ max | $k_{dN}$ min | $k_{dN}=\frac{V_{pd} \cdot k_{tk}}{max\ V_{pk}}$ | Parameter score | $\frac{1}{3}\sum_{d=1}^{3} k_{dN}$ | GROUP SCORE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | TrD | p2 | 6 | 5 | 1.0 | 0.694 | 0.694 | $\updownarrow$ | 0.796 | $\uparrow$ |
| | | p5 | | 5 | | | 0.694 | $\updownarrow$ | | |
| | | p6 | | 6 | | | 1.0 | $\uparrow$ | | |
| 2. | ED | p1 | 6 | 4 | 1.0 | 0.694 | 0.444 | $\downarrow$ | 0.815 | $\uparrow$ |
| | | p3 | | 6 | | | 1.0 | $\uparrow$ | | |
| | | p5 | | 6 | | | 1.0 | $\uparrow$ | | |
| 3. | TD | p2 | 6 | 3 | 1.0 | 0.694 | 0.250 | $\downarrow$ | 0.648 | $\updownarrow$ |
| | | p5 | | 5 | | | 0.694 | $\updownarrow$ | | |
| | | p7 | | 6 | | | 1.0 | $\uparrow$ | | |
| 4. | $D_{oe}$ | p3 | 6 | 6 | 1.0 | 0.694 | 1.0 | $\uparrow$ | 0.454 | $\downarrow$ |
| | | p6 | | 3 | | | 0.250 | $\downarrow$ | | |
| | | p9 | | 2 | | | 0.694 | $\downarrow$ | | |

$\uparrow$ - the reduced groups TrD and ED satisfy the set criterion

$\downarrow$ - the reduced group Doe does not satisfy the set criterion

$\updownarrow$ - the reduced group TD is at the limit of the set criterion and can be found in the group satisfying the given criterion

Introducing the additional assessment criterion for the machine is conducted in order to additionally affirm the obtained result for the product and market position of the grinding machine or the manufacturer, depending on the elements set for analysis. Three most significant parameters from each group, dimension are taken into consideration. Namely, in relation to the much more significant ones, the less significant parameters determined according to the degree of importance can be given a high score by the experts, placing the group in a better ranking position and obtaining a seemingly good result.

Being familiar with the set criteria of assessing and selecting the grinding machine results in facts stating that, for example, without satisfying the technological and economic parameters of quality related to ground products, the grinding machine (grinder or mill) cannot be selected. . Based upon these facts, a conclusion can be drawn regarding the need to satisfy the basic parameters ( $n_{Nd}$ ), functionally related in the following way: machine-raw material-product. The new lower limits of the distribution coefficient in modified conditions (the criterion of the selected parameters' importance) are being set:

$$\min k_{dn} = \frac{n_{Nd} \cdot V_{pk} \cdot K_{tk}}{\sum_{d=1}^{3} \max V_{pk}} = \frac{n_{N3} \cdot V_{p5} \cdot k_{t5}}{\sum_{d=1}^{3} \max V_{p6}} = \frac{3 \cdot 5 \cdot 0.833}{18} = 0.694$$

## Analysis of the obtained assessment results

The published preliminary research on assessing the selected grinding machine can, in most cases, provide positive indicators since the assessment parameters are placed within widely set criterion limits (min 10 and max 60 points or ranging from 0.166 to 1.0).

Experimental research set the new, extreme parameter limits (points and concentration coefficients) where the weighing coefficients preferred higher point values. In this way, the detected preliminary research weaknesses were removed.

By introducing an additional criterion for assessing the most significant parameters [1], this method gained quality in its approach to the analysis procedure. By designing a chart placed on the x, y, -x and –y axes and plotting the coordinate points for TrD:

$V_{pNs}$=3.8; for ED: VpNs=4.3; for TD: $V_{pNs}$=-3.9 and for $D_{oe}$: $V_{pNs}$= –3.3

we obtained 4 characteristic field surface areas:

$P_I$ =16.34  $P_{II}$ = 16.77  $P_{III}$ = 12.87  $P_{IV}$ = 12.54

situated within the maximum, $P_{max}$=36 and minimum, $P_{min}$=1.0 limits.

## Calculating the intensity of dimensions

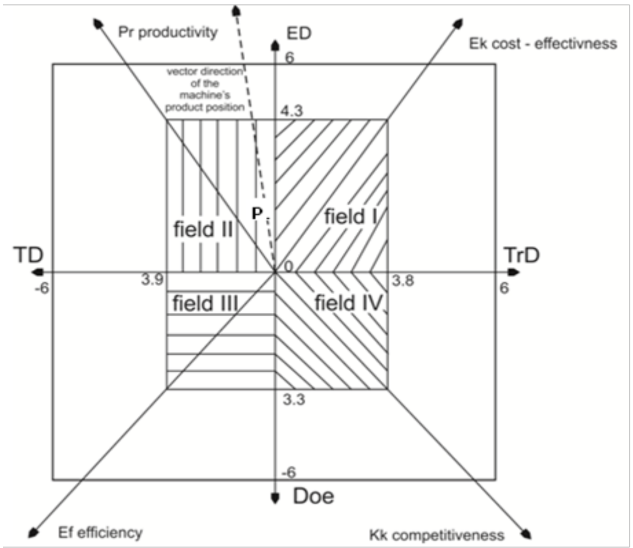
The value VpNs of coordinates for each dimension ED, $T_{rD}$, TD, $D_{oe}$, is calculated as the average value (average mean) of the sum of dimension points that belong to a certain axis.
- the y axis coordinate is calculated as: y = $V_{pNs}$(ED) + $V_{pNs}$(Doe)

- for determining the x axis coordinate, we use the formula: x = VpNs(TrD) + VpNs(TD).

By entering the numeric values into the given formulae, we obtain the coordinate points P:

for the x axis, x=1
for the y axis, y = -0.1

which, with the zero point, create the vector direction of the grinding machine's position and its assessment position. The methodological procedure for determining the strategic position of a machine or a grinding machine manufacturer is detailed in the provided example (Image 2.).




The meaning of abbreviations:
$T_r$D- market dimension
ED- economis dimensuon
$T_e$D- technological dimension
Doe- dimension of maintenance
an environmental protection

Image 2. A diagram, a systematic overview of the awarded points $V_{pNs}$ with field surface sizes (I, II, III, IV) and vector directions of dimension movements

The vector directions $E_k$ cost-effectiveness, $P_r$ productivity, $E_f$ efficiency and $K_k$ competitiveness mark the proportionate directions and intensity of improvements for one dimension in relation to another, associated one.

The selected point P, with the coordinates (x, y) and the preferred field, shows the product and market position of a grinding machine according to which we can set a strategy for deciding whether to keep the machine in the production process or procure a new one. By observing the pictorial representation (Image 2), we can see that the vector direction (0,P) provides an overview of the powerful product and economic position of the grinding machine, while its less effective and competitive ability can be compensated by attractive offers of machines at the global market, and its position in the technological scheme of processing rock and waste materials depends upon the type and properties of the materials and the performance construction demands set for the machine. The team of experts, based upon the results obtained from the analysis, gives suggestions, opinions and recommendations to the user or investor as to which part and in what volume they should act in order to accomplish a successful investment procedure. Image 3. provides a graphic overview of the experimental results for assessing the grinding machine according to the 4 dimensions and the linear regression equation model [1].

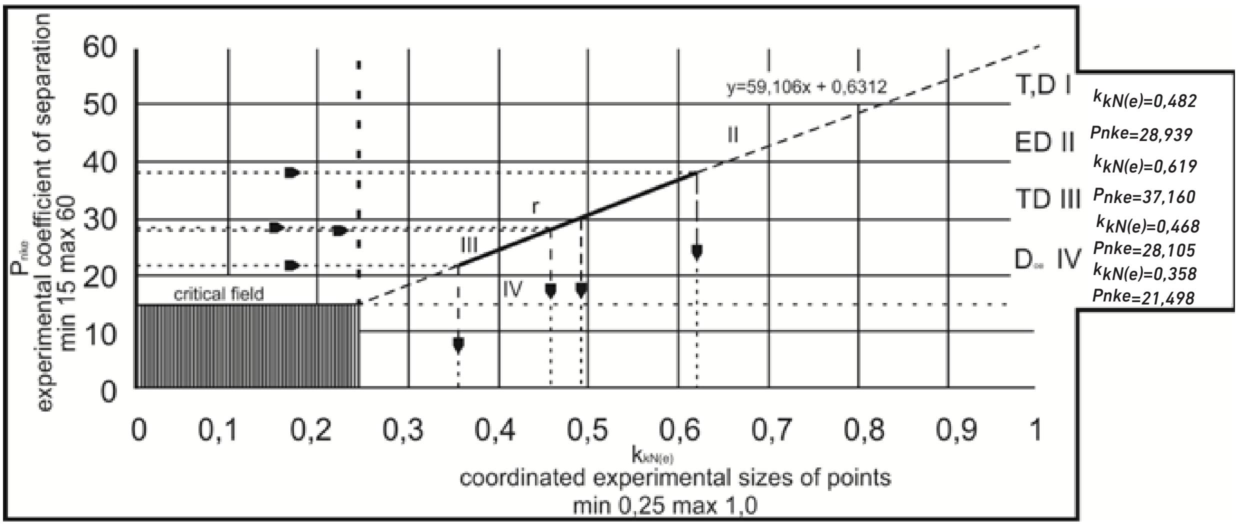



Image 3. A graphic overview of experimental results for assessing the grinding machine according to the 4 dimensions and the model $y=b_0 + b_1x$

# Assessment of the Modified SPACE Method Applicability

The method for determining the strategic position of grinding machines or machine manufacturers is based on a large number of parameters classified into four groups, dimensions. The selection of dimensions and parameters depends on the assessment task set and the investment procedure (existing machine or a new one), as well as the structure of participants taking part in the task of assessing the machine, facility or machine manufacturer. Each parameter in the dimension is valuated, and based upon that, the vector direction and field size are calculated and determined in the matrix-diagram where the production, technological, economic and competitive positions of an industrial product (machine) are identified. In this way, we accomplished a comprehensive approach towards perceiving the research problem, i.e. the options for selecting the best solutions have increased. The proficiency in choosing and selecting parameters according to their significance was left to the experts who, upon inspecting the project task, created a parameter plan matrix and assessed each parameter which was supported by valid proof and explanations. Overviews of assessment results were provided in several numerical and graphic ways (e.g. Image 3.), pointing at the sought after solution of the problem. By processing more "samples" of the position assessment, it is possible to compare results and make the right decision regarding machine manufacturer selection.

# Conslusion

From the modified *SPACE* analysis conducted on a specific example of a mineral raw material grinding machine, we can conclude that it is completely applicable in practice. Subsequent research regarding this method can use the SWOT (Strengths, Weaknesses, Opportunities and Threats) method as the basis for the technical and economic assessment of internal strengths and weaknesses, as well as external opportunities and threats.

In order to diagnose the current or future product position of a machine or facility in strengthening the investment decision-making process, special attention is paid to the selection of the type and number of analysis dimensions encompassing a certain feature or characteristic. With the purpose of strengthening the decision on machine assessment, we introduced additional criteria for machine assessment, taking into account the three most significant parameters from each group, dimension, in order to additionally confirm the obtained result regarding the product position of the grinding machine or machine manufacturer.

The issue of application and volume of parameter review, whether they can be supplemented or corrected according to the circumstances and new information, as well as the team of experts' objectivity in deciding on scores (awarding points) are the potential problems that can affect the assessment objectivity and result in obtaining different movement directions.

The modified *SPACE* method is applicable only in the area of the same rank or similar group (type) of production units or technical systems.
The methodology of entering and processing the selected parameters through this methodological procedure remains the same in case of additional assessments of the machine's position:

*- through the SWOT method for technical and economic assessment of internal strengths and weaknesses, as well as external opportunities and threats[4], and*

*- through "the machine's pros and cons method" [1].*

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# *Modifikovana SPACE metoda za utvrđivanja proizvodno-tržišne pozicije industrijskog proizvoda na primjeru mašina za usitnjavanje sirovina*

**SAŽETAK**

*SPACE* (Strategic Position and Action Evalution) metoda je analitička tehnika koja se koristi u strateškom upravljanju i planiranju kompanija, koja zahvata objekt analize preko dvije interne dimenzije (finansijska snaga i konkurentska snaga) i dvije ekstremne dimenzije (stabilnost okruženja i snaga grane poslovanja) [3,5,7].Analiza procjenjuje unutrašnje i spoljašnje okruženje da bi se dobila odgovarajuća ideja o poslovnoj strategiji i razvojnim pravcima kompanije [2,6]. Modifikacijom metodoloških tokova *SPACE* metode a prema zadatku istraživanja i izborom dimenzija ocjene i seta parametara koji pokrivaju svaku od četiri odabrane dimenzije, u radu je na primjeru mašina za usitnjavanje izvršena identifikacija njene pozicije sa aspekta tehničkih, tehnoloških, troškovnih i ekoloških parametara. U nastavku analize, a radi jačanja odluke o ocjeni mašina uvedeni su dopunski kriteriji ocjene mašine koji uzimaju u obzir po tri najznačajnija parametra iz sveke od grupa. Osim mašina za usitnjavanje sirovina modificirana *SPACE* metoda omogućava i analizu referenci proizvođača mašina ili industrijskog postrojenja prerade sirovina, koji dobiveni podaci ocjene mogu poslužiti za donošenje odluke investitorima i preduzećima o nabavci nove mašine (postrojenja), rekonstrukciji ili modernizaciji postojeće.

**Ključne riječi:** parametri, dimenzije, matrica, ocjena, odlučivanje

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