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**Rationale for the construction of centrifugal spreader of mineral fertilizers**

Investigational construction features of rotor working organ and their influence on the high-quality indexes of work of throwing about of mineral fertilizers.

The obtained formulae allow to determine the absolute velocity fat disk and angle of departure required for determining the width of the lens cover. On the basis of analysis of motion of financial particle for the blades of centrifugal working organ along a sending rib structural descriptions of the fourblade throwing about are grounded.

Withdrawn simple enough for engineering application of the formula, giving an opportunity to substantiate the design of the disk diffuser fertilizers, which is guaranteed to improve scattering.
**mineral fertilizer spreader centrifugal type blades, centrifugal working body, disc, even distribution of granules**

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# Analysis methods for measuring system by repeatability and reproducibility

Then to the organization to ensure a stable market position, which leads to success in competition, must focus their attention on all of their production processes with respect to the quality of its products supplied to its customers. Measurement parameter of the products, their analysis and evaluation, is inherent to the production process in organizations around the world. Whether the product meets the requirements of the customer depends on the observed variance parameter of the product but also the variability of the measurement system itself. The measurement plays a key role in scattering the monitored parameter of the product, so it must be analyzed. Tool through which we can assess the accuracy and appropriateness of the measurement system is called a measurement system analysis.
**measurement variability, product, process, repeatability, reproducibility**

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**Методы анализа для измерения систем повторяемости и воспроизводимости**

Производители, чтобы обеспечить стабильное положение на рынке, должны сосредоточить свое внимание на поддержании качества своей продукции на всех производственных этапах. Измерение параметров продуктов, их анализ и оценка является неотъемлемой частью производственного процесса на предприятиях по всему миру. Будет ли продукт соответствовать требованиям заказчика зависит не только от отклонения контролируемого параметра продукта, но и от изменчивости самой измерительной системы. Измерения играют ключевую роль в рассеянии значений контролируемого параметра продукта, поэтому оно должно быть проанализировано. Инструмент, через который мы можем оценить точность и уместность измерительной системы называется анализом системы измерения.

**измерение изменчивости, продукт, процесс, повторяемость, воспроизводимость**

**Introduction.** The measurement system variability exists, which affects the measured data and the decisions based on them ie., The variance of the endpoint of the product may be caused by either the product itself but also the measurement system. The aim of the analysis measurement system (MSA) is to verify the accuracy of the measurement system for manufacturing processes, respectively. estimate that the measurement system contributes to the total variance endpoint product.

Quality tools are an active part of the measurement process in the application, development and continuous improvement of the effectiveness of the quality system (Hrubec, J.- Žabár, P. - Prístavka, M. - Škůrková, K., 2008; Prístavka, M. a kol. 2011). In application, development and continuous improvement of the effectiveness of the quality system are an active part of the analysis capabilities of instruments, production equipment and process capability (Prístavka, M., - Hrubec, J., 2009).

Statistical methods are important in engineering practice group, which includes analysis capabilities of instruments, production equipment and process capability. These tools are an active part of the measurement process in the application, development and continuous improvement of the effectiveness of the quality system (Prístavka, M., - Hrubec, J., - Škůrková, K., 2008).

The term MSA - Measurement System Analysis involves the following processes: Verify that the correct value is measured and identified all the critical issues related to the environment that are correlated with the measurement. Determine which statistical properties of the measurement system must exhibit in order to be acceptable (Kredatusová, M. - Bujna, M. 2010). The implementation of this provision, it is important to know how the data should be used, because without this information it is not possible to determine the statistical properties. Measurements must be carried out in random order, to ensure that any changes that might occur, will be distributed at random measurements.

**Materials and Methods.** We have determined the verification tools to measure the reference points and prepared the measurement procedure for verifying the dimensional characteritics of door panels. The measuring equipment includes:

- Mitutoyo micrometer (12.7–0.01 mm);
- measuring cylinders (ø 1.00–10.00 mm);
- feeler gauge (0.05–1.00 mm).

Mitutoyo micrometer – basic information:

1. code number: 543-681B;
2. serial number: 10131238;
3. model: ID-S1012B;
4. measuring range: 12.7–0.01 mm;
5. identification number in the organisation: 57020;

6. date of calibration: 16/01/2012;
7. date of next calibration: 16/01/2013.

The procedure of the survey based on the average and dispersion is as follows:

1. ensure the selection of n> 5 parts, which pose an actual or expected range of variability of the process,
2. mark operators as A, B, C etc. and parts numbered 1 to n, so that operators could not see the numbers,
3. convert calibration of the instrument, if it is part of the normal process of measurement, the operator A measure n parts in random order, and writes the results to row 1,
4. operator B and C, measured the same number of parts, without having to subtract the value of each show, and record the results in rows 6 and 11,
5. This cycle is repeated with another random measurement data will be entered in rows 2,7,12, data is entered into the column, if it is measured as the first piece of item 7, then record the result in the column labeled Volume 7, if necessary to convert three measurement cycle is repeated and the data entered in rows 3,8 and 13
6. where operators work in a variety of changes, can be used an alternative method, the operator A measure of all 10 parts of a value entered in line 1, the operator A repeat measurement in a different order and writes the results in rows 2 and 3, the same transfer operator B and C (MSA, 2009).

Additionally, the organisation must develop a control and management plan defining all the methods used to control and manage the process and meeting the requirements set by the customer.The organisation must have studies of the measurement system analysis, for example repeatability, reproducibility (R&R) of gauge, partiality, linearity, stability for all new or modified measuring and test gauges (Petrášová, 2006).

Repeatability – Commonly referred to as the variability of 'operator'. It is the variability of measurements obtained with one measurement instrument that has been used several times by the same operator when measuring the identical feature on the same part. The best term for repeatability is the 'variability within the system', where the measurement conditions are defined as follows:

- defined part;
- device;
- gauge;
- method;
- operation;
- environment and assumptions.

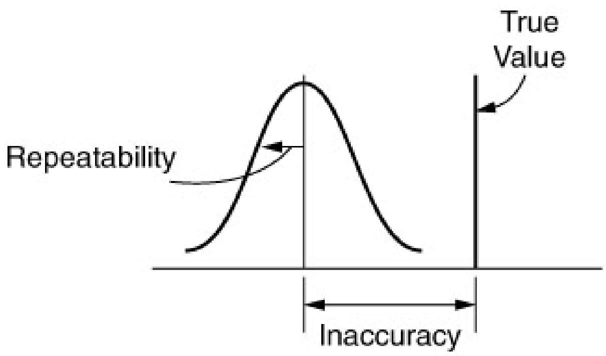
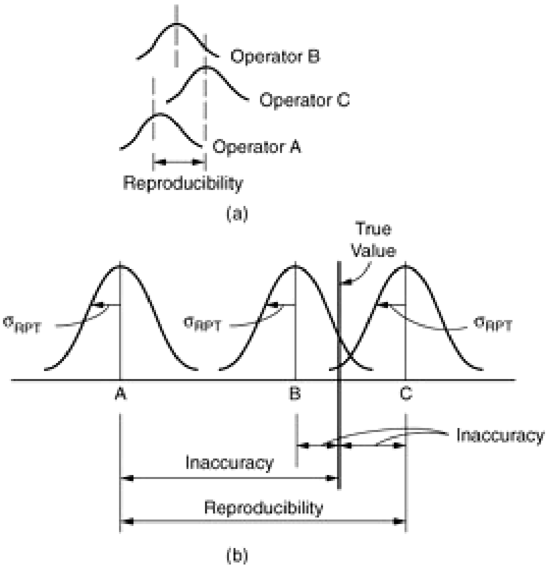



Figure 1 – Repeatability (Stamatis, 2002)




Where: a – shows a reproducibility situation with three operators; b – shows the general rule of reproducibility when there is more than one measurement situation

Figure 2 – Reproducibility (Stamatis, 2002)

**Results and Discussion.** To determine a contribution of the measurement system to an overall variability, it was necessary to verify the micrometer capability and thus to meet the requirement for the measurement system for assembly of door panels. Measurements were performed on the basis of the methodology described in the MSA reference manual. As mentioned above, the Mytutoyo micrometer was used to measure the reference points on door panels that are attached to the measuring device.

The product of the number of repetitions and measured samples must be higher than 15. The said criterion is met in this case because we have chosen 10 samples and 2 repeated measurements.

Table 1 – Data collection sheet

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Gauge Repeatability and Reproducibility Report** (standard method) | | | | | | | | | | | |
| Part NO & name | | | Front Right | | | Gage name | | | | | | Date | | |
| Characteristics | | | 1A01 J8 (X) | | | Gage no | | | | | | | | |
| Specification | | | Th | 2 | Td | -2 | Gage type | | | | | | | |
| Operator/ | | | Part | | | | | | | | | | | |
| | | M. no | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Average | |
| 1 | A | 1 | 1.79 | 1.82 | 1.70 | 1.88 | 1.81 | 1.82 | 1.82 | 1.77 | 1.87 | 1.89 | | |
| 2 | | 2 | 1.80 | 1.83 | 1.70 | 1.88 | 1.79 | 1.83 | 1.81 | 1.78 | 1.86 | 1.91 | | |
| 3 | | 3 | | | | | | | | | | | | |
| 4 | | x | 1.795 | 1.825 | 1.7 | 1.88 | 1.8 | 1.825 | 1.815 | 1.775 | 1.865 | 1.9 | Xa = | 1.818 |
| 5 | | R | 0.01 | 0.01 | 0 | 0 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | Ra = | 0.01 |
| 6 | B | 1 | 1.78 | 1.81 | 1.70 | 1.88 | 1.79 | 1.82 | 1.84 | 1.79 | 1.87 | 1.88 | | |
| 7 | | 2 | 1.80 | 1.82 | 1.71 | 1.87 | 1.80 | 1.82 | 1.84 | 1.77 | 1.87 | 1.88 | | |
| 8 | | 3 | | | | | | | | | | | | |
| 9 | | x | 1.79 | 1.815 | 1.705 | 1.875 | 1.795 | 1.82 | 1.84 | 1.78 | 1.87 | 1.88 | Xb = | 1.817 |
| 10 | | R | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0 | 0 | 0.02 | 0 | 0 | Rb = | 0.008 |
| 11 | C | 1 | 1.79 | 1.83 | 1.70 | 1.90 | 1.82 | 1.83 | 1.84 | 1.78 | 1.85 | 1.90 | | |
| 12 | | 2 | 1.78 | 1.80 | 1.72 | 1.90 | 1.83 | 1.82 | 1.84 | 1.79 | 1.86 | 1.88 | | |
| 13 | | 3 | | | | | | | | | | | | |
| 14 | | x | 1.785 | 1.815 | 1.71 | 1.9 | 1.825 | 1.825 | 1.84 | 1.785 | 1.855 | 1.89 | Xc = | 1.823 |
| 15 | | R | 0.01 | 0.03 | 0.02 | 0 | 0.01 | 0.01 | 0 | 0.01 | 0.01 | 0.02 | Rc = | 0.012 |
| 16 | | | 1.79 | 1.818 | 1.705 | 1.885 | 1.807 | 1.823 | 1.832 | 1.78 | 1.863 | 1.89 | X = <br> Rp = | 1.81933 <br> 0.185 |
| 17 | | [ Ra = | 0.01 | ] + [ | Rb = | 0.008 | ] + [ | Rc = | 0.012 | ] / | 3 | | R = | 0.01 |
| 18 | | [Max X = | 1.823 | ] - [ Min X = | | 1.817 | ] = $X_{DIFF}$ | | | | | | $X_{DIFF}$ = | 0.006 |
| 19 | | [ $UCL_R$ = D4 * R ] = | | 3.27 | * | 0.01 | | | | | | | | 0.0327 |
| 20 | | [ $LCL_R$ = D3 * R ] = | | 0 | * | | | | | | | | | 0 |
| 21 | | [ $UCL_X$ = X + A2*R] = | | 1.819 | + | 0.01 | * | 1.88 | | | | | | 1.83813 |
| 22 | | [ LCLx = X - A2*R] = | | 1.819 | - | 0.01 | * | 1.88 | | | | | | 1.80053 |
| For information on the theory and constants used in the form see *MSA Reference Manual, Third edition*. | | | | | | | | | | | | | | |

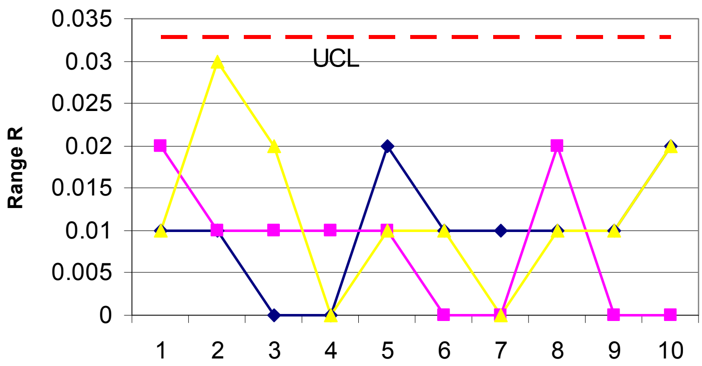



Figure 3 – Control chart for range

Based on the control chart for range, it is clear that no value within the range does exceed the upper control limit. Therefore, we could continue with following calculations, as stated in the repeatability and reproducibility report.

**Gauge Repeatability and Reproducibility Report**

(standard method - T)

| | | | | | |
|---|---|---|---|---|---|
| Part NO & name | | Gage name | | Date: | |
| Characteristics | | Gage no | | | |
| Specification | Th= 2 | Td= -2 | Gage type | | |

From data sheet: R = 0.01 $X_{DIFF}$ = 0.006 Rp = 0.185

*Repeatability - Equipment variability (EV)*

$$EV = \overline{R}\, x K_1$$

= 0.01 x 0.8862

= 0.0089

| No. | $K_1$ |
|---|---|
| 2 | 0.8862 |
| 3 | 0.5908 |

%EV = 100 x [EV/(T/6)]
= 100 x [0.009/(4.000/6)]
= 1.33%

*Reproducibility - Operator Variation (AV)*

$$AV = \sqrt{\left[(X_{DIFF} x K_2)^2 - (EV^2/nr)\right]}$$

= 0.0024

n = 10
r = 2
k = 3

| Operator | 2 | 3 |
|---|---|---|
| $K_2$ | 0.707 | 0.5231 |

%AV = 100 x [AV/(T/6)]
= 100 x [0.002/(4.000/6)]
= 0.37%

*Repeatability & Reproducibility (R&R)*

$$R\&R = \sqrt{(EV^2 + AV^2)}$$

= 0.0092

%R&R = 100 x [R&R/(T/6)]
= 100 x [0.009/(4.000/6)]
= 1.38%

| Parts | K3 |
|---|---|
| 2 | 0.7071 |
| 3 | 0.5231 |
| 4 | 0.4467 |
| 5 | 0.403 |
| 6 | 0.3742 |
| 7 | 0.3534 |
| 8 | 0.3375 |
| 9 | 0.3249 |
| 10 | 0.3146 |

*Part variability (PV)*

PV = Rp x $K_3$
= 0.185 x 0.3146
= 0.0582

%PV = 100 x [PV/(T/6)]
= 100 x [0.0582/(4.0000/6)]
= 8.73%

*Total variability (TV)*

$$TV = \sqrt{(R\&R^2 + PV^2)}$$

= 0.0589

*Resolution of measuring device*

N = [PV/R&R] x 1.41
N = 9 categories
(min. 5 categories)

☐ Refused

☐ Accepted with a reserve

☒ Accepted

For information on the theory and constants used in the form see *MSA Reference Manual, Third edition*.

Figure 4 Repeatability and reproducibility report of the gauge, J8 point

In this section, we have focused on the evaluation of measurement for the assembly of door panels by the repeatability and reproducibility method. We followed the procedure provided in the MSA reference manual. All measured values were entered into the data collection sheet and individual ranges were displayed in the control chart for range. No range does exceed the upper control limit; therefore, we could proceed with another calculation.

The results obtained are as follows: repeatability EV = 0.0089, reproducibility AV = 0.0024, combined value R&R = 0.0092, compoment variability PV = 0.0582 and total variability TV = 0.0589.

The required process variability (precision reference quality indicator) is given lower tolerance limits LCL and UCL upper specification limit, because with it we count in further calculations. The resulting percentage % R&R = 1.38 %, and the number of different categories ndc = 8.

**Conclusion.** We followed the procedure that gives reference guide MSA. All measured values were entered into the worksheet to collect data and then the individual margins shown in the control chart margins. No margin does not exceed the upper regulatory limit. The repeatability and reproducibility of the percentage of the variability of the measurement system to the total variability of the process or. to the width of the tolerance field. The method can distinguish between variability caused by handling and measuring equipment. We can conclude that the system is capable to measure because the conditions R&R < 10 % and ndc ~ 5 were met.

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**Методи аналізу для вимірювання систем повторюваності і відтворюваності**

Виробники, щоб забезпечити стабільне положення на ринку, повинні зосередити свою увагу на підтриманні якості своєї продукції на всіх виробничих етапах. Вимірювання параметрів продуктів, їх аналіз та оцінка є невід'ємною частиною виробничого процесу на підприємствах по всьому світу. Чи буде продукт відповідати вимогам замовника залежить не тільки від відхилення контрольованого параметру продукту, а й від змінності самої вимірювальної системи. Вимірювання грає ключову роль в розсіюванні значень контрольованого параметру продукту, тому воно має бути проаналізоване. Інструмент, через який ми можемо оцінити точність і доречність вимірювальної системи називається аналізом системи вимірювання.
**вимірювання змінності, продукт, процес, повторюваність, відтворюваність**

Одержано 27.09.13