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THE METHOD OF MODELING AND NEW PROPOSITION OF GEOMETRY OF WORKING ELEMENTS USED TO TREATMENT OF CONCRETE SURFACE

Introduction

It has been as a result of many-year studies on the treatment of concrete surfaces that the quality of treatment by lapping, grinding, polishing or cleaning depends on the proper selection of the geometrical form of the working elements of machines, their kinematic parameters, and the properties of both processed and processing materials. It has been found based on the performed analysis of the disk-type working elements that they have the highest effectiveness of action. The effect of the geometrical form, its dimensions and the arrangement of elements can be expressed as the so called effectiveness of their utilization, which is determined using he computer modeling analysis and optimization of the parameters of motion of the working disk elements of machines employed in surface treatment [1-4].

Working disk element analysis method

Working elements, arranged on the base, may have geometrical forms as shown in Figure 1. In the computation model, they occur as the friction characteristics of the working element. Disk locations, at which they are not arranged are called take-outs. The date in Figure 1 are only a general illustration of some selected solutions of the geometrical structure of working disk elements. The computation program enables the formulation of any arbitrary figure and dimensions of a single working element, along with its placement in an arbitrary figure and dimensions of a single working element, along with its placement in an arbitrary location on the base using a rotation and displacement operation, and with the simultaneous use of working elements of a different form.

The obtain effective treatment, the disk rotates with the rotational speed ω_o and the forward speed V_p. Additional velocities may be forward speed with a perpendicular sense in relation to the forward speed. The developed modeling analysis enables one to take into consideration all types of motion, owing to the path of disk displacements that is formulated within it, which is composed of the motion trajectory definition. The definition of the disk motion includes the definitions of disk axis point location and the disk kinematic parameters at the beginning and at the end of a particular stage of motion.

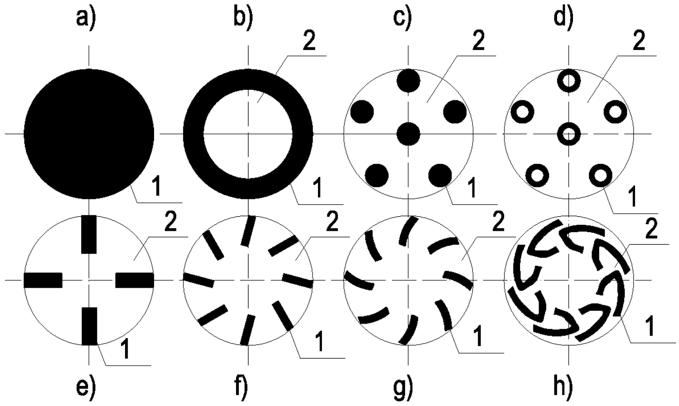

Fig. 1. Selected forms and arrangement of the friction elements of a disk for the treatment of flat surfaces: a) solid disk; b) ring; c) round; d) multi-ring elements; e) and f) blade friction elements; g) and h) radial friction elements. 1 - disk friction element; 2 - take-out

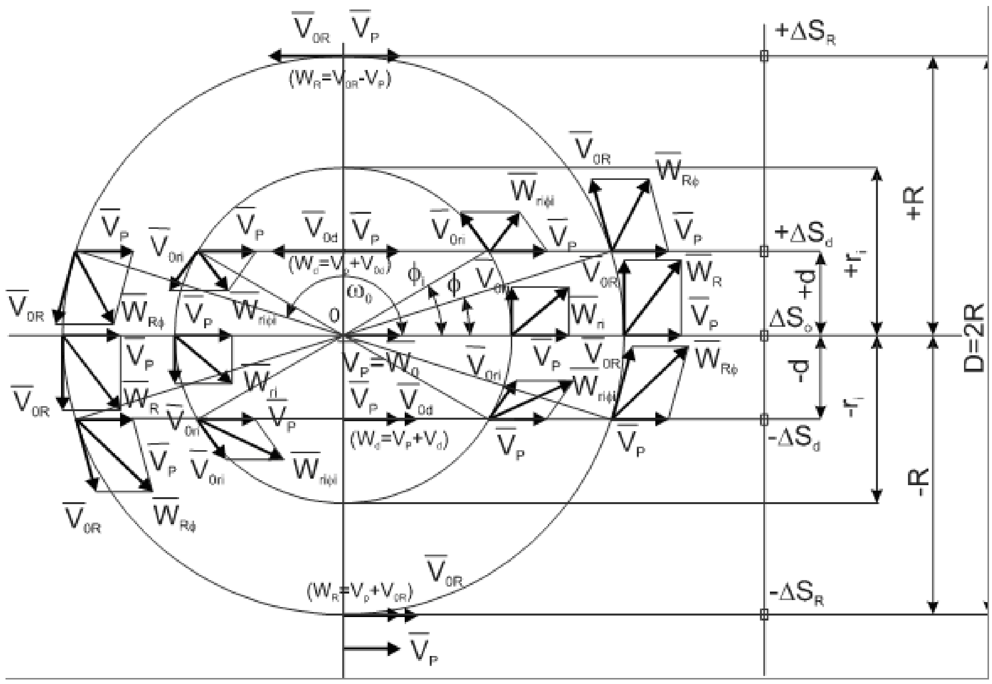

Fig. 2. Variation of the resultant velocity depending on $\omega_i = \nu_p + \nu_{0ri}$ $(r_i = 0,...R)$

The immovable elementary surface of the material being treated (ΔS) is subjected to action associated with the passage of different points of the disk on which the values of the resultant velocity occur, which are different in terms of the magnitude and direction of motion. For a more clear illustration, we will use a solid disk operating in rotary and forward motion, as shown in Figure 2.

By summing resultant velocities in all points of working surface of the disk and by multiplying their action upon the immovable elementary surface of the treated material by the interval (quantum) of time, we will obtain the length of the working element contact line per a given point (ΔS) of the surface treated. In the program, the time quantum, dt, is preset, for which sensors memorize $L_i = (V_p + V_{ori} \ldots)dt$, at the end of which the values of the parameters of the system $V_p + V_{ori}$ and location of the disk axis central point are defined for a successive sensor. The construction of the program permits one to consider the effect of the action of disk working element surface points on the elementary surface being cleaned, and thus to select the required working element contact line. It is for these points of action in the range (+R, –R) that we build practically useful diagrams of the effectiveness of working element action, according to the following relationship:

$$S_{g1} = \sum_{i=1}^{n} L_i(m) \qquad (1)$$

and determine, at the same time , the maximum, minimum, and average numerical values of the mean and standard deviation.

The effect of action, ”S_g”, of the disk with rotational-forward motion is a function relationship dependent on the following three variables: forward velocity, V_p; disk rotational speed, ω_o; and the geometrical structure of the disk, B:

$$S_{g_g} = f(V_p, \omega_o, B) \qquad (2)$$

The developed program contains subroutines related to the relevant known geometrical structures of the disk. They are useful in the analysis of the action of a particular disk structure and inhomogeneity of distribution, S_{gi}, over the width of the surfaces treated. The average effectiveness of working element action, at the same time, will be equal to:

$$S_{g1} = \frac{1}{n}\sum_{i=1}^{n} S_{g_i}(m) \qquad (3)$$

where: S_{g1} - value of effectiveness, as defined in the sensor (m). The objective function in the process of optimization of the working element kinematic parameters is the standard deviation index of the effectiveness of action on the surface treated, according to the formula:

$$\delta = \frac{\sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(S_g - \overline{S_g}\right)}}{\overline{S_g}} \qquad (4)$$

The value of the standard deviation index is, together with the index of average effectiveness, a reasonable criterion for the comparison of the qualitative characteristics of different geometric structures of working disks and, above all, a criterion for optimization in the process of modeling the geometrical structure of the disk element of a cleaning machine, the selection of kinematic parameters, and the determination of the width of overlapping of passes in forward motion and the selection of additional motions, for both the disk axis itself and disk working elements. The task was solved for four variants of disk axis motion path, composed of the rectilinear trajectories of motion at the velocity V_{p_1} (Fig. 3), i.e. following the single disk-pass variant according to the scheme $O_1 - O_2$, variant II of a single pass according to the scheme $O_1 - O_2 - O_1$, and a single action with overlapping according to the scheme $O_1 - O_2 - O_3 - O_4$ and two - pass action with overlapping according to the scheme $O_1 - O_2 - O_1 - O_3 - O_4 - O_3$.

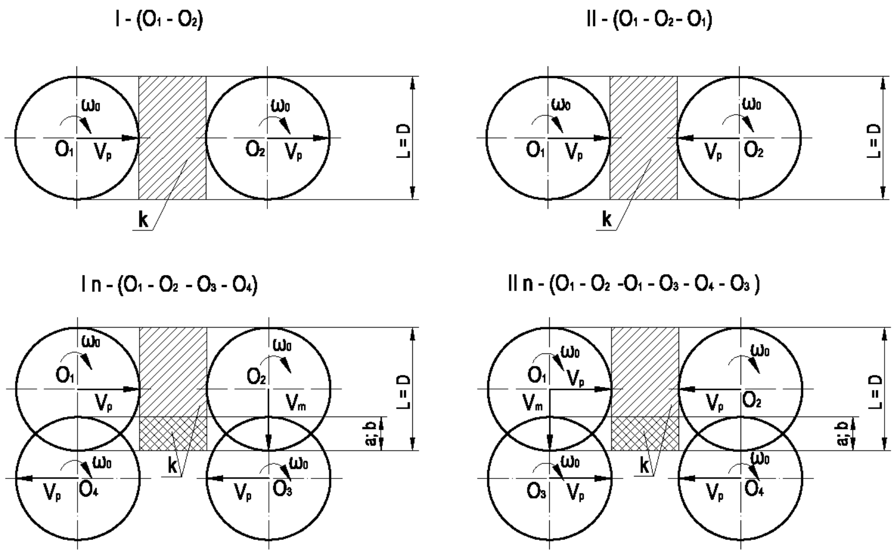

Fig. 3. Computation schemes for different variants of the disk axis path in surface treatment.
Variant *I* - single pass with the axis path according to the scheme $O_1 - O_2$;
Variant *II* - double pass with the axis path according to the scheme $O_1 - O_2 - O_1$;
Variant I_π - variant with overlapping of the successive pass onto the preceding pas according to the scheme $O_1 - O_2 - O_3 - O_4$;
Variant II_π - double pass with overlapping of ”a” or ”b” according to the scheme of disk axis motion $O_1 - O_2 - O_1 - O_3 - O_4 - O_3$;
k - schematic illustration of the multiplicity of passing over the width of treatment of the surface L = D;
V_m - velocity of machine motion

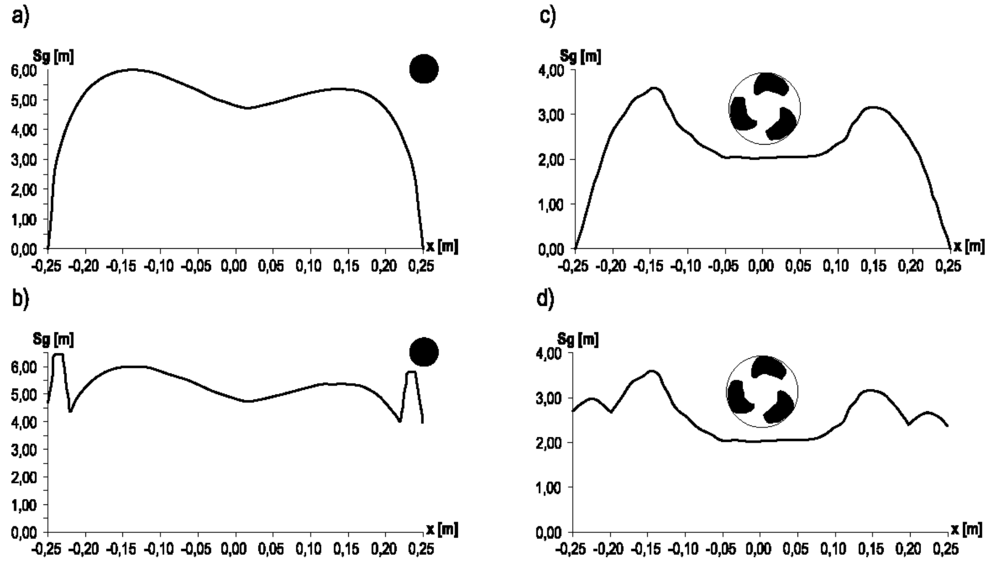

Fig. 4. Diagrams of the effectiveness of the action of:
a) a solid disk with diameter D = 0.5 m; V_p = 0.1 m/s; ω = 72 rpm
I - single pass
b) a solid disk with diameter D = 0.5 m; V_p = 0.1 m/s; ω = 72 rpm
II_π - (with an overlapping of 3 cm).
c) kidneys placed on the disk with the diameter D = 0.5 m; V_p = 0.1 m/s; ω = 72 rpm
I - single pass
d) kidneys placed on the disk with the diameter D = 0.5 m; V_p = 0.1 m/s; ω = 72 rpm
II_π - (with an overlapping of 3 cm)

To obtain a uniform distribution of the effectiveness of action of working disk elements on the entire treated surface, a treatment technology with overlapping of the successive pass onto the preceding on is used. When performing the analysis of action effectiveness for different structural solutions, the optimization of overlapping of successive passes was also employed following the criterion of the minimum of the standard deviation index. For the analysis of the effect of the index of effectiveness of action on the surface treated, the disk diameter D = 0.5 m and the parameters V_p = 0.1 m/s and ϖ_o = 72 rpm were taken. The disk surface structures subjected to analysis are shown in Figure 4, with accurately defined sizes distribution of "friction" elements in the plan.

Conclusions

The diagrams for the first variant indicate an explict asymmetry of the effectiveness distribution for the solid disk, S_g, along the line of sensors (x) corresponding to the width of the surface treated L = D. The asymmetry of effectiveness distribution, S_g, will occur for all working disk elements. In the case of a double pass (variant II of the S_g diagram), this is symmetrical relative to the rectilinear trajectory of disk axis motion, x = 0.

The pattern of the symmetry degree of the distribution diagram, S_g, is retained in variants I_π and II_π and of solid disk action, because additional actions are only possessed by the external treated band with a width of the optimal overlapping of the acting pass, undesired jumps of action effectiveness occur, which indicated the need of purposeful searching for structural considerations and programming three disk axis displacements that will assure the most rational method of surface treatment in the cleaning process.

References

[1] Rajczyk J., Kalinowski J., Badanie efektywności procesów obróbki zacierania powierzchni betonowych, [w:] Budownictwo o zoptymalizowanym potencjale energetycznym, praca zbiorowa pod red. T. Bobki, Wyd. Politechniki Częstochowskiej, Częstochowa 2004.

[2] Rajczyk J., Bolotnyj A.V., Automatyzacja procesów obróbki powierzchni betonowej przez zacieranie, Masz. Urz. Narz. 1999, 1.

[3] Rajczyk J., Kosiń M., Maszyny do obróbki powierzchni przez szlifowanie, [w:] Budownictwo o zoptymalizowanym potencjale energetycznym, praca zbiorowa pod red. T. Bobki, J. Rajczyka, Wyd. Politechniki Częstochowskiej, Częstochowa 2007.

[4] Rajczyk J., Rajczyk Z., Bolotnyj A.V., Sposób analizy struktury geometrycznej elementu roboczego maszyny do obróbki powierzchni betonu, [w:] Stroitel'stvo i architektura. Prilozenie, Materialy XI Mezdunarodnogo naucno-metodiceskogo mezvuzowskogo seminaria „Perspektivy razvitija novych technologij v stroitel'stve i podgotovke inzenernych kadrov Respubliki Belarus", Cast 2, Brest 2004.

Abstract

The article presents the methodology of approach to the optimization of the geometrical form of a disk-type element for the treatment of surface by grinding, lapping, etc.

Metodyka modelowania i nowa propozycja geometrii narzędzi roboczych używanych do obróbki powierzchni betonowych

Streszczenie

Artykuł poświęcony jest metodyce konstruowania elementu obróbczego do zacierania i szlifowania powierzchni materiałów mineralnych. W metodyce uwzględniono wpływ parametrów efektywności oddziaływania na skuteczność obróbczą uzależnioną od geometrii elementu obróbczego i trasy ruchu po obrabianym materiale.