Kinematic Analysis of the Flat Surfaces Lapping

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INTRODUCTION

The lapping process, for fine abrasive machining, requires a relative complex kinematics to be used [1,3,5-7]. This condition results in non- uniformity of the active surface wear of lapping disk, which in turn, decides about the lapping surface flatness, as it is simultaneously a machining basis. In the standard executory system of the single-disk lapping machine [4], a dressing of the surface of lapping tool 1 occurs in result of the displacement of conditioning rings 2 with workpieces 3, placed in the separators 4, in radial direction - to inside or out of the disk (Fig.1 and Fig.2). The correction value of the setting in the ring centers has an influence on the wear of respective fragments of the working disk.

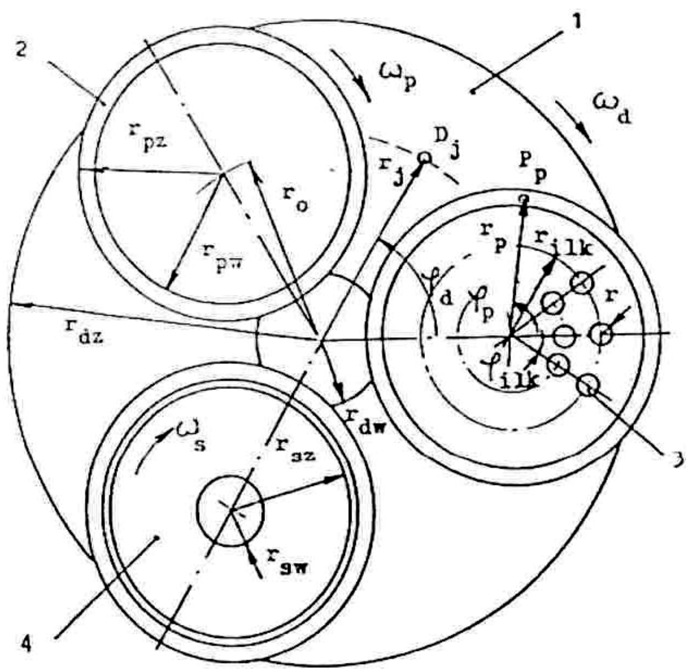

Fig.1. Standard kinematic system of single-disk lapping machine: 1 - lapping tool, 2 - conditioning ring, 4 - separator zone filled with workpieces 3

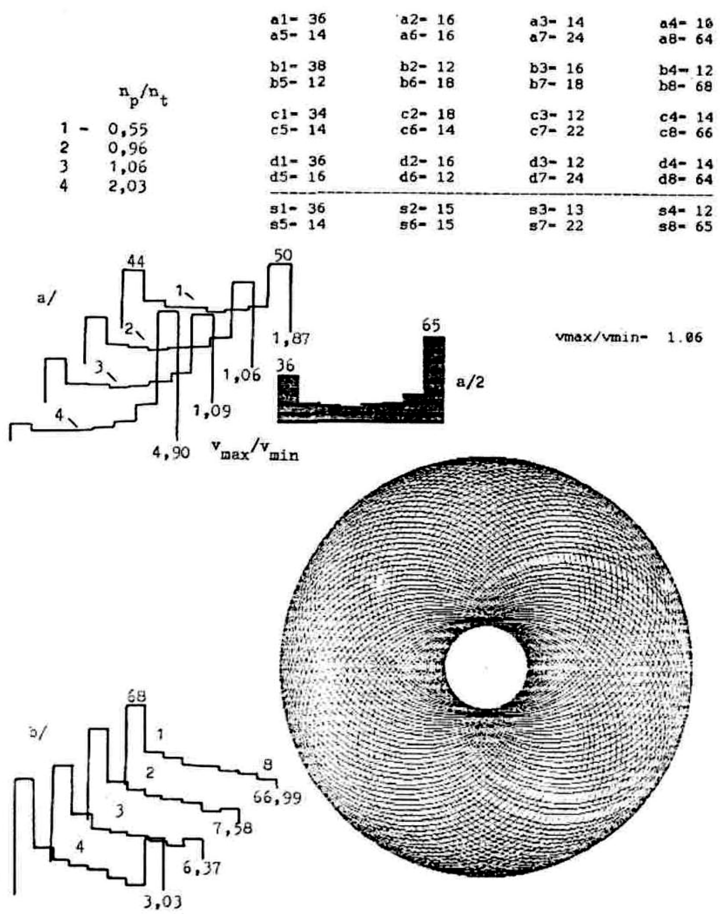

Fig.2. Some simulation analysis results in the rotary system:
a) synchronous, b) asynchronous ($n_t = n_d = 97\ min^{-1}$, $2r_{dw}/(r_{dz}-r_{dw}) = 1$, t = 120 s)

SIMULATION RESULTS

It was proposed in the paper to replace the wear tests with computer simulation of kinematic and determination the contact path of workpieces with defined points s of the lapping disk in radial section. The path s was considered as a diagnostic parameter. It was assumed that the workpiece displacement in the executory system of lapping machine is described by the following function:

$$r_{ilk} = | r_{ilk} | e^{j\varphi ilk} \qquad (1)$$

where: $\varphi_{ilk} = \omega_s t + \varphi_{oilk}$

and where:

i - determines the number of separators ($i = 1 ... i_s$),

l - radius number, on which the lapped elements were arranged ($l = 1 ... l_s$),

k - serial number on the given circle of separator ($k = 1 ... k_l$).

In the analyzed lapping system, the lapped elements are equipotently arranged in the separator on concentric circles. The developed simulation program was used in the analysis of the

Lapmaster 36 lapping machine, equipped with three conditioning rings. The s contact path of D_j definite point of the lapping tool with conditioning rings, was determined and with the lapped pieces. On the Figure 3 there are shown the exemplary progresses of dependence for the central position of rings. A minimum distance was taken in account, between the elements of l_{min} = 6 mm and maximum of l_{max} = 25 mm. The same caution concerns the position of elements in relation to external and internal profile of the separator. In the same time, an optimalization has been done concerning the arrangement of elements onto respective radii of the separator, with satisfying the condition of their maximum packing. The relative speeds were also analyzed in concern to: workpiece - lapping tool (v_d) and conditioning ring - lapping tool (v_p) system. They amounted by way of example, for the case of Figure 2, v_d = 0.69 - 3.0 m/s and v_p = 0.89 - 1.91 m/s.

In result of simultaneous radial displacement of the ring centers (Fig.4 - Fig.6), a change of local extremes was obtained, in these profile places, where the contact path with pieces has a substantial influence on the disk wear.

On the extreme fragments of lapping tool, a considerable profile change was reached in consequence of ring displacement, but in the same time a local convexity or concavity take place. The influence of conditioning ring position on the central zone state of lapping tool may be considered as insignificant one. In view of this above truth, a position dependence of pieces in the separator has been determined, what influences the summary lapping path (Fig.7).

From the carried-out simulation, it results that the arrangement diversification of elements in the respective conditioning rings, influences to a small degree the wear uniformity of lapping disk. It should be also pointed-out that in the work it was assumed the wear value proportionality Z from the path contact s of definite point of the lapping tool with workpieces and conditioning rings.

Generally it may be written that the wear is a function of:

$$Z = f[W(PO), W(MS), p, v, a^t, h, s] \quad (2)$$

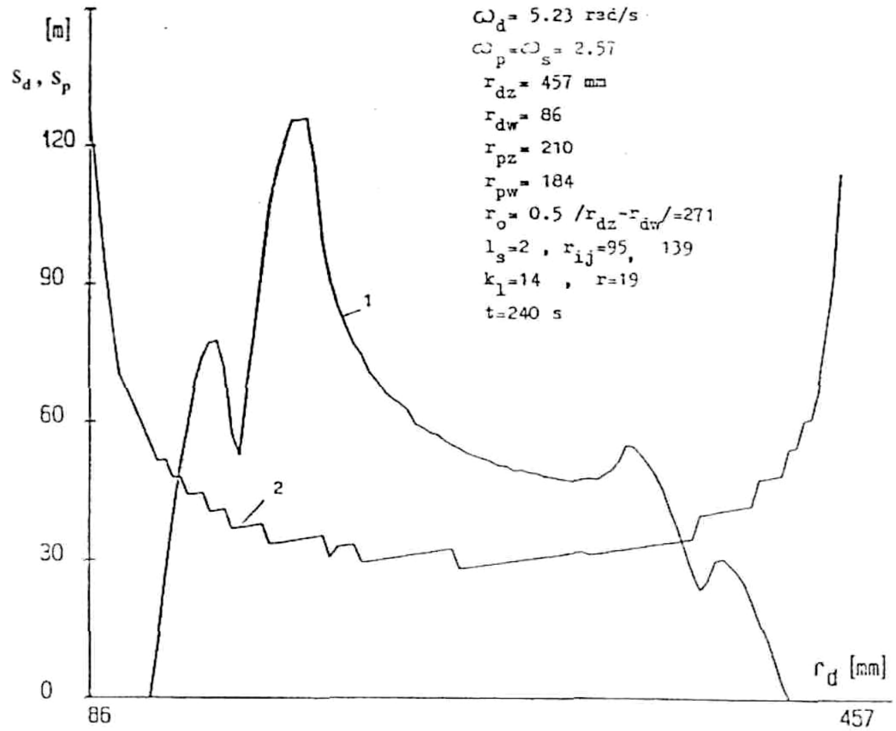

Fig. 3. Diagrams of contact path s of workpieces (1) and conditioning rings (2) with lapping tool in radial section

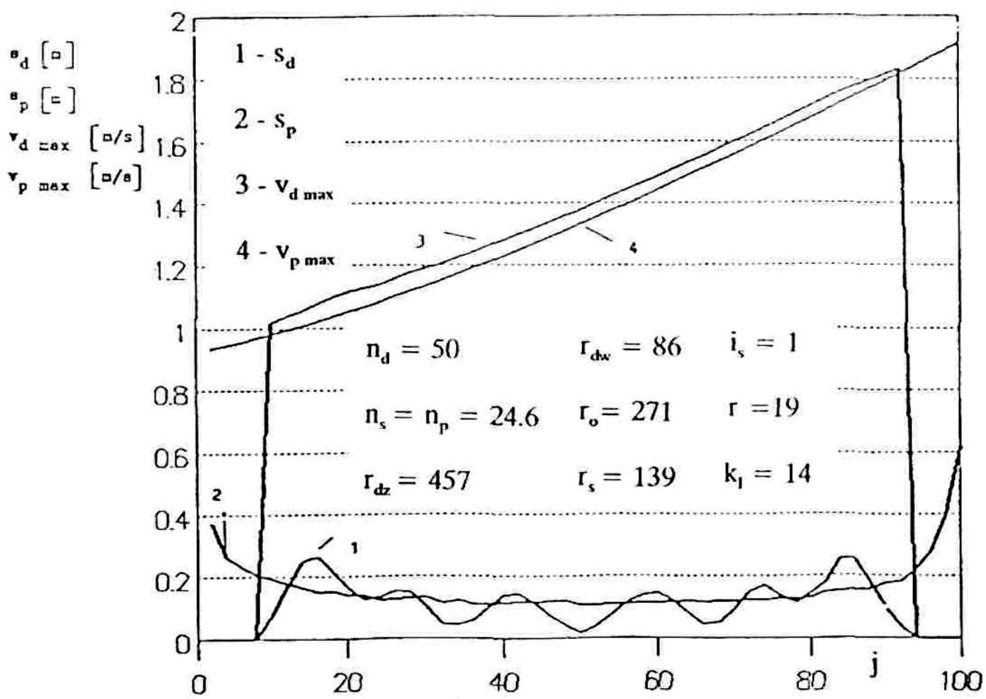

Fig. 4. Simulation results for the circular elements (t = 2.5 s)

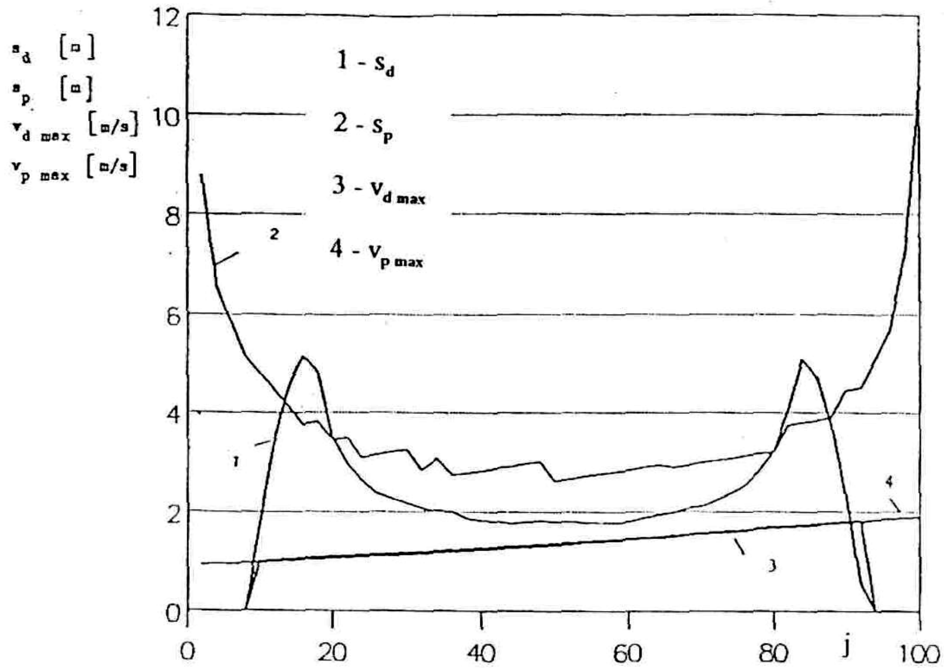

Fig.5. Simulation results for t = 60 s
(other geometric and kinematic parameters like these for Fig.4)

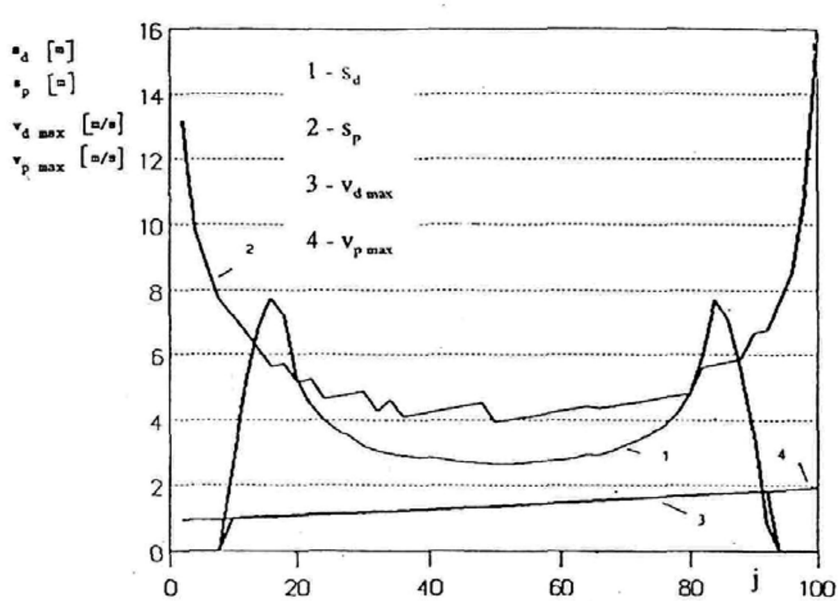

Fig.6. Simulations results for t = 90 s
(other geometric and kinematic parameters like these for Fig.4)

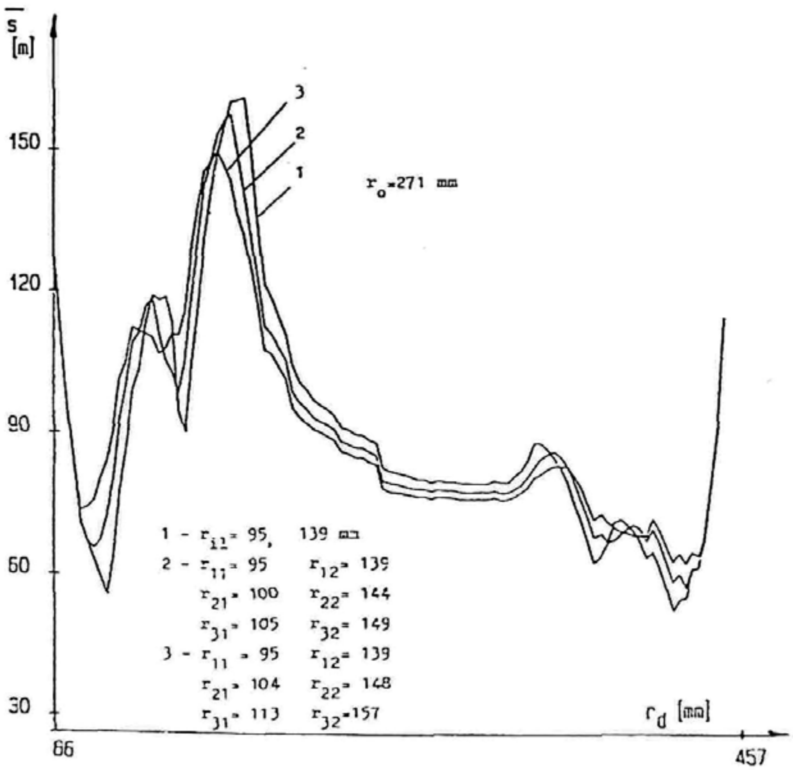

Fig.7. Diagrams of summary contact path of workpieces and conditioning rings with lapping tool in radial section for diversified arrangement of elements in separators (other geometric and kinematic parameters as for Fig.3)

where: W(PO) - properties of workpiece,
W(MS) - properties of abrasive,
p - unit pressure,
v - lapping speed,
a^t- tangential acceleration,
h - size of work slot (clearance).

In result of the simulation, the obtained diagrams of the contact path are approximated to the profiles of disk wear, determined experimentally [2].

FINAL REMARKS

The proposed estimation method of flat lapping tool state, can be used in tests of the models concerning the executory systems of lapping machines.

Taking into consideration the variability of kinematic conditions can, in further work, simplify the finding the most favorable system, with assuming the admissible wear unevenness of the active surface of lapping tool.

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