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VIBRO-ROLLING OSCILLATIONS

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Abstract: There are established methods for realizing manufacturing through vibro –rolling of the exterior surfaces. On the duration of the experiments, proposals of improving the vibro –rolling devices performances have been analyzed and formulated based on constructive new solutions.

1. INTRODUCTION

There are already acknowledged procedures to process exterior surfaces by vibro-rolling.

During the experimental testing, several possible solutions have been expressed and analysed, to improve the performances of the vibro-rolling device based on new constructive methods.

2. CONSTRUCTIVE SOLUTIONS FOR THE ROLLING HEAD

The initial constructive solution for the rolling head during the experimental stage is presented in Figure 1.

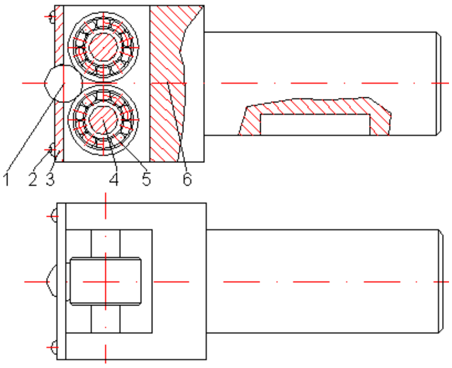

Fig.1. Rolling head used for the vibro-rolling device: 1. rolling ball; 2. screw for temple clamping; 3. temple; 4. shaft; 5. rolling bearing; 6. fork

In this case, the ball represents the pressure body pushing against the part surface. The backward push is taken by the radial bearings (5) mounted on the shafts (4), which are stiffly screwed, on their turn, in the fork bore holes (6). The fork tail is clamped into the frame bore holes, being protected against rolling by a parallel key. (Lee& Tarng 2001)

The temple (3) is meant to maintain the ball in contact with the bearing exterior ring, in the absence of the pushing force.

The role of the bearings is to ensure a smooth functioning of the rolling head, without sliding friction. This can be achieved completely if the functioning does not involve feeding, but it doesn't determine the generation of a system of impressions, but only of a single sinusoidal impression.

The caption of Figure 2 is the following:

- v_o – speed of the oscillatory movement;
- v_p – tangential speed determined by the part rotation (n_p);
- v_s – feeding speed;
- v_f – speed resulting from the combination of v_p and v_s speeds;

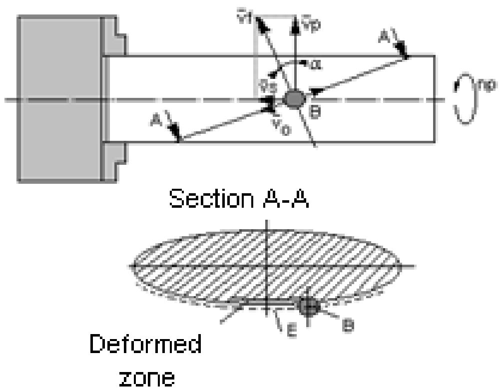

Fig.2.Chart presenting various speeds involved in vibro-rolling

If the oscillatory movement is determined on a parallel direction to the part axis, the rolling is achieved on v_p direction, also entailing a sliding movement on v_s direction.

If the oscillatory movement is determined on v_o direction perpendicular on v_f, the rolling will be achieved without sliding on v_s direction.

To obtain a movement without sliding on $v_{s,}$ it is not enough to tilt the rolling head, but to also to provide an oscillatory movement perpendicular on v_f ; it implies tilting the entire vibro-rolling device, solution which entails constructive complications. Also, the device tilting must be calculated separately for every single change in the feeding value, which entails again operation complications. Another major impediment to a good rolling is the necessity to obtain a very subtle balance between the sliding forces. If the rolling friction between the ball and the part is higher than the sliding friction between the ball and the bearing exterior surface, the rolling on the feeding direction is replaced by sliding.

We will next analyse two new methods used in vibro-rolling, which could replace the solution presented in Figure 1. These methods are only proposals, as they need further studies and development.

3. VIBRO-ROLLING DEVICE WITH CURVE CONVEX-PROFILE ROLLER

This method is intended primarily to reduce the friction forces on the direction of the roller oscillatory movement (parallel with the part axis). As presented in Figure 2, the convex-profile processing roller is fed against the processing surface by a concave-profile pressure roller (Figure 3).

The vibrating movement is an angular oscillatory movement having as oscillation centre the vertical axis which is parallel to z` - z axis. The vertical rotation axis is the same with that of the gear, which drives the gear rack. (Deacu & Pavel 1977)

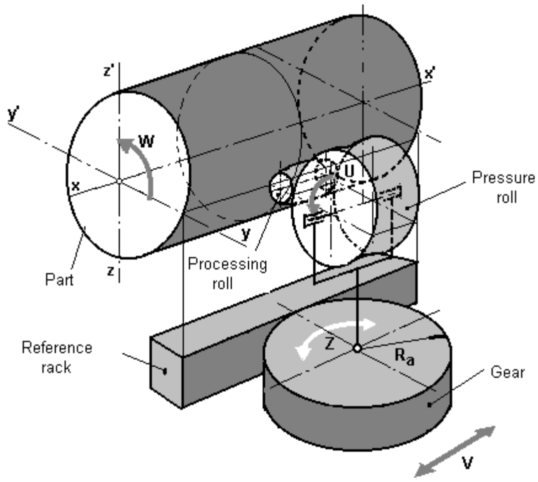

Fig. 3. Basic diagram of the vibro-rolling using a convex-profile roller

The gear rack is parallel to the part axis and is rigidly mounted on the machine frame. The gear division radius must be the same as the profile radius of the processing roller. The main advantage of this method is that due to the combination (simultaneous operation) of movements “z” and “v”, the curve-profile roller will roll without sliding on the part surface in an angular oscillatory movement, thus preventing any possible friction between the roller and the part. (Keesen 1975)

The gear – gear rack mechanism can be replaced by a band mechanism, just like that used on Maag grinding machines.

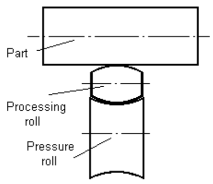

Fig. 4. Chart representing the processing operation

The drawback of this method is the fact that the roller impression on the part surface is much wider than with the ball processing, the resulting impression systems not being able to meet the requirements of the vibro-rolling processing.

4. VIBRO-ROLLING DEVICE WITH SELF-SUSTAINING OSCILLATIONS

The second scientific proposal is the use of an elastic system to obtain self-sustaining oscillation. This method could be used to remove the driving element of the vibration device. The following chart is meant to ensure the theoretical support for potential future construction of this device (Figure 4).

The processing roller is pressed down on the processing surface with an F force. It is rolled on the part surface and has the possibility to rotate around w – w` axis or to slide along the L-length guideway. The roller oscillation phases are presented in Figure 6. (Klocke.& Liermann 1996)

Once in A position, the roller will be rotated by the arm fitted with a spiral arc, as this one has the tendency to expand, and the end of the bar (N) will slide along the C-D curve guideway (β angle < angle of the friction cone), up to N` point, rotating the roller on w – w` axis (Figure 6).

At this point, the roller will be at an α angle relative to the perpendicular line on the part axis, determining a pushing force of the roller (of the M point) from A to B. During the movement from A point to B point, the arc will be compressed, so that when reaching point B, the movement can be reversed. N will move toward N` due to the arc expansion, modifying at the same time the position of the roller axis relative to the part axis. Thus, a transversal force is obtained, which is pushing the roller from point B to point A, compressing the arc at the same time. The cycle is repeated and a roller oscillatory movement is occurring, with a frequency and amplitude determined by the geometric parameters of the device.

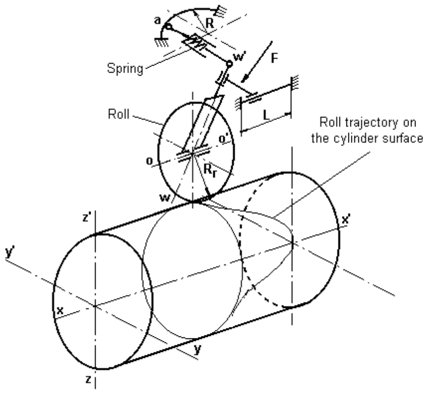

Figure 5. Short presentation of the device; the roller impression on the part is a sine curve

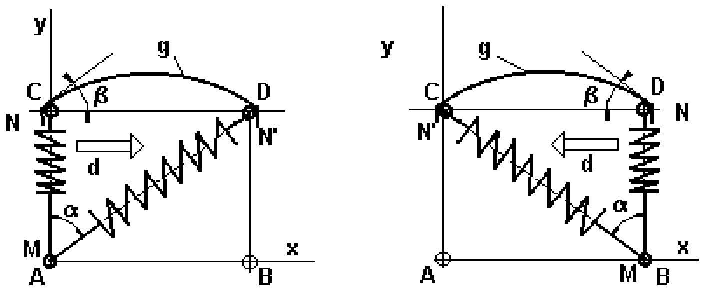

Figure 6. Representation of an oscillatory cycle

The disadvantage of the above-presented method is the difficult construction of this device.

The two “unconventional” solutions have both disadvantages related mainly to construction difficulties.

For the solution presented in Figure 1, the efforts needed to achieve a perfect rolling between the elements of the rolling head (ball, bearing) are also considerable, determining some constructive complications of the device.

A practical solution which allows the sliding friction between the ball and its frame, and facilitates a satisfying rolling between the ball and the part is presented in Figure 8. This variant has a simple and solid construction, the assembling of the parts 1 and 2, respectively 3 and 4 being realised by pressing. Part 3 is made of anti-friction bronze, to enable a slight ball rolling.

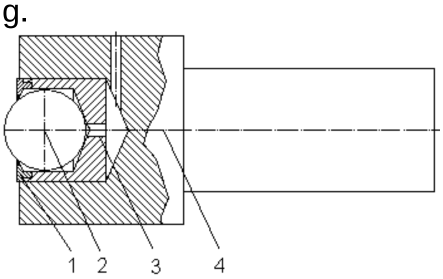

Figure 7. Common rolling head. 1. retainer ring; 2. ball; 3. anti-friction part; 4. Frame

At the same time, the space between the ball and part 3 is filled with molybdenum disulphide (MoS_2), having superior anti-friction properties. (Wahl 1987)

This variant has been tested within the experimental stage of our doctoral studies, obtaining high-quality impression systems. What still remains unknown is the reaction of this type of head to long-term wearing, as it needs long-term experimental testing.

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