Miniaturized piezoelectric vibratory conveyor for the flexible handling of very different small parts

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Abstract

Part feeding is a major bottleneck for successful automation in micro assembly. In this paper a miniaturized piezoelectric vibratory conveyor is presented which was developed for the flexible handling of very different small parts at the wbk Institute of Production Science of the Karlsruhe Institute of Technology (KIT).

1 Introduction

In micro assembly handling tools have in general to be adapted to every single part and only offer a limited level of flexibility. Therefore, at the Institute of Production Science a piezoelectric vibratory conveyor working according to the micro slide principle was developed. On its conveying panel very different small parts regardless of shape and geometry can be conveyed in any direction, positioned and can partly even be oriented without additional devices only by adjusting magnitude and phase of the oscillations [1]. By means of the limitation of vertical acceleration to less than *1 g* the micro slide principle allows a very gentle and smooth conveying process. Thin and fragile green metal parts before sintering could be conveyed without damage or abrasive wear with conveying speeds up to 5 m/min. The spectrum tested up to now covers the range from a micro gear to a pencil standing upright (mass ratio 1:10000).

By the miniaturization of the vibratory conveyor a modular and flexible feeding system consisting of various vibratory conveyors located side by side is now to be developed. The system then can be used not only to convey, position and orient parts, but also to separate and sort them [2].

2 Design of the miniaturized vibratory conveyor

The design of the miniaturized vibratory conveyor is illustrated in figure 1. The core of the newly developed conveyor is the bearing of the conveyor panel. It is effected

via two especially developed integrated flexural bearings. With a total of three translational degrees of freedom these flexural bearings allow for the oscillations which are necessary for the conveyance according to the micro slide principle. The generation of oscillation is carried out by three piezo stack actuators which are arranged according to the degrees of freedom of the flexural bearings. These piezo stack actuators are preloaded via flexure elements which are especially dimensioned for the use in the vibratory conveyor.

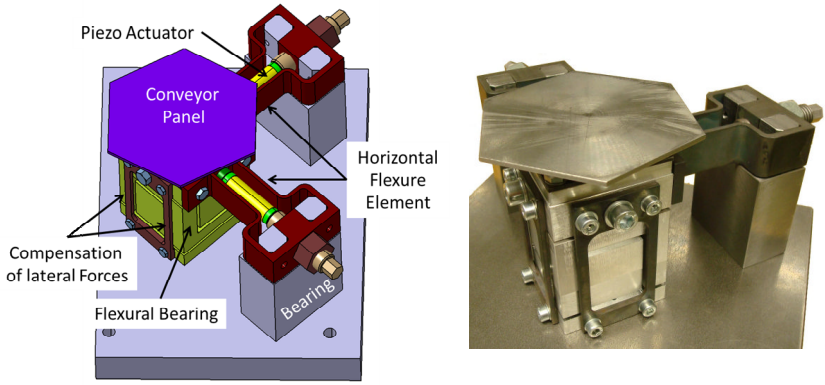

Figure 1: Miniaturized piezoelectric vibratory conveyor

2.1 Flexural bearings

The horizontal flexural bearing consists of two parallelograms which are nested into each other and permit in each case translational movements in the direction of the x- respectively y-axis (figure 2).

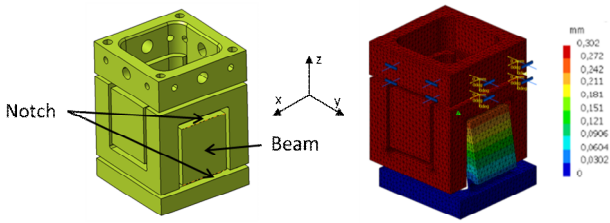

Figure 2: Horizontal flexural bearing

As a result of the superposition of these two degrees of freedom oscillations in any horizontal direction are possible. The vertical movement of the flexural bearing can be neglected ($\Delta z = 0{,}003\ \mu m$).

According to figure 3, left, the vertical bearing is set into the horizontal element. The vertical movement of the conveying surface is facilitated by an especially dimensioned spring plate (figure 3, right).

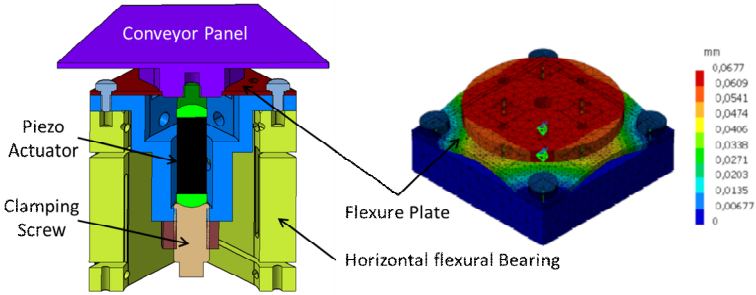

Figure 3: Vertical flexural bearing

2.2 Preloading of the piezo actuators

The piezo stack actuators have to be preloaded if used in the vibratory conveyor because they are not to be subjected to tension. By tightening the clamping screw the especially developed horizontal flexure elements permit a preloading of the actuators which is independent from assembly and adjustment of the vibratory conveyor. At the same time, the horizontal flexure element (figure 4) shows a very low transverse rigidity ($c_{quer} \approx 1/12\ c_{längs}$) so that it does not interfere with the dynamics of the second laterally aligned horizontal axis.

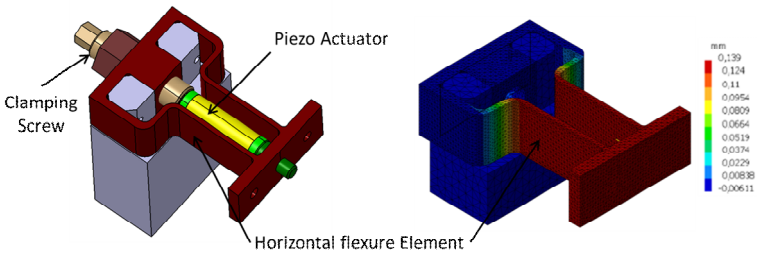

Figure 4: Horizontal flexure element

The forces that result from the transverse rigidity of the horizontal flexure elements and that act on the horizontal flexural bearing are balanced by compensation springs arranged at the opposite side (figure 1).

The preload of the actuator in vertical direction is effected by the already mentioned spring plate (figure 3).

3 Commissioning

The finished vibratory conveyor is shown in figure 1, right. Compared to the initial configuration a size reduction of 50 % was achieved. By the achieved dimensioning of rigidity of the flexural bearings and the horizontal flexure elements the system shows high dynamics in the three vibration directions and is at the same time highly resistant to undesirable rotational and stagger oscillations. However, modal frequencies occur in the desirable operating range due to the associated comparatively low rigidities in the three vibration directions of the system. Anyway, the vibratory conveyor operates very well at $f = 200\ Hz$, within a range of $300\ Hz < f < 320\ Hz$ and at $f = 360\ Hz$. With horizontal accelerations of up to $40\ m/s^2$ the most different parts could be conveyed, positioned and partially oriented by rotation about their vertical axis in the first tests.

4 Summary and outlook

In the present contribution concept and commissioning of a miniaturized piezoelectric vibratory conveyor are introduced. During the first conveying tests the most various parts could be conveyed, positioned and partially also oriented. The small amplitudes of the micro slide principle also facilitate a gentle and smooth conveyance. Thin and fragile green metal parts before sintering could be conveyed without damage or abrasive wear.

By the combination of several piezoelectric vibratory conveyors to a modular conveying system an automated flexible feeding system for small parts is to be designed in connection with image processing. The setting up process respectively the adaptation to a new spectrum of parts then remains limited to the loading of an appropriate part-specific software program.

References

[1] Munzinger, C.; Dieckmann, A. M.; Leberle, U. et al.: Assembly automation for micro-products coupling a vibration conveyor with a gripper. EUSPEN 9th International Conference 2009, San Sebastian, Spain, S. 529-532

[2] Fleischer, J.; Leberle, U.: Automated supply of microparts based on the micro slide conveying principle. CIRP Annals - Manufacturing Technology 2011, Budapest, Hungary, S. 13-16