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CONSTRUCTIVE AND TECHNOLOGICAL POSSIBILITIES OF FIVE AXES MACHINING WITH ROTARY/TILTING TABLE

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Abstract

Keyword: ***Five axes machining on rotary-tilting table***

The present paper work tries to shows the main technological and constructive aspects for the case of five axes machining, based on the rotary-tilting table as the forth and fifth CNC machine axes, together to the three linear machine CNC axes. As constructive aspects, we can mention the necessity for the rotary-tilting table with the diameter of 630 mm to be able of great speed at rotation (cca 150 rpm) and with zero backlash on the B axis, and respectively 40 rpm and also zero backlash on the A axis.

How the requested conditions of the table construction are realized, this is in the paper work showed. Regarding the technological aspects, two main conditions must be mentioned: the high speed and the increased rigidity on A axis and they are necessary in order to be able at good reaction in interpolation time, and good stiffness at vibrations in the cutting process at high power.

INTRODUCTION

The authors of the present paper work try to shows the best constructive variant for the rotation/tilting feed mechanism of the new table unit MRI 630-2 with a CNC axes.

The reason of the best choice in this case is the technological aspect, based on the five axes machining, having the cutting process by milling in the interpolation time on the curved contour at the nominal power and under the precision limits. The most frequent used solutions based on tooted gears are not the best, because they have a bad energetic efficiency, and permits low speed only. All usual solutions are adequate for positioning only, and are very restrictive for contouring process.

CONTENT

The following variants are to be mentioned as constructive possibilities in this matter:

-- ***tooted gear*** variants: -- Duplex worm gear with mechanical periodic adjustment of the backlash trough the axial moving, **fig. 1**

-- Con Drive worm gear (globoid profile) with mechanical adjustment of the backlash (having two axial worms half), **fig.2**

-- double Duplex worm gear (as parallel synchronous preloaded double feed mechanism, **fig. 5**

-- double Con Drive worm gear (as parallel synchronous preloaded double feed mechanism), **fig. 6**

--OTT-special profile worm gear mechanism with backlash adjustment (having two axial preloaded worms half), **fig. 3**

-- pinion pair – gear and worm - gear pair as parallel synchronous preloaded double feed mechanism, **fig. 4**

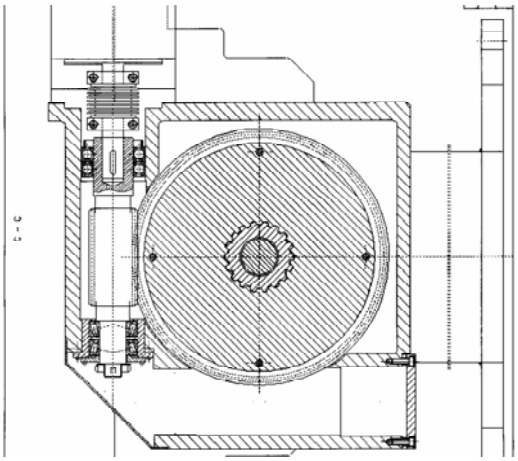
-- ***direct drive*** feed mechanism by servo motor built-in type (Fanuc style) at rotation B axis only;

-- ***ball screw drive*** simplex or duplex synchronous feed mechanism at tilting A axis, **fig. 7.**

The most representative samples for these variants are presented with the comments, as follows.

First, all tooted gear variants, from the excessive preloading on the teet surfaces, they

have a bad energetic efficiency, with great friction, great wear, hitting, and low speed and needs to have powerful servomotors.



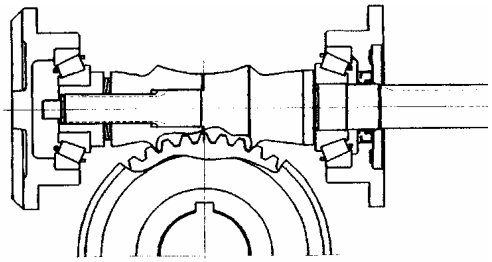
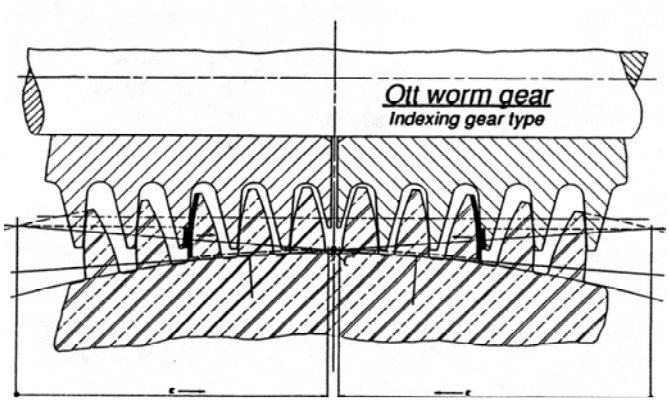
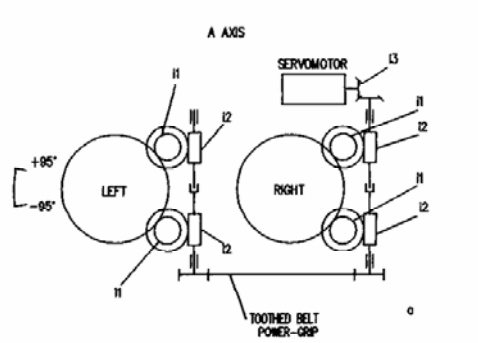
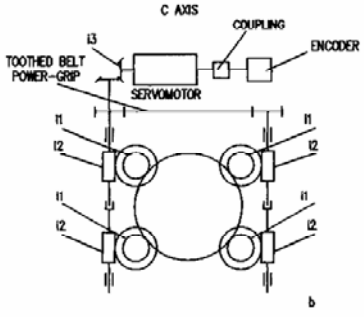


Fig. 2 – CON DRIVE solution (top), [3]

Fig. 1 – Duplex worm gear variant (left), [1]







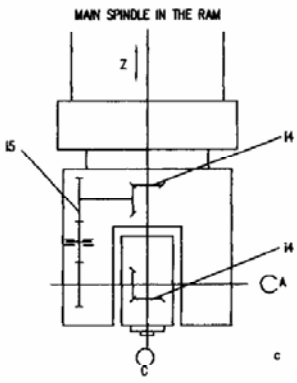


Fig. 3 – Special profile worm gear, [4]

Fig. 4-Parallel feed mechanism, [1]

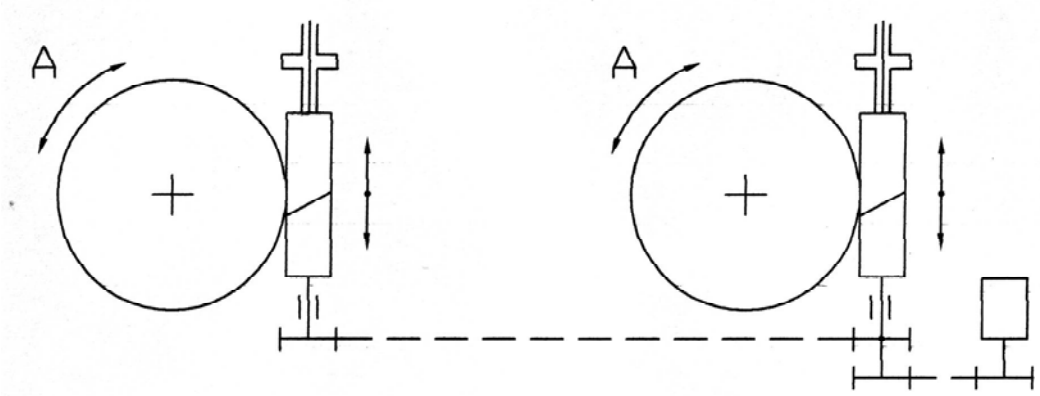


Fig. 3 - Tilting axis A by double DUPLEX gear mechanism
(backlash adjustment by axial moment of worm)

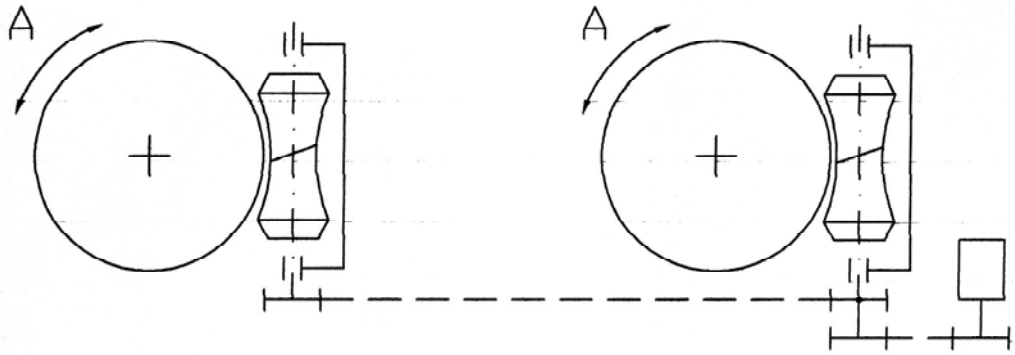


Fig. 3 - Tilting axis A by double CONDRIVE gear mechanism
(backlash adjustment by excentric bushings)

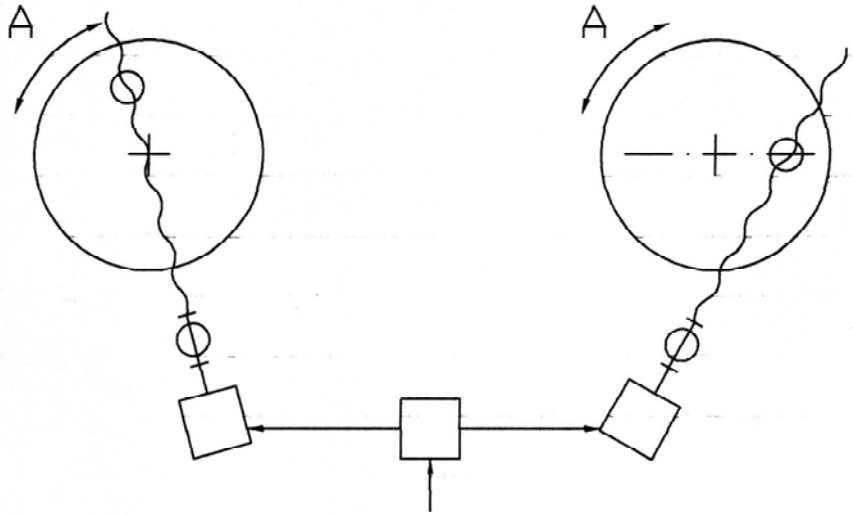


Fig. 3 - Tilting axis A by two ball screw mechanisms
at 90 DEG phase difference

Also, the **fig. 1** shows the case of Duplex gear as single pieces of worm, this case need to adjust periodically the axial worm position, in order to compensate the wear.

The second case is showed in **fig. 2** with a single worm of globoid profile having two half, in order to adjust the backlash and to compensate the wear by axial adjustment.

The third case is with OTT special profile of worm (**fig. 3**), having two half axially, in order to can adjust the backlash and to compensate the wear.

All the next four cases are based on double feed mechanism as parallel synchronous symmetrical or asymmetrical preloaded, in order to support a heavy charges, with zero backlash and high precision.

Also, the **fig. 4** shows the case with double pinion – gear and double pair of worm-gear symmetrical preloaded, for two applications: for tilting movement, or for swiveling movement, both cases droved by a single standard servomotor. The next case (**fig. 5** on top of page 4) is provided with double pair of Duplex worm – gear for tilting movement, as parallel synchronous feed mechanism symmetrical preloaded. Other case, (**fig. 6** on middle of page **4**) is provided for tilting movement with double globoid profile worm-gear pair, as parallel synchronous symmetrical preloaded feed mechanism. Al the three over mentioned cases as double parallel feed mechanisms are droved by a single standard servomotor.

One special case is with direct driving by servomotor built-in type (Fanuc style) for table rotation on B axis only. (This is classical solution of Fanuc and it is not sowed by figure in the present paper work). Here it is not easy to obtain the angular accuracy at the rotation B axis, because the speed and the mechanical amplifier ratio are high enough.

The last variant (**fig. 7** on bottom of page 4) is based on ball screw driving, single or double, for tilting A axis. In the case of double ball screw, the movement source is one single servomotor, having one dividing unit to the both directions trough two synchronization units, in order to respect the mathematical laws of the movements for the both sides. This case can be solved by mechanical units, or by two separate servomotors based on the help of special software.

CONCLUSIONS:

The first author of this paper work want to perform one CNC two axes table MRI 630-2, as detacheable table, in order to extend the technological milling possibilities to five axes machining. The table is provided to A – tilting and B – rotation movements, with high performances (rotation speed up to 150 rpm, tilting speed 40 rpm, positioning accuracy 4 arcsec, capacity of milling under interpolation time up to 15 kw, etc), all these in his doctorate stage.

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