

## ABOUT THE EVOLUTION OF THE FIVE AXES MACHINING IN THE LAST 30 YEARS

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### Abstract

Keyword: *Five axes machining*

The 5-axes CNC machining of the complexes parts is not one very new technology. We also can talk about of 30 years of experience in the world on this domain, which evoluated belong the time, depending of the computers evolution. Even the special applications on the most important domains as aeronautics, engines, naval, military, etc., the evolution was limited of the technological performances and also the computers performances. Evan today, wend the evolution is oriented to the virtual axes machines, the evolution is not stopped. It is a new way of this technology just at the beginning, which can touch incredible performances in the future.

The CNC five axes machining of the complex prismatic parts is a 30 years old technology, which evoluated belong the time together with the CNC's and computer's evolution, but also with technological performances of machine tools. Regard the main steps of the evolution at these machines, we must mention the main areas of application, as: aeronautics, engines, navy, military, plastic materials, as high level domains, with lot of money.

The specialized machine tool builders were in the strategic plans of the main industrialized countries implicated, interested in the past on the cool war, and today in the technological and economical domination.

In this way, 30 years ago, that means in 1977, some American companies (Giddings and Lewis, Cincinnati Milacron, etc), as well European companies (Forest-France, Starrag-Swiss, etc), were implicated in the special machine tool performing, destined for very special parts, as follows: machines for turbine propeller at ships (fig.1), for turbo engines in aeronautics (fig.2), for profiled parts in aeronautics (fig.3).

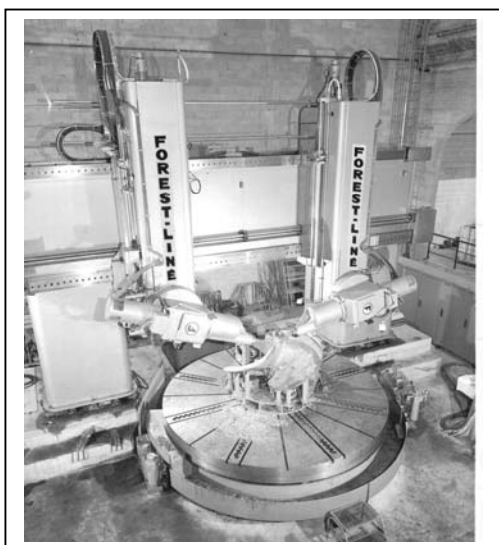


Fig. 1, [1].

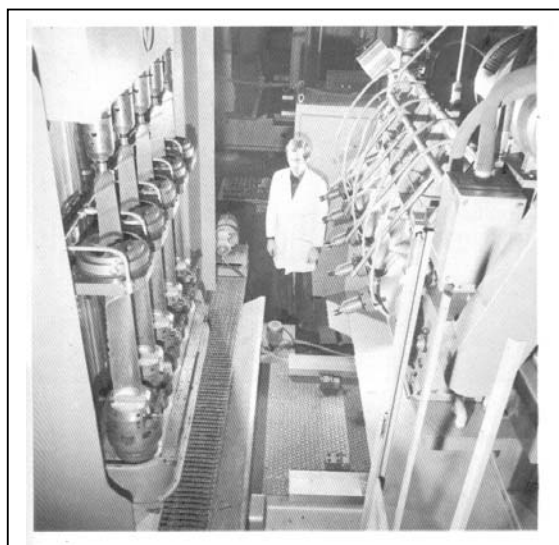


Fig. 2, [1]



Fig. 3, [1].

For the last one, at the time, was adapted one special two axes milling head “twist head”, which was provided with two rotating movements as two independent rotating axes, having the tool center point as center of movements, but having mechanical angular limits and also technological limits. Basically, the idea was that the tool axis to be normally at the part surfaces in the contact point, according to the Fresnet coordinates, from the analytic and differential geometry.

The numerical control equipments at the time were as “hard type”, that means Numerical Control Constraint, with hard cards for any geometrical function from the tool trajectory, (as sample Kronsberg Nordica-Norway, General Electric-USA, etc).

The CNC's (Computer Numerical Control) equipments were developed later, at the beginning of the years '80, but in the first period they were seriously limited regarding the technological performances (8 bits). Later, at the middle of the years '80, the performances of the CNC units were improved, now having 16, 32, and even 64 bits, higher speed and larger calculation capacity and memory, and this fact permitted to improve the machine technological performances (as sample Siemens, Fanuc, Mazac, Allen Bradley, Heidenhain, Fidia, etc).

One important stage at the middle of the years '80 was the launching of the TCPM software (Tool Center Point Management), which one open the way to the new machine tool generation, equipped with the new more performing heads with one or two CNC rotary axes (tilting and swiveling milling head), or new more performing tables with one or two CNC rotary axes (rotary and tilting table). This soft permits to calculate the positions of all the machine axes in real time in which moment, on the programmed trajectory of the tool center point. Also, the calculation speed was improved, as well the curve interpolation, that means for the five axes machining case, the circle generation on the free oriented plane in the three dimensions geometrical space, and also the possibility of the all five machine axes interpolation on this circle.

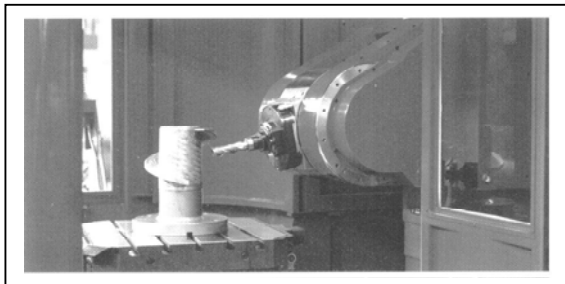


Fig. 4, [2]

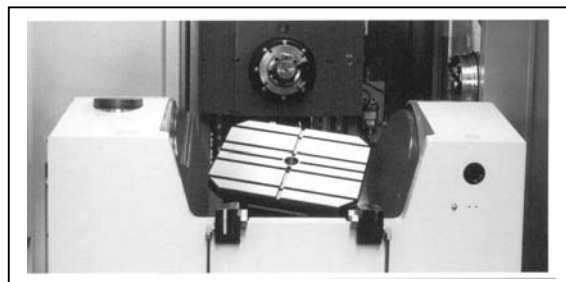


Fig. 5, [2].

Samples of CNC milling heads or tables, as well combinations, it can see in the figures 4, 5, 6, 7.

In this way, the figure 4 shows the combination between tilting head on A axis and rotary table on B axis, the figure 5 shows the rotary-tilting table on A and B axes, the figure 6 shows the tilting and swiveling milling head on A and C axes, and finally the figure 7 shows the combination with two rotary tables (table on table on B and A axes).

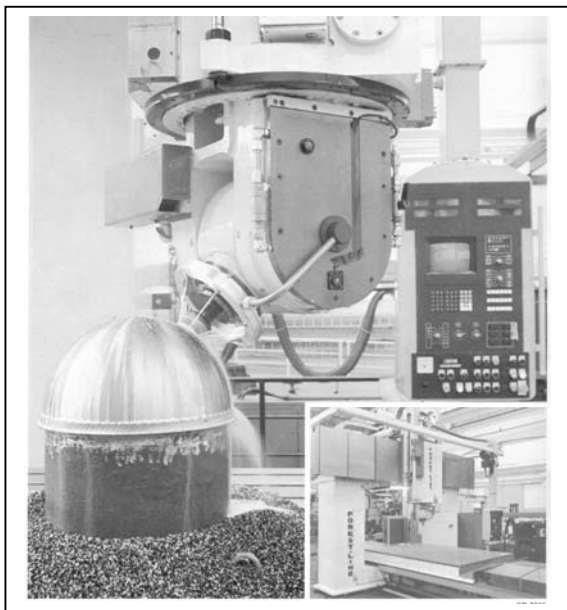


Fig. 6, [1].

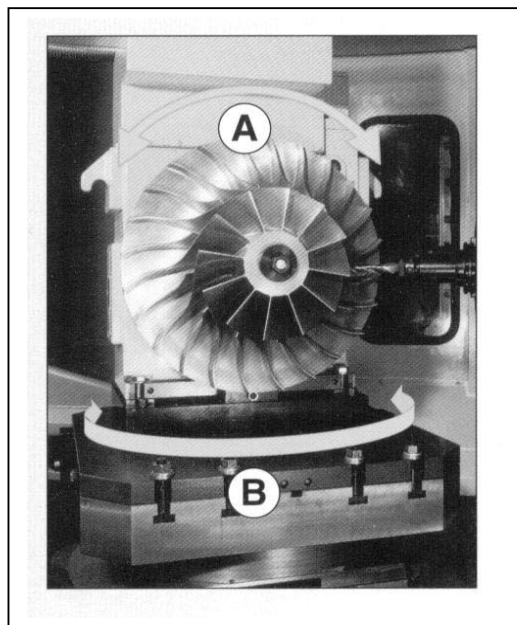


Fig. 7, [2].

In this way, after the middle of the years '90 some similar activities were by us initiated on this top technology, for foreign clients or for internal needs. Also, it was performed some new products in the milling head area, as: automatically universal indexing milling head at SC Stimin SA Oradea (fig.8), two CNC axes milling head (performed by the author of the present paper work – fig. 9 and delivered to Canada and exposed to the IMTS Chicago 2000 exhibition (fig.10), and later it was mounted on one large bed milling Canadian machine at Reko Machine Builders (fig. 11).

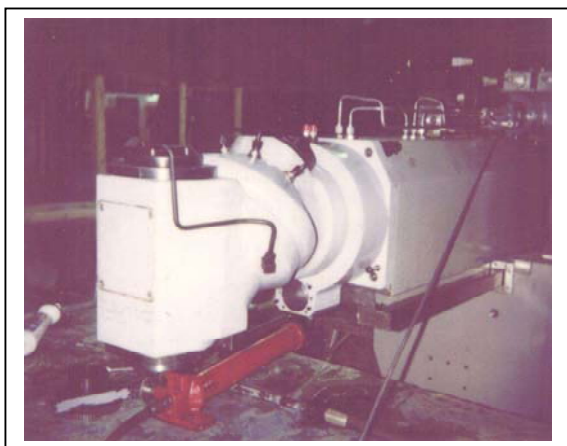


Fig. 8, [2] – (top)



Fig. 9, [2] – (right)



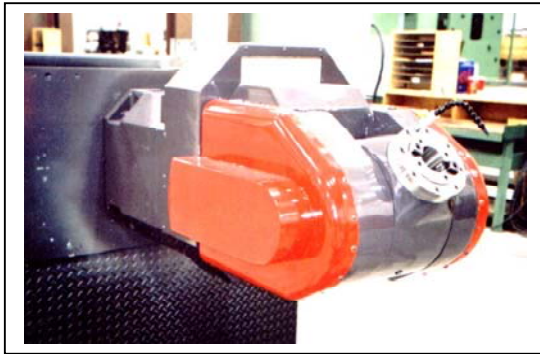


Fig. 10, [2] – (top)



Fig. 11, [2] – (right)

One revolutionary jump in this domain was started at IMTS Chicago exhibition by Giddings and Lewis, with the first “Hexapod Machine” with virtual axes (fig. 12). This fact launched in the world one big impulse in the research area, so that the results were the launching of new industrial models on the market by some famous companies as DMG – Germany (fig.13). Here is a hybrid machine, having the real linear machine axes combined with the rotary virtual axes of the tripod head, obtaining one universal milling center “Tricenter”, launched in 2002.

It is remarkable the fact that after 2002, a new age appears on the machine tools market, with new machines provided with parallel feed mechanisms based on CNC actuators instead the classical feed mechanisms, machines without large castings, guide ways, milling heads or rotary tables with real axes. Instead the machine are equipped with performing CNC actuators, CNC units and powerful software in order to control the machine virtual axes, including the 5 axes of complexes surfaces generation.

Here the working part is fixed on the socle, and the tool perform all movements around the fixed part, controlled by the computer, in order to attack all the faces, including the ATC (Automatic Tool Changing), APC (Automatic Pallet Changing), etc.

As sample is Okuma Company, which presented at SC Stimin his last technical level.

Today at the last machine tool generation, more difficult and more expensive is the software against the mechanical parts, even including the electrical parts, and also the manufacturing as well the technological equipment is assisted by the computer and based on the soft. The soft is specialized on the application and need the effort to be performed by the soft people together to the mechanical engineering and with the help of the mechanical engineering team.

**And this is just the beginning.**

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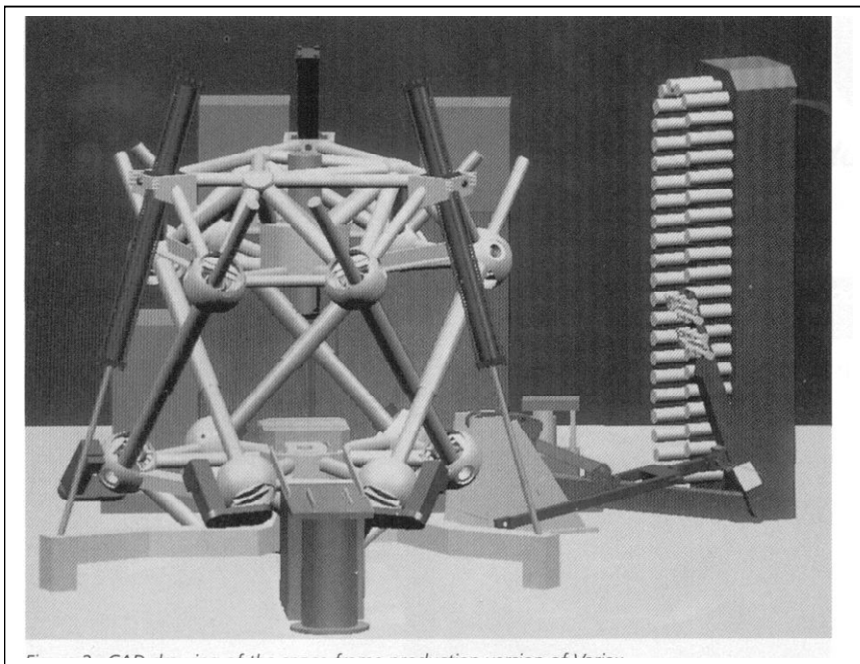
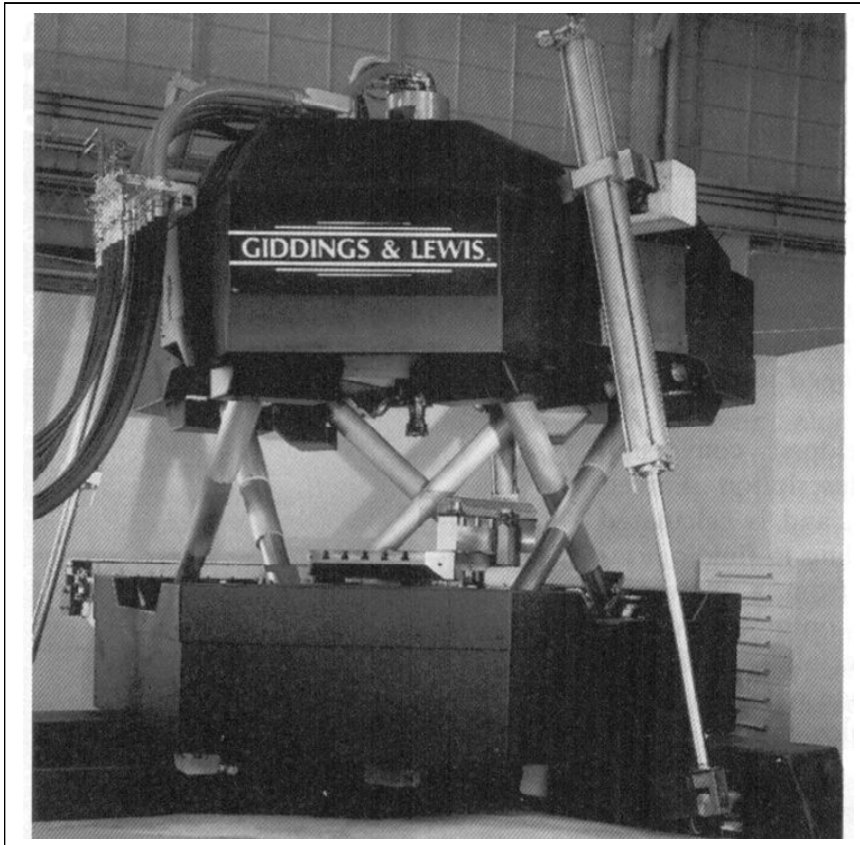


Fig. 12, [3] : top – The Hexapod Machine, bottom – Machine Model.



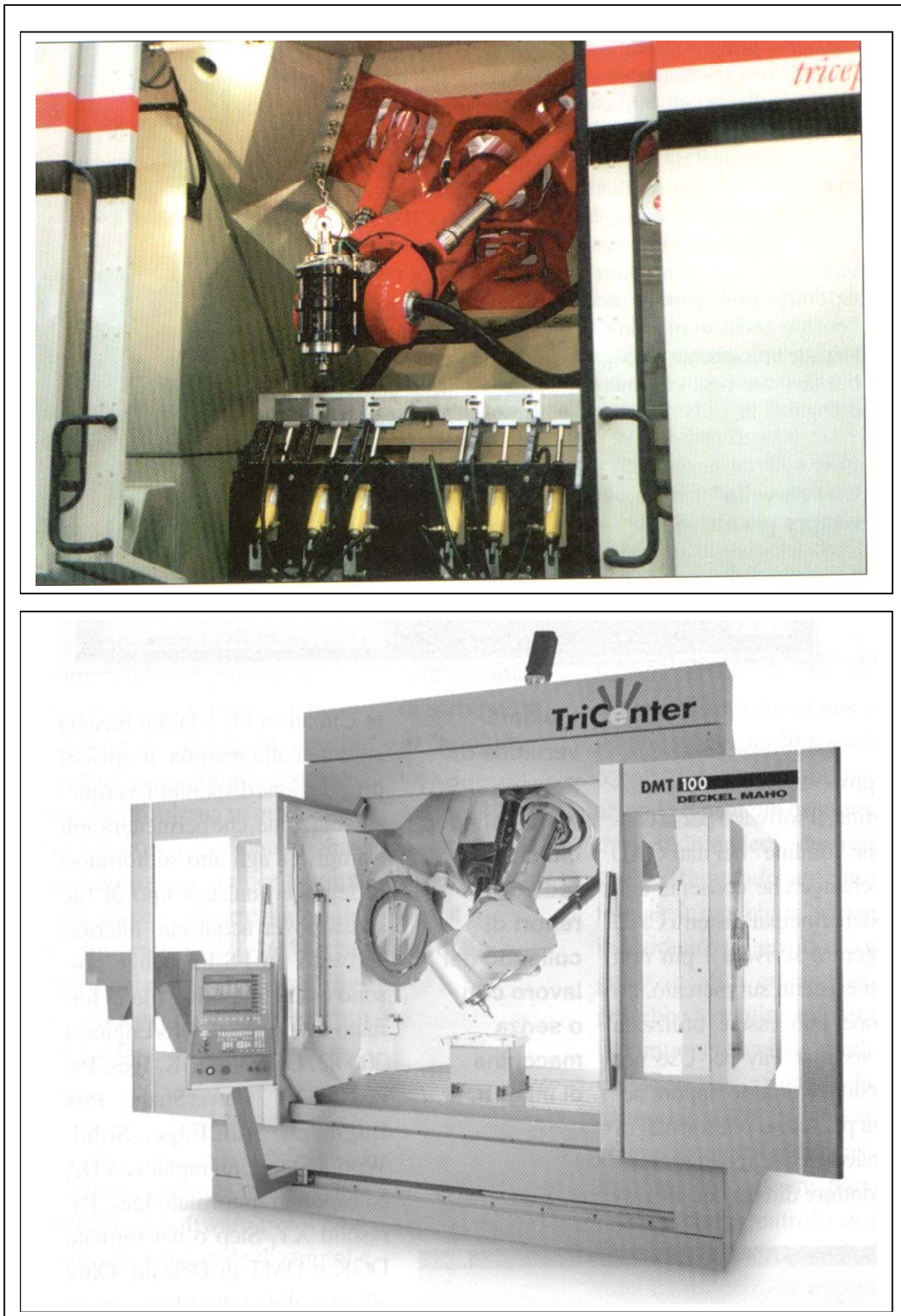


Fig. 13, [4] – Tricenter Machine with Tripod Milling Head