Force and torque measuring devices for drilling and milling simulation

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Abstract: - Cutting force measurement during material working processes on machine tools is the reference point for the precise phenomenon and also for the parameters control which affect it. In this paper construction details were presented relating to the two prototyped cutting force measuring instruments adequate for drilling and milling operations. Their low construction cost and their experimental measuring reliability could be adopted as a productive tool in manufacturing processes and used in factories regardless of size.

Key Words: - 3D measuring device, drilling, milling

1 Introduction

The size of the forces which are developed during the removal processes not only principally affects the tool life but it is also related to the selected cutting parameters which define every stage of production, see [1], [2] and [3]. Apart from the above mentioned use it is also possible with the proper method of experimental cutting forces measurement process, to control not only the tool life but also the production rate. Usually the cost of installing these devices is too high mainly for small and medium size factories. A sizeable amount of the above mentioned cost is absorbed by the supporting electronic equipment (modulator, signal amplifier and recorders), see [4] and [5], which accompany the main measuring instrument (measuring "head"). Thus, a decrease in the total cost of the whole measuring device is possible to provide its production (with only a slight variation in its reliability).

It should be mentioned that the manuals for selecting cutting tools provided by the manufacturers, suggest suitable values for cutting parameters, according to the working material type, the original surface of the raw material, the cutting rate (productivity) and the tool life. Although these aren't necessarily the best possible values under these circumstances, it is impossible to define them exactly.

Despite the fact that they could be found in a specific area, there is still the possibility of finding great variation in these values. This complicates the "best" cutting parameters estimation. The problem becomes more complicated when every stage of the process needs different cutting parameters. A solution could be given when a special experimental procedure is concluded, by selecting the results and inputting them in a suitable improving algorithm.

The object of these experiments is the measuring of the developing forces during the removal process of the working specimen under various cutting parameters. In order to carry out all the above-mentioned procedure, low cost cutting force measuring devices are essential with high reliability.

The measuring devices which will be presented lower have all the essential characteristics in order to provide the "best" cutting conditions in milling and drilling operations.

2 Cutting force measuring device for drilling operation

The proposed measuring device is presented in axonometric view, in Fig. 1. It consists of discreet components as described lower:

(a) The Flange A supporting the whole device, is fastened on to the main table of the drilling machine with two hexagonal bolts. Four projected beams are set on the flange A upper face, working as normal force (F_z) sensors. The normal force F_z is transmitted, through the flange B normal displacement, to the inner free tip of the F_z sensors. Two half-bridge strain gauges are stacked on the upper and lower sensor faces producing an output signal analog to their strain caused by the sensors bending, see Fig.3.

(b) The flange B can slide vertically moving through the four normal driving shafts. Besides this, flange B is supporting the torque sensors lower tips whilst their upper tips are fitted into the flange C. The torque sensors are square section prisms, which are bent due to a small cyclic movement of flange C. The measuring signal for torque M is produced through two strain gauges per sensor (total 8 strain gauges) stacked on the tensile and compressive sensor faces, respectively to the F_z sensors. The flange C is allowed to rotate relative to the flange B via an axial ball bearing, see Fig.1.

(c) The flange C consists the top measuring device part. The drilling specimen is fastened on the upper face of flange C with two fastening bars and four fastening bolts, see Fig.1. The main assembling allen bolt placed in the center of the whole device supports the proper moving of the contributing components.

(d) The electronic measuring device for torque M and vertical force F_z is shown in Fig.2. The half-bridge strain gauges are stacked on the two opposite faces of the torque and vertical force sensors. The output signal is recorded on a typical voltmeter or on graphical chart recorder, or either on a data acquisition recording equipment. The material and the dimensions of the sensors are related to the type of the strain gauges and to the magnitude of the expected force and torque.

3 Cutting forces measuring device for milling operations

The measuring device for milling operations is presented in Fig.3. The structural concept of this measuring device is similar to the previous one, for drilling operations described above. The main contributing parts are four plates named A, B, C and which slide on ball bearings. The shape of the sensors as well as their fixing method on each one of the moving plates, are analog to the characteristics of the sensors used in the drilling measuring device, concerning the vertical force measuring, named F_z.

As a modulator and amplifier, an electronic device could be used the same one which is also used in the drilling measuring device, shown in. Fig. 4.

4 Conclusions

The construction method, the cost and the repeatity of the concluded experimental results, show that the measuring devices for drilling and milling operations as described above, could present improved performance not only in the laboratory but also in production scale. Nevertheless special attention must be paid to the sensors geometrical and material characteristics as well as during the strain gauge assembly and the fixing onto their working surfaces. It should be mentioned that the total size of the above devices could be changed depending on the needs of the expected cutting forces.

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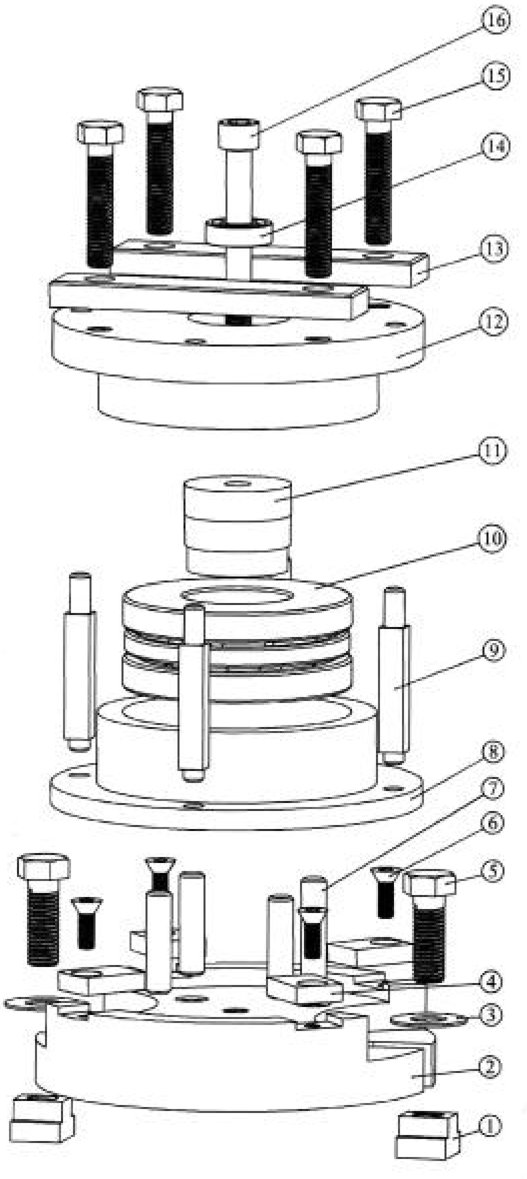

16 assembling bolt
15 working specimen fastening bolt
14 single row ball bearing
13 working specimen fastening bar
12 flange C
11 axial bearing defector
10 axial ball bearing
9 torque sensor
8 flange B
7 normal driving shaft
6 sensor fastening bolt
5 fastening bolt
4 normal face F_z sensor
3 washer
2 flange A
1 fastening nut

Fig. 1 Cutting forces measuring device for drilling operations

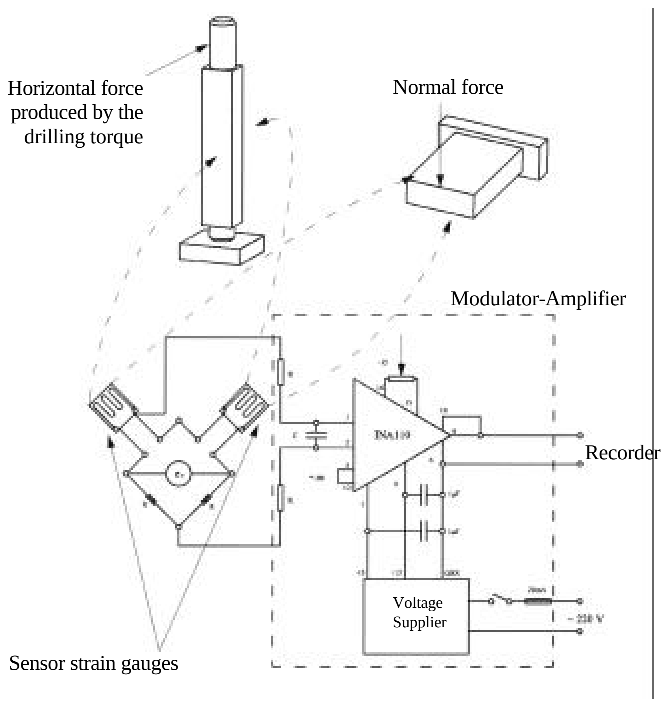

Fig. 2 Strain gauges electronic circuit construction concerning the measuring device for drilling operations

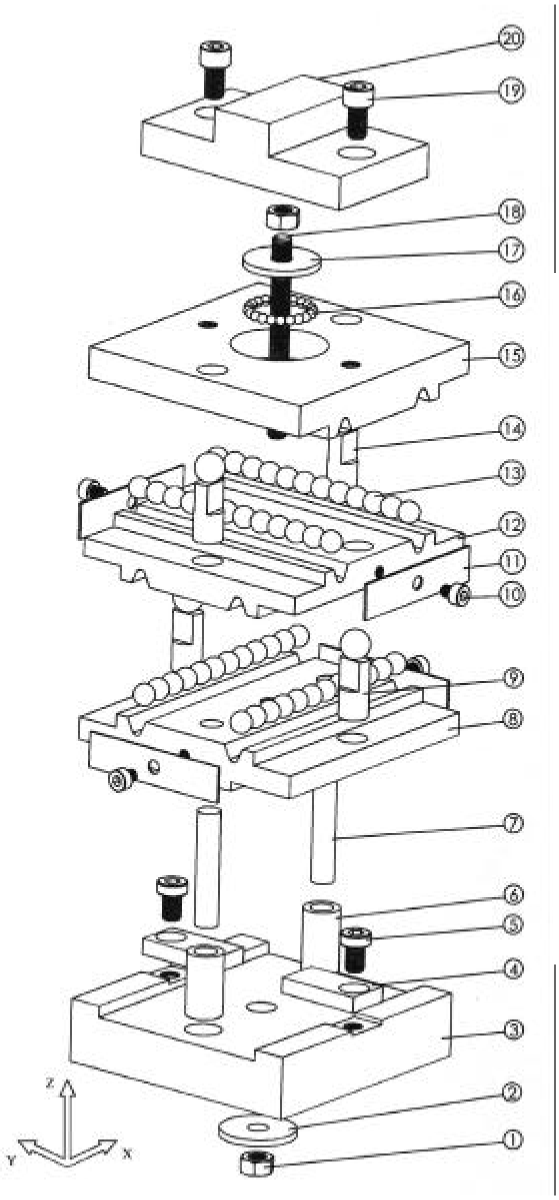

Fig 3. Cutting forces measuring device for milling operations

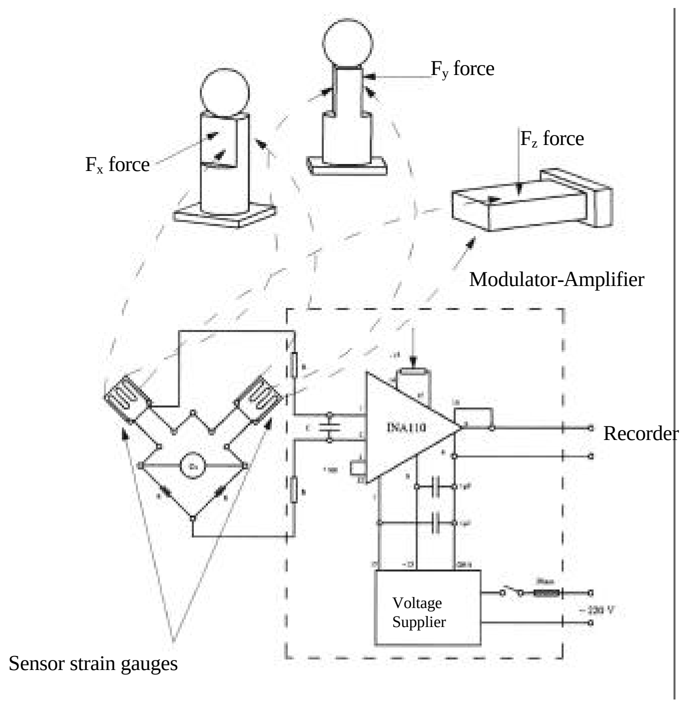

Fig. 4 Strain gauges electronic circuit construction concerning the measuring device for milling operations