ANALELE UNIVERSITĂȚII
"EFTIMIE MURGU" REȘIȚA
ANUL XV, NR. 1, 2008, ISSN 1453 - 7397

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Measuring Force System Set-Up

In this paper, are presented the results of cutting force and torque measurements were undertaken by a 4-axis 9272 KISTLER dynamometer. The DynoWare software was used for processing of the measurements. We can conclude that the values of torque, cutting force were higher compared to dry drilling, as we expected.

Keywords: *cutting force, torque measurements, dynamometer*

1. Introduction

Cutting processes are widely used in industry to manufacture metallic products, providing high form and dimensional accuracy, and surface quality with high degree of flexibility. Machinability of an engineering material is a crucial technological property that denotes its adaptability to machining processes in view of factors such as cutting forces, tool wear, and surface roughness. Effective and reliable machinability databases for cutting of metals are of paramount importance to assist manufacturers to apply proper machining conditions for the work-piece material each time processed and relevant decision making.

Drilling is one of the most common cutting operations being necessary for machine building and assembling in a variety of applications. But it should be borne in mind that drilling, especially when opening new holes, is essentially a rough machining method and cannot meet satisfactorily the aforementioned requirements.

2. Experimental

The cutting force and torque measurements were undertaken by a 4-axis 9272 KISTLER dynamometer. As a piezoelectric device offers high capacitance in dynamic forces and linearity, necessary for rendering the force fluctuations in drilling due to chip removal difficulties. The *DynoWare* software was used for processing of the measurements. The whole instrumentation for the cutting force determination is illustrated in Fig. 1.

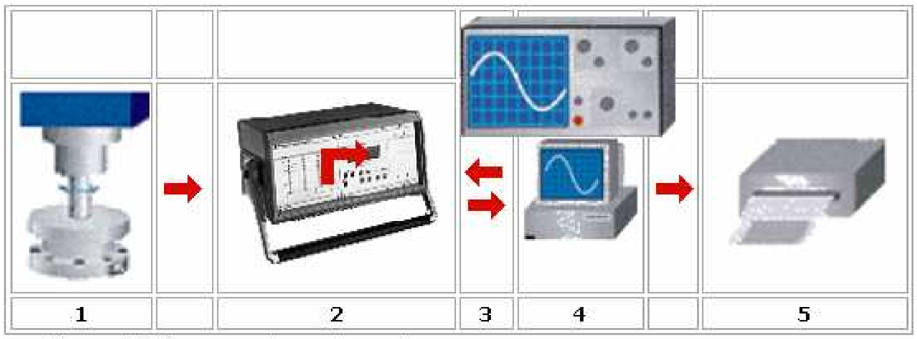

Figure 1: Dynamometer system set-up

where:

1 represents the **Dynamometer** (3 axes plus torque)
2 represent the **Charge amplifier**
3 represent the **Oscilloscope**
4 means the **Computer**
5 refer to the **Printer**

2.1. Drills

The drills used in the experiments are twist drills of cylindrical shank made of high speed steel with 5% in cobalt according to DIN 338 HSS-Co (high speed steel cobalt alloyed). This tool material is suitable for processing metals of increased strength and hardness, the two work-piece materials tested in this study fall within the effective range, and exhibit high wear resistance and excellent resistance to thermal recovery. The tip angle is 135°, standard for drilling metals, and the twist angle is 35° allowing easier chip removal. The dimensional characteristics of the drills are given in Table1.

Table1. Dimensional characteristics of the drills used in the experiments

Diameter (mm)	Total length (mm)	Twist length (mm)
8	117	75
10	133	87
12.5	151	101

2.2. Work-piece materials – Specimens

Specimens made of St37 steel and Aluminum alloy 5005, according to DIN 17100 and DIN AlMg1, respectively were used for testing; their dimensional characteristics are given in Table2.

Table2. Work-piece dimensions

	Length (mm)	Width (mm)	Height (mm)	Pieces
St 37	80	70	40	5
AL 5005	150	50	50	1

St37 steel is a carbon steel of wide use, relatively soft and possessing good machinability. It has low content in carbon and its ingredients are presented in Table3.

Table3. Chemical composition of St37

C	Fe	Mn	P	S	Si
0,24 - 0,36	98	0,9	0,04	0,05	0,28

Al 5005 is an aluminum alloy of medium hardness, also widely used in structural applications; its chemical composition is given in Table4.

Table4. Chemical composition of Al 5005

Si	Fe	Cu	Mn	Mg	Cr	Zn		
0,3	0,7	0,2	0,2	0,5 - 1,1	0,1	0,25	0,15	Al

Principal mechanical and physical properties of both materials used for processing are listed in Table 5. The great difference in hardness between the two alloys is evident, a fact that will be considered in the statistical analysis of the experiments.

Table 5. Mechanical and physical properties of the work-piece materials

	St 37	Al 5005
Density (Mg/m^3)	7.91	2.70
Hardness (HB)	≤ 135	≤ 51
Maximum tensile strength (MPa)	415	145
Yield point (MPa)	205	35
Special heat (J/kgr·K)	447	900
Thermal conductivity (W/m·K)	360	205
Melt point (^oC)	1510	652

3. Results and discussion

3.1 Dry drilling

In the tests 27 holes were drilled, corresponded to the combinations of 3 feed rates and 9 rotational frequencies. The results are tabulated in Table 6.

Table 6. Experimental mean values of torque (M) and axial force (F)

M (N cm)		n (rev/min)								
		81	**115**	**162**	**226**	**321**	**452**	**637**	**904**	**1274**
s (mm/rev)	**0,1**	473	516	501	453	439	473	575	591	684
	0,2	1050	1023	1014	950	916	969	1196	1242	1236
	0,3	1453	1412	1331	1407	1365	1601	1605	1642	1839
F (N)		**n (rev/min)**								
		81	**115**	**162**	**226**	**321**	**452**	**637**	**904**	**1274**
s (mm/rev)	**0,1**	1105	1093	1060	1042	1064	1136	1321	2088	2194
	0,2	2051	1994	1900	1879	1951	2263	3243	3602	3589
	0,3	2750	2674	2654	2743	2889	3485	4123	4396	4808

4. Conclusions

The initial tests conducted dry and replicated using cutting oils, show us, the most physically significant factors leading to safe conclusions were detected that could be introduced to the stochastic models. In the lubricated tests the values of torque, cutting force were higher compared to dry drilling, as expected.

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