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Study of roundness on cylindrical bars turned of aluminium-cooper alloys UNS A92024

M. Marcos-Bárcena[a], M.A. Sebastián-Pérez[b], J.P. Contreras-Samper[a], M. Sánchez Carrilero[a], M. Sánchez-López[a], J.M. Sánchez-Sola[a, 1]

[a] Departamento de Ingeniería Mecánica y Diseño Industrial. Universidad de Cádiz. Escuela Superior de Ingeniería. c/Chile s/n, E-11003, Cádiz, Spain.
Tel. +34956.015137. Fax. +34956.015101. e-mail: josemiguel.sanchez@uca.es

[b] Departamento de Ingeniería de Construcción y Fabricación. UNED. Escuela Técnica Superior de Ingenieros Industriales. Apdo. 60249, E-28080, Madrid, Spain.

Abstract: Aluminium alloys are broadly employed in aerospace industry for the production of the different elements that conform the airships. Moreover, the appearance of emergent government legislations in environmental matters has forced the replacement of machining methods in the last years, which prevents or minimizes the employment of substances or fluids. In that sense, the turned one has been used in dry for the performance of the experimental part of this work.

In this work, macrogeometric deviations of UNS A92024 (Al-Cu) cylindrical bars are analyzed (roundness), and turned dry under some conditions of imposed cutting (cutting speed and feed). Also, an exponential relation between roundness and the cutting parameters is established for the dry turning process of UNS A92024 alloy.

The obtained relationship allows us to predict the behavior of these deviations in the range of cutting speed and feed considered.

Keywords: Turning, UNS A92024, Roundness, Parametric Model, Continuous Surface.

1. INTRODUCTION

Light alloys are widely employed in the production of elements or pieces integrating the products of most industrial sectors. In this sense, the aluminium industry has benefited from its extensive use. Nowadays, it ends up affecting some sectors of the market and, particularly, the aerospace industry, which is one of the sectors where this type of alloys has a larger number of applications.

Taking this into account, the aluminium-copper alloys are being thoroughly used in the production of structural components of the airships, mainly because of the excellent relationship between their weight and their mechanical properties. This growing use is

[1] Corresponding Author

encouraging the undertaking of studies intended to analyze the different ways of conformance of these alloys.

One of the most characteristic ways of conforming alloys is chip outburst machining. On the one hand, in this type of processes those denominated cutting fluids with objects are usually applied to the refrigeration of the tool and the elimination the effects due to high temperatures. On the other hand, the lubricant action of these fluids decrease of the friction in the cutting area, facilitating the evacuation of the chip and causing a descent in the rate of tool wear due to friction.

However, the regulations in environmental matter have forced in the last years to develop cutting fluids of low environmental impact.

Nevertheless, the dry machining causes alterations both in the tool and in the piece, giving place to deviations on the design specifications. In this work, we carried out a study of the macrogeometric deviations taking place in the process of turning in-dry aluminium alloy and copper UNS A92024 in a range of cutting speeds moderated with depth of cutting constant [1,2]. In short, the deviation of roundness has been analyzed, for which a parametric model has been established in function of the technological parameters, cutting speed and feed.

2. EXPERIMENTAL PROCEDURES AND MATERIALS

In this work, the workpieces used in the turning tests were cylindrical bars of UNS A92024 (Al-Cu) alloy. The diameters were 80 mm and the lengths 190 mm. Table I includes the percent mass nominal composition of UNS A92024 alloy. Previously to performing the tests, the surface of the cylindrical workpieces were rough-dressed by a high feed horizontal turning process in order to remove the surface deposits formed in the storing period.

Table1.
Nominal composition of alloy UNS A92024 (% mass)

Cu	Mg	Mn	Si	Fe	Zn	Ti	Cr	Al
4.00	1.50	0.60	0.50	0.50	0.25	0.15	0.10	Rest

Turning tests in absence of cutting fluids were conducted in a CNC horizontal lathe, model EmcoTurn 242 TC, equipped with a numerical control Emcotronic TM 02. The above-mentioned tests were carried out using a fixed cutting depth, d, of 2 mm, and combining values of between 43 and 170 m/min with feed values from 0.05 to 0.3 mm/r.

Titanium nitride (TiN) DCMT 11 T 308 F2 TP100 turning inserts were used as cutting tools. In order to guarantee the initial conditions of each test, a new tool was used in each experiment. Figure 1 shows the experimental device for the turning tests.

A digital-clock comparator with scale division 1 μm and a connected adapter to the RS-232 were the elements used in the measurements of roundness. These elements, allowed the automatic acquisition of the data. The representative value of the roundness in each machined sample was obtained from the mean value of the roundness obtained in 10 circles traced on the lathed surface.

3. RESULTS AND DISCUSSION

In figure 2(a), the evolution of the values means is represented for the deviations of roundness in function of the cutting speed for each feed used. On a first observation carried out on this figure, it can be deduced that, in general, when the cutting speed is increased, there is a decrease of these deviations. This fact seems to indicate that the geometric precision, at least in what respects to this parameter, increases with cutting speed. In this way, the biggest deviations are obtained for speeds of 43 m/min.

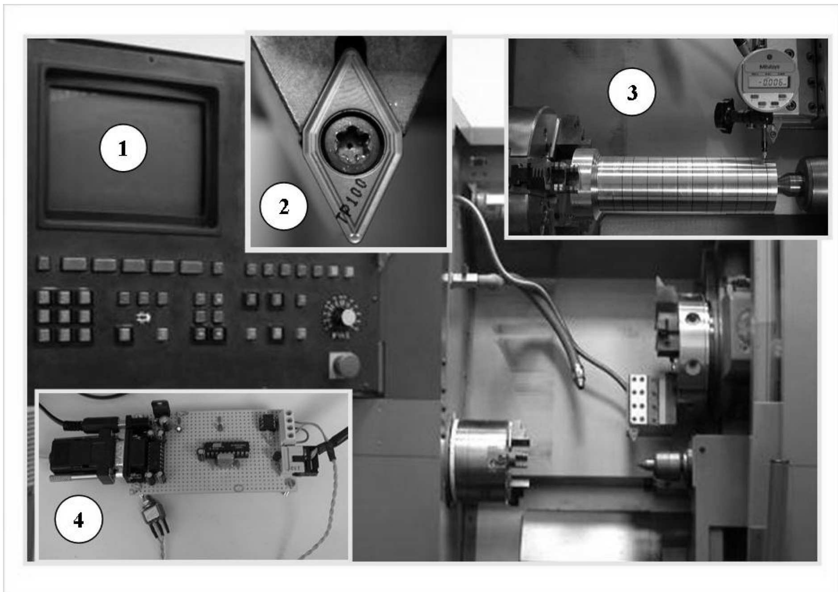

Figure 1. Experimental devices for the turning test and measurements of roundness: 1. CNC horizontal lathe equipped with a numerical control. 2. Tools used. 3. Digital-clock comparator. 4. Adapter to the RS-232 of PC.

An inverse tendency seems to be deduced from the study of the deviation of roundness with the feed, as in figure 2(b). Indeed, as it can be appreciated in this figure, as the imposed feed increases deviations of the roundness become larger. From the above-mentioned data, it can be inferred that geometric precision, at least in what refers to this parameter, diminishes with feed increment. In this way, the largest deviations are obtained for 0.3 mm/r feed.

Taking all this into account, we may conclude that lathed high-speed and lower feed allow a better approach to geometric specifications.

The previous results suggest the possibility of looking for a parametric model that relates the roundness RD, in function of the technological parameters employed as variables. In general, the parametric models have a potential form regarding taylor-made models. In this case, the adjustment to models of these characteristics presents a very low coefficient of determination, which indicated that the adjustment carried out was not good enough. For this reason, we decided to change the model, using an approach of exponential type regarding what the disposition of the points suggests. Therefore, a model was proven as follows:

$$RD = C \cdot e^{\sum_{i=1}^{2}\sum_{J=1}^{2} K_{ij} \cdot a^{i} \cdot v^{yj}} \tag{1}$$

When applying non-linear regression, the coefficients and exponents of the pattern are determined, being:

$$RD = 11.210 \cdot e^{(-102.429 \cdot a \cdot v^{-0.570} + 330.364 \cdot a \cdot v^{-1.140} + 226.591 \cdot a^{2} \cdot v^{-0.570})} \tag{2}$$

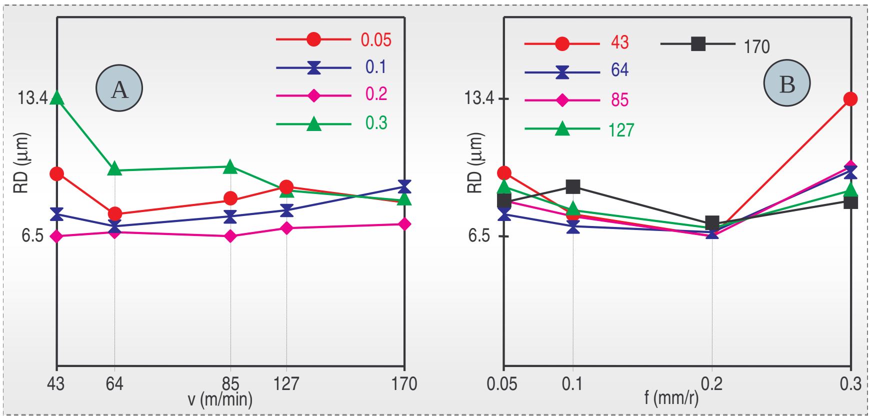

Figure 2. (a) Evolution de RD with v for f established. (b) Evolution of RD with f for v established

The adjustment made allows a superior adjustment to 80% of the obtained values and those proposed by the expression (2) [3].

4. CONCLUSIONS

In the machining of aluminium alloys, geometric and dimensional deviations are obtained from those specified in design, due to the interactions the system tool-workpiece. These interactions are magnified when the machining process is carried out in absence of cutting fluids.

Roundness deviation has been analyzed in the turning of aluminium-copper alloys with constant cutting depth. This study has revealed that speed increase together with feed decrease show tendencies to loss of precision in roundness. The data obtained have allowed us to establish a parametric model for the deviation of roundness that shows that it is the feed the one that causes the largest variations in this variable.

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