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COMPARISON OF POLISHING TIME OF PREVIOUSLY MILLED SAMPLES AT DIFFERENT CUTTING CONDITIONS

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ABSTRACT
In order to reduce polishing time, the lowest surface roughness possible is sought in milling operations. In order to determine whether polishing time is directly related to previous milling conditions, several tests were performed. In side milling with cylindrical milling tool, feed per tooth f of 0.02 and 0.06 mm tooth^{-1} revolution^{-1} were considered. In ball-end milling, feed per tooth f of 0.05 and 0.40 mm tooth^{-1} revolution^{-1}, and radial depth of cut Rd of 0.25 and 0.40 mm were taken into account. Results show that, in side milling, cutting time was the same regardless of feed employed. On the contrary, in ball-end milling, highest polishing time was obtained if both feed and radial depth is high. At low feed and/or radial depth values, polishing time decreases markedly.
Keywords: polishing time, side milling, ball-end milling.

1. INTRODUCTION
In moulds and dies manufacturing, a manual polishing operation is necessary after finish milling, since machine polishing is usually applied to flat, cylindrical or spherical surfaces [1]. However, manual polishing depends remarkably on the worker's abilities [2]. The aim of the present paper is to relate topography obtained in side and ball-end finish milling processes to the polishing difficulty. In a previous paper, specifications of polishing test were stated [3]. In the present work, roughness obtained in polishing operation of previously milled surfaces is presented. First, steel blocks were milled, using either cylindrical or ball-end milling tools. Then surfaces were polished and roughness was measured after different polishing times.

2. MATERIALS AND METHODS
2.1. Materials
WNr. 1.2344 hardened steel blocks of hardness HRC 52, of 66 x 50 x 40 mm were machined. Machined area was 66 x 6 mm.

2.2. Methods
Milling operations
Cylindrical tools of diameter 6 mm having 6 cutting edges, and ball-end milling tools of diameter 6 mm having 2 cutting edges were used. Tool overhang was 22 mm in all cases. A Mori-Seiki vertical machining centre was employed. Cutting conditions were:
- Cylindrical milling tool: Cutting speed v_c = 180 m·min^{-1}; axial depth of cut *Ad* = 6 mm; radial depth of cut *Rd* = 0.15 mm; air cooling. Feed per tooth *f* = 0.02 and 0.06 mm·tooth^{-1}·revolution^{-1}.

- Ball-end milling tool: Cutting speed v_c = 180 m·min^{-1}; axial depth of cut *Ad* = 0.15 mm; air cooling. Feed per tooth *f* = 0.05 and 0.4 mm·tooth^{-1}·revolution^{-1}; radial depth of cut *Rd* = 0.25 and 0.4 mm.

Polishing operations
An automatic polishing machine Mecapol P230 was employed. Corundum polishing pads were used with grain size 400. Parameters employed in the polishing tests are presented in Table 1.

Table 1. Characteristics of polishing tests

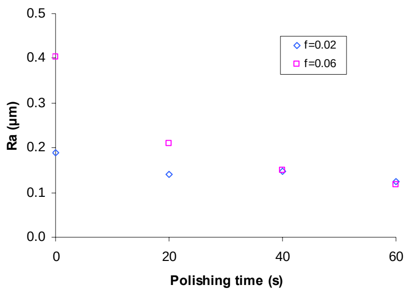
Surfaces milled by	Force (daN)	Speed (min^{-1})	Test time (s)	Total time (s)
Cylindrical tool	1.5	50	20	60
Ball-end tool	1.5	50	10	60

Roughness measurements
A Taylor Hobson Taylsurf Series 2 roughness stylus profilometer with Taylor Hobson µltra software (v. 4.6.8) was used. Different roughness parameters were measured: *Ra*, *Rt*, *Rk*, *Rpk* and *Rvk*. Each measuring process consisted of first measuring roughness of the milled surface and then measuring roughness after different polishing times, in order to study the evolution of roughness parameters with polishing time. Ten measurements were performed in the longitudinal direction and five measurements in the transversal direction, from which an average roughness value was calculated.

3. RESULTS

3.1. Cylindrical milling tool

Roughness for surfaces obtained with cylindrical milling tool is presented in Figure 1.



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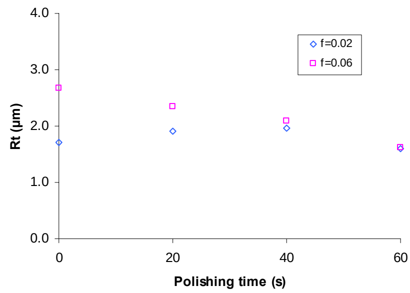

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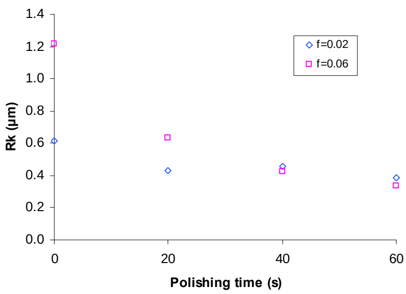

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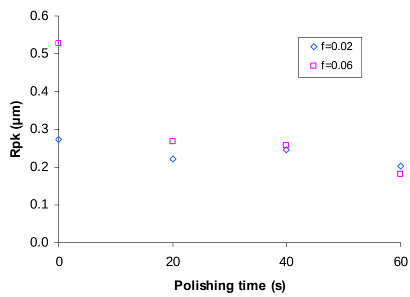

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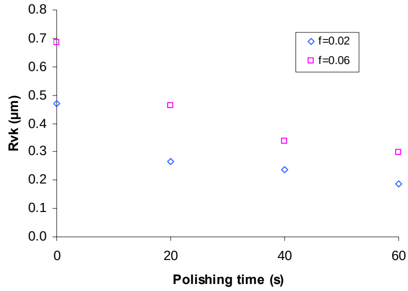


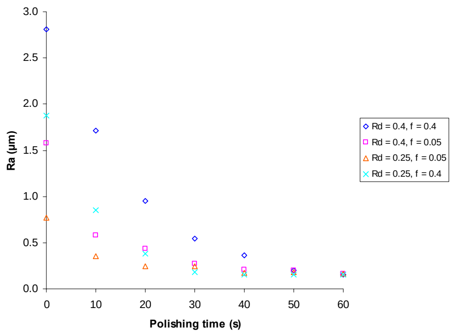
(e)

Figure 1. Roughness Ra, Rt, Rk, Rpk and Rvk in polishing test of previously milled surfaces with cylindrical tool, at f = 0.02 mm tooth^{-1} revolution^{-1} and f = 0.06 mm tooth^{-1} and revolution^{-1}

Most roughness parameters decrease until *t* = 60 s. From that moment on, roughness remains almost constant, regardless of feed employed.

3.2. Ball-end milling tool

Roughness results for ball-end milled surfaces are presented in Figure 2.



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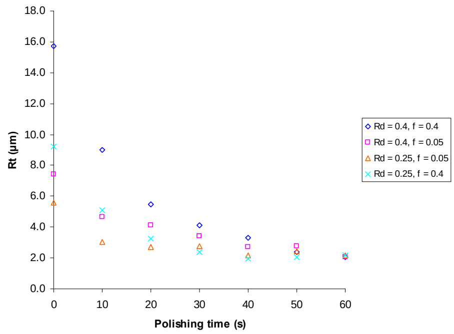

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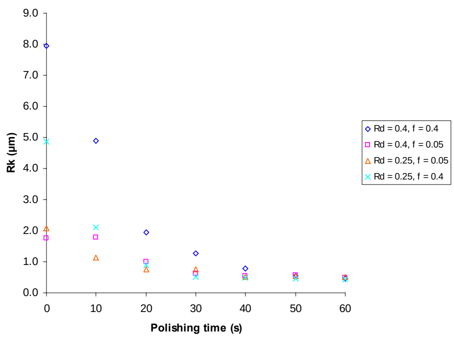

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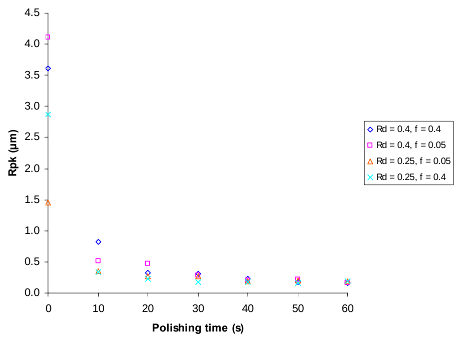

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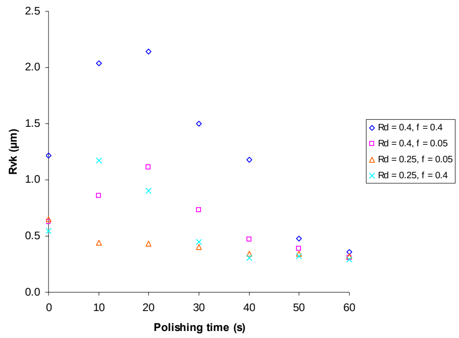

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Figure 2. Roughness Ra, Rt, Rk, Rpk and Rvk in polishing test of previously ball-end milled surfaces, at f = 0.05 mm tooth^{-1} revolution^{-1} and f = 0.40 mm tooth^{-1} and revolution^{-1}; Rd = 0.25 mm and Rd = 0.40 mm

According to most roughness parameters, at f = 0.05 mm·tooth^{-1}·revolution^{-1} and *Rd* = 0.25 mm samples were completely polished after 20 s. Samples obtained at f = 0.05 mm·tooth^{-1}·revolution$^{-1,}$ *Rd* = 0.40 mm, and f = 0.4 mm·tooth^{-1}·revolution^{-1}, *Rd* = 0.25 mm were completely polished after 40 s. Samples obtained at f = 0.4 mm·tooth^{-1}·revolution^{-1}, *Rd* = 0.4 mm was completely polished after 60 s. Except at low f and low *Rd*, *Rvk* increases after polishing for 10 s with respect to not polished samples. Depending on the shape of previously milled surface, peaks removal in the polishing operation may lead to an increase of valleys proportion with respect to peaks, when roughness is characterized by means of the linear material ratio curve or Abbott-Firestone curve [4].

4. CONCLUSIONS

In contour milling, in the feed range studied, polishing time after side milling was the same regardless of feed employed.

In ball-end milling, in the feed and radial depth range studied, highest polishing time was needed when both feed and radial depth of cut is high. If either feed or radial depth of cut is low, polishing time decreases markedly.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

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