Heliyon 9 (2023) e22738

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Improvement of steel alloys using indirect cooling grinding (I.C.G.)

Ali Heydari [a], Masoud Pour [b], Mohammad Reza Gharib [a,*]

[a] Department of Mechanical Engineering, University of Torbat Heydarieh, Torbat Heydarieh, Khorasan Razavi, Iran
[b] Department of Mechanical Engineering, Faculty of Advanced Technologies, Quchan University of Technology, Quchan, Iran

ARTICLE INFO

Keywords:
Grinding
Surface roughness
Surface temperature
Indirect cooling
Depth of cut

ABSTRACT

Appropriate choice of machining conditions contributes directly to improved performance of the machining process. Cooling and lubricating the grinding surface in the machining process has been done using different methods, but each method has its own disadvantages. A new cooling system is proposed in this research to improve the surface roughness in flat-surface grinding. The workpiece is cooled using a mixture of water and antifreeze as a coolant, without directly contacting the cutting tool. The temperature of the workpiece surface remains fixed, and grinding of the workpiece is performed. This novel method has several benefits including no oxidation of workpiece and tool surfaces, no surface hardening from rapid cooling, no chip addition to the coolant, and extended grinding capabilities without replacement. The proposed methodology was tested on four steel alloys, including hot-worked and cold-worked steel, as well as two improved alloys. The tests involved changing various parameters such as the depth of cut, surface temperature, and coolant flow-rate, to analyze how they affected surface roughness. According to the results, the proposed method was remarkably efficient for low-chromium steel alloys. The best surface roughness was obtained using the indirect cooling system for the 1.1191 steel alloy (an improved steel alloy). In general, better results (lower roughness at higher cutting depth) were achieved at higher coolant flow-rates.

1. Introduction

Manufacturing processes have always aimed to achieve higher production rates and produce high-quality parts. Machining covers a range of material removal procedures, including but not limited to turning, milling, and grinding, which are considered as fundamental methods within this basic group. Many kinds of research and studies have been performed and investigated the machining parameters [1–3]; surface roughness [4,5], and coatings [6,7]. But the grinding has been the main finishing process for achieving the aforementioned objectives. More than 42 % and 25 % of all machining tools and machining processes in the United States are related to grinding, respectively [8]. With the advancement of grinding machine technology, the economic efficiency of these machines has improved significantly. Thus, the material removal rate and grinding production rate have rapidly approached those of the turning and milling processes.

Numerous investigations have been performed to understand the grinding process better and improve its performance; these works have focused on six main parameters: surface roughness, temperature, force, grinding wheel topography, chattering vibration, and

* Corresponding author.
E-mail address: m.gharib@torbath.ac.ir (M.R. Gharib).

https://doi.org/10.1016/j.heliyon.2023.e22738
Received 3 September 2023; Received in revised form 17 November 2023; Accepted 17 November 2023
Available online 25 November 2023