Strojniški vestnik - Journal of Mechanical Engineering 57(2011)5, 425-439
DOI:10.5545/sv-jme.2009.055
Paper received: 24.09.2009
Paper accepted: 07.01.2011

Conservative-Force-Controlled Feed Drive System for Down Milling

Branko Tadic[1] – Djordje Vukelic[2,*] – Janko Hodolic[2] – Slobodan Mitrovic[1] – Milan Eric[1]
[1] Faculty of Mechanical Engineering, University of Kragujevac, Serbia
[2] Faculty of Technical Sciences, University of Novi Sad, Serbia

Reviewed in this paper are the results of theoretical and experimental investigation of a novel down milling method. The method is based on controlling feed speed using conservative forces, where the active force which provides motion is the horizontal component of the cutting force. Feed motion is therefore realized without any active forces (active drive systems), while the feed speed is regulated by precision breaking of the workpiece, which is possible through hydraulic damping. In addition to the basic theoretical model of the feed drive system, the paper also presents the dynamic model of the drive system, taking into consideration fluid compressibility. Based on the model proposed, a physical instance of the feed drive system was designed, built and tested. The results of preliminary experimental investigation speak in favour of the proposed theoretical model, which enables practical application of this type of feed drive systems.

Keywords: down milling, special feed drive system, continuous feed speed control, damping

0 INTRODUCTION

Milling is a basic machining process by which a surface is generated progressively by the removal of chips from a workpiece as it is fed to a rotary cutter in a direction perpendicular to the axis of the cutter [1]. Surfaces can be generated by two methods: up milling (the cutter rotates against the direction of the feed of the workpiece) and down milling (the cutter rotates in the same direction of the feed of the workpiece). Both methods have some advantages and disadvantages [2].

In the past few years major attention has been given to research of the milling process. These research works refer to various aspects such as: influence of cutting parameters on surface roughness [3] to [5], dynamic problems in milling [6] to [8], tool wear in milling operations [9] and [10], stability of milling process [11] to [13], calculations of chip thickness in milling operations [14], optimal tool geometry selection [15], optimal tool path selection [16] to [18], optimization of machining parameters in milling using geometric programming [19], optimization of machining parameters in milling using genetic programming [20], optimization of machining parameters in milling operations using genetic algorithm [21] to [23], optimization of machining parameters in milling operations using artificial neural networks [24] and [25], optimization of machining parameters in milling operations using a combination of the genetic algorithm and artificial neural networks [26] and [27], optimization of machining parameters in milling operations using a combination of artificial neural networks and particle swarm [28].

This extensive research volume testifies of the importance of milling as machining technology. In spite of this, some core principles underlying kinematics and statics of cutting, have remained unchanged. The shape realized in any milling process depends on three important factors; tool geometry, workpiece geometry and relative motion between tool and the workpiece. The relative motion between tool and workpiece has two components. The first component of motion consists of the rotation of the tool around its own axis and the second is a feed motion of the workpiece relative to the tool. A combination of these two motions together with tool geometry and its interaction with the workpiece geometry defines the final shape of workpiece [1] and [2]. Having this in mind, a particularly significant machine tool component is the feed drive, which provides constant feed motion of the workpiece

*Corr. Author's Address: University of Novi Sad, Faculty of Technical Sciences,
Trg Dositeja Obradovica 6, 21000 Novi Sad, Republic of Serbia, vukelic@uns.ac.rs