IRF2018

Proceedings of the
6th International Conference on
INTEGRITY-RELIABILITY-FAILURE

(Lisbon/Portugal, 22-26 July 2018)

Editors

J.F. Silva Gomes and Shaker A. Meguid

FEUP-INEGI
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PREFACE

IRF2018 is the sixth international gathering of a prestigious series of Integrity-Reliability-Failure conferences coordinated by the International Scientific Committee of Mechanics and Materials in Design. This series of conferences are wholy devoted to advances in mechanics, materials, structural integrity and design. IRF2018 is jointly sponsored by the University of Porto, the University of Toronto and the Portuguese Society for Experimental Mechanics. The conference attracted over 200 participants with 258 accepted submissions involving 702 authors from 42 different countries around the world. The conference themes which address novel and advanced topics on Integrity, Reliability and Failure focused on Automotive, Locomotive, Aerospace, Civil Engineering and Biomechanics, including Computational Mechanics, Experimental Mechanics, Fracture and Fatigue, Composite and Advanced Materials, Tribology and Surface Engineering, Mechanical Design and Prototyping, Biomechanical Applications, Civil Engineering Applications, Energy and Thermo-Fluid Systems, and Industrial Engineering and Management, among other topics.

The conference also included an Open Forum on *"Can Professors Balance Scholarly Work, Teaching and Admin? The Challenges Going Forward"*, where an expert panel with many years of collective and active researchers and educators addressed the issue of balancing the activities of teaching, research and services within the universities.

We believe that the meeting offered our delegates a forum for the discussion and dissemination of their recent work in assessing the integrity, reliability and failure of engineering structures, components and systems, fostered research that integrates mechanics and materials in the design process, and promoted exchange of ideas and international co-operation among scientists and engineers in this important field of engineering.

We are particularly indebted to the authors and special guests for their presentations. Each of the 258 contributions offered opportunities for thorough discussions with the authors. Particularly, we acknowledge the excellent contributions of the participants, their innovative ideas and research directions, the novel modeling and simulation techniques, and the invaluable critical comments. We are also indebted to the outstanding keynote speakers who highlighted the conference themes with their contributions and covered the main topics of the conference. We also take this opportunity to thank the members of the International Scientific Committee and the reviewers for their time and helpful suggestions, the symposia organisers for their efforts and valuable contributions to the success of the event, and the local organising committee for an absolutely superb organization of the meeting in this magnificent city. To all of you, we offer our gratitude.

Given the rapidity with which science is advancing in all areas related to the topics discussed in the present meeting, the next conference in this series (Integrity-Reliability-Failure / IRF2020) will take place in the beautiful city of Funchal/Madeira, in July 2020. Undoubtedly, we expect IRF2020 to be as stimulating and interesting as IRF2018, as evidenced by the excellent contributions offered in this current event. We look forward to seeing all of you in Madeira in July 2020.

Shaker A. Meguid and J.F. Silva Gomes
Lisbon / Portugal, July 2018

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NUMERICAL STUDY OF VIBRATIONS IN THE MILLING PROCESS

Ana Isabel Pereira[1,2], Manuel Braz César[1,3(*)], João Eduardo Ribeiro[1,4]
[1]ESTIG, Instituto Politécnico de Bragança, Bragança, Portugal
[2]CeDRI, Bragança, Portugal
[3]CONSTRUCT-LESE, University of Porto, Portugal
[4]CIMO, Bragança, Portugal
[(*)]*Email:* brazcesar@ipb.pt

ABSTRACT

Nowadays there is a great need to increase productivity along with high quality levels, which constitutes a major challenge to the industry and engineering development. In spite of the existence of advanced equipment capable of mass producing with great precision and performance such as CNC machines, some vibration induced issues may appear during the machining process that need to be addressed. The present research is based on a study of the dynamic behaviour of a milling CNC machine to identify and optimize vibration-sensitive parameters values (cutting speed, feed, axial penetration and radial penetration) in order to reduce the effect of chatter in milling process. Initially, the theoretical basis of milling operation is presented. Then, the response surface method (RS) and Genetic Algorithms (GA) are used to optimize the milling parameters. Based on the results obtained, it was possible to identify optimal parameters to minimize machining vibration.

Keywords: milling, machining, chatter, optimization methods.

INTRODUCTION

Machining processes are of crucial importance in the metallic manufacturing industry. Machining equipment can produce a large number of mechanical pieces using chip removal operations which must have the required dimensional, geometric and surficial quality. However, interaction between the workpiece and the tool may lead to the occurrence of machining vibrations, which are related with problems of reduced workpiece quality, poor surface finish, reduced tool life span and eventually low productivity (Altintas, 2000, Muhammad *et al.* 2017). In last decades, many researches have been studied this problem and tried minimize their effect in the final quality of product (Ribeiro, 2017). The goal of the present work is to develop a methodology that optimizes several machining parameters to minimize chatter vibrations. To this purpose advanced optimization techniques were used based on experimental measurements obtained during a machining process of a workpiece in a CNC milling machine.

RESULTS AND CONCLUSIONS

In order to measure the vibrations during the machining process a triaxial accelerometer fixed on the quill part of milling machine was used. The experiments were implemented using sixteen combinations of three parameter levels. In this case, four parameters were used in the experimental research: cutting spend, feed speed, axial and radial depths. The results obtained with the experimental measurements (RMS values) are shown in Table 1.

Table 1 - RMS values obtained with the experimental measurements

Test	x	y	z	M1	M2	M3	M4
1	3.6918	3.6978	8.8105	9.5550	6.7564	12.5083	8.8105
2	4.7740	5.0433	10.9222	12.0304	8.5067	15.9655	10.9222
3	4.1866	3.9018	9.8390	10.5844	7.4843	13.7408	9.8390
4	4.0771	4.3012	10.0749	10.9546	7.7461	14.3761	10.0749
5	4.1044	4.1535	9.0586	9.9654	7.0466	13.2121	9.0586
6	5.2110	5.4193	12.7689	13.8713	9.8085	18.1882	12.7689
7	4.8602	4.8153	9.6779	10.8097	7.6436	14.4932	9.6779
8	8.7763	10.1459	16.7088	19.5480	13.8225	26.8547	16.7088
9	9.1686	10.4323	17.0569	19.9943	14.1381	27.4892	17.0569
10	3.0784	2.7774	8.8117	9.2390	6.5330	11.5891	8.8117
11	2.7371	2.3011	7.6310	7.9704	5.6359	9.9321	7.6310
12	1.9439	1.9489	5.8828	6.1972	4.3821	7.8317	5.8828
13	3.1111	2.6861	8.2274	8.6548	6.1199	10.9135	8.2274
14	3.2123	2.8492	8.7841	9.2346	6.5299	11.6333	8.7841
15	3.5037	3.0897	8.3948	8.9453	6.3253	11.4845	8.3948
16	3.1888	2.6196	7.3290	7.7831	5.5035	9.9486	7.3290

The main objective was to determine the ideal parameters in order to reduce chatter vibrations in the milling process. An optimization procedure was carried out based on the Response Surface Method (RS) and a Genetic Algorithm (GA). It this study, test number 2 (x = 4.1044; y = 4.1535; z = 9.0586) and number 6 (x = 4.7740; y = 5.0433; z = 10.9222) were identified by the RS method as being relevant in the system. Measure number 2, along with function 1 and function 2, were those that resulted in lower values, as well as function 2 for measure 4 and for measure 1. It is also verified that all parameters vary and are important to avoid machining vibrations, the ideal parameters reduce to vc = 2546; va = 4584; pa = 0.10; pr = 2, vc = 2546; va = 1018.4; pa = 0.10, pr = 2, vc = 2684.9, va = 1041.3, pa = 0.21, pr = 2.1 and vc = 2981.8, va = 4492.3, pa = 0.2, pr = 2.1.

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