Listă 10 lucrări științifice relevante

[1] **Tulcan Aurel,** Iclănzan Tudor, Stan Daniel, *Modelarea funcţionării părţii de comandă a unei linii automate flexibile de presare la rece – partea a II-a,* A VII-a Conferinţă naţională "Tehnologii şi utilaje pentru prelucrarea prin deformare plastică la rece -TPR 2000"-cu participare internaţională, 11-12 Mai, Cluj-Napoca, 2000, pp. 183(6), ISBN 973-97486-3-5.

[2] **Tulcan Aurel**, Rosinger Stefan, *Capacitatea productivă şi consumul energetic ale unor sisteme de fabricaţie prin presare la rece,* A VII-a Conferinţă naţională "Tehnologii şi utilaje pentru prelucrarea prin deformare plastică la rece -TPR 2000"-cu participare internaţională, 11-12 Mai, Cluj-Napoca, 2000, pp. 169(6), ISBN 973-97486-3-5.

[3] **Tulcan Aurel**, Stan Daniel, Seiculescu Valentin, Iclănzan Tudor, Ciorba Ioan, *L´Etude Experiméntal des Paramètres d´Auto Frettage des Tubes à Parois Épais,* Academic Journal of Manufacturing Engineering, Vol 1(4), pp. 21(5), **2003**, ISSN 1583-7904.

[4] **Tulcan Aurel**, Seiculescu Valentin, Stan Daniel, Iclănzan Tudor, Bernath Alexander, *Virtual simulation of a coordinate measuring machine behaviour for high-speed measurement,* Simulation Design and Control of Foundry Processes, Krakow, Poland, 2006, pp. 167(9), ISBN 83-88309-41-2.

[5] **Tulcan Aurel**, Stan Daniel, Turc Cristian, Cosma Cristian, Dume Adrian, *Design of Linear Drive Systems to Retrofit a Coordinate Measuring Machine*, 14th International Conference on Modern Technologies, Quality and Innovation (ModTech 2010), Slănic Moldova, **2010**, pp. 647-650(4), ISBN 2066-3919, WOS:000282604000159.

[6] **Tulcan Aurel**, Tulcan Liliana, Stan Daniel, *CMM Design Based on Fundamental Design Principles,* Modern Technologies in Industrial Engineering II, ModTech 2014, Polonia, Advanced Materials Research, Vol 1036, pp. 517-522(6), **2014**, ISSN 10226680 / 978-303835255-6, *Trans Tech Publications, Switzerland, doi:10.4028/www.scientific.net/AMR.1036.517* SCOPUS, Google Scholar.

[7] **Tulcan Aurel**, Cioană Cristian, Stan Daniel, Cosma Cristian, *Coordinate measuring machine variations for different probe configurations,* The 16th International Conference Modern Technologies, Quality and Innovation - ModTech 2012 - New face of T.M.C.R., Sinaia, România, **2012**, pp. 989-992(4), ISBN 2066-3919.

[8] **Tulcan Aurel**, Tulcan Liliana, *Design of Experiments in CMM Probe Configuration Study*, 2016 International Conference on Production Research – Africa, Europe and the Middle East. 4th International Conference on Quality and Innovation in Engineering and Management, Cluj-Napoca, **2016**, pp. 75-80(6), ISBN 978-606-737-180-2.

[9] **Tulcan Aurel**, Vasilescu Mircea Dorin, Tulcan Liliana, *Study of the Influence of Technological Parameters on Generating Flat Part with Cylindrical Features in 3D Printing with Resin Cured by Optical Processing*, Polymers, Vol 12(9), 1941, **2020**, pp. 24 + 11 (Supplementary Materials), ISSN 2073-4360, DOI: 10.3390/polym12091941; WOS:000579963900001, FI 3.426, (**Q1**).

[10] **Tulcan Aurel**, Vasilescu Mircea Dorin, Tulcan Liliana, *Comparative Study of the Influence of Bio-Resin Color on the Dimension, Flatness and Straightness of the Part in the 3D Printing Process,* Polymers, Vol 13(9), 1412, **2021**, pp. 21, ISSN 2073-4360, DOI:10.3390/polym13091412; WOS:000650706300001, FI 3.426, (**Q1**).

MODELAREA FUNCŢIONĂRII PĂRŢII DE COMANDĂ A UNEI LINII AUTOMATE FLEXIBILE DE PRESARE LA RECE – PARTEA A II-A

A. Tulcan, T. Iclănzan, D. Stan
Universitatea "Politehnica" din Timişoara, România

Rezumat

In lucrare se prezintă modul de descriere secvenţială, pe baza Grafcet-ului de nivel 2, a comportamentului părţii de comandă în scopul obţinerii efectelor dorite la partea operativă a liniei flexibile de presare la rece. Au fost descrise, la nivel de specificaţii tehnologice a părţii de comandă, modurile de funcţionare şi oprire, cât şi cel privind siguranţa în exploatare a liniei.

Cuvinte cheie: linii automate de presare, modelare funcţionare, grafcet

1. Elaborare grafcet de nivel 2

In scopul abordării mai uşoare a procesului de modelare a liniei, s-a conceput o organigramă, prezentată în fig.1, legată de modul de punere în funcţiune a liniei. Pornind de la aceasta, în vederea realizării unor modele de dimensiuni *acceptabile*, diversele faze în funcţionarea liniei [5],[6],[7] au fost descrise prin mai multe grafcet-uri ierarhizate între ele.

Pornirea şi oprirea liniei a fost descrisă (fig.2) prin grafcet-ul **G1** (grafcet "*master*"), care este totodată şi grafcet de *siguranţă* în exploatare [1],[2],[3],[4]. Punerea sub tensiune a parţii de comandă se face prin acţionarea butonului P, în condiţiile în care nici unul dintre microîntrerupătoarele L_{11}, L_{12} sau L_{13} nu este acţionat (banda nu a atins lungimea de avarie, respectiv, între presa 1 şi presa 2, banda perforată nu s-a rupt). Oprirea generală a liniei se face prin acţionarea butonului O. In cazul atingerii buclelor de avarie [5],[6] sau la ruperea accidentală a benzii perforate, situată între cele două prese, prin intermediul acestui grafcet se comandă oprirea automată a liniei. Aceasta se realizează cu ajutorul macroacţiunii "*Forţează*" [2],[3] asociată etapei 10, macroacţiune care obligă grafcetul **G5** (grafcet "*slave*" faţă de **G1**), indiferent de *situaţia* în care se află, să treacă în etapa 50, etapă în care linia nu mai funcţionează.

In fig.3…5 sunt reprezentate grafcet-urile **G2**, **G3**, **G4** care descriu modul de funcţionare al motoarelor electrice a preselor, respectiv alimentarea cu aer comprimat. Prin acţionarea butoanelor de pornire P_{MP1}, respectiv P_{MP2} se comandă pornirea motoarelor celor două prese, care vor funcţiona până când se comandă oprirea lor prin acţionarea butoanelor de oprire O_{MP1}, O_{MP2}, sau a butonului de oprire generală O. Alimentarea cu aer comprimat se

CAPACITATEA PRODUCTIVĂ ŞI CONSUMUL ENERGETIC A UNOR SISTEME DE FABRICAȚIE PRIN PRESARE LA RECE

A. Tulcan, S. Rosinger
Universitatea "Politehnica" din Timişoara, România

Rezumat

In lucrare se prezintă expresiile de calcul ale capacității productive nominale și efective a utilajelor individuale și a sistemelor de fabricație prin presare, deducându-se relația capacitate productivă a sistemelor de fabricație și regimul de funcționare a preselor din sistem. Totodată se definesc consumurile de energie electrică pe unitatea de produs realizat pe un sistem de fabricație prin presare la rece în funcție de modul de funcționare a utilajelor componente, stabilindu-se astfel regimul optim de funcționare din acest punct de vedere.

Cuvinte cheie: utilaje de presare, linii automate, capacitate productivă, consum energetic

1. Introducere

Avându-se în vedere că presele (de comandă sau comandate) constitutive ale unui sistem de fabricație (S.F.) prin presare la rece dispun de variante posibile de funcționare, se cere să se precizeze, pentru diversele situații tipice de aplicație, care sunt variantele de funcționare optimale. In acest context, prezintă interes a se evidenția eventuale corelări obligatorii sau eventuale influențe ce apar între natura regimului de funcționare a S.F. pe de o parte, și pe de altă parte, arhitectura S.F., capacitatea productivă a SF și consumul energetic aferent prelucrării unui produs.

2. Capacitatea productivă a S.F.

Stabilirea capacitătii productive a unui S.F. pornește de la realizarea unei diferențieri [2] între:

⇒ capacitatea productivă nominală C_{pn} a unui utilaj de presare singular echipat cu sculă de deformare servind realizării unui anumit produs, aceasta fiind cea corespunzătoare funcționării presei în regim de lovituri repetate (LR) cu n cd/min, scula de deformare realizând un număr de i produse la fiecare lovitură de berbec.

$$C_{pn} = n \cdot i \quad [piese/min] \tag{1}$$

L´ÉTUDE EXPERIMÉNTAL DES PARAMÈTRES D´AUTO FRETTAGE DES TUBES À PAROIS ÉPAIS

Par Aurel TULCAN[1], Daniel STAN[1], Valentin SEICULESCU[1], Tudor ICLĂNZAN[1] et Ioan CIORBA[2]

ABSTRACT: The paper presents the experimental results at thick walls tubes shrinking. On the shortened high rings from two different materials, tests were performed by using a bearing ball or a drift as a tool, either on the rings at the room temperature or on the heated rings. The press axial force and the permanent radial deformation were considered as response functions.
KEY WORDS: thick walls tubes, tube forming, plastic deformation, shrinking.

1 INTRODUCTION

Il y a beaucoup d´installations qui ont des pièces tubulaires sollicitées à une pression intérieure élevée. L´amélioration de résistance de ces pièces peut être faits par:

- accroître les dimensions;
- frettage;
- auto frettage.

Il y a une grande différence entre les tubes frettés et les tubes auto-frettés [Ciorba, 2001]. Dans le premier cas les tensions initiales existantes dans les différentes couches du matériau sont réalisées par l´assemblage par serrage de deux tubes et dans le deuxième cas par une technologie spéciale de déformation appliquée à un seul tube. Le procédé technologique d´auto frettage d´un tube à paroi épais consiste en réalisation à l´intérieur du tube une pression élevée. Cette pression va déterminer l´apparition à l´intérieur du tube des tensions équivalentes qui dépassent la limite conventionnelle d´élasticité (σ_c) sur tout l´épais de paroi (tube complètement auto fretté) ou jusque un diamètre intermédiaire (D_c), situé entre le diamètre intérieur et le diamètre extérieur (tube partiellement auto fretté). Quand la pression d´auto frettage disparaît, à l´intérieur du tube restent des déformations variables sur l´épais de paroi: maximales à l´intérieur et minimales à l´extérieur [Deutch, 1979], [Buzdugan, 1986]. Pendant le processus d´auto frettage quand l´effort unitaire équivalent atteint la valeur de la limite conventionnelle d´élasticité (σ_c), à l´intérieur du tube partiellement auto fretté on peut distinguer deux zones (fig.1) délimitées par la couche située sur le diamètre intermédiaire (D_c):

- une zone elasto-plastique située entre le diamètre intérieur (D_i) et le diamètre intermédiaire (D_c),
- une zone élastique située entre le diamètre intermédiaire (D_c) et le diamètre extérieur (D_e).

Quand la pression d´auto frettage disparaît, la zone elasto-plastique ne revient plus à sa forme initiale à cause de déformations rémanentes. La zone élastique tend revenir à sa forme initiale, mais étant empêchée par la zone plastique produit des tensions de compression à l´intérieur de cette zone.

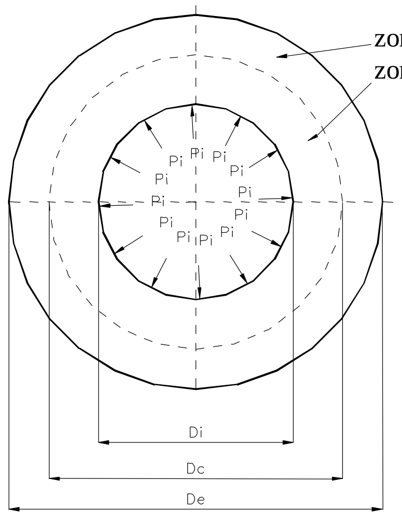


Figure 1. Tube partiellement auto fretté

L´avantage d´auto frettage consiste le fait qu'on obtienne un tube avec résistance supérieure avec la même épaisseur de paroi. Pendant la fonction du tube auto fretté, les tensions existantes à l´intérieur dépassent les tensions de compression existantes dans la paroi du tube. Elles peuvent atteindre la valeur de pression d´auto frettage sans modifications dimensionnelles à l´intérieur du tube.

[1] Universitatea Politehnica din Timişoara,

[2] Uzina Mecanică Reşiţa

E-mail: atulcan@eng.utt.ro; dstan@eng.utt.ro; vseiculescu@eng.utt.ro; ticlanzan@eng.utt.ro; iciorba@umres.ro.

VIRTUAL SIMULATION OF A COORDINATE MEASURING MACHINE BEHAVIOR FOR HIGH-SPEED MEASUREMENT

A. Tulcan[1], V. Seiculescu[1], T. Iclănzan[1], D. Stan[1], A. Bernath[2]
[1]Politehnica University of Timişoara, Romania,
[2]Industrielle CNC-und Meßtechnik, Germany
atulcan@eng.upt.ro, vseiculescu@eng.upt.ro, ticlanzan@eng.upt.ro, dstan@eng.upt.ro, alexander.bernath@icncmt.de

Abstract

The paper presents the main aspects regarding the 3-dimensional measuring role in the quality assurance. The accuracy of a coordinate measuring machine (CMM) is very important to be known starting by the initial concept and design, for a workpiece quality measurements results. In the first part, the paper deals with different aspects regarding the factors which influence CMM precision as: the machine architectures, rigidity, working speed, e.g. Owing to the demand for shorter cycle times for measurement tasks, coordinate measuring machines are required to be used at high speeds. In such high-speed measuring processes, dynamic errors will have a greater influence on the accuracy. For a specific CMM (Presingo 755), the dynamic error states will be analysed. The major deflections at the probe position owing to accelerations are obtained by using finite-element analysis (FEA).

1. BASICS OF A COORDINATE MEASURING MACHINE

1.1. The influence factors in 3-dimensional measuring

Three-dimensional measuring represents today an indispensable technique for parts quality assurance and for companies competitively on the market, too. The evolution of parts, from cylindrical or prismatic shape to freeform surfaces, implies an evolution of measuring systems, which have to correspond more and more to the requirements of an ″agile production″ [1].

Today, 80% of workpieces control is effectuated on coordinate measuring machines (CMMs) [2], which are very popular throughout industry, and are available in a wide range of sizes and designs with a variety of different probe

DESIGN OF LINEAR DRIVE SYSTEMS TO RETROFIT A COORDINATE MEASURING MACHINE

Aurel Tulcan[1], Daniel Stan[1], Cristian Turc[1], Cristian Cosma[1] & Adrian Dume[1]

[1]"POLITEHNICA"University of Timisoara-Romania, Department of Materials and Manufacturing Engineering

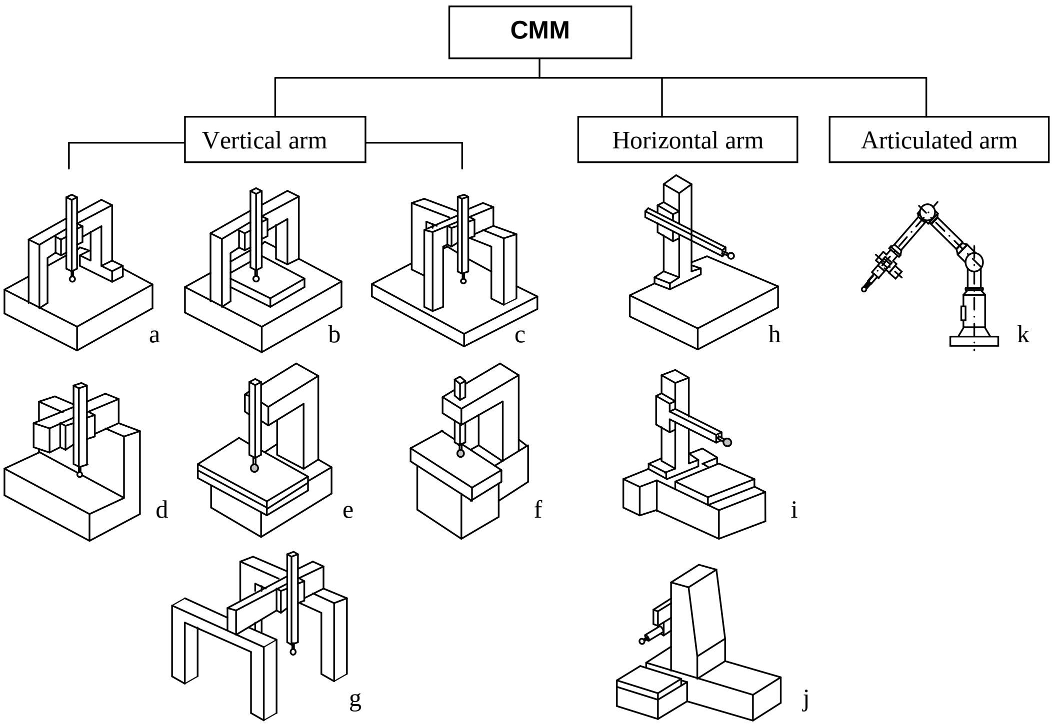
Corresponding author: Aurel Tulcan, atulcan@eng.upt.ro

Abstract: Coordinate measuring machines (CMMs) have come a long way since the early models. For the consolidated architectures, one of the actual tendencies is to improve the dynamic parameters of the CMM. On the other hand, in many companies there are many coordinate measuring machines, manually controlled, whose performance can be improved by a retrofit action. The paper presents the results obtained from the retrofit action for a manual coordinate measuring machine TESA MicroMS 343. In the first part, the main drive system, generally used to motorize a CMM, are analyzed. Following this study, the linear drive nut was chosen because this drive system ensures an optimal ratio between performance, compact design and price. The second part of the paper presents the design solutions for the X, Y, and Z-axis drive systems and the "new" CMM numerically controlled.

Key words: CMMs, Linear Drive System, Ball screw, Gear-rack, Linear drive nut system, CMM Design

1. INTRODUCTION

Over the last decades, more and more coordinate measuring machines (CMMs) has been applied to the inspection process in various industries (Raphaphet, 2002). This is mainly due to the flexibility they offer and the relative agility when compared to hard gages for small and medium production batch sizes. The evolution of parts, from cylindrical or prismatic shape to freeform surfaces with tighter tolerances, implies an evolution of CMMs, which have to correspond more and more to the requirements of a ″agile production″. Today, 80% of work pieces control is effectuated on CMMs, which are available in a wide range of sizes, designs and architectures (Figure 1) with a variety of different probe technologies (Iacmm, 2009).



a) Moving bridge; b) Fixed bridge; c) L–shaped bridge; d) Cantilever with fixed table; e) Column; f) Moving table cantilever; g) Gantry; h) Moving ram horizontal arm; i) Moving table horizontal arm; j) Fix table horizontal arm; k) Articulated arm.

Fig. 1. Coordinate measuring machines architectures

Advanced Materials Research Vol. 1036 (2014) pp 517-522
© (2014) Trans Tech Publications, Switzerland
doi:10.4028/www.scientific.net/AMR.1036.517

CMM Design Based on Fundamental Design Principles

Aurel TULCAN[1,a*], Liliana TULCAN[2,b] and Daniel STAN[3,c]

[1] Politehnica University Timisoara, Faculty of Mechanical Engineering, Department of Materials and Manufacturing Engineering, Bld. Mihai Viteazu nr.1, 300222-Timisoara, Romania

[2] Politehnica University Timisoara, Faculty of Mechanical Engineering, Department of Materials and Manufacturing Engineering, Bld. Mihai Viteazu nr.1, 300222-Timisoara, Romania

[a]aurel.tulcan@upt.ro, [b]liliana.tulcan@upt.ro, [c]daniel.stan@upt.ro

Keywords: Coordinate measuring machine, CMM architecture, Mechanical design, Dynamic errors, Finite-element analysis (FEA), Design of Experiments (DOE).

Abstract. The paper presents an approach concerning the CMM design. The first stage of this research deals with the acquisition and the development of knowledge about the CMM design. The main mechanical design aspects to achieve a high positioning and measuring accuracy are presented and two main objectives are assigned: high repeatability (design for repeatability) and high predictability of the machine response to the main error sources (design for predictability). In the second stage of this research the dynamic errors states for this CMM design have been analyzed. In high-speed measuring processes dynamic errors will have a great influence on the accuracy. This study has been performed by using finite-element analysis (FEA) of the mechanical frame. The total deformation of the mechanical frame for different accelerations of the moving assemblies has been calculated. The major deflections at the probe position due to the accelerations are obtained by using FEA. These results give a prediction about the dynamic error of the CMM.

Introduction

Over the last decades, more and more coordinate measuring machines (CMMs) has been applied to the inspection process in various industries. CMMs are available in a wide range of sizes and designs with a variety of different probe technologies. The main subsystems of the CMM are mechanical frame, data handling and control system, probing system and measuring software, which, once integrated and brought in the condition of interacting, constitute the CMM itself. The mechanical frame should be high precision and capable of positioning the sensorial element in any point of its measuring envelope in an extremely repeatable mode.

A variety of machine configurations are available: bridge, cantilever, column, gantry, horizontal arm and articulated arm [1]. Each configuration has advantages that make it more suitable for a particular application. In order to perform measuring tasks with a large flexibility and high accuracy, a new coordinate measuring machine has been design. The architecture of the CMM is L-shape Bridge with a measuring range of 500x600x400 mm.

The design of the CMM 564 was driven by the following objectives:

- Volumetric measuring uncertainty of less than 2.5 μm;
- Measuring volume of 500×600×400 mm, where the plane of 500×600 mm corresponds with the horizontal plane;
- Maximum velocity of the individual machine axes of 300 mm/s;
- Accessible cost.

1. Main Design Considerations

In the design stage of a CMM the acquisition and the development of knowledge about the design of high precision machines is very important. In the most of the cases, the mechanical frame of a CMM is the physical representation of a Cartesian Reference System and can be characterized

COORDINATE MEASURING MACHINE VARIATIONS FOR DIFFERENT PROBE CONFIGURATIONS

Aurel Tulcan[1], Cristian Cioană[1], Daniel Stan[1], Cristian Cosma[1]

[1]Politehnica University of Timişoara-Romania, Department of Materials and Manufacturing Engineering

Corresponding author: Aurel Tulcan, atulcan@eng.upt.ro

Abstract: In applying a Coordinate Measuring Machine (CMM) to measure a part, many factors affect the measurement results. In CMM research, there is often a need to measure the same feature repeatedly using multiple settings. The effects of changing the probe head configuration are very important to be known in this case. The aim of this research was the determination of what effects the selection of the measurement plane, stylus length, and stylus tip size would have on the CMM's ability to repeatedly measure a diameter of a sphere. A design of experiments (DOE) and an ANOVA study for different probe head configurations was conducted using a TESA MicroMS343 CMM. The results of this research indicate that if these factors were changed, the CMM would not repeatedly result in the same measurement reading. The interactions between the factors all show minor measurement variations for the same feature.
Key words: CMM, Design of experiments, Dimensional metrology, Measurement uncertainty, ANOVA.

1. INTRODUCTION

Many researches in the field of CMM have been conducted in the past to increase usage in the industry as inadequacies are uncovered and new needs develop. The areas that researches have covered are the development of new probe compensation algorithms, part orientation optimization, sampling strategies, computer generated inspection paths, accuracy improvement by developing hardware, software and operating strategies (Berisso and Ollison, 2010), (Feng et al., 2007), (Hamburg-Piekar and Donatelli, 2006), (Nardelli and Donatelli, 2006), (Pirateli-Filho and Giacomo, 2003), (Raphaphet, 2002).Accuracy and repeatability of the measurement can be affected by multiple sources. One of these that may not be quite as obvious includes the probe diameter, the length of the probe stylus, the probe contact angles and the required probe contact force.

Often, in research, to ensure the interest of the feasibility study, some assumptions have to be made. For this study, two assumptions have been made:

- Various probe and stylus configurations will not affect the measurements made on a CMM.
- CMM's ability to probe parts from multiple directions;

On the market there are many probes available for CMMs. These probes can be grouped in contact or non-contact probes. Non-contact solutions include laser scanning options and calibrated video camera solutions. Contact probes can be divided into two groups, discrete (TTPs) and scanning (SP). Scanning probes are continuous contact probes and are useful in the gathering of high-speed data on a part's form characteristics. Touch trigger probes (TTPs) are the most prevalent technology available and are good when fewer data points are needed, such as measurements for position or size (Renishaw, 2012). The TTPs are piezo probes, strain-gage probes, and kinematic resistive probes.

During this study, the kinematic resistive probe was used. The main problem with kinematic probes is what is known as pre-travel, or their lobing error, that occurs due to the mechanical design of the probe (Figure 1). Lobing error is due to the changes in the required pre-travel pressure of the probe as the contact vector rotates around the Z axis of the probe. The map of lobing error is approximately triangular

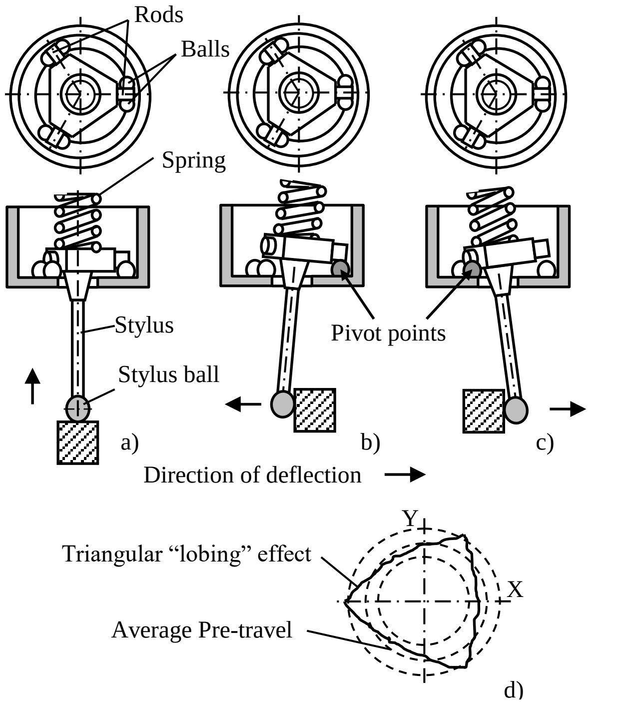


Fig. 1. Kinematic resistive probe mechanism

DESIGN OF EXPERIMENTS IN CMM PROBE CONFIGURATION STUDY

Aurel Tulcan[1], Liliana Tulcan[2]

[1] Material and Manufacturing Engineering Department, Politehnica University of Timisoara, Bld. Mihai Viteazu nr.1, Timisoara, Romania, aurel.tulcan@upt.ro

[2] Mechanical Machines, Equipment and Transportation Department, Politehnica University of Timisoara, Bld. Mihai Viteazu nr.1, Timisoara, Romania, liliana.tulcan@upt.ro

Abstract

The measurement accuracy of a workpiece on a Coordinate Measuring Machine (CMM) can be affected by many factors. In CMM research, there is often a need to measure the same feature repeatedly using multiple settings. One of these settings is the change of the probe and stylus configurations. It is therefore essential that the accuracy can be estimated. The goal of this research is to determinate of what effects the selection of the TP20 touch-trigger probe module, stylus length, and stylus tip ball size would have on the CMM's ability to repeatedly measure a diameter of a gauge ring. This research, conducted by using a TESA MicroMS343 CMM, applies the design of experiments (DoE) and analysis of variance (ANOVA) approach to investigate the impact of the factors and their interactions to the measuring result. The results of this research indicate that the CMM would not repeatedly result in the same measurement reading.

Keywords:
CMMs, Three dimensional metrology, Touch trigger probe, Design of Experiments (DoE).

1 INTRODUCTION

Nowadays, the required quality standards of the products are increasing considerably and therefore the manufacturing tolerances are becoming tighter. Coordinate metrology has become essential for dimensional metrology. Most of the manufactured parts are inspected by Coordinate Measuring Machines (CMMs). The universal applicability and the increased capability of CMMs enable a wide range of application of this technology. CMMs are able to measure a wide range of geometrical parameters. For almost any kind of workpiece, CMM is able to measure its size, form, location and orientation tolerances [1], [2].

For each of the workpiece geometrical parameters the user may adopt any of a number of measurement strategies. These strategies include the selection of a particular probe and stylus configuration, the number and position of measuring points and the direction and speed of approach of the probe [3]. The selected measurement strategy adopted for the workpiece measurement determine the way in which the errors are introduced in to the measurement system and influence the measurements uncertainty. For the coordinate metrologist, estimating the accuracy of measurements made with three dimensional CMMs is of extreme importance for maintaining confidence and reliability in the measurements. The factors which may lead to effects on measuring result and measuring uncertainty can be summarized in six groups: measuring machine, environment, workpiece, measuring strategy, operator and task definition [2]. A source of errors that may not be quite as obvious includes the stylus tip diameter, the length of the probe stylus, the probe contact angle and the required probe contact force. Many researches have been done in the past on many of the sources of errors that can affect the accuracy and repeatability of the measurement [4], [5], [6], [7], [8], [9], [10], [11], [12].

This research aims to determine of what effects would have, on the CMM's ability to repeatedly measure a single diameter, the selection of the probe module, stylus length and stylus size. Stylus systems are selected for measurements depending on the workpiece and measuring job. In the literature is recomended to use short styli with large size [1], [2], [3]. But, there are workpieces with small features or features which require a deep reach to be measured. In this case the selection of the stylus system require long stylus with small size. In this research, to ensure the interest of the feasibility study, one assumption has been made: various TP20 probe module and stylus configurations will not affect the measurements made on a CMM.

Probing systems for CMMs are an integral part of the entire measuring system and form the link between machine and the workpiece to be measured. Proper selection, configuration, qualification, and use are vital to tap the full potential of a CMM. Probes used on the CMMs can be grouped in contacting (touch) or non-contacting (optoelectronic) probes [13], [14]. Contacting probes are categorized into touch-trigger probes (TTP) used to measure discrete points or measuring probes (SP). Touch trigger probes (TTPs) are the most prevalent technology available and are good when fewer data points are needed, such as measurements for dimension and position. The TTPs are piezo probes, strain-gage probes, and kinematic resistive probes.

This research deals with the kinematic resistive probes. This probes are based on a mechanism in which three pairs of contacts displaced by 120°, that constitute an isostatic support, are kept closed by means of the force generated by a spring. (Figure 1a and 1b). Due to the fact that setting points are displaced by 120° the probing force is not uniform. The probing forces when the workpiece surfaces S1, S2 and S3 (Figure 1a) are measured are shown in the equations (1), (2) and (3).

$$F_{c1} = \frac{F_S \cdot R}{L} \quad (1)$$

$$F_{c2} = \frac{F_S \cdot 2R}{L} \quad (2)$$

$$F_{c3} = F_s \quad (3)$$

polymers

MDPI

Article

Study of the Influence of Technological Parameters on Generating Flat Part with Cylindrical Features in 3D Printing with Resin Cured by Optical Processing

Aurel Tulcan [1,*], Mircea Dorin Vasilescu [2,*] and Liliana Tulcan [2,*]

[1] Department of IMF, Politehnica University Timisoara, 300006 Timisoara, Romania
[2] Department of MMUT, Politehnica University Timisoara, 300006 Timisoara, Romania
* Correspondence: aurel.tulcan@upt.ro (A.T.); mircea.vasilescu@upt.ro (M.D.V.); liliana.tulcan@upt.ro (L.T.)

Received: 22 July 2020; Accepted: 24 August 2020; Published: 27 August 2020

check for updates

Abstract: The objective of this paper is to determine how the supporting structure in the DLP 3D printing process has influences on the characteristics of the flat and cylindrical surfaces. The part is printed by using the Light Control Digital (LCD) 3D printer technology. A Coordinate Measuring Machine (CMM) with contact probes is used for measuring the physical characteristics of the printed part. Two types of experiment were chosen by the authors to be made. The first part takes into consideration the influence of the density of the generated supports, at the bottom of the printed body on the characteristics of the flat surface. In parallel, it is studying the impact of support density on the dimension and quality of the surface. In the second part of the experiment, the influence of the printed supports dimension on the flatness, straightness and roundness of the printed elements were examined. It can be observed that both the numerical and dimensional optimum zones of the support structure for a prismatic element could be determined, according to two experiments carried out and the processing of the resulting data. Based on standardized data of flatness, straightness and roundness, it is possible to put in accord the values determined by measurement within the limits of standardized values.

Keywords: 3D printing; additive manufacturing; surface deviation; parametric dimensioning; digital light processing; design of experiments; 3D metrology

1. Introduction

In both research and production, the quality obtained by the 3D printing process has an essential role in making parts or assemblies with the functional role [1–4]. At the same time, the use of this technology allows us to reduce manufacturing costs [5,6], as well as the level of pollution [7–10]. 3D printing is a relatively new technological process [11,12] that permits the generation of parts faster than other similar methods of fabrication. In the specialized literature, there are several studies related to 3D printing, among them are those dealing with the medium's evolution in time [13,14].

The flat and profiled surfaces have an essential role, both in terms of kinematic and functional movement. The use of such an approach to generating specific features of the parts at low expense allows a reduction of both costs in design and production [15,16]. It is possible to take into consideration the analysis of the flat or round surfaces, which ensure the generation of the facets on which the movement can be achieved linearly or by rotation, with high speed and precision.

Generation of round or flat elements created by the conventional processing of injection materials or by the Fused Depositing Modeling (FDM) printing process [17–19], used the melted plastic as an extruded component and deposited it layer-by-layer in predetermined locations.

In the digital light processing (DLP) [20] the optical polymerization of materials is taken into consideration for generating parts.

polymers

MDPI

Article

Study of the Influence of Technological Parameters on Generating Flat Part with Cylindrical Features in 3D Printing with Resin Cured by Optical Processing

Aurel Tulcan [1,*], Mircea Dorin Vasilescu [2,*] and Liliana Tulcan [2,*]

[1] Department of IMF, Politehnica University Timisoara, 300006 Timisoara, Romania
[2] Department of MMUT, Politehnica University Timisoara, 300006 Timisoara, Romania
* Correspondence: aurel.tulcan@upt.ro (A.T.); mircea.vasilescu@upt.ro (M.D.V.); liliana.tulcan@upt.ro (L.T.)

Received: 22 July 2020; Accepted: 24 August 2020; Published: 27 August 2020

check for updates

Abstract: The objective of this paper is to determine how the supporting structure in the DLP 3D printing process has influences on the characteristics of the flat and cylindrical surfaces. The part is printed by using the Light Control Digital (LCD) 3D printer technology. A Coordinate Measuring Machine (CMM) with contact probes is used for measuring the physical characteristics of the printed part. Two types of experiment were chosen by the authors to be made. The first part takes into consideration the influence of the density of the generated supports, at the bottom of the printed body on the characteristics of the flat surface. In parallel, it is studying the impact of support density on the dimension and quality of the surface. In the second part of the experiment, the influence of the printed supports dimension on the flatness, straightness and roundness of the printed elements were examined. It can be observed that both the numerical and dimensional optimum zones of the support structure for a prismatic element could be determined, according to two experiments carried out and the processing of the resulting data. Based on standardized data of flatness, straightness and roundness, it is possible to put in accord the values determined by measurement within the limits of standardized values.

Keywords: 3D printing; additive manufacturing; surface deviation; parametric dimensioning; digital light processing; design of experiments; 3D metrology

1. Introduction

In both research and production, the quality obtained by the 3D printing process has an essential role in making parts or assemblies with the functional role [1–4]. At the same time, the use of this technology allows us to reduce manufacturing costs [5,6], as well as the level of pollution [7–10]. 3D printing is a relatively new technological process [11,12] that permits the generation of parts faster than other similar methods of fabrication. In the specialized literature, there are several studies related to 3D printing, among them are those dealing with the medium's evolution in time [13,14].

The flat and profiled surfaces have an essential role, both in terms of kinematic and functional movement. The use of such an approach to generating specific features of the parts at low expense allows a reduction of both costs in design and production [15,16]. It is possible to take into consideration the analysis of the flat or round surfaces, which ensure the generation of the facets on which the movement can be achieved linearly or by rotation, with high speed and precision.

Generation of round or flat elements created by the conventional processing of injection materials or by the Fused Depositing Modeling (FDM) printing process [17–19], used the melted plastic as an extruded component and deposited it layer-by-layer in predetermined locations.

In the digital light processing (DLP) [20] the optical polymerization of materials is taken into consideration for generating parts.