AN ANALYSIS OF THE THERMAL EXPANSION OF A MACHINE TOOL

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ABSTRACT

HIGH-SPEED MACHINING HAS BECOME MORE AND MORE IMPORTANT IN RECENT YEAR. IN ORDER TO ACHIEVE THIS GOAL, THE HIGH-SPEED SPINDLES ARE USED. WITH THE INCREASING ROTATIONAL SPEED, THE PROBLEM OF TEMPERATURE RISE OCCURS. THIS RESEARCH USES THE TAGUCHI METHOD TO FIND THE OPTIMUM PARAMETERS FOR AN OIL-AIR LUBRICATION SPINDLE WITH CERAMIC BEARINGS. THE EFFECTS OF THE DESIGN PARAMETERS ON THE TEMPERATURE RISE AND THE THERMAL ERROR OF THE SPINDLE CAN ALSO BE OBTAINED. THE RESULTS CAN BE USED TO MINIMIZE THE TEMPERATURE RISE AND THE THERMAL DEFORMATION OF AN OIL-AIR LUBRICATION SPINDLE WITH CERAMIC BEARINGS. FOR THE FEEDING SYSTEM, THIS RESEARCH APPLIES A PRELOAD ON THE SCREW TO COMPENSATE THE THERMAL DEFORMATION. WITH VARYING FEED RATES AND PRELOADS, THE TEMPERATURE RISE, THE THERMAL DEFORMATION AND THE POSITIONAL ERRORS WERE MEASURED. THE THERMAL DEFORMATION AND THE POSITIONAL ERRORS ARE COMPARED. THE LAST PART OF THIS RESEARCH FOCUSES ON THE THERMAL ERRORS OF A PLANER-TYPE MACHINING CENTER. THE TEMPERATURE RISE AND THE THERMAL DEFORMATION WERE MEASURED BY USING THERMOCOUPLES AND CAPACITANCE PROBES. MULTIPLE-VARIABLE REGRESSION ANALYSIS WAS USED TO DEVELOP A THERMAL MODEL. THE MODEL IS FOUND TO GREATLY IMPROVE THE ACCURACY.

Keywords : OIL-AIR SPINDLE , FEEDING SYSTEM , PLANER-TYPE MACHINE TOOL , TAGUCHI METHOD , THERMAL DEFORMATION

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REFERENCES

[1] 何俊龍, "高精度車床熱誤差及補償研究" , 國立中興大學碩士論文,1998 [2] MAURER,T.J. P.L. JEAKLE AND C. WILLNER ,"SPINDLE LUBRICATING SYSTEM",U.S.PATENT:3, 939,944 [3] AOYAMA,T.AND I. LNASAKI ,"STUDY OF OIL-AIR LUBRICATION OF HIGH-SPEED BALL BEARING SYSTEM FOR MACHINE TOOL APPLICATION", NAMRCXV PROCEEDINGS 1987,PP.558-564 [4] 高志忠, "高速球軸承在油氣潤滑系統下之性能研究" , 國立中正大學碩士論文,1995 [5] 郭慶祥，"工具機高速主軸之性能測試與分析"，大葉大學碩士論文，1999 [6] 趙相松，"陶瓷軸承主軸單元動特性的實驗研究"，中國機械工程,VOL.10,1999 [7]

OKUSHIMA, K. ,"COMPENSATION OF THERMAL DISPLACEMENT BY COORDINATE SYSTEM CORRECTION", ANNALS OF THE CIRP,VOL. 24/1/1975,PP.327-331 [8] MOSHE BARASH ,"THERMAL EFFECTS ON THE ACCURACY OF NUMERICALLY CONTROLLED MACHINE TOOLS" , ANNALS OF THE CIRP , VOL.35/1.1986, PP.255-258 [9] OPTIZ, H. AND R. NOPPEN, "A FINITE ELEMENT PROGRAM SYSTEM AND ITS APPLICATION FOR MACHINE TOOL STRUCTURAL ANALYSIS" MTDR, VOL.13,1972,PP55-60 [10] BRYAN, J., "INTERNATIONAL STATUS OF THERMAL ERROR RESEARCH"， ANNALS OF CIRP ， VOL. 39/2/1990 [11] WECK M. AND L. ZANGS, "COMPUTING THE THERMAL BEHAVIOR OF MACHINE TOOLS USING THE FINITE ELEMENT METHOD POSSIBILITIES AND LIMITATIONS", MTDR, VOL.16,1975, PP185-194 [12] ARAMAKI ET.AL, "THE PERFORMANCE OF BALL BEARING WITH SILICON NITRICDE CERAMIC BALLS IN HIGH SPEED SPINDLE FOR MACHINE TOOLS" ASME , JOURNAL OF TRIBOLOGY , VOL.110,1988 [13] CHEN, J.S. , "COMPEMSATION OF THERMAL DISPLACEMENT BY COORDINATE SYSTEM CORRECTION " ， ANNALS OF THE CIRP , VOL.24 1975 , PP.327-331 [14] NAKAMURA AND KAKION, "A PERFORMANCE EVALUATION OF PRELOAD SWITCHING SPINDLE"JOURNAL OF JAPAN SOCIETY OF PRECISION ENGINEERING , VOL.60.NO.5 , PP688-692 , 1994 [15] 王榮邦, "CNC工具機加工精度與熱誤差之研究" , 國立台灣大學碩士論文, 1996 [16] YUN, W.S., "THERMAL ERROR ANALSIS FOR CNC LATHE FEED DRIVE SYSTEM" , INT. J. TOOLS MANUFACT. VOL.39 , 1999 [17] 鄧應揚, "工具機進給系統之熱傳分析" , 中正大學碩士論文,2000 [18] 孟令人, "高精度工具機熱變形補償控制技術" , 國立台灣大學碩士論文， 1997 [19] 吳政憲、郭慶祥、朱佑泰、余俊德, " 工具機油氣潤滑主軸之性能測試" , 中國機械工程學會 第十七屆學術研討會論文集, 1999 [20] 田口玄一著, " 田口式品質工程概論",中國生產力中心出版, 1980 [21] 田口玄一著, " 田口式品質設計的實驗計畫法",中國生產力中心出版, 1981 [22] 黎正中譯, " 穩健設計之品質工程",台北圖書公司, PP.63-67 , 1993 [23] 吳宗正, " 迴歸分析" , 三民書局, PP.75-92 , 1992 [24] 陳景堂, " 統計分析:SPSS FOR WINDOWS入門與應用" , 儒林書局,1999 [25] 吳明隆, " SPSS統計應用實務" , 松岡電腦圖書資料股份有限公司,2000