The Study of Dynamics Performance of High-speed Spindle of Machine Tools

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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 PROBLEMS OF TEMPERATURE INCREASE, REDUCED ROTATIONAL ACCURACY, UNSATISFACTORY STATIC AND DYNAMIC STIFFNESS HAVE TO BE OVERCOME. HOWEVER, HEAT GENERATION AND DYNAMIC LOADING CAUSED BY HIGH SPEED OPERATION HAVE BEEN THE LIMITING FACTORS FOR INCREASING THE SPEED LIMIT OF MANY HIGH SPEED BALL BEARING APPLICATIONS. THEREFORE, HOW TO SELECT PROPER LOCATIONS, PRELOAD VALUES AND LUBRICATION TECHNIQUES FOR THE BEARINGS ARE MAJOR TASKS TO EFFECTIVELY REDUCE HEAT GENERATION AND TO MAINTAIN THE SATISFACTORY STIFFNESS. WITH THE INCREASING ROTATIONAL SPEED, NEW LUBRICATION TECHNIQUES ARE APPLIED ON THE HIGH-SPEED SPINDLES INSTEAD OF THE CONVENTIONAL GREASE LUBRICATION. RECENTLY, OIL-AIR LUBRICATION HAS BEEN USED ON HIGH-SPEED BALL BEARING BECAUSE OF PRECISE OIL QUANTITY CONTROL AND HIGH COOLING EFFICIENCY. HOWEVER, THE FLUCTUATION OF OIL SUPPLY RESULTED FROM THE PERIODIC OIL FEEDING IS UNFAVORABLE. THE BEARING PRELOAD IS ALSO THE MAIN FACTOR TO THE DYNAMIC PERFORMANCE OF A SPINDLE. THE PRELOAD AFFECTS THE SPINDLE STIFFNESS AND INDUCES THE TEMPERATURE INCREASE. THE TEMPERATURE INCREASE IS GOING TO CHANGE THE PRELOAD AGAIN. ALL THE RELATED FACTORS AFFECT THE DYNAMIC ROTATIONAL ACCURACY. THE COMPLICATED RELATIONSHIPS BETWEEN THESE FACTORS AND THE DYNAMIC PERFORMANCE OF THE SPINDLES ARE URGENT TOPICS TO STUDY. MOST PREVIOUS RELATED STUDIES WERE ANALYZED ONLY FOR THE OIL-AIR LUBRICATION BEARINGS OR SIMPLE TEST SPINDLES. THEIR RESULTS WERE NOT COMPLETE. IN THIS STUDY, A COMMERCIAL OIL-AIR LUBRICATION SPINDLE WILL BE USED TO STUDY THE DYNAMIC PERFORMANCE WITH VARIABLE OPERATING PARAMETERS. THE PRELOAD OF THE BEARING IS ALSO VARIED TO SEE ITS EFFECT ON THE DYNAMIC PERFORMANCE. FINITE ELEMENT METHOD WILL ALSO BE APPLIED TO PREDICT THE STATIC AND DYNAMIC STIFFNESS, THE TEMPERATURE INCREASE AND THE THERMAL EXPANSION. THE PREDICTED AND EXPERIMENTAL RESULTS WILL BE COMPARED TO ENSURE THE ACCURACY. THE DEVELOPED TECHNOLOGY WILL BE HELPFUL IN SPINDLE DESIGN FOR THE INDUSTRY.

Keywords : HIGH-SPEED MACHINING, BEARING PRELOAD, DYNAMIC ROTATIONAL ACCURACY, OIL-AIR LUBRICATION, STATIC STIFFNESS, DYNAMIC STIFFNESS.

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