Journal of Fiber Bioengineering and Informatics 8:3 (2015) 593–601
doi:10.3993/jfbim00150

Film Flow Field Analysis of Hydrodynamic Polishing Based on FLUENT ⋆

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Abstract

The characteristics of film flow field have important effects on the quality of hydrodynamic polishing. Oriented preparation requirements of amorphous film substrate, in order to further study the floating height of hydrodynamic polishing base plate in working conditions, the mathematical model is established and the theoretical analysis has been carried out for the wedge hydrodynamic floating polishing base plate. The relationship between buoyancy and floating height is researched. The floating height is calculated under the known loads, and then the pressure distribution along the circumferential direction of base plate is analyzed. Film flow field is simulated and analyzed using the FLUENT based on the calculated floating height. It indicts that the bearing capacity of wedge combination plane decreases with the increase of floating height, and the downward trend slows down gradually. The pressure peak distributes near the interface of wedge flow field and parallel flow field. Through the pressure distribution comparison of simulation and calculation, the correctness of the mathematical model and simulation method is verified.

Keywords: Film Flow Field; Hydrodynamic Polishing Base Plate; Pressure Distribution; Buoyancy; FLUENT

1 Introduction

Amorphous alloy material is one of the most popular areas in the condensed matter physics over the past decade [1]. The vast majority of amorphous alloys have high strength and hardness. It is widely used in the field of construction materials and micro-devices. Vapor condensation method is a common method for preparing amorphous films, and the substrate is indispensable material during the preparation of amorphous film, what is more, the quality of substrate will seriously affect the surface morphology of the amorphous film. And that, in order to obtain a

⋆Project supported by the National Nature Science Foundation of China (No. 51575493, 51205358), Zhejiang Provincial Nature Science Foundation (No. Y15E050069), and Zhejiang Provincial Science Technology Department of China (No. 2014C31021).

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thin, defect-free and good adhesion's alloy film, it asks for a substrate having ultra smooth surface without injury, avoiding mechanical damage, excessive corrosion and other factors which having impact on the surface [2], so, conventional chemical mechanical polishing technology is not fully suitable for the ultra-precision polishing of amorphous film substrate.

Hydrodynamic polishing can meet processing requirements of high flat surface and can achieve a high degree of reproducibility. Y. T. Su et al. conduct a deep research for hydrodynamic polishing [3–7]. Because of the high-speed rotary of the cutting tools, it generates hydrodynamic effects between the tool and the workpiece because of the wedge effect, which forms defibrination film between the tool and the workpiece. The abrasive in the film flow field will be effected by the shear stress of the flow field, and the shear stress will drive the abrasive to process the surface of the workpiece. By lubrication theory [8] and polishing mechanism known [9], through controlling the operating parameters of the film flow field between tool and workpiece and the characteristics between tools and workpiece, the processing characteristics of hydrodynamic polishing can be grasped fully.

This paper analyses the hydrodynamic floating polishing film flow field based on the two-dimensional simulation of FLUENT according to the hydrodynamic theory in order to further study the floating upward height of the hydrodynamic floating polishing base plate. The study object of this paper is wedge hydrodynamic floating polishing base plate. The simplified model is built based on its symmetry and the pressure of various positions in the flow field is calculated with Reynolds equation. Then the buoyancy of the flow field is got and verified that it can overcome gravity of the base plate. The floating upward height is got. Based on the calculating results, the flow field simulation of hydrodynamic floating polishing base plate is fulfilled by FLUENT. Through the pressure distribution comparison of simulation and calculation, the correctness of the mathematical model and simulation method is verified.

2 Hydrodynamic Floating Polishing Base Plate Model

The structure of the hydrodynamic floating polishing base plate is shown in Fig. 1. The main feature of the base plate is symmetrical to the center, and it is constituted by some same combined planes around the circumferential direction. The width in the radial direction of the combined planes is L, the length along the circumferential direction is B, what is more, the length of bevel is B_1, and the length of plane is B_2. In the case of that L is smaller than radius, the top view of combined planes can be seen as rectangle of which length is B and width is L. In the working condition, the hydrodynamic floating polishing base plate is fixed in the relative position of the horizontal plane, and the polishing plate below rotates. Because L is smaller than radius, the rotation of polishing plate can be seen as translation relatively to combined planes. Its speed is the line speed of that midpoint of L. It will produce a wedge fluid between combined plate and the working surface of polishing plate. The fluid which is driven by polishing plate flows in from the slope port of combined plane, then flows out from the other end of the plane. Based on the forming mechanism of hydro hydrodynamic [9], in a convergence space, incompressible fluid will form hydrodynamic when the fluid flows from a bigger inlet to a smaller outlet. Because the size of each combined plane is same and distributed uniformly along the circumference, so only need to analyze one of the combined planes' working situation, then the working situation of the entire base plate can be got. The simplified model is shown in Fig. 2.

In Fig. 2, W is the own weight of the base plate, h_1 is the thickness of the inlet's fluid, h_2 is