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Decreasing turbulent helium flow in hard disk drive

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Abstract. A spoiler installed in a hard disk drive is helpful for reducing the flow which strikes the Head Gimbals Assembly (HGA) causing positioning errors and vibration. Filling a hard disk drive, with an installed spoiler, with helium gas was simulated by ANSYS Fluent software by using a realizable k – ε model to carry out the turbulence calculation of helium flow. The results show that the pressure fluctuation in a hard disk drive with a spoiler installed is lower than in a hard disk drive without, and accordingly the lower pressure fluctuation can reduce the force caused by pressure on the platter disks and reduce vibration in the hard disk drive.

1. Introduction

Hard disk drives (HDDs) are the most important storage units for computers and electronics equipment. HDD developments have concentrated on higher storage and higher rotational speed. However, there needs to be an improvement in the positioning accuracy. The higher speed inside HDDs induces vibration on the Head Gimbals Assembly (HGA). Higher rotational flow inside HDDs can be reduced by using a spoiler, damper, disk separator and air shroud for decreasing the flow velocity inside. Furthermore, filling helium gas inside HDDs can reduce the vibration on the HGA, because helium density is lower than air; its properties can improve the HDDs performance by decreasing the impact force from the flow.

Much research has investigated the fluid flow in HDDs by numerical simulation. The air flow simulation with the finite element method. The results show that when the HDD is working, the pressure disturbances at the outside of the platter disks are more intense than at the inside, caused by the flow, and they found pressure disturbances around the lower side of the platter disks, that affect the vibration on the actuator arms [1]. When the arms are at the inner edge of the platter disks, against the flow inside the HDD that causes the vibration on the HGA [2-6]. While reducing the air flow velocity inside the HDD using a spoiler that can reduce the average velocity by 55.86%, and the spoiler also reduces the turbulent flow in the HDD [7]. Afterwards, a helium-filled hard drive investigation has been performed by using ANSYS software. The gas inside the HDD when the HDD was working at higher speed the helium-filled hard drive can improve the vibration and positioning errors [9-10]. The performance of the HDD when it’s working, finding that the properties of helium can transfer the heat better than air, and also reduce the flying height of the HDD at higher rotational speeds. The vibration in the helium filled HDD using ANSYS/CFX Software was simulated with Direct Numerical Simulation (DNS) and found that helium can distribute the flow better than air, while the turbulent flow in helium was less than in air [11-13]. When the fraction of helium was higher. There are 2 types of vibration in helium filled

HDDs, in the flying height direction and in the circumferential direction, that vibration in the flying height direction is more effective to the vibration on the HGA [14-18] and when the fraction becomes pure helium, the amplitude of the arm vibration is lower and the displacement is less than in air [19]. Furthermore, many researchers suggested that helium can reduce the flow velocity for a higher speed, but helium still has a turbulent flow that can affect the vibration. In this paper, the helium simulation with a spoiler is investigated to compare the velocity and turbulent flow in the HDD [20-21].

2. Modelling procedure

2.1. *Gas Properties*
A geometrical model of a 3.5-inch hard disk drive with spoiler and no spoiler was built [22] with ANSYS Design Modeler. The rotational speed is 7,200 rpm (revolutions per minute) in a counter-clockwise direction. The properties of filling gases [23] at working temperature (50^0C) [24] are shown in Table 1. The flow in the cap between the platter disks was simulated, which is the most effective by the rotational speed. The boundary area in this study is shown in Figure 1.

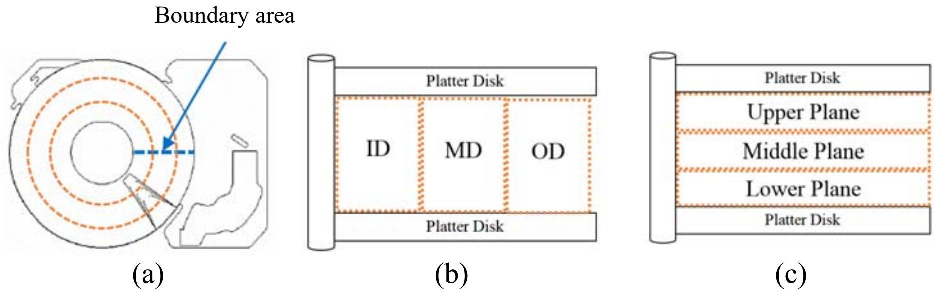

Figure 1. (a) Boundary area behind the spoiler (b) Boundary area of disks positions (c) Boundary area of planes

Table 1. Physical property of air and helium in this work

Properties	Air	Helium
Density (kg/m^3)	1.0925	0.1512
Dynamic viscosity (kg/m·s)	1.9608×10^{-5}	2.0939×10^{-5}
Kinematic viscosity (kg/m·s)	1.79947×10^{-5}	1.3844×10^{-4}

2.2. *Numerical Analysis*
The k- ε model was used for HDDs filled with both gases, because the k- ε turbulence model is the most common model to simulate the flow characteristic, using less running time [25]. The Reynolds number is given as follows

$$\mathrm{Re} = \frac{\omega r^2}{\nu} \tag{1}$$

Where ω is the angular velocity (7,200 rpm),
r is platter disk radius (mm) and
ν is the kinematic viscosity (kg/m·s).

The Reynolds number of the disks with 44.45 mm radius is 83,007 for air and 10,761 for helium then the transition Reynolds number is more than 4,000 when the flow is turbulent [24-25]. Thus, the flow inside HDD is turbulent for both of air and helium.

3. Results and discussion

3.1. Pressure disturbance

The results of the simulation show that the air filled HDD has a higher internal pressure in the no spoiler case as shown in Figure 2 and Figure 3.

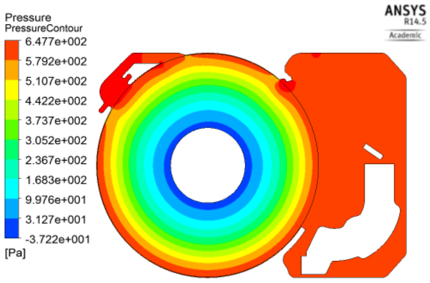

Figure 2. Pressure contour in air-filled HDD

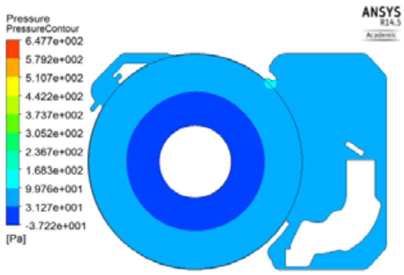

Figure 3. Pressure contour in helium-filled HDD

The helium filled hard drive was observed to reduce the pressure disturbance of the flow by previous research [5], which predicted that pressure disturbance causes the vibration in the HDD. We were interested in the pressure reduction in helium-filled HDDs so the investigation proceeded by comparing the flow in the helium-filled HDD between the installed spoiler case and with no installed spoiler as follows.

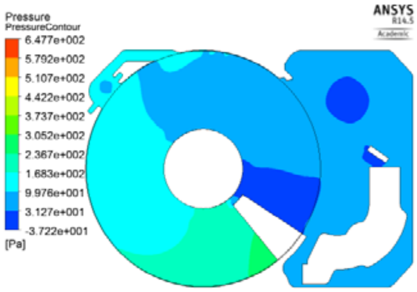

Figure 4. Pressure contour in helium-filled HDD with a spoiler

Figure 3 shows higher pressure at the front of the spoiler and lower pressure distribution behind the spoiler. The absolute pressure distribution in helium-filled HDD is presented in Table 2.

Table 2. Absolute pressure distribution in helium-filled HDD (Pa)

Position	Installed spoiler	Uninstalled spoiler
Inner of disks (ID)	0.7741	13.4463
Middle of disks (MD)	33.7132	31.7316
Outer of disks (OD)	84.3457	32.1940

The spoiler can reduce the pressure force behind the HGA, agreeing with the previous research [6], because of the pressure disturbance effects affecting the vibration on the HGA. In the helium-filled HDD, the spoiler can reduce the pressure at the inside of the platter disks from the HGA, and also reduce the vibration on the HGA too.

3.2. Velocity profile

Figure 5 and Figure 6 show the velocity profile of the no spoiler cases was simulated and it was found that the velocity magnitude is not significant. Then, the simulated HDDs with the spoiler in the helium-filled case was tested and the high velocity at the inside of the platter disks observed was in compliance with the air filled study [7], [22].

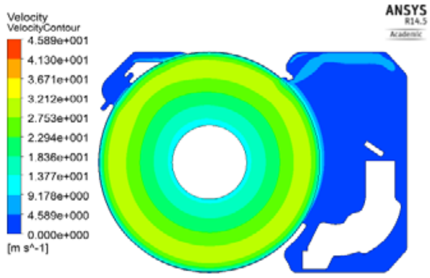

Figure 5. Velocity contour in air-filled HDD

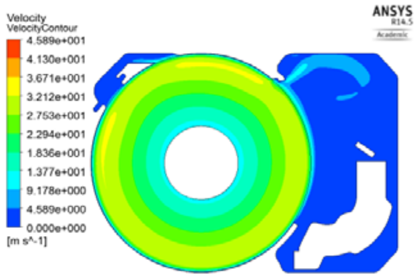

Figure 6. Velocity contour in helium-filled HDD

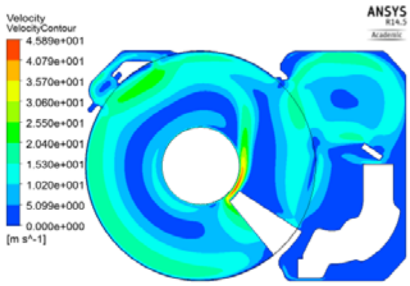

Figure 7. Velocity contour in helium-filled HDD with a spoiler

Figure 7 shows the flow direction of helium at the middle plane of the simulated HDD. The spoiler clearly changes the direction from the outside of the platter disks to the inside of the platter disks. The spoiler reduces the flow velocity at the outside of the platter disks. Therefore, the spoiler can reduce the flow velocity before it affects the HGA, and it can reduce the positioning errors caused by the vibration of the HGA [11].

4. Conclusions

The density of helium is lower than air, thus, filling an HDD with helium can reduce the pressure disturbance. The simulation results indicate that the HDD with installed spoiler can reduce the pressure disturbance behind the spoiler, reducing the force on the HGA. The velocity profile in the installed spoiler case also reduces the flow velocity behind the spoiler, decreasing the flow that affects the HGA as well. The lower force on the HGA and lower velocity that the spoiler causes can decrease the vibration on the HDD as well as the positioning errors caused by the flow.

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