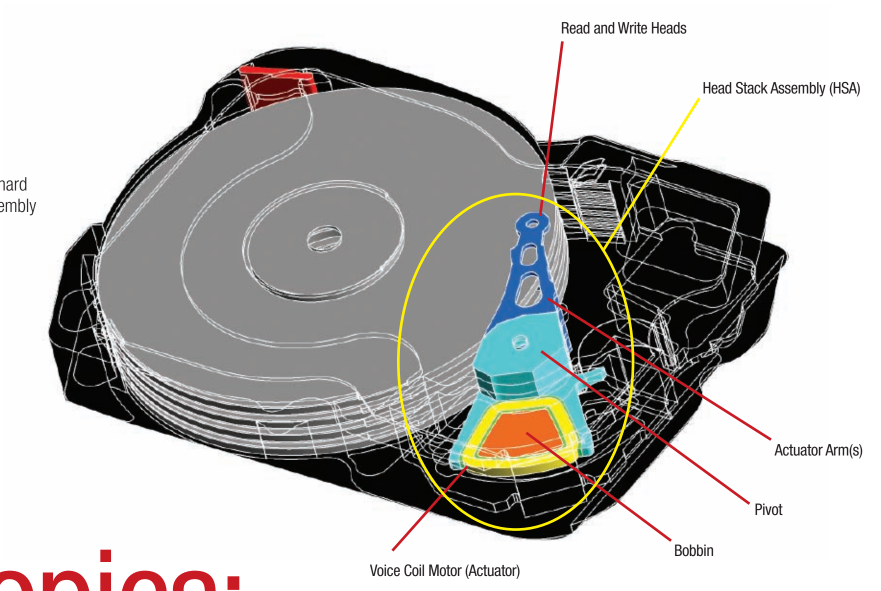
Schematic of hard disk drive assembly



Hot Topics: High-Capacity Hard Disks

Samsung uses simulation to improve thermo-fluidic performance of hard disk drives.

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Recently, the capacity of hard disk drives (HDD) has reached the phenomenal level of more than one terabyte per single drive. Robust mechanical design played a key role in this achievement, since drive development challenges today are not related to just a single physics but to multiphysics. In the past, most mechanical-originated failure modes were identified using only a good understanding of HDD dynamics. But as the tracks on the disk become more tightly packed to achieve higher capacity for the drive, nanometer-level positioning of read and write elements is very important in response to the external and internal vibration of the HDD. These vibrations are often caused by air flow and heat transfer.

To achieve nanometer-level precision, faster seek and access time is needed. This requires higher current, which, in turn, leads to temperature rise in the voice coil motor (or actuator), usually simply called the coil. The coil moves the actuator arm holding the read and write heads, and the arms, heads and coil together are called the head stack assembly (HSA). Temperature rise in the coil can cause undesirable mech-anical performance. This temperature rise is strongly dependent on the location of the HSA, and convective heat transfer can affect the temperature rise when the HSA is in different positions. Using both ANSYS CFX and ANSYS Mechanical software, engineers at Samsung made an engineering discovery that allowed them to improve thermo-fluidic performance of the HDD. The finding also provided insight into the design of high-performance HDDs.

As always in simulation-driven product design, simulation during the early stage of HDD development is an important contributor to a successful time to market. The range of simulation for the HDD industry includes both basic and advanced features of ANSYS Mechanical and ANSYS CFX software. Samsung uses software from ANSYS because of its expandability to multiphysics capabilities. For instance, flow-induced vibration has been used to understand and predict the HSA's dynamic

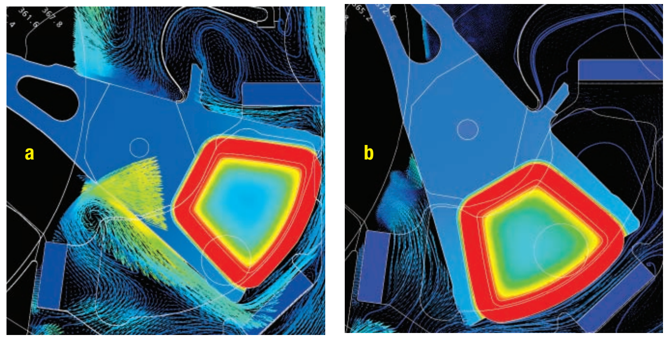
performance for different configurations. The model can be extended in the future to run thermally induced vibration or shock in a systematic manner with relatively little effort.

The simulation models for the HDD contain solid and fluid regions. Samsung engineers used the fluid region to solve for flow and heat transfer. They used the solid domain to determine heat transfer only, and, in this study without considering radiative heat transfer. Temperature rise in the solid regions, particularly the coil and actuator arms, is of great interest because these regions are strongly tied to the reliability of the entire drive.

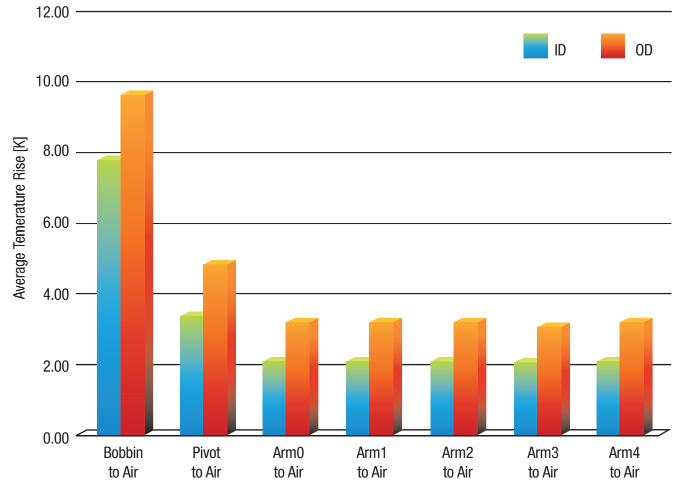
Using ANSYS CFX capabilities, the Samsung team calculated temperature, velocity and pressure with two different models: with the HSA positioned at the inner radius of disk (ID) and at the outer radius of disk (OD). Intuitively, the engineers knew that different outcomes for flow-induced vibration would occur at each location. However, the team had seldom explored simulations of temperature discrepancies because of the large model required to encompass the two different physics — flow and heat transfer.

The model contained five arms and four disks. The fluids simulation determined that a high flow rate passes through the coil when the HSA arm is positioned in the ID. This creates a high convection coefficient on the surface of the voice coil motor, resulting in a relatively low temperature rise. The arms actually block air flow from passing to other areas of the disk, and the air flow tends to move toward the voice coil. However, with the arm on the OD, a path for air to flow in the circumferential direction is opened up, so that less air flow travels through the coil and a low convective heat transfer coefficient is generated. This observation is the critical reason that temperature rise is quite different in the two cases.

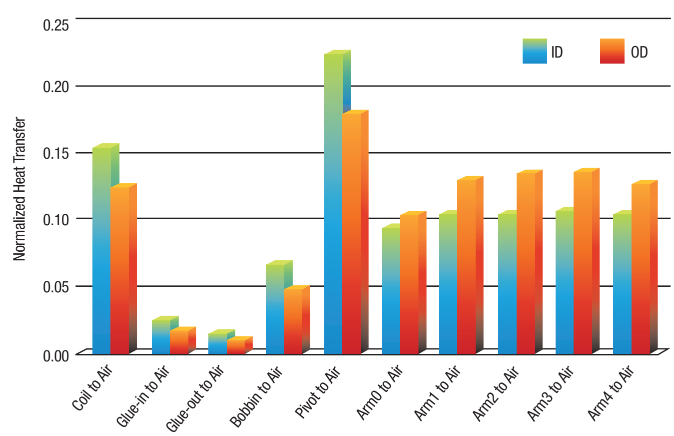
Temperature rise within different parts of the HSA were also investigated using structural mechanics simulation. The bobbin has the highest temperature swing compared to other parts since it is located closest to the coil heat source. The temperature rise for all five arms is almost the same. Samsung engineers performed an analysis to determine if there was uniformity of convective heat transfer from each part compared to the total convective heat transfer. They determined that more heat is transferred through the inner arms located between two disks. The results reveal that the heat transfer path of conduction and convection modes are highly dependent upon the location of the HSA. This understanding is critical to the thermal packaging design of the HDD. ■



Temperature field and associated velocity vector of air flow in both (a) inner-located arm and (b) outer-located arm models



Temperature rise in different locations in the head stack assembly of a hard disk drive with the actuator arm in different positions (ID – inner diameter, OD – outer diameter)



Heat transfer in different locations in the head stack assembly of a hard disk drive with the actuator arm in different positions (ID – inner diameter, OD – outer diameter)