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Specification

Rotating storage device and its control method

Field of the invention

The present invention relates to a rotating storage device and a control method thereof, and more particularly relates to the art effective for measures for contamination in a hard disk unit or for a write error caused by contamination etc..

Background art

For example, if contamination such as dust exists in a hard disk unit, adhesion of contamination onto a head is acknowledged as a cause of unstable flight of the head. Contamination adhered on a magnetic disk medium in the hard disk unit is also acknowledged as a cause of adhesion of the contamination onto the head or an error in information read/write on the magnetic disk.

Therefore, in processes of assembling the hard disk unit, measures for contamination such as sufficient cleaning of parts, assembly in a clean environment (clean room, etc.) and adopting an automated processing by mechanization are taken. However, these processes are hard to be all automated so that manual process generating dust may not be eliminated. Also, insufficient cleaning of parts



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cannot be avoided because of unequal process capabilities. Consequently, a certain level of contamination shall inevitably be acceptable.

Accordingly, the conventional art comprises measures for various types of contamination or defects and growth of defects caused by contamination.

For example, Japanese Patent (Laid-Open) No.2000-156051 discloses the art to judge that adjacent defect registration is required for a read error recoverable by offset read and perform the adjacent defect registration of a sector in the reverse direction of said sector and offset direction. Thus, the minimum defect can be registered before a defect grows by performing adjacent defect registration after detecting a read error, and high data reliability can be obtained with the minimum number of defective sectors.

For example, Japanese Patent (Laid-Open) Heisei No.5-28675 discloses the art to use a magnetic head lift mechanism to make a magnetic head contact a magnetic disk immediately before the start of rotating the magnetic disk, then rotate the magnetic disk in this state. Said report indicates that minute dust can be removed by making the magnetic head contact the magnetic disk.

For example, Japanese Patent (Laid-Open) Heisei No.5-54577 discloses the art to stop or slow down rotation of the spindle while the magnetic head is not performing a

read/write operation, then make the magnetic head contact the magnetic disk. The report says that minute dust can be removed by making the magnetic head contact the magnetic disk.

For example, Japanese Patent (Laid-Open) Heisei No.6-203503 discloses the art to contrive loading and unloading periods focusing on changes in the tangential force of head contact to the contact start stop (CSS) in order to prevent the disk from being damaged and remove dust adhered on the head rail surface. Both prevention of a disk damage and dust removal are enabled by controlling load and unload operations to be performed while the number of disk rotations is few.

For example, Japanese Patent (Laid-Open) Heisei No.2000-90612 discloses the art to remove dust from a contact pad by controlling numbers of disk rotations at load and unload operations for controlling the pitch angle of the head slider to efficiently remove dust adhered and accumulated on the contact type head slider.

However, the recent improvement of storage density requires more detailed measures to defect on a disk surface and defect growth. Even levels of contamination and defects out of matter with conventional arts do matter with the hard disk unit enabling high storage density.

All measures for the contamination provided by conventional arts are to make the head contact the magnetic

disk medium, and are not appropriate for the hard disk unit of high storage density designed on premise of higher storage density. Contact between the head and disk may cause new contamination.

For the art described in above-described Japanese Patent (Laid-Open) Heisei No. 2000-156051, a specific result can be expected for defect growth, but no measure is taken for an existing defect and only a passive measure such as not to use peripheral storage area assuming that they are defective sectors is taken.

The purpose of the invention is to provide the art to remove contamination without generating new contamination by contact between the head and disk.

Another purpose of the invention is to improve write reliability around a possible defect to effectively use the storage surface of the magnetic disk medium.

Further another purpose of the invention is to improve write reliability without deteriorating the performance of write operation.

Summary of the Invention

According to one aspect of the present invention there is provided a control method for the rotating storage device, said rotating storage device comprising a storage medium driven to rotate and a read/write head for information on said storage medium, said control method comprising the steps of:

performing writing action to write information to said storage medium;

referencing to a defect list stored in a storage area provided in elsewhere of said rotating storage device to judge whether the track having the sector into which said write has been done or an adjacent track or a nearby track of said track contains a defect; and

verifying said write if the result of said judgment is "true".

According to another aspect of the present invention there is provided a control method for a rotating storage device comprising a storage medium driven to rotate and a read/write head for information on said storage medium; said control method comprising steps of:

- performing writing action to write information to said storage medium;

- reading a gain value or an amplitude value of an automatic gain circuit for amplifying a signal via said head;

- calculating dispersion of said signal from said head using said gain value or said amplitude value;

- determining whether a predetermined threshold value is exceeded by comparing a measured value stored in the dispersion table recorded in elsewhere of said storage region in said rotating storage device and a dispersion value obtained from said calculation; and

- verifying said write when the result of said judgment is "true".

According to still another aspect of the present invention there is provided a control method for a rotating storage device comprising a storage medium driven to rotate and read/write head for information on said storage medium, said control method comprising the steps of:

- performing writing action to write information to said storage medium;

- determining whether said write operation is done within a certain period starting from immediately after loading said head on said storage medium or within a time required for processing a predetermined number of commands; and

- verifying said write when a result of said determination is "true".

According to still another aspect of the present invention there is provided a rotating storage device comprising:

a storage medium driven to rotate;

a read/write head for information on said storage medium, a means to read information onto said storage medium;

a defect list storing defective sector information;

means for determining whether said defective sector is contained in a track containing a sector on which said write has been done or a track adjacent to or nearby said track by referencing to said defect list; and

means for verifying said write when a result of said judgment is "true".

According to still another aspect of the present invention there is provided a rotating storage device comprising:

a storage medium driven to rotate;

a read/write head for information on said storage medium; means for writing information onto said storage medium; means for reading amplitude information of a gain value of an automatic gain circuit for amplifying a signal via said head or an amplitude value of said signal;

means for calculating dispersion of a signal of said head from multiple said gain values or amplitude value;

a dispersion table containing dispersions of signals on said head individually stored in divided areas on said storage medium;

means to judge whether a predetermined threshold value is exceeded by comparing a value in said dispersion table and a dispersion value obtained by said calculation; and

means to verify said write when a result of said judgment is "true".

According to still another aspect of the present invention there is provided a rotating storage device comprising:

a storage medium driven to rotate;

a read/write head for information on said storage medium;

means for writing information onto said storage medium; means for determining whether said write operation is done within a certain period starting from immediately after loading said head on said storage medium or within a time required for processing a predetermined number of commands; and

means for verifying said write when a result of said judgment is “true”.

The hard disk unit of the invention adopts the ramped loading mechanism, and tracks are followed around the disk outside valid storage areas for a specific period after the head is loaded from the ramped loading mechanism onto the magnetic

disk medium. According to experiment and study by the inventors, much contamination often adheres on the head after being loaded from the ramped loading mechanism. The contamination and unstableness of head flight are assumed cooperatively to rub the contamination onto the surface of the magnetic medium. A temperature on the surface of the magnetic medium onto which the contamination is rubbed partly rises and a problem of magnetic information loss arises. The invention is effective for such a problem. Because the head immediately after being loaded is located on an area on the disk outside valid storage areas; the problem of data loss does not arise. In addition, because track following is performed on outer circuits of the disk for a certain period, the head flight can be stabilized during the track following. Furthermore, much contamination can be blown off by wind pressure generated during track following. Namely, the invention removes contamination immediately after loading from the ramped loading mechanism and avoids the problem of data loss caused by contamination. Furthermore, the head flight can be stabilized.

The invention also can repeat moving to the inside and outside of the disk on outer circuits of the disk after the track following on the outer circuits, and the speed of moving to the outside can be increased to greater than, preferably, a several times over the speed of moving to the

inside. The head is slowly moved to the inside and swiftly moved to the outside. By this mechanism, contamination on outer circuits of the disk can be swept out of the surface of the disk. Because a filter for trapping contamination is usually installed nearby outer circuits of the disk, contamination is effectively trapped, and level of contamination in the hard disk unit can be reduced. At the same time, such sweep off operation adds a vibration in the horizontal direction of the head. Contamination adhered on the head can effectively be removed by the wind pressure generated by disk rotation and the horizontal vibration.

The invention also verifies write operation in the following cases: The first case is a specific period immediately after the head is loaded. Based on the experiment and study by the inventors reveal that the head flight is not stabilized for a certain period after the head is loaded. The certain period may be, for example, several seconds.

The second case is an existence of a defect adjacent to the track including a sector onto which write has been done. This case is indicated based on an opinion resulted from the experiment and study indicating that the head may collide to a nearby defect and so flight may not be stabilized. For example, the case in which write is done onto a sector of a track adjacent to a defective track can be presented. Whether a defect occurs can be known by

referring to the defect list.

The third case is that the head flight is judged to be unstable from a signal input from the head. An analog signal input from the head is amplified by a preamplifier, then converted into a digital signal by a read/write channel. At this time, the input signal is converted into digital after its amplitude is made constant by an automatic gain circuit. Stability of the head can be judged from dispersion of an obtained gain value of the automatic gain circuit. Dispersions in a normal state are measured beforehand, and are stored in a dispersion table. Then, a dispersion value at write operation and a dispersion value stored in the table are compared, and if the former dispersion value exceeds a specified threshold value, the head flight is judged to be unstable. In addition, because a dispersion value depends on a disk diameter, the disk can be divided into appropriate areas and a dispersion value of each area can be stored.

The invention performs verification operation when the above-described case occurs. The verification operation is to read written data and compares it with write data to see whether the two data items are identical or not. If they are identical, successfulness of write can be confirmed. If not, write operation is performed again. Then, the write and verification operation is repeated until the data is normally written.

In addition, even if verification operation is performed in said cases, the ratio of the operation against entire write operation is few percent. Therefore, the range of performance deterioration in write operation can be ignored. On the other hand, according to the opinion of the inventors, many write errors occur in said cases, and many of them can be prevented by verification operation in said cases. The storage reliability of the disk unit can significantly be improved without deteriorating its performance.

Brief Description of the Drawings

Fig. 1 shows a block diagram showing an example of a hard disk unit as an embodiment for carrying out the invention.

Fig. 2 shows a flowchart showing an example of a control method as an embodiment for carrying out the invention.

Fig. 3 depicts a side view typically showing nearby peripheral areas on a disk. Fig. 3(a) shows a state in which track following is performed on a head to -128 cylinder. Fig. 3(b) shows a state in which a head is performing a sweep off operation.

Fig. 4 depicts a graph showing time functions representing

locations of cylinders which a head trails by the control method described in the embodiment for carrying out the invention.

Fig. 5 depicts a block diagram showing an example of a hard disk as another embodiment for carrying out the invention.

Fig. 6 depicts a flowchart showing an example of a control method for a hard disk unit as an embodiment for carrying out the invention.

Description of Numerals

1: Disk, 2: Spindle motor, 3, 3': Heads (magnetic heads), 4: Arm, 5: Voice coil motor, 6: VCM driver, 7: Back emf monitor, 8: Servo controller, 9: Head preamplifier, 10: Read/write channel, 11: Hard disk controller, 12: RAM, 12a: Data buffer, 12b: Dispersion table, 12c: Defect list, 13: ROM, 14: Host interface, 15: Bus, 16: Host device, 17: Ramped loading mechanism, Vin: Inner circuit direction speed, Vout: Outer circuit direction speed, x: Cylinder number

Best Mode for Carrying out the Invention

Preferred embodiments for carrying out the invention

is detailed based on the drawing. However, the invention can be carried out in various embodiments so it should not be interpreted limiting on the contents of the embodiments for carrying out the invention. In addition, the same numbers are assigned to the same elements throughout all embodiments for carrying out the invention.

(Example 1)

Fig. 1 shows a block diagram showing an example of the hard disk unit as a particular embodiment for carrying out the invention. The hard disk unit of Example 1 comprises disk 1 (magnetic storage medium) on which information is magnetically stored, spindle motor 2 for driving disk 1 to rotate, magnetic head 3 for storing information onto disk 1 or reading stored information, arm 4 supporting magnetic head 3 and voice coil motor 5 (actuator) for driving arm 4. Voice coil motor 5 is driven by VCM driver 6, and the reverse electromotive force of voice coil motor 5 is monitored on the back emf monitor 7. VCM driver 6 is controlled by support controller 8.

An analog output from head 3 is amplified by head preamplifier 9 and input to read/write channel 10. In read/write channel 10, the analog signal from head 3 is adjusted to a specific amplitude by the automatic gain circuit and converted into a digital signal, then sent to hard disk controller 11 as read or write data. In addition, a gain value of the automatic gain circuit can be

fetches from read/write channel 10, but this processing will be described later.

Hard disk controller 11 controls the entire hard disk unit. For example, hard disk controller 11 receives a servo signal from read/write channel 10, then outputs a driver signal to VCM driver 6. Alternatively, hard disk controller 11 receives a command such as a write request and sends a read or write gate to read/write channel 10 to control read or write operation.

Hard disk controller 11 is connected to RAM 12, ROM 13 or host interface 14 via bus 15. A host interface 14 interfaces host device 16. A program processed by the MPU in a hard disk controller 11 is stored in ROM 13. A program for controlling the hard disk unit, for example, is loaded from magnetic storage medium 1 into RAM 12. Alternatively, RAM 12 functions as a buffer for data input from and output to the disk unit or as a storage area of a defect list or a dispersion table described herein below.

The disk unit in the described embodiment has a ramped loading mechanism. When disk 1 is in a stopped state, head 3 is stored in the ramped loading mechanism 17. By adopting the ramp loading mechanism 17, durability to vibration, shock and other mechanical hazards may be improved.

Fig. 2 shows a flowchart showing an example of a control method in the method for carrying out the present invention. Processing is started by turning on the power

or starting the hard disk unit by releasing it from sleep mode or other means. Disk 1 in a stopped state is driven to rotate by spindle motor 2. When rotations of disk 1 reaches the specified rotational speed, head 3 is loaded onto disk 1 (Step 20). Because head 3 is stored in ramped loading mechanism 17 when disk 1 has stopped rotating, loading is executed by moving head 3 from ramped loading mechanism 17 to disk 1 in a rotating state. At this loading, back emf monitor 7 monitors an output from voice coil motor 5, and movement of arm 4 can be controlled so that head 3 gently moves onto disk 1. Movement of arm 4 is controlled by driving voice coil motor 5 using a driving current generated by VCM driver 6 when it receives a signal from servo controller 8.

A servo pattern representing location information is tried to be detected by head 3 moved onto disk 1. The servo pattern is written on disk 1 beforehand. When the servo pattern is appropriately read, a location of head 3 can be confirmed. Completion of loading head 3 is judged by confirming that reading the servo pattern is successful (Step 21). Servo pattern reading is continuously tried until loading is completed.

When loading head 3 is judged to be completed, seek for the cylinder with cylinder number $x=-128$ starts (Step 22). After head 3 reaches -128 cylinder, a state in which the cylinder is followed is retained for a specific period,

for example, 40 ms (Step 23).

In the present description, cylinder numbers x are defined to be assigned in ascending order from outer circuits to inner circuits of disk 1. That is, inner circuits of the disk have greater numbers. However, the outmost circuit is not designated to be cylinder number 0, but the number of a cylinder located somewhat inner from the outmost circuit of the disk becomes 0. Areas on cylinders with number 0 and greater are valid storage areas, and used by a user and as areas reserved by the system. Areas on cylinders with numbers less than 0 are areas on outer circuits of the disk, and are not used for data storage operation. The -128 cylinder exists in an area around the disk.

Fig. 3(a) is the side view typically showing track following on head 3 to -128 cylinder. Head 3 indicated by the dashed line typically shows loading head 3 from the ramped loading mechanism. The right side of disk 1 (central part of disk 1) is omitted.

As shown in the figure, head 3 is followed to the track contained in the cylinder of $X = -128$ in areas around the disk (area other than the valid storage areas). In addition, multiple disks 1 actually exist, and heads 3 are located on both sides of disks 1, but they are omitted in the figure. The expression about heads "above a track" in the specification means that the heads exist with specific

distances in the normal line direction from the surface of the magnetic storage side on magnetic storage medium 1. That is, locations of head 3 and magnetic storage medium 1 are relative, and "above a track" or "over a track" indicating the location of the head includes "downwards", "sideward" and "oblique direction" when the magnetic storage side is facing downwards, sideward or in an oblique direction, and a gap scheduled by design originally exists between the head and storage side.

Thus, by track following to areas around a valid storage area on a disk within a specific period, e.g., 40 ms, after head 3 is loaded, contamination can be blown off head 3 by wind pressure generated from rotation of the disk. Especially, according to the findings of the inventors, much contamination often adheres to head 3 immediately after being loaded from ramped loading mechanism 17. In such case, much contamination can be removed from head 3 in an initial stage of loading by following tracks in areas around the disk immediately after loading. As a result, an influence of contamination in subsequent operations can effectively be controlled and the write reliability can be improved. In addition, track following is performed in areas around the disk so even if contamination adhered on head 3 is rubbed onto the magnetic storage side on disk 1, there is no possibility of data loss because areas around the disk are not used to store

data. Furthermore, according to the opinion of the inventors, flight of head 3 immediately after being loaded is comparatively unstable. Therefore, track following for a specific period immediately after loading acts to stabilize head flight in an early stage. This processing enables subsequent operations be performed in a stable head flight state, and contributes to improvement of write reliability.

An example of track following to -128 cylinder is described here, but needless to say, following to cylinders in other outer areas on the disk is also all right. However, following at a location where the air bearing surface (ABS) of head 3 does not hang over 0 cylinder in the innermost circuit of areas around the disk is desirable. Head 3' indicated by the dashed line in Fig. 3(a) shows track following on the innermost areas on the disk. The inventors experimentally recognize that much contamination is accumulated in areas around the ABS of head 3. Even if much contamination is accumulated in areas on the outmost circuit of the ABS, the contamination is not adhered by rubbing on the track area located on 0 cylinder as long as the said condition is satisfied. Therefore, data storage areas can be protected completely. The outmost circuit of areas around the disk on which track following by head 3 is enabled is determined in consideration of danger of collision to ramped loading

mechanism 17.

After the end of Step 23, -200 is specified to cylinder number x (Step 24) to start seek on cylinder number x (Step 25). Cylinder number -200 is the outmost circuit of disk 1 on which head 3 determined in consideration of danger of collision to ramped loading mechanism 17 can be sought. However, cylinder number -200 is only an example, and needless to say, it changes according to a track density, assignment of ramped loading mechanism 17 or other condition.

Next, x is incremented by 2 (Step 26) to determine if it is less than 0 (Step 27). If x is less than 0, control returns to Step 25 and seek on x cylinder is started. That is, if the target cylinder of following by head 3 is in an area around the disk, head 3 is moved toward inner circuits of disk 1 at a speed corresponding to increment by 2.

When x is determined to be 0 in Step 27, that is, when the target cylinder of head 3 enters a valid storage area, the process proceeds to Step 28 and seek on x cylinder. Then increment of x is specified to -10 (Step 29) to determine if x is greater than -200 (Step 30). If x is greater than -200, seek on x cylinder is started (Step 28). That is, head 3 is moved toward outer circuits of disk 1 at a speed corresponding to increment of -10 this time. The moving toward outer circuits continues until the target cylinder search reaches -200 cylinder.

Fig. 3(a) is the side view typically showing said moving toward inner circuits and outer circuits. Head 3 assumes that the limit of the inner circuit direction is 0 cylinder and the limit of outer circuit direction is -200 cylinder, and moves between these limits to the inner circuit direction at a speed of V_{in} , and to the outer circuit direction at a speed of V_{out} . Speed V_{in} corresponds to cylinder increment by 2 and speed V_{out} corresponds to cylinder increment by 10. That is, head 3 moves slowly toward inner circuits and moves faster toward outer circuits.

Such head 3 operation is a sweep off operation toward outer circuits and acts to sweep contamination off peripheral areas on the disk toward the outer circuit direction of the disk. This operation also gives a vibration in a horizontal direction to head 3 itself. This vibration shakes contamination off head 3. It is expected to exhibit the effect that contamination may be removed more surely from cooperative effect of said vibration and wind pressure generated by rotation of disk 1.

Increase variable Loop for 1 in Step 31 to determine whether Loop is 3 or greater (Step 32). If Loop is 3 or less, return to Step 25 and perform said sweep off operation. Such sweep off operation shall be repeated three times. After this, start usual control (Step 33).

Fig. 4 is a graph showing functions representing

locations of cylinders which head 3 trails by said control. If reading a servo pattern is successful at time t_0 , start seek on -128 cylinder, and retain this head position for a specific period from time t_1 to time t_2 . After this, perform seek on -200 cylinder, then gently move to 0 cylinder. After this, quickly move to -200 cylinder and perform a first sweep off operation. A time required for control to reach -200 cylinder is t_4 . The same operation is furthermore repeated twice, the usual control is started from time t_8 .

According to the hard disk unit and control method described in the embodiment for carrying out the invention, much contamination adhered on head 3 can be removed by track following for a specific period in an initial stage of head loading. Because the track following in an initial stage of loading is performed in peripheral areas on the disk, a problem of data loss caused by contamination can also be prevented from being rubbed. In addition, sweeping contamination off to outer circuits of the disk by a head sweep off operation in peripheral areas on the disk and moreover, more effective contamination removal from head 3 by a vibration in a horizontal direction can be expected.

Needless to say, the cylinder numbers, cylinder increment values that determine speed of moving toward inner or outer circuits and repeating times of sweep off operations are only examples. The fact that said values

can appropriately be changed according to conditions such as a time required for one-time seek is well known by the person skilled in the art.

(Example 2)

Fig. 5 is a block diagram showing an example of a hard disk unit as another embodiment for carrying out the invention. The overview of the hard disk unit of the embodiments of the invention is the same as that shown in Figure 1. However, as shown in Figure 5, the hard disk unit of this embodiment for carrying out the invention comprises per-zone base amplitude dispersion table 12b and defect list 12c. In addition, data buffer 12a is one of functions described as the RAM 12 functions of the embodiment for carrying out the invention. Dispersion table 12b and defect list 12c are read from disk 1 and stored in RAM 12. In addition, an example of table 12b and defect list 12c stored on disk 1 is shown here, but these tables need not always be stored on disk 1. For example, the tables can be stored in a semiconductor nonvolatile memory in the hard disk unit.

Dispersion table 12b stores dispersions of signal amplitudes from head 3 for individual zones created by dividing the surface of disk 1 into concentric circle shapes. Signal amplitudes are obtained from gain values of the automatic gain circuit mounted in read/write channel 10. A signal from head 3 is amplified by head preamplifier

9 and input to read/write channel 10. The signal has a certain level of amplitude dispersion. Read/write channel 10 uses the automatic gain circuit to adjust a signal level before analog to digital conversion. A signal amplitude can be known by measuring a gain value of the automatic gain circuit, and dispersion of a signal amplitude can be seized from a dispersion of the signal amplitude. The dispersion can be represented by widths of the mean value, maximum value and minimum value of the amplitude. Because the dispersion values depend on a diameter direction of disk 1, a dispersion value per zone divided into a concentric circle shape is stored into a table. Such a dispersion table can be referenced for a control that will be described later.

Defect list 12c registers sectors judged to be defective by inspection at shipment from the factory or sectors assumed to be defective around a defective sector. The reason why the sectors around the defective sector are registered beforehand is because growth of the defect is expected. Sectors judged to be defective during use are additionally registered from time to time into the defect list used as a secondary table. Such a defect list can be referenced for a control that will be described herein below.

Fig. 7 is a flowchart showing an example of a control method for the hard disk unit described in said embodiments

for carrying out the invention.

Data is received from host device 16 after processing is started (Step 34). The case in which a write command is received as data is considered here. Next, set the verification flag to "0". The verification flag indicates whether verification is required after write processing, and when it is set to "1", verification is required.

Next, the process determines whether the processing time of the write command is immediately after head loading (Step 36). Whether it is immediately after head loading is determined by, for example, using an internal clock to determine whether a specific period has been passed from the time of head loading or by using an appropriate counter to determine whether the specific number of commands are processed. For example, if a certain period has been passed, the process sets a time of few seconds (for example, less than 10 seconds, about 5 seconds) and determines whether the set time has been passed. If not, the process sets the verification flag to "1" (Step 37). If the time has been passed, the process proceeds to Step 38.

The flight of head 3 is unstable immediately after head loading, then a command may be executed while a flight height is high. If write processing is performed in such a condition, normal write often fails. These findings are based on results of experiments and studies of the

inventors. Therefore, verify process is performed immediately after loading as described later.

Next, the process converts a logical address contained in received data into a physical address (Step 38). Physical addresses are specified by cylinders, heads, and sectors. Because the target cylinder can be known, refer to the defect list 12c in this stage to judge whether there is any defective sector nearby the target cylinder (Step 39). As a concept of "nearby", assume that cylinders up to a cylinder in a distance corresponding to few tracks. Desirably, "nearby" shall mean adjacent. If a cylinder adjacent to or nearby the target cylinder contains a defective sector, the process sets the verification flag to "1" (Step 40). If not, the process proceeds to Step 41.

A defective sector generally exists as a protrusion on a disk surface or a magnetized film peeling off a defective section exists as a convex. If head 3 collides against such a protrusion, the head rises high. Even if head 3 does not collide, disturbance of air current caused by a rotation of disk 1 raises head 3 high. Such rise of the head causes a write error as said. Therefore, verification is also required even when the head flies around a defective sector.

Next, the process starts seek toward a target cylinder (Step 41) and obtain a dispersion value of a zone containing the target cylinder from table 12b (Step 42).

Next, when seek nearly reaches the target cylinder, a dispersion value of a signal amplitude of head 3 (Step 43) is measured. As aforementioned, a dispersion value can be obtained by using automatic gain circuit of the read/write channel. Recently, a gain value is output as an output of a read/write channel. This function can be used as is. A dispersion value can be measured by, for example, storing the maximum and minimum values of a signal at reading a gray code per servo pattern nearby the target (write object sector).

Then, when head 3 reaches the target sector, hard disk controller 11 raises a write gate and writes write data onto disk 1 (Step 44). The process determines whether all data items have been written (Step 45). If not, the process reverts to Step 44 and retry the processing. If the data items are written, the process issues a command termination status (Step 46).

In this stage, the process compares the obtained dispersion value (difference between the maximum value and minimum value) to a dispersion value stored in the table and judge whether the value is within the scheduled range (Step 47). For example, if the obtained dispersion value exceeds the dispersion value stored in the table for 40 percent, the obtained dispersion value is determined to be outside the range. If it is outside the range, the verification flag is set to "1". The condition under which

the dispersion value is determined to be outside the range is the condition where the head height greatly varies. Under such condition, a write operation is performed with high possibility while the head height is high, then the verification is required.

Next, the process determines whether the verification flag is set to "1". If the flag is "1", the process perform verify processing (Step 50). The verification procedure may be carried out by referring to an error code (ECC) to see if it is identical. The process determines whether the error code is identical (Step 51), and if it is, the process terminate processing (Step 53). If not, the process retries write processing (Step 52). After this, the process performs verify processing again, and repeats this processing until no problem arises. On the other hand, if verification is not required (verification flag = 0) in Step 49, the process terminates processing (Step 53).

According to the hard disk unit and control method according to Example 2 of the invention, perform write processing after judging whether loading has just been ended, whether write is done onto nearby a defect, and whether write is done while the head flies in a stable sate. Experimentally, write in such state often terminates with an error so perform verification. In other cases, do not perform verification. Even if verification is

performed in the said state, it is 1 percent or less of entire processing according to the study of the inventors. Therefore, the processing reliability of the hard disk unit can be improved by reducing write errors without deteriorating the performance of the hard disk unit.

In addition, whether above mentioned loading has just been done, whether write is done on nearby a defect, and whether write is done while the head is in a stable flight state are desirably all determined. However, one of these items or any arbitrary combination of them may be written and verified.

Herein above, the invention by the inventors has concretely been described based on examples of the invention, however, the present invention is not limited to the above described examples and various modification may be possible without departing from the scope and spirit of the present invention.

For example, the voice coil motor (VCM) was provided as an example in the embodiment, however, another motor or actuator may be used.

The hard disk unit was also given as an example of a rotating storage device in the embodiment. However, application of the invention is not limited to the hard disk unit, but also applicable to a storage device with a rotating storage medium such as CD-R/W, DVD, and re-writable optical or optical-magnetic MO storage device

such as a MO storage device. For example, the present invention may be also applicable to removable rotating magnetic storage devices such as a ZIP device and floppy disk device.

Effects given by representative features included in the invention disclosed by the application are as follows. Contamination can be removed without generating new contamination by contacting a head and a disk. Even if there is a defect, the reliability of write around the defect is improved, and a storage surface of a magnetic disk medium can most effectively be used. The write reliability can be improved without deteriorating the performance of a write operation.

Claims

1. A control method for the rotating storage device, said rotating storage device comprising a storage medium driven to rotate and a read/write head for information on said storage medium, said control method comprising the steps of:

performing writing action to write information to said storage medium;

referencing to a defect list stored in a storage area provided in elsewhere of said rotating storage device to judge whether the track having the sector into which said write has been done or an adjacent track or a nearby track of said track contains a defect; and

verifying said write if the result of said judgment is "true".

2. A control method for a rotating storage device comprising a storage medium driven to rotate and a read/write head for information on said storage medium; said control method comprising steps of:

performing writing action to write information to said storage medium;

reading a gain value or an amplitude value of an automatic gain circuit for amplifying a signal via said head;

calculating dispersion of said signal from said head using said gain value or said amplitude value;

determining whether a predetermined threshold value is exceeded by comparing a measured value stored in the dispersion table recorded in elsewhere of said storage region in said rotating storage device and a dispersion value obtained from said calculation; and

verifying said write when the result of said judgment is "true".

3. A control method for a rotating storage device comprising a storage medium driven to rotate and read/write head for information on said storage medium, said control method comprising the steps of:

performing writing action to write information to said storage medium;

determining whether said write operation is done within a certain period starting from immediately after loading said head on said storage medium or within a time required for processing a predetermined number of commands; and

verifying said write when a result of said determination is "true".

4. A rotating storage device comprising:

a storage medium driven to rotate;

a read/write head for information on said storage medium, a means to read information onto said storage medium;

a defect list storing defective sector information;

means for determining whether said defective sector is contained in a track containing a sector on which said write has been done or a track adjacent to or nearby said track by referencing to said defect list; and

means for verifying said write when a result of said judgment is "true".

5. A rotating storage device comprising:

a storage medium driven to rotate;

a read/write head for information on said storage medium; means for writing information onto said storage medium; means for reading amplitude information of a gain

value of an automatic gain circuit for amplifying a signal via said head or an amplitude value of said signal;

means for calculating dispersion of a signal of said head from multiple said gain values or amplitude value;

a dispersion table containing dispersions of signals on said head individually stored in divided areas on said storage medium;

means to judge whether a predetermined threshold value is exceeded by comparing a value in said dispersion table and a dispersion value obtained by said calculation; and

means to verify said write when a result of said judgment is “true”.

6. A rotating storage device comprising:

a storage medium driven to rotate;

a read/write head for information on said storage medium;

means for writing information onto said storage medium; means for determining whether said write operation is done within a certain period starting from immediately after loading said head on said storage medium or within a time required for processing a predetermined number of commands; and

means for verifying said write when a result of said judgment is “true”.