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Analysis of the Formation of Magnetic Transition in Digital Magnetic Recording System

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Abstract: ***The write head generates a magnetic field that permeates through the recording medium which is magnetized. By controlling the coil current of the write head, the magnetic field can be altered according to the bit pattern to be recorded. A magnetic field is generated when current passes through the write coil and a bubble is created under the head gap. If the field inside the write bubble exceeds the media coactivity segment of the media enclosed by the bubble is magnetized according to the current direction which means a transition is occurred. More closely transitions will lead to the recording of more number of bits for the same length of data track which means higher density. But transition is not sharp like a step function; rather it takes place over a finite length of media. In this paper, simulation analysis of Head field using Karlqvist model and its gradient are done with some design criteria and analysis of required head current has been done also. Finally analysis of transition width has been done by considering a given M-H loop and the Head field.***

Keywords:Head gap field; Head medium gap; Transition width

1. Introduction

The write head generates a magnetic field that permeates through the recording medium which is magnetized. By controlling the current in the coil of write element, the magnetic field can be altered according to the bit pattern to be recorded. (temporal pattern of bits) [1] . As the media moves with respect to the write head, the temporal bit pattern is transferred into a spatial sequence of bit cells.

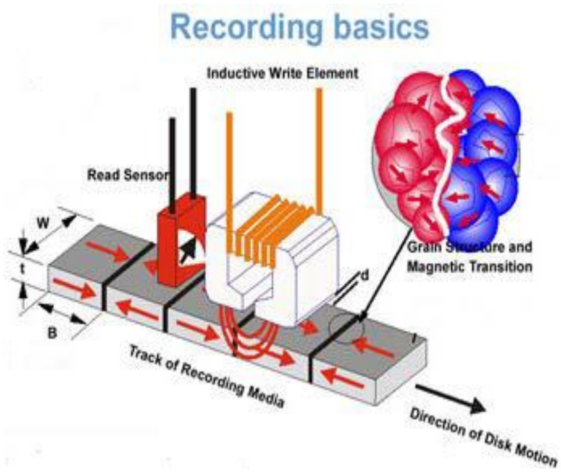


Figure 1: Magnetic Recording technology

Transitions on the media created during the write process can create magnetic field. The flux coming out of the media transitions are of alternative polarity. The read head senses these transition flux and produce readback voltage waveform.

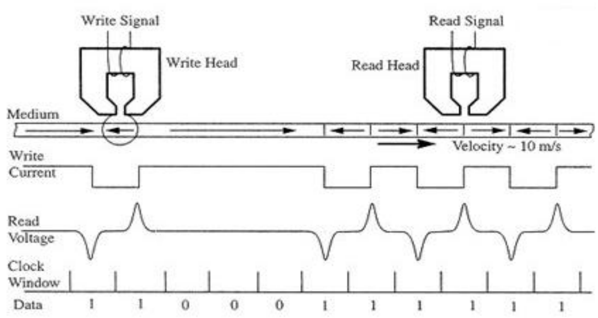


Figure 2: Magnetic Recording working principle

Model of write process: Current through the write coil creates a magnetic field [2-3]. If field inside the write bubble exceeds the coercivity H_c of the media Segment of the media enclosed by the bubble is magnetized. Head is stationary and media is moving with respect to the head Front side of the bubble is the leading edgeand the other side is the trailing edge. Transition is formed at the trailing edge of the bubble. More closely the transitions are, more bits are recorded for the same length of data track. It means higher density. Transition is not sharp like a step function. But it takes place over a finite length of media

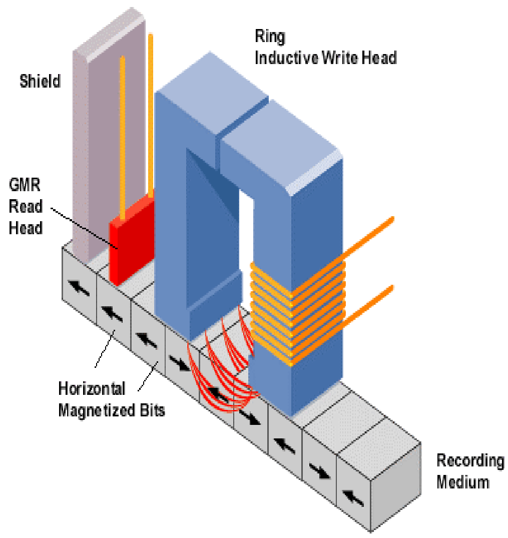


Figure 3: Magnetic Recording Process

2. Karlqvist Head Field and Gradient of Head Field

Karlqvist head field model is used to find the field inside the media due to head gap field . There are some assumptions for this modeling i) infinite permeability of the magnetic core ii) region of interest is small compared with the size of the core.
Karlqvist head field can be expressed as follows

(= (-)

Here, for our analysis we choose the following parameter values
Coercivity of the medium (H_C) = 270 kA/m
Reamanent magnetization of medium (M_r) = 400 kA/m
Head-to-medium gap (d) = 20 nm
Media thickness (δ) = 20 nm
Head gap length (g) = 180 nm
y = = 30 nm
Gradient of head field is obtained as follows

= [-

Now for the first simulation let us consider Hg= 400 kA/m which is greater than H_C. From figure 4, it can be seen that maximum gradient of head field is occurred at -90.12 nm and 90.12 nm. At the distance Head Field is 178.4771 kA/m.

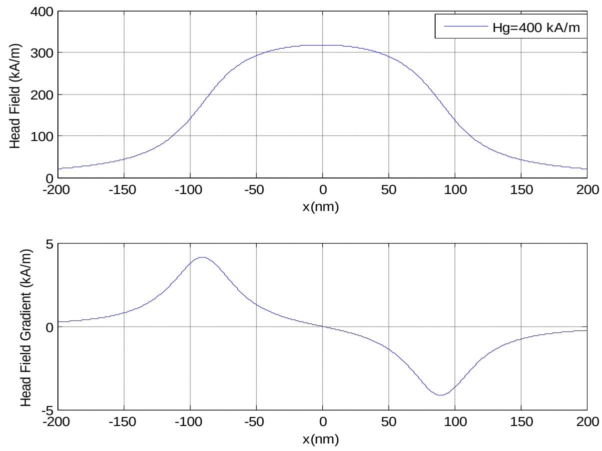
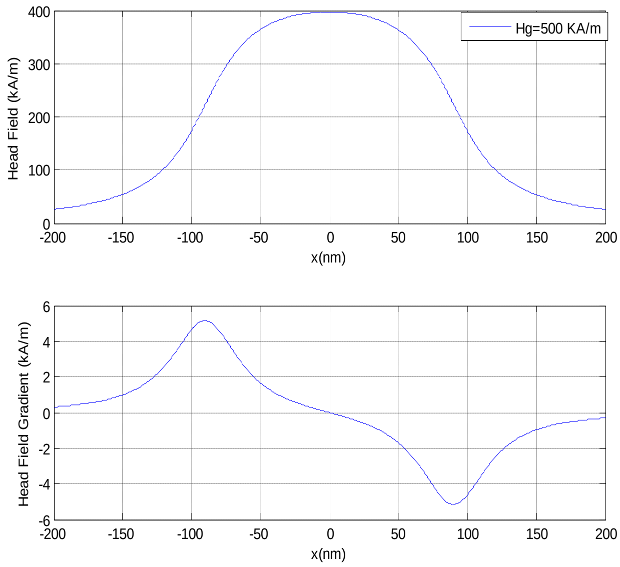


Figure 4: Head field and Gradient of Head field

2.1 Optimum Value of Head Gap Field

We want the head gap field should be such that the Head field inside the bubble is equal to Coercivity of the medium ( ) and that head gap field is the optimum one.In order to do that we have done simulation for different values. In figure 5 shows some plots of head field and its gradient have different values and figure 6 shows the plot of field for different values at the same value of where the maximum gradient of occurs. From these two figures, the optimum value of has been approximately obtained as 605 KA/m.



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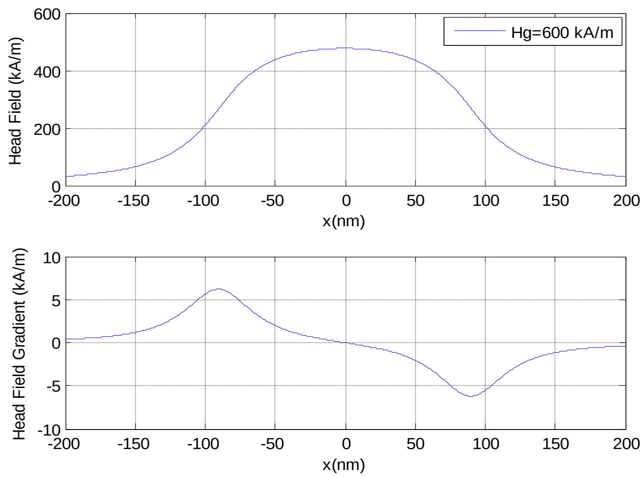

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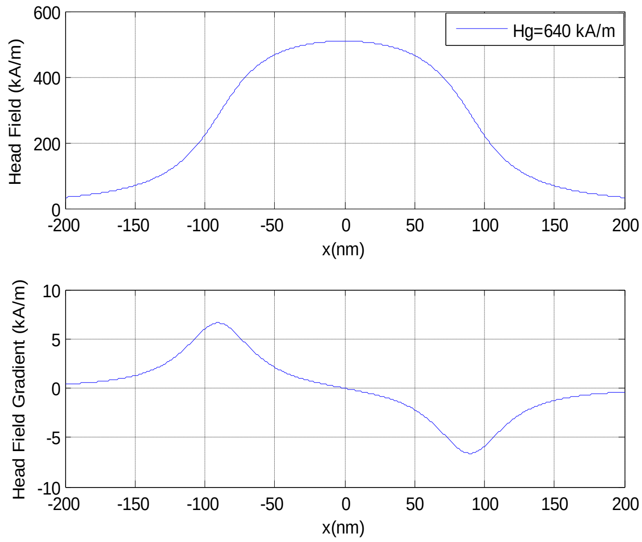


(c)

Figure 5: Head field and Gradient of Head field for different

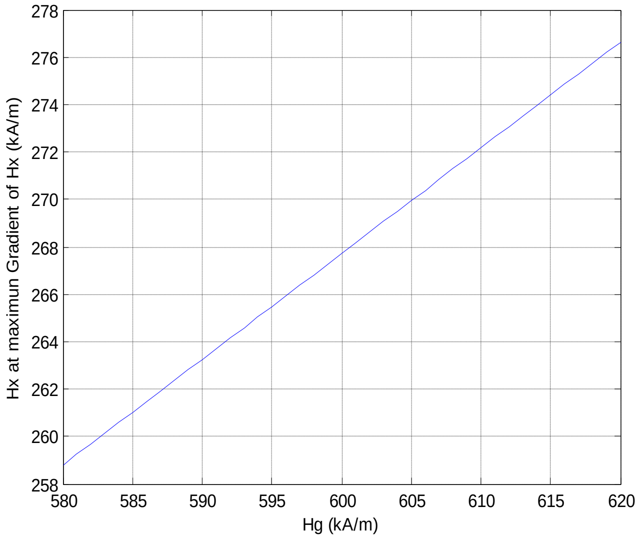


Figure 6: Head field at maximum gradient with respect to Different

2.2 Write Current for Optimum Head Gap Field

From the simulations of the previous sections, optimum head gap field is 605 kA/m. We know that Head efficiency is defined as follows

η =

Where,
N= number turns in the write coil
I= Current in the write coil
Now here head efficiency = 1, therefore
Current in the write coil, = = 108.9 mA for =1
Current in the write coil, = = 5.445 mA for =20
The part of the M-H loop has been specified as follows

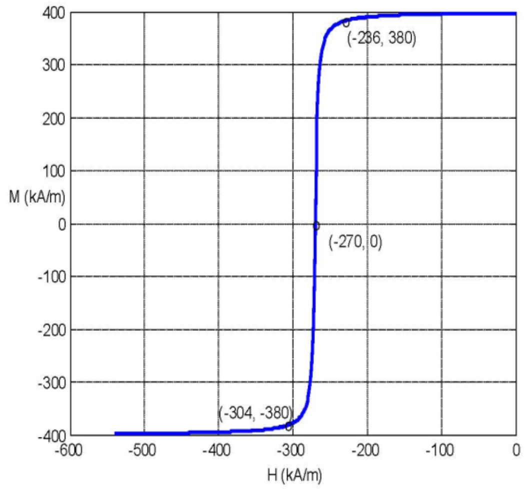


Figure 7: M-H loop

Here for the simulation purpose we choose the M-H loop
= 304 kA/m
=236 kA/m
So from the fig.12 of part 1 we have found that
=84.61 nm for
=95.63 nm for

Transition width, a= = 11.02 nm

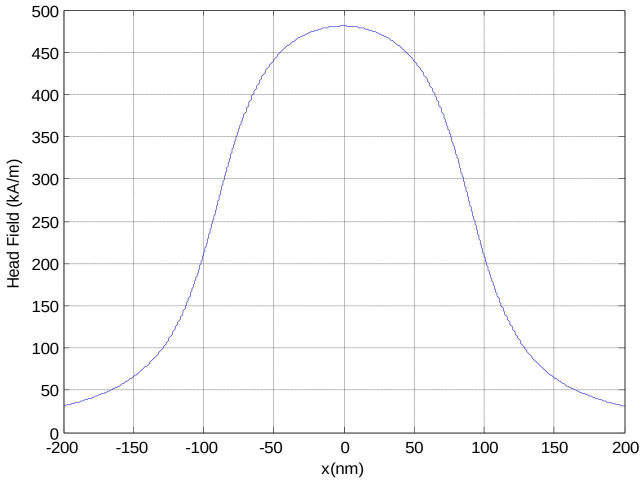


Figure 8: Head field for d=20 nm

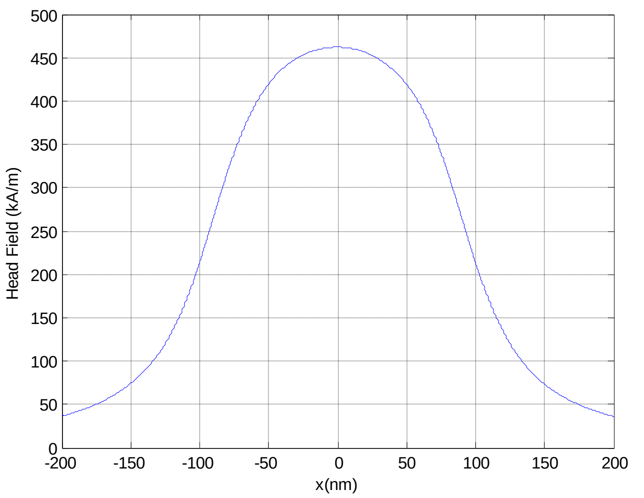
3. Transition Width for Different Head-Medium Gap

In this section the effect of changing the head-medium gap on the transition width will be discussed. Table 1 shows the calculated transition width from head field simulated plot (figure 9) and M-H loop (figure 7) for different head-medium gap.

Table 1: Transition width for different head-medium gap

Head-medium gap	Transition width
20 nm	11.02 nm
25 nm	13 nm
30 nm	15.07 nm
40 nm	20.02 nm

Therefore it can be concluded that (keeping all other parameters unchanged) if we only increase the head-medium gap, then the transition width will be increased accordingly.



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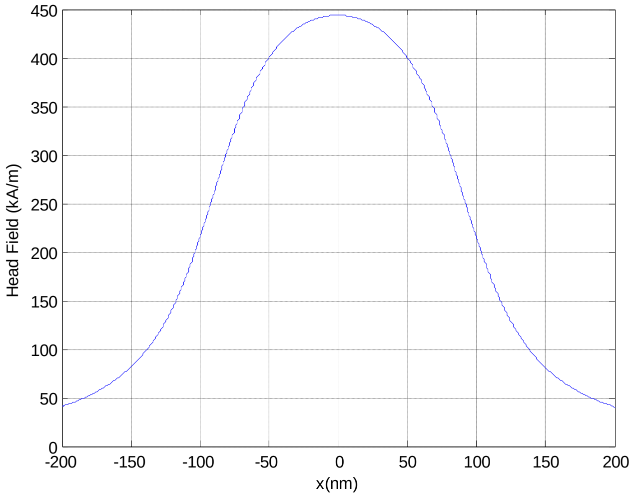

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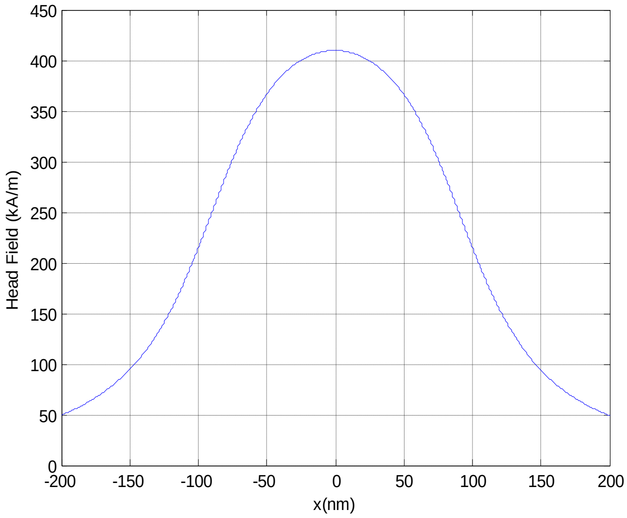

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Figure 9: Head field for head gap width of a) 25 nm b) 30 nm c) 40 nm

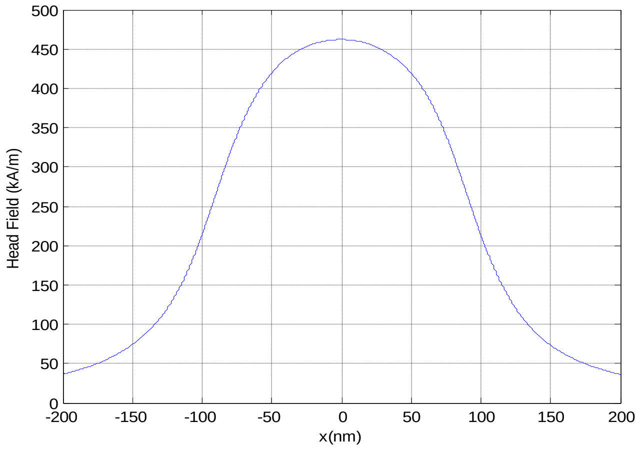
4. Transition Width for Different Medium Thickness

In this section the effect of changing the head-medium gap on the transition width will be discussed. Table 2 shows the calculated transition width from head field simulated plot (figure 10) and M-H loop (figure 7) for different head-medium gap.

Table 2: Transition width for different medium thickness

Medium thickness	Transition width
20 nm	11.02 nm
30 nm	13.01 nm
40 nm	15.06 nm
50 nm	17.26 nm

Therefore it can be concluded that (keeping all other parameters unchanged) if we only increase the medium thickness, then the transition width will be increased accordingly.



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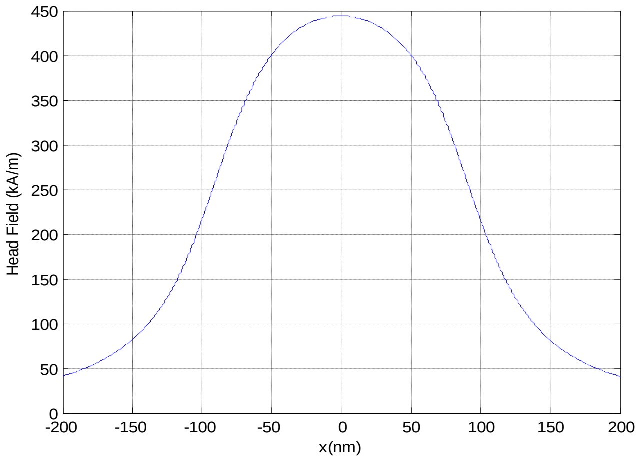

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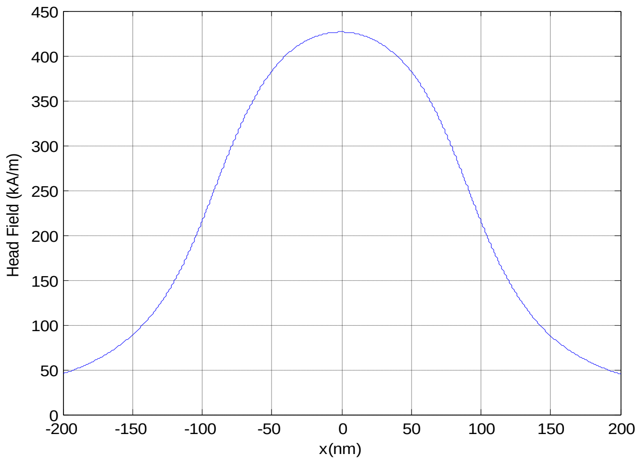

(c)

Figure 10: Head field for head gap width of a) 30 nm b) 40 nm c) 50 nm

5. Conclusion

In this paper we have observed the effect of head gap field on the head field in the write bubble and also extracted the optimum value of the head gap field and finally measured the required current for producing that optimum head gap field. In the second part we have done the analysis of dependency of transition width on the head-medium gap and medium thickness. Finally we can conclude that transition width is increasing with the increase of head medium gap and medium thickness, however we want the transition should be as sharp as possible, and therefore it is better to have small head medium gap and less medium thickness.

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