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การจำลองกระบวนการการผลิตแขนยึดจับหัวอ่านฮาร์ดดิสก์ไดร์ฟที่มีผลต่อความสูงที่คงที่

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บทคัดย่อ

องค์ประกอบหนึ่งของแขนยึดจับหัวอ่านฮาร์ดดิสก์ไดร์ฟ คือ ส่วนโค้งที่มีลักษณะแบบวงแหวนซึ่งมีผลต่อความสูงที่คงที่โดยตรงเพื่อให้ได้รับความสูงคงที่ที่เหมาะสม ส่วนโค้งที่มีลักษณะแบบวงแหวนจะต้องผ่านกระบวนการการปรับโดยเลเซอร์และการหลอมให้อ่อนตัวแล้วทำให้เย็นลง จากกระบวนการข้างต้นจะส่งผลให้เกิดมุมที่เบี่ยงเบนไป ซึ่งจะทำให้มุมคงที่ในแนวยกซึ่งเป็นส่วนช่วยให้ฮาร์ดดิสก์ไดร์ฟมีประสิทธิภาพในการเขียนและการอ่านข้อมูลได้ดียิ่งขึ้น จุดประสงค์หลักของงานวิจัยเล่มนี้คือ เพื่อได้รับความเข้าใจปัจจัยต่างๆและการปรับปรุงวิธีการรักษาระดับของมุมคงที่ในแนวยก ในงานวิจัยเล่มนี้จะแสดงให้เห็นถึงการเปรียบเทียบระหว่างผลการจำลองกับผลจากการผลิตจริงของแขนยึดจับหัวอ่านฮาร์ดดิสก์ไดร์ฟ

คำสืบค้น

แขนยึดจับหัวเขียนอ่าน, การปรับโดยเลเซอร์, การวิเคราะห์ระบบไฟไนต์เอเลเมนต์, เสถียรภาพในแนวยก, ส่วนโค้งที่มีลักษณะแบบวงแหวน

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MODELING OF MANUFACTURING PROCESS AFFECTING ON SA (STATIC ATTITUDE)

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ABSTRACT

One component of HDD suspension is the Gimbal flexure which affects on static attitude directly.

For attaining the proper static attitude, Gimbal flexure has to be processed by laser adjustment and annealed. From these processes will result in the deviated angle that make PSA (Pitch Static Angle) which supports HDD has a higher effectiveness for reading and writing data. In this research defined objective to understand in various factor and improve method to maintain the Pitch Static Attitude (PSA). The research presents simulation result compared to the real process in HDD suspension manufacturing.

KEYWORDS

suspension, laser adjustment, finite element analysis, pitch stability, gimbal flexure, hard disk drive

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I . Introduction

Presently, HDD suspension uses many processes for assembly. The assembly comprises components such as the suspension, usually formed of a metal such as stainless steel, a spring, a load beam and a gimbal flexure, each of which must have rigid areas and flex spring areas, and a head which includes a highly sensitive transducer that is attached to an air bearing head or"slider". The gimbal is one of the most critical regions of the suspension. The closer the suspension assembly can float on a cushion of air (or"fly") on the surface of the data storage media, the more densely information can be stored on the device. However, it is critical that the suspension assembly does not touch the disk as the impact with the spinning disk can destroy not only the suspension assembly but the storage disk and the data stored thereon. Therefore there must be precise balancing of the suspension assembly and the gimbal flexure. The gimbal must be responsive in order to maintain a level height above the microsized peaks and valleys of the data storage disk. It must also resist static pitch and roll but in this research will only focus on pitch static attitude (PSA), especially pitch stability. Especially, concentrate on the region on gimbal flexure which has a high stability to control static attitude or pitch angle when apply the same heat flux value on that region. The stability can be measured by comparing between deviated angle after laser adjustment process simulation and deviated angle after annealing process simulation.

II. Literature Review

2.1 The Laser Adjustment Process:

gimbal flexure arm is a part of the suspension which is bent by scanning laser beam in order to adjust the pitch as illustrated in figure1. After finishing laser adjustment, the deformed gimbal flexure will be processed by annealing heat treatment so that the bent arm's angle or PSA is maintained in required angle. Without annealing, the residual stress occurred in laser adjustment causes the bent angle to improperly change [1], [2].

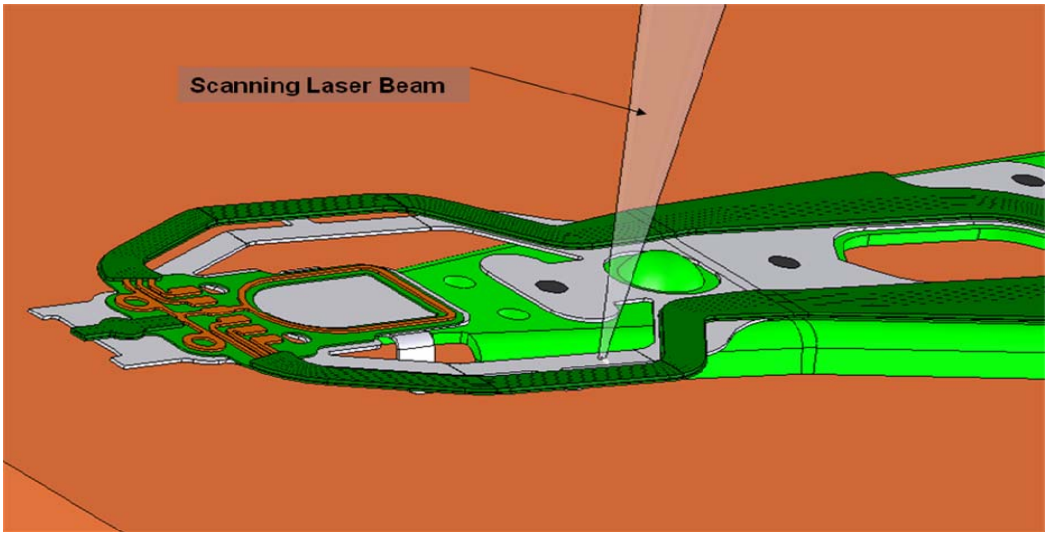

Figure 1
Laser adjustment process

2.2 PSA (Static Attitude) Measurement:

From the free state of suspension, it is formed to the reference z-height as shown in figure 2 and 3 respectively. PSA is measured by mean angle of the slider bonding surface rotation about transverse axis of the suspension assembly relative to the clamp surface datum [3] as shown in Figure 4.

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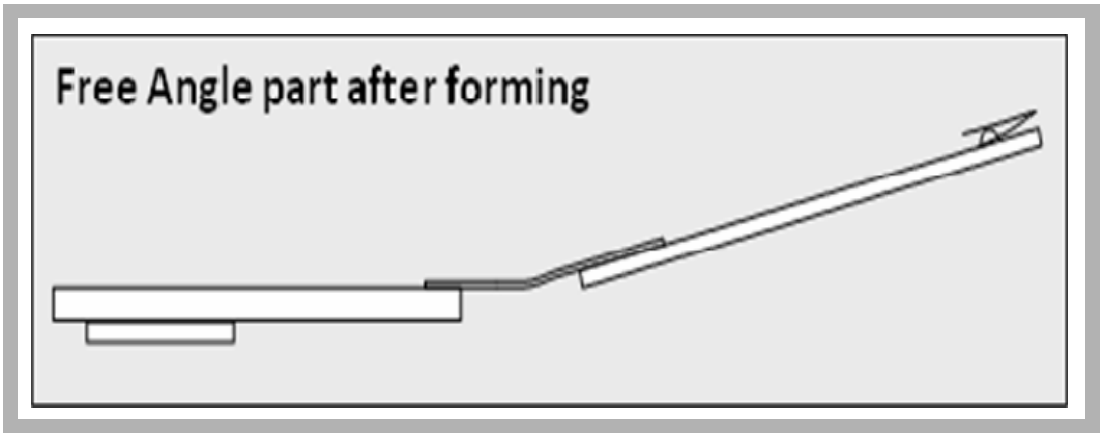

Figure 2
Free angle part after forming

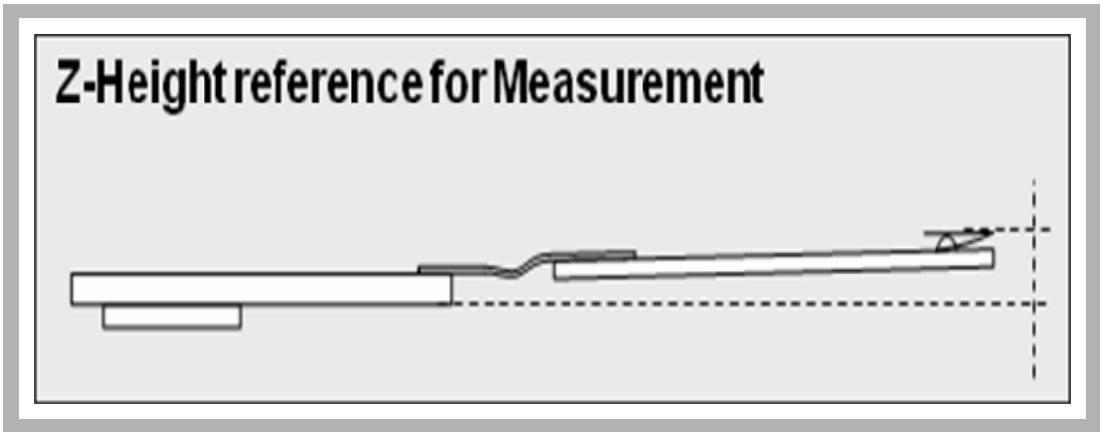

Figure 3
Z-Height reference for measurement

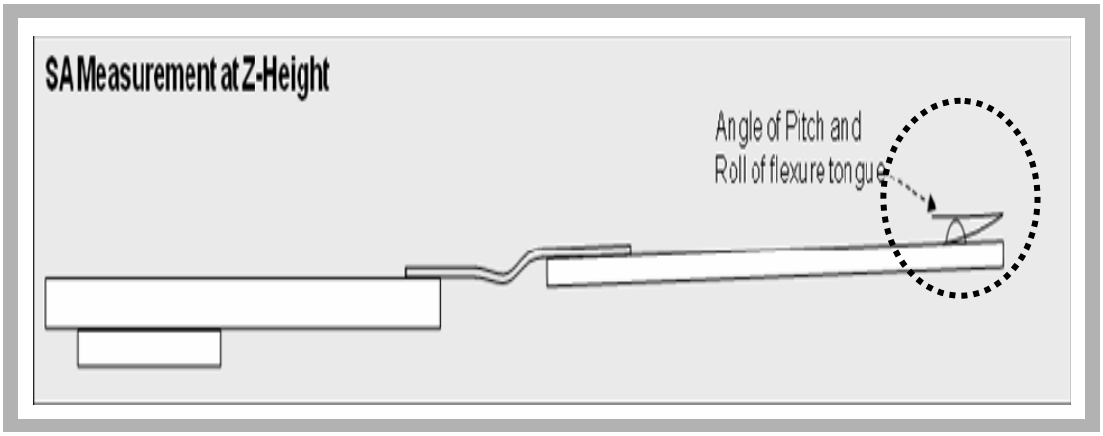

Figure 4
SA measurement at z-height

III. Experimental Procedures

3.1 Experimental overview:

For analyzing the deviated angle that is affected by laser adjustment process, we focused on the area that is irradiated by laser beam and its intensity as shown in Figure 5.

Actually, area of laser scanning depends on the required amount of adjustment but normally the full gimbal's arms can be scanned. In this simulation, we separate the gimbal area into four regions. Each zone has area equal to 0.018 mm^2 as shown in Figure 6.

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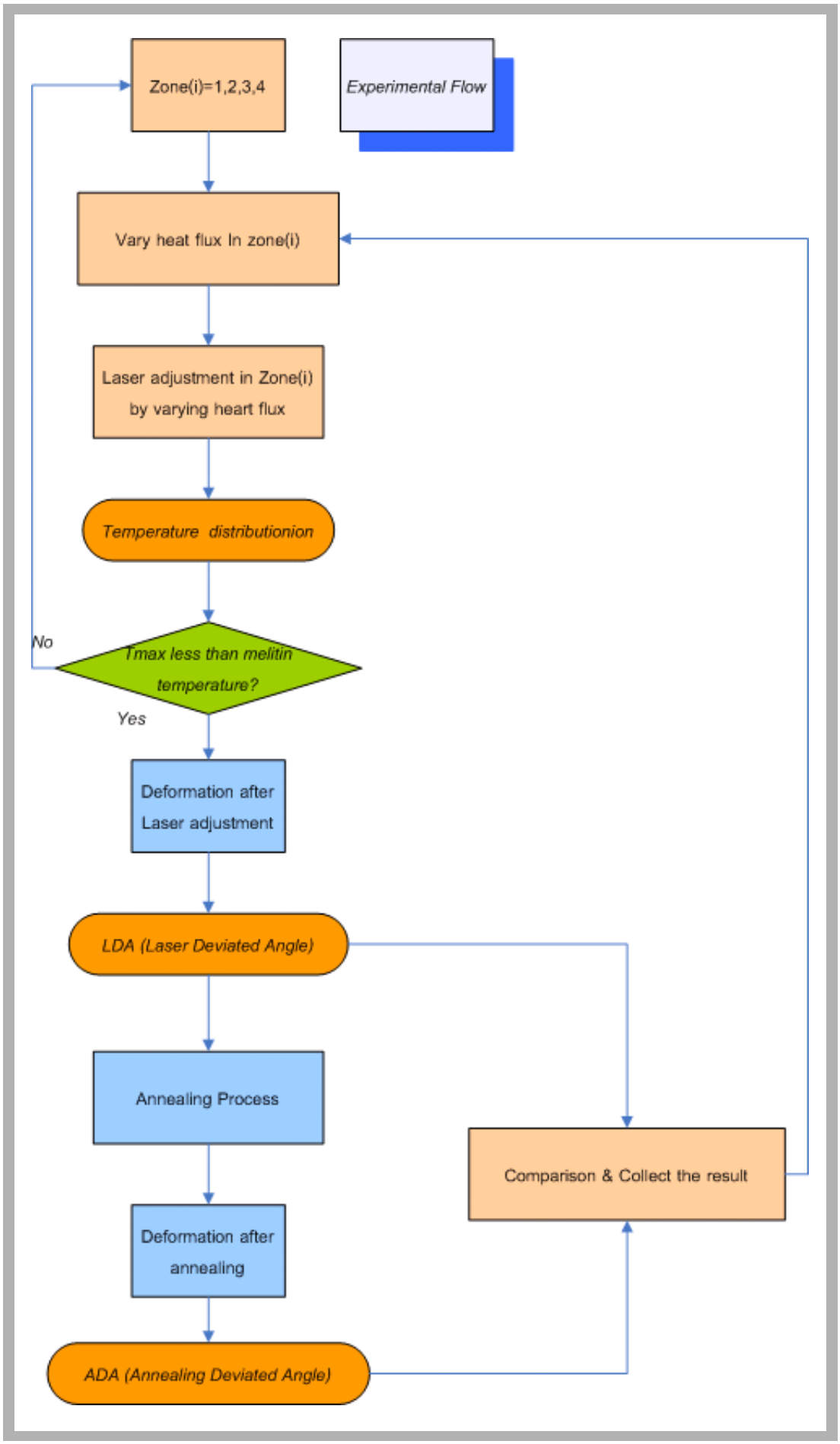

Figure 5
Experimental flowchart

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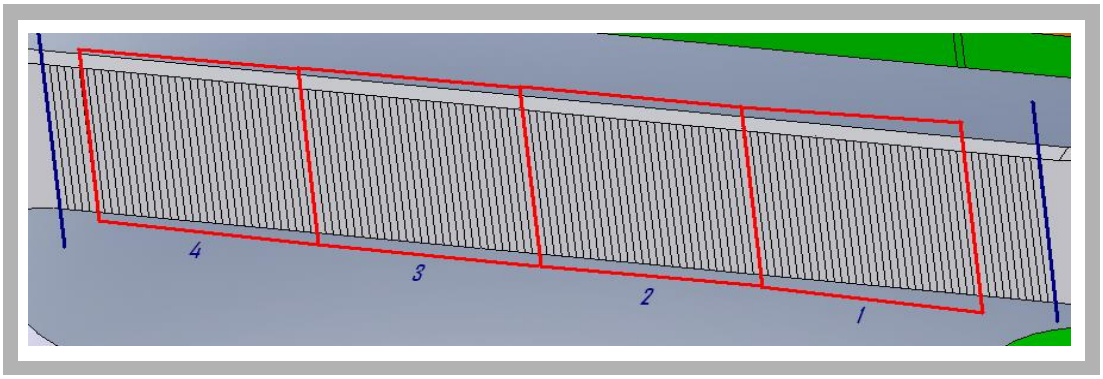

Figure 6
Separation of irradiated zone

Apply each heat flux (960, 1920 and 2600 w/mm^2) in each zone of gimbal area. But the maximum temperature (see in TABLE 2, 3, 4 and 5) that occurs after apply heat flux, it must not over the melting temperature of stainless steel (see in TABLE 1) that is a material component of gimbal. So, this research applies only three heat flux values.

After finishing thermal experiment, it is necessary to define the measurement of angle in this experiment. The two different angles that are affected by laser adjustment and after annealing process are determined. The deviated angle is measured by the following.

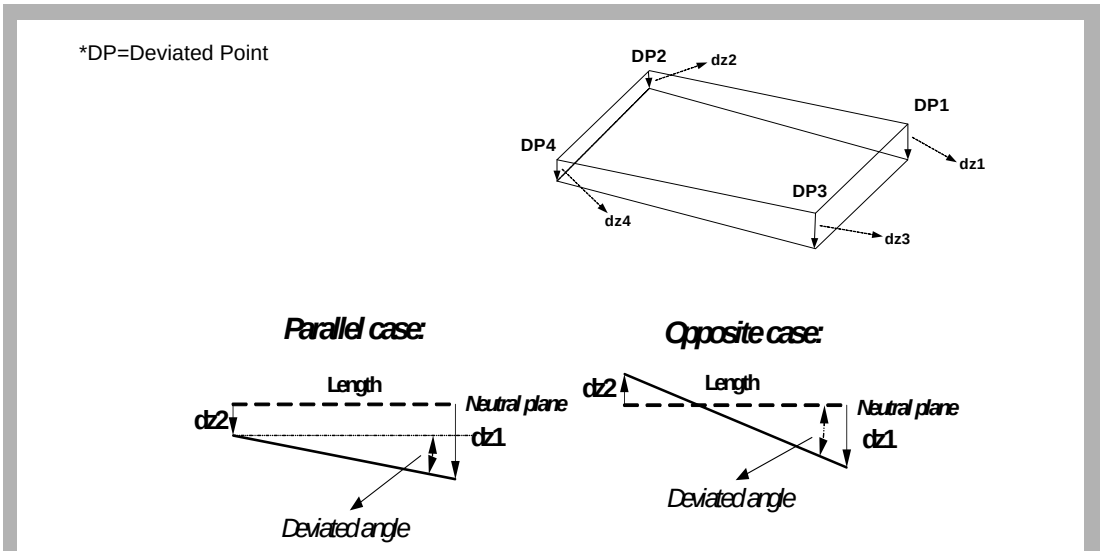

Figure 7
Deviated angle measurement

The definition of deviated angle is measured form deformed reference point to the neutral plane. Note that neutral plane is the flat surface that directly contacts to the slider part.

$$deviated\ \ angle = \arctan\left(\frac{|dz1 - dz2|}{Length}\right) \qquad \text{Parallel Case} \qquad (1)$$

$$deviated\ \ angle = \arctan\left(\frac{|dz1 + dz2|}{Length}\right) \qquad \text{Opposite Case} \qquad (2)$$

IV. Numerical Simulation

The laser adjustment process is the analyses of stress or deformation that is affected by various thermal conditions in ANSYS [4] finite element simulation software.

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1) Material properties: In the interested part of suspension model is considered only gimbal flexure that consists of stainless steel (gimbal), copper and polyimide (Flexible circuit). The following mechanical and thermal properties are shown in Table 1. These properties are used for setting in ANSYS software.

Table 1
Material properties

Mechanical	Material Properties			
Properties	Unit	SST	CU	PI
Young's modulus	GPa	193	124	5.86
Poisson's radio	-	0.31	0.34	0.33
Density	Kg/m^3	8070	8878	1383
Thermal expansion	1/ 'C	1.30E-05	1.80E-05	0.1
Ten, yield strength	MPa	1200	540	150
Cum, yield strength	MPa	1200	540	150
Ten, ultimate strength	MPa	1400	600	200
Cum, ultimate strength	MPa	1400	600	200
Melting temperature	°C	1398 – 1454	1083	3652 - 3697

2) Boundary condition: It is separated into two sub parts, thermal and mechanical condition. For thermal part, laser adjustment is modeled by applying heat flux on each region of Gimbal flexure's arms. The annealing process is simulated by convection of stagnant air. For mechanical part, the deformation is additionally affected by prior thermal condition.

V. Results

Experimental result

After finishing laser adjustment, the residual stress will make deviated angle spring back, so the annealing process is applied for relieving the residual stress as shown in figure 8.

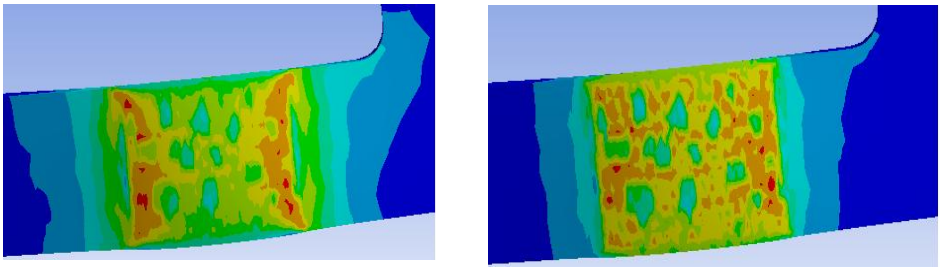

Figure 8
The residual stress without annealing (Left). The residual stress processed by annealing (Right)

From Table 2 to Table 5 are the deviated angle data that contain of the deviated angle after laser adjustment, deviated angle after annealing process. And plot the data of the both angle in line graph as shown in Figure 9 and 10. To compare deviated angle between after laser adjustment and angle after annealing process, Figure 11 was shown the difference of deviated angle between after laser adjustment and angle after

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annealing process. The different angle shows the stability of angle maintaining. The stability will be better if the difference is less.

Zone 1						
Heat Flux (W/mm^2)	**960**		**1920**		**2600**	
Process	**Laser**	**Anneal**	**Laser**	**Anneal**	**Laser**	**Anneal**
DP_1 (mm.)	0.00915	0.00678	0.01827	0.01353	0.02473	0.01831
DP_2 (mm.)	-0.00657	-0.00487	-0.01313	-0.00973	-0.01778	-0.01317
T_{max} (^oC)	384.69		1046.2		1409.7	
Deviated Angle (degree)	1.096	0.812	2.188	1.621	2.96	2.193

Table 2
Experimental result for zone 1

Zone 2						
Heat Flux (W/mm^2)	**960**		**1920**		**2600**	
Process	**Laser**	**Anneal**	**Laser**	**Anneal**	**Laser**	**Anneal**
DP_1 (mm.)	0.01232	0.00891	0.02459	0.01776	0.03332	0.02408
DP_2 (mm.)	-0.00894	-0.00646	-0.01785	-0.01289	-0.02419	-0.01747
T_{max} (^oC)	531.6		1045.2		1418.3	
Deviated Angle (degree)	1.482	1.071	2.956	2.135	4.003	2.894

Table 3
Experimental result for zone 2

Zone 3						
Heat Flux (W/mm^2)	**960**		**1920**		**2600**	
Process	**Laser**	**Anneal**	**Laser**	**Anneal**	**Laser**	**Anneal**
DP_1 (mm.)	0.01557	0.01155	0.03112	0.02308	0.04213	0.03124
DP_2 (mm.)	-0.01141	-0.00845	-0.0228	-0.01689	-0.03087	-0.02286
T_{max} (^oC)	538.9		1057.9		1328.2	
Deviated Angle (degree)	1.88	1.394	3.753	2.784	5.075	3.766

Table 4
Experimental result for zone 3

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Zone 4						
Heat Flux (W/mm^2)	**960**		**1920**		**2600**	
Process	**Laser**	**Anneal**	**Laser**	**Anneal**	**Laser**	**Anneal**
DP_1 (mm.)	0.0187	0.01383	0.03737	0.02762	0.0506	0.03739
DP_2 (mm.)	-0.0138	-0.0102	-0.02758	-0.02037	-0.03734	-0.02758
T_{max} (^oC)	540.5		1060.9		1424.2	
Deviated Angle (degree)	2.264	1.674	4.518	3.342	6.107	4.52

Table 5
Experimental result for zone 4

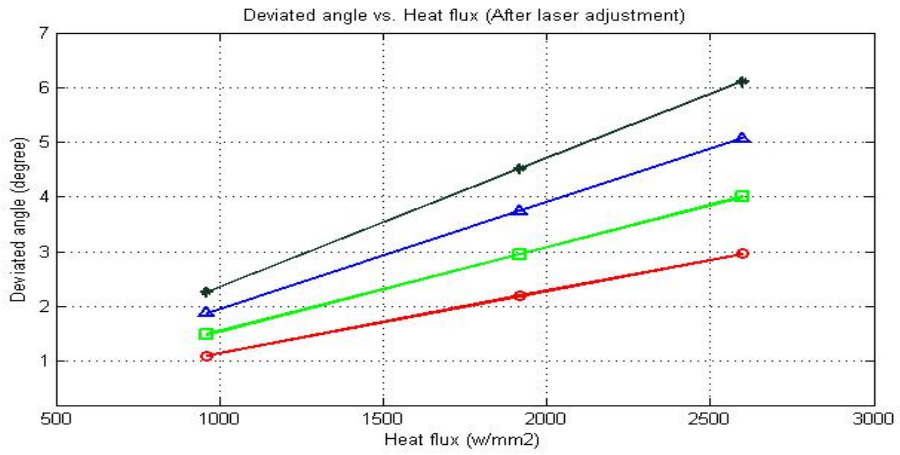

Figure 9
Deviated angles (LDA) in each zone after laser adjustment (LDA : laser deviated angle)

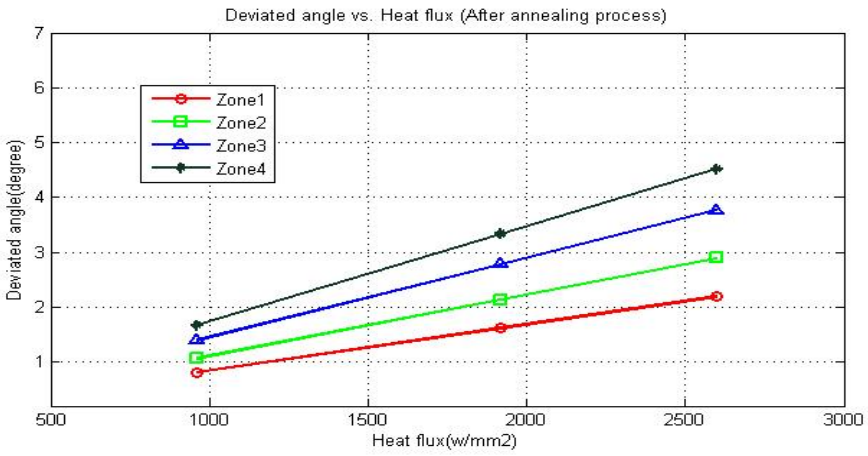

Figure 10
Deviated angles (ADA) in each zone after annealing process (ADA : annealing deviated angle)

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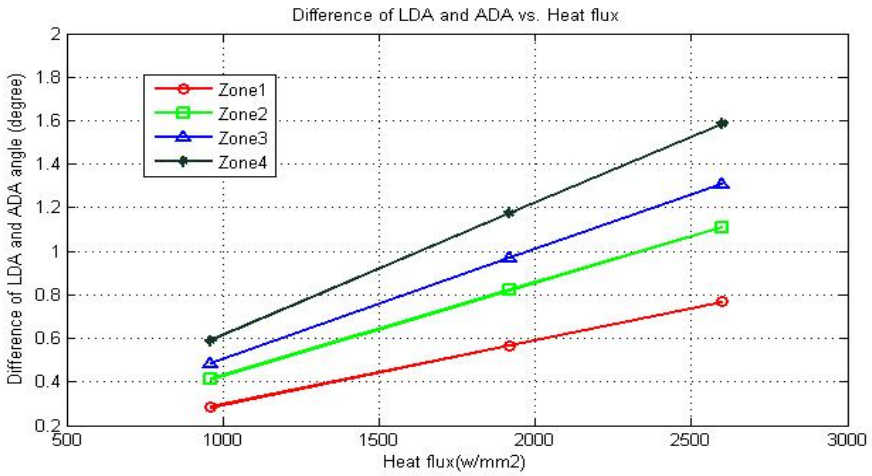

Figure 11
Difference of deviated angle between LDA and ADA (LDA : laser deviated angle, ADA : annealing deviated angle)

VI. Conclusions

- For every zone, the laser deviated angle (LDA) increases when it is started form zone 1 to zone 4 or alternatively from base to the tip of both gimbal flexure's arms.
- When focusing on the same heat flux that is applied for each zone, the zone4 give the maximum of LDA than the others.
- For every zone, the laser deviated angle (ADA) increases when it is started form zone 1 to zone4 or alternatively from base to the tip of both gimbal flexure's arms.
- When focusing on the same heat flux that is applied for each zone, the zone4 give the maximum of LDA and ADA than the others.
- There is the reduction of residual stress that occurs in laser adjustment process. It can help to maintain the LDA after finishing the laser adjustment process, this is an example of zone1; it can be found that the stress distribution after laser adjustment can be reduced by annealing.
- When considering in each zone, the stability of maintaining the deviated angle is represented by the difference of LAD and ADA is reduced while the heat flux increases.
- When focusing on the same heat flux, 960, 1920 and 2600 W/mm^2, the zone 1 results the best stability to maintain the bent angle of gimbal flexure's arms.
- The stability of maintaining the bent angle of gimbal flexure's arm decreases when starting from zone1 to zone4.

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