The Study of the Multi-Header Hot Bar in Bonding Process by FEA

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บทคัดย่อ—การเชื่อมแบบกดทับเป็นวิธีการที่นิยมในการเชื่อมหาง TGA (Trace Gimbal Assembly) เข้ากับอีบล็อค (E-Block) บางครั้งเรียกว่ากระบวนการรีโฟลว์ (Reflow) ซึ่งเป็นกระบวนการหนึ่งในกระบวนการผลิตฮาร์ดดิสก์ไดร์ (Hard Disk Drive) การเชื่อมโดยใช้แท่งเชื่อม (Hot Bar) ครั้งละหนึ่งหัวดังเช่นที่เคยทำกันมาอย่างต่อเนื่องตั้งแต่ในอดีต ทำให้ต้องสูญเสียเวลาในการผลิตฮาร์ดดิสก์ไดร์ฟมาก จากการศึกษาโดยใช้ระเบียบวิธีไฟไนท์เอลิเมนต์ทำให้สามารถปรับปรุงวิธีการเชื่อมให้เชื่อมได้ครั้งละหลายๆ หัว เพื่อช่วยลดเวลาในการผลิตฮาร์ดดิสก์ไดร์ฟ จากการทดสอบพบว่า ค่ายูนิตต่อชั่วโมง (Unit Per Hour, UPH) ของกระบวนการเชื่อมเพิ่มขึ้นถึง 80 เปอร์เซนต์ ยิ่งเพิ่มจำนวนหัวเชื่อมจำนวนเปอร์เซนต์ก็เพิ่มขึ้นตามไปด้วย ในขณะที่คุณภาพของการเชื่อมยังคงเดิมเมื่อเทียบกับการเชื่อมครั้งละหนึ่งหัว

คำสำคัญ: การเชื่อมแบบกดทับ, ไฟไนต์เอลิเมนต์, แท่งเชื่อม, รีโฟลว์

Abstract- The reflow interconnection is a common connection between the head gimbal assembly (HGA) and the E-Block in a manufacturing process of hard disk drive. Sometimes the interconnection process is called lapping bonding. At present, the reflow process uses one header of the hot bar at a time for bonding. However, time to market is very important. Such the approach is time consuming for the hard disk drive production. In this study, the finite element method was used for improvement the reflow process which twelve headers of the hot bar were used at a time for bonding. The even number of the hot bars was recommended. In addition, the heat transfer was considered carefully by control the hottest area and uniformity of the heat distribution on the reflow area. The results from peel test and electrical test revealed that the quality of lapping bonding by multi header can be compared with that by one header. Increasing of the hot bar header is able to increase the percent of UPH as well.

Keywords: *interconnection; finite element; hot bar; reflow*

I. INTRODUCTION

The common technique for bonding between the TGA tail and PCCA (Printed Circuit Cable Assembly) in reflow process is the soldering with a hot bar. A header of the hot bar is used for connection at a time in current. The interconnection reflow process is shown in Fig. 1[1].

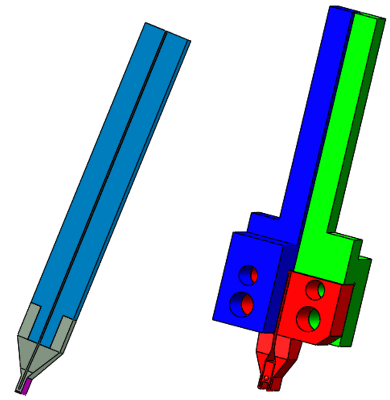
Fig.1 Reflow area on Head Stack Assembly

To increase the capacity of the hard disk drive that adding the media is necessarily and leads to more header. Consequently, a number of connections are required [2]. In this investigation proposes increasing the unit per hour of the hard disk drive manufacturing that the multi-header of the hot bar was being developed to support in the reflow process. The common defects after experienced reflow process are incomplete, burn pad and low peel strength must be retained same as the old design (one header at a time). The heat transfer is insufficient from the hot bar to the TGA pad and the solder pad which is on PCCA leads to incomplete result. The hot bar reflow touch with polyamide root of burn pad resulted which leads to low peel strength value. The electrical current density passed through the header of the hot bar and then generated the amount of heat at the small area on the hot bar head is the key of design and development of hot bar reflow.

II. MATERIAL

In this study aims to analyze the behavior of current density on the header of the hot bar and proposes to increase the number of header of the hot bar. The basic components of the reflow process are categorized into 3 parts. The first is power supply (Uniflow 4) to control the power passed through the hot bar reflow soldering as shown in Fig. 2. The input power not much has changed while increased the header of the hot bar. The second is the hot bar connector for connecting using the nut and the screw that designed for adjustable the position in z-axis. The connector consisted of mechanism of automatic movement of the hot bar soldering, included the microscope (30X) connected on top of the clamp; operators are able to focus the part during bonding in reflow process. The last is the hot bar reflow soldering as shown in Fig. 3 (a) single head and (b) dual headers at a time, after the electrical current passed through the hot bar then the electrical current will be changed to thermal energy following Joule's law[3]. The component of the solder material for lapping bonding in reflow process follow green technology is shown in Table 1. In the study used 3D model, the hot bar included the Haynes230 and copper will be created by SolidWorks. The dimension of the header of the hot bar will be controlled using GD&T.

Fig. 2 Power supply



(a) (b)

Fig. 3 The hot bar reflow (a) single head and (b) dual head

TABLE I: The component of the solder material

Name	CAS No.	wt%
Tin	7440-31-5	95.5
Silver	7440-22-4	3.8
Copper	7440-50-8	0.7

The 3D model of the hot bar will be imported into Ansys Workbench for analysis by finite element method to calculate the hottest area on the hot bar.

III. METHOD

The classical design of the header of the hot bar in the reflow process is able to bond one TGA tail at a time. The number of the header of the hot bar is defined following the number of the solder lead pitch as shown in Fig. 4. The width of the header is equal to flying lead width to make sure that the tip is superimposed completely by all flying lead. The 3D model is imported into finite element software for Thermo-Electric analysis to study the temperature distribution on the header. Tetrahedron element is used in this analysis. The material properties of the haynes230 that varies with temperatures are shown in Table 2 [4]. The heat convection will be not considered because the reflow process is in the clean room and reflow time is quite short. Following the Joule's law [4], the Joule heating equation gives the power per unit volume as Eq. (1)

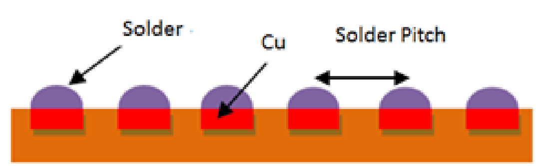


Fig. 4 Solder on PCCA

$$\frac{dP}{dV} = \vec{J} \cdot \vec{E} \qquad (1)$$

Where, $\vec{J}$ is the current density, and $\vec{E}$ is the electric field. In a conductor of conductivity σ, $\vec{J} = \sigma\vec{E}$ and thus

$$\frac{dP}{dV} = \vec{J} \cdot \vec{E} = \vec{J} \cdot \frac{\vec{J}}{\sigma} = \vec{J}^2 \rho \qquad (2)$$

TABLEII: The material properties of the Haynes230

Temperature (˚C)	Thermal Conductivity (W/m*K)	Specific Heat (J/kg*K)
25	8.9	3.97×10^8
100	10.4	4.19×10^8
200	12.4	4.35×10^8
300	14.4	4.48×10^8
400	16.4	4.65×10^8
500	18.4	4.73×10^8
600	20.4	4.86×10^8
700	22.4	5.74×10^8
800	24.4	5.95×10^8
900	26.4	6.09×10^8
1000	28.4	6.17×10^8
Mass Density at 25 ˚C = 8.97 g/cm^3		

Where $\rho = \frac{1}{\sigma}$ is the resistivity and varies with the different temperatures. This directly resembles the I^2R term of the macroscopic form. In the reflow process uses the alternating current, the power will be controlled around 70 to 100 Watts and the resistance of the solder tip will be determined, as shown in the Fig. 5. The hot bar with multi-header was designed and can be considered as the parallel circuit in the portion of Haynes230.

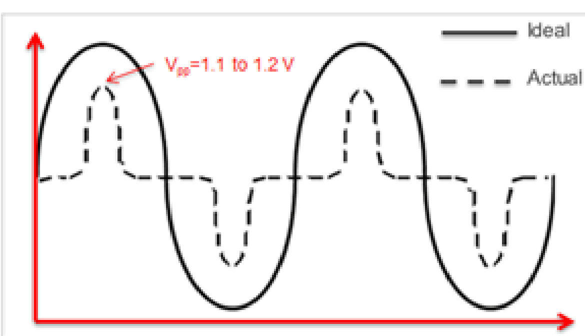
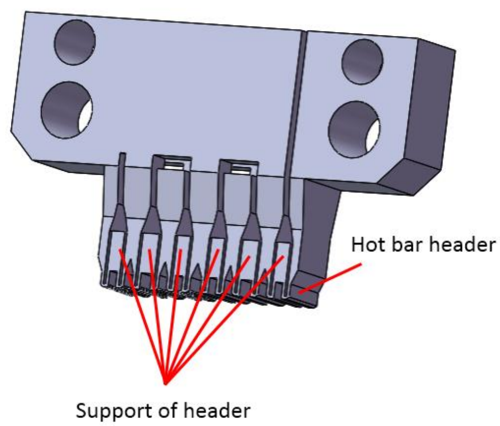


Fig. 5 Input power

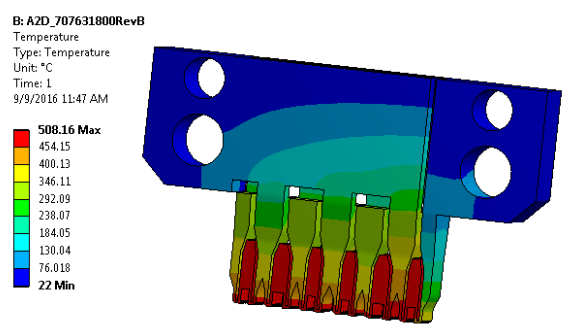
IV. RESULTS

The current density on the hot bar is very important for control the thermal distribution on the header of the hot bar leads to support of the hot bar head (among the headers of the hot bar) as show in the figure 6 (a). Each model need to optimize the support of the header of the hot bar to control the current density. The heat distribution began from the center of the header and spread to the both side of the reflow area and the support of the header. By this technique author recommends that the number of hot bar head should be even number. In this study only show the hot bar with six headers but actually it can be twelve headers or more than of hot bar at one time bonding.

By finite element analysis revealed the hottest area on the header of the hot bar reflow, it also showed thermal distribution around the header of the hot bar as shown in Fig. 6(b). The teeth of the header can be modified for flying lead, for example long slot, partial teeth.



(a)



(b)

Fig. 6 (a) 3D model of the hot bar with twelve headers and (b) Thermal distribution of the header of the hot bar

V. CONCLUSION

In this study, the finite element method was used for improvement the reflow process which multi-headers of the hot bar were used for bonding the TGA tail to PCCA at a time. Moreover, the heat distribution on the headers began from the middle of the head and spread to the width of the solder reflow area throughout. The hot bar with multi-headers should use parallel circuit in the portion of Haynes in order to heat transfer as above. The TGA tail should be folded before reflow and adjust the position of the tail before press the hot bar on flying lead. Otherwise, it can be the root cause of burn pad and incomplete in bonding process.

The results from peel test and electrical test revealed that the quality of lapping bonding by multi-headers can be compared with that by one header. Increasing of the header can increase the percent of UPH as well.

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