CHAPTER III

GIMBAL BOND OPERATION IMPROVEMENT

3.1 Introduction [1]

3.1.1 Purpose

This process tells how to bond the suspension to the 30-series slider using Ablebond 8385 adhesive. This operation is the one value-added operation.

3.1.2 Process Control

1) Grounded ESD wrist band must be worn at all times.
2) Contamination control measures specified in Engineering Specification. This includes:
   - Operation to be done in controlled environment.
   - Cleanroom gloves to be worn on both hands at all times.
   - Cleanroom garments to be worn at all times.
3) Pre-clean work station & equipment.
4) Ablebond 8385
   - Pre-mixed Ablebond adhesive to be stored at -40° F or colder. Pot life of Ablebond pre-mixed adhesive = 8 hours maximum. *And*, do not use adhesive which has become stiff, stringy, blocky, etc.

3.2 Work Instruction [1]

3.2.1 Pre-Operation

1) Inspect the gimbal bond flipper. This is done by placing a JIT tool into the flipper, locking it in position with the locking cam, rotating the flipper in a

[1] Gimbal Bond Manufacturing Process Document.

counter-clock-wise motion, and checking the alignment of the JIT tool pins to the flipper pins. If the pins do not line up the spring will not fall on the tool properly. If the pins do not line up contact a technician.

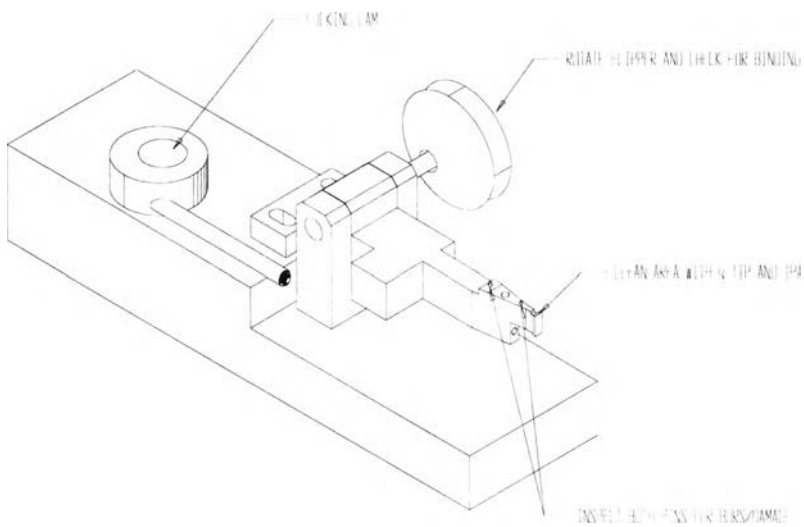

Figure 3.1 Gimbal bond fixture.

2) If the flipper is hard to rotate contact a Technician to have it cleaned.

3) Inspect the vacuum tweezers to insure that the stainless steel tip does not extend beyond the end of the rubber tip. If any stainless steel extends below the rubber tip, damage will occur to the spring while loading. The operator can use UV adhesive to secure the rubber tip in the proper location and may also trim the flange for better visibility while loading.

4) Inspect the rubber tip under 30x for signs of contamination. Replace tips with any non-removable contamination or when rubber is missing from the end.

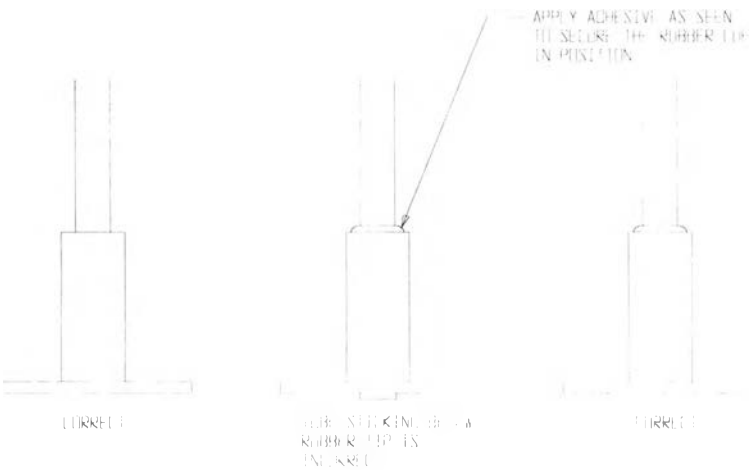

Figure 3.2 The characteristics of good rubber tip and rejected rubber tips.

5) Failure to meet any of the criteria is cause not to build any parts.

3.2.2 Post-Operation

1) Obtain the correct suspensions for bonding.

2) Load JIT tool into flipper. Lock the JIT tool with the locking cam.

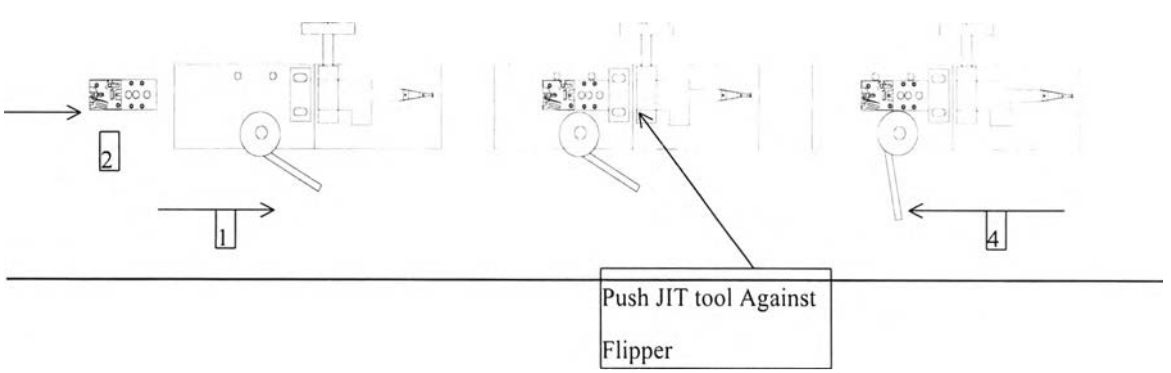

Figure 3.3 The steps of loading JIT tool into fixture.

3) Preferred Suspensions Loading Method

3.1) Carefully, flip the tray so that the suspension lie in the tray lid and do not need to be flipped during loading.

3.2) Using the vacuum tweezers only, pickup a suspension and place it onto the flipper. No fingers should be used to manipulate the suspension into position on the flipper.

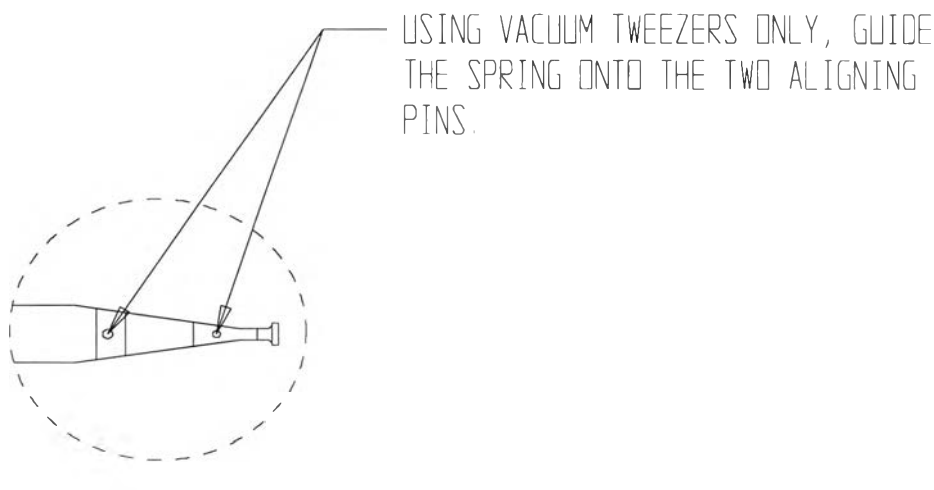

Figure 3.4 The aligning pins on flipper arm.

4) Apply adhesive to gimbal by applying exactly one dot of adhesive to the center area of the bond tab, biased away from the horizontal strut. See Figure3.5.

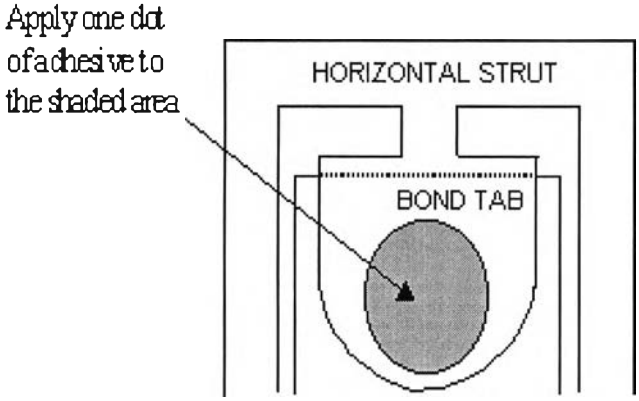

Figure3.5 The location on bond tab to be applied one dot of adhesive.

5) Spread or smear the adhesive dot to the whole bonding tab area as shown in Figure 3.6

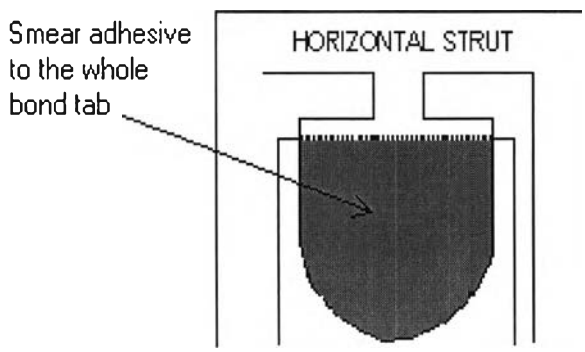

Figure 3.6 The bond tab area that adhesive must be spread on it.

6) Rotate the flipper counter-clock-wise and release vacuum on the part allowing the spring to fall onto the alignment pins of the tool. Then rotate flipper clockwise to start position.

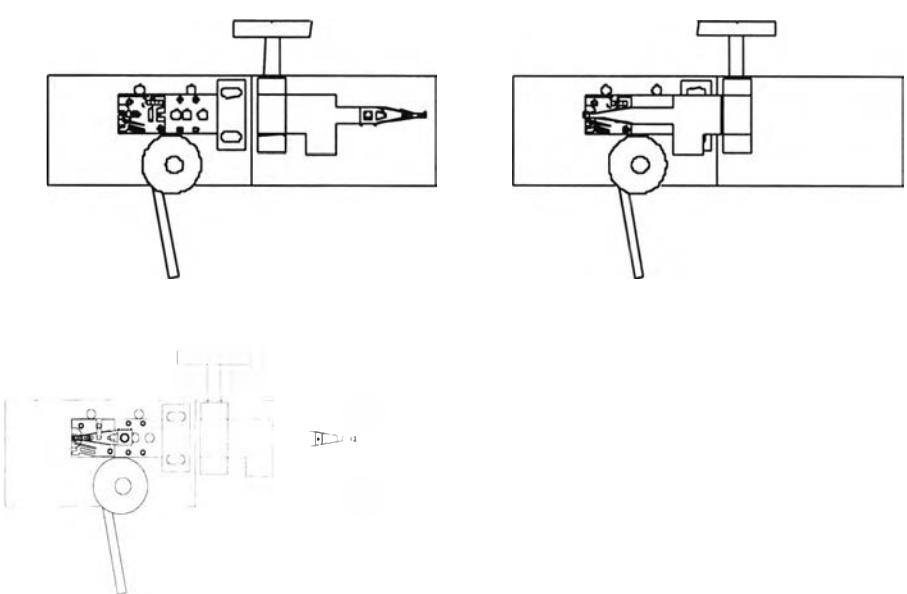

Figure 3.7 Steps of rotating flipper arm.

7) Turn Pie wedge of JIT Tool and lay it on the back load arm of suspension.

8) Release the cam, remove the JIT tool and place the tool into the carrier tray.

3.2.3 Gimbal Bond Inspection

1) All inspections should be done at 30-40x scope.

2) From the top of the tool inspect to insure that the gimbal bond criteria is met. Reference applicable product criteria.

3) From the trailing edge view, verify the gimbal bond meets the trailing edge view gimbal bond requirements. Reference applicable product criteria.

4) At NO time should an operator attempt to FORCE the part to meet gimbal bond criteria by pushing on the gimbal with a pin vise, tweezers or any other object.

5) For product with wires. Verify no wire damage has occurred and wires are still in proper orientation. Reference applicable product criteria.

6) Verify no strut or other spring damage has occurred. Reference applicable product criteria.

7) Any part that fails to meet the inspection criteria should be rejected unless stated otherwise

8) Place the JIT tools in the tray

9) Stage for next operation.

3.3 Motion and Time Study

In order to improve the capacity of the Gimbal bond operation, methods studies[1] are made to improve the existing method of operation by following these steps.

1) Make a preliminary survey

2) Determine the extent of analysis justified.

3) Investigate the approaches to operation analysis.

4) Make motion study when justified.

5) Compare the old and the new methods.

6) Present the new method.

7) Check the installation of the new method.

8) Correct time values.

9) Follow up the new method.

To follow the first four steps, the current standard motion and time of gimbal bond operation is brought to analyze. Each elements performed at gimbal bond operation including its used time is shown in the observation table as Table 3.1.

[1] Motion and Time Study by Benjamin W. Neibel.

Product	Ultra4
Operation	Gimbal Bond
Date	Jan 21, 1999
Location	C52, C53, C83
Prepared by	TASBONGKOT D.

Element No.	Element	FREQ.	AVG. Time	Select Time	Rating	Normal Time
1	Pick up JIT Tool tray from Kanban	5	1.60	0.32	100.00%	0.32
2	Load JIT Tool to Flipper	1	2.11	2.11	100.00%	2.11
3	Load flexure to flipper arm	1	2.17	2.17	100.00%	2.17
4	Apply epoxy on flexure	1	5.63	5.63	100.00%	5.63
5	Flip flipper arm	1	1.45	1.45	100.00%	1.45
6	Support Pie wedge	1	1.68	1.68	100.00%	1.68
7	Unload JIT Tool to tray	1	2.32	2.32	100.00%	2.32
8	Pick up tray	5	2.20	0.44	100.00%	0.44
9	Move flipper out	5	2.00	0.40	100.00%	0.40
10	Inspect & send JIT tool tray to conveyor	5	5.80	1.16	100.00%	1.16
11	Record data	5	1.80	0.36	100.00%	0.36
12	Open flexure tray	30	12.30	0.41	100.00%	0.41
		Summation time (sec)				18.45
		Hour per piece				0.0051
		UPH				195
		Capacity				11,057

Table 3.1 Motion and time of each element performed at gimbal bond operation.

FREQ. : Frequency or the numbers of units performed by each operator at a time.

AVG. Time : Average time from many operators at that operation used for performing each element to finish the parts as the same number of frequency.

Select Time : Average time for finishing a single unit.

Rating : The percentage of units that will be performed compared to total loading.

Normal Time : Select time that is weighted to rating.

3.4 Problem Correction

The best method to increase operation capacity is trying to increase UPH of that operation by eliminating some elements of such that operation. The method engineering is applied to find the better way to produce the product. Making an analysis is the fourth stage of method engineering. It is to utilizes the primary approaches to operation analysis and the principles of motion study to decide which alternative will produce the best product. These primary approaches include: purpose of operation, design of part, tolerances and specifications, materials, process of manufacture, setup and tool, working conditions, material handling, plant layout, and principle of motion economy. The most important question that should be asked when studying the events on the operation elements is **Why.** Typical questions that should be asked are **why this element is necessary.**

This kind of question is always asked to consider the importance of that task. This question is asked to all work elements performed in this operation After making motion study as the fourth step of procedure from the standard UPH, there are two elements at gimbal bond operation that are interesting for analysis and improvement and those two questions that are interesting are:

1) Why do the operator have to smear the adhesive to shade area on bond tab?

And 2) Why do the operator have to turn the pie wedge and lay on load arm because it will, however, be turned out and in again at next operation, Flex Bond operation?

From these two questions, the fifth stage of method engineering is to develop the ideal method. It is to select the best procedure for operation, inspection, and transportation by considering the various constraints associated with each alternative. The proposed methods to improve the gimbal bond operation to increase its capacity are;

3.4.1 New method for applying adhesive (Ablebond 8385) by eliminating smearing adhesive. From studying the adhesive properties, its viscosity is around 6,900 to 20,000 cps. With this number, the adhesive should itself spread around the bond tab after the flexure is flipped on the slider.

3.4.2 Eliminate turning pie wedge to lay on load arm of flexure after bonding. From studying the JIT tool, there are two locating pins on JIT Tool that are long enough to hold the flexure on the JIT tool without camp lock. Moreover, eliminating turning pie wedge at gimbal bond operation is also to eliminate the element of turning pie wedge out at flex bond operation. Because flex bond operators need to open pie wedge again to bond flex on the flexure.

3.5 Evaluation Factors and Procedure

3.5.1 Evaluation Factors

Gimbal Bond is one of the critical operation in HGA assembly process. There are five majors that are evaluated and need to have data collection procedures, i.e. Mechanical defect in part of Gimbal Bond criteria, Gimbal Bond shear strength, Roll Static Attitude (RSA)/Pitch Static Attitude (PSA), and Fly Performance.

1) Gimbal Bond criteria[1]

The first evaluation factor called "Gimbal Bond Criteria" is the factor which identifies the mechanical defect. The squeeze out adhesive must be specially focused on. It is an important factor that will represent the bonding strength. All units can not be tested in term of the bonding strength because bonding strength test must be performed in pattern of shear test that will be mentioned in next factor. This factor will focus on these criteria as followings;

1.1) No gimbal bond adhesive overflow or splatter on trailing end of slider.

1.2) Gimbal bond adhesive must not bridge to other parts of the HGA (See Figure3.9).

[1] Manufacturing Process "Product Criteria".

1.3) No gimbal bond adhesive on horizontal gimbal bond (except within 0.003" window on the bond tab neck). See figures 3.8A-B.

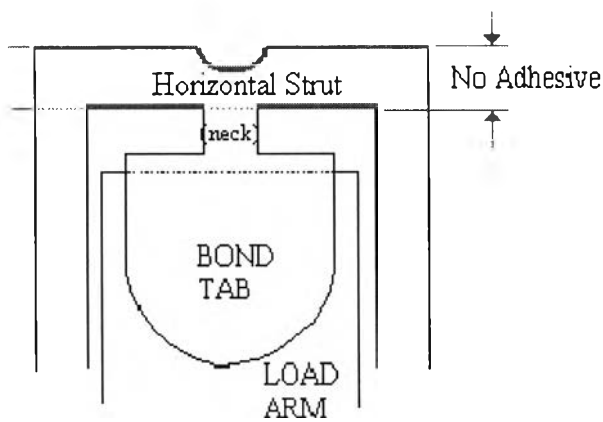

Figure3.8A The area of horizontal strut that is not allowed adhesive on.

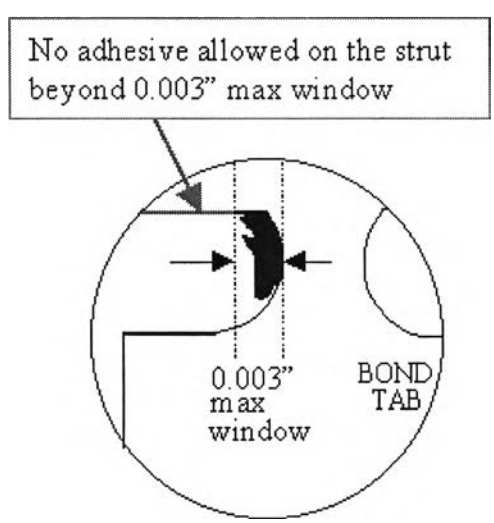

Figure3.8B The area of bond tab neck that no adhesive allowed beyond 0.003" maximum.

1.4) Adhesive fillet is allowed around entire perimeter of bond tab & neck, but must be visible space between fillet and side struts. See Figure3.9

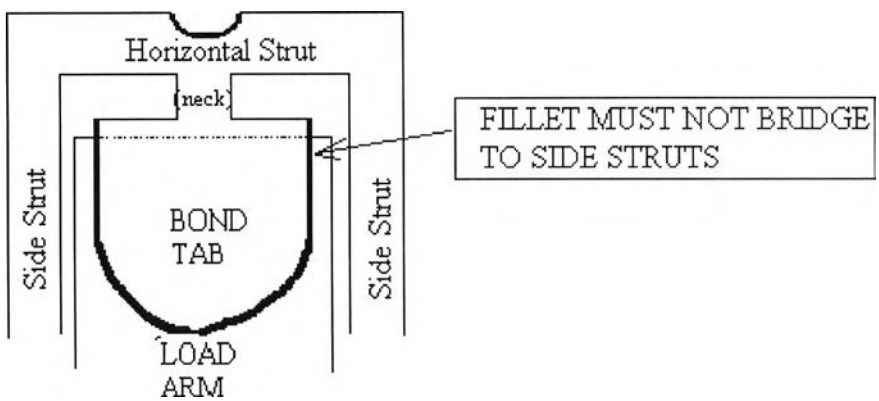

Figure3.9 Adhesive fillet around entire perimeter of bond tab.

1.5) Adhesive in neck area is allowed but not preferred. Visible gaps in the adhesive are allowed on the neck and bond tab areas not under the load arm. See Figure3.10.

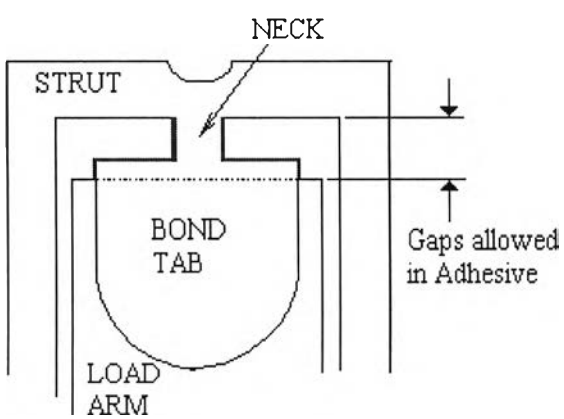

Figure 3.10 The visible gap allowed on the neck and bond tab area.

2) Gimbal Bond Shear Strength

Gimbal Bond Shear Tests must be done on a regular basis for all products, to monitor quality of adhesive and workmanship in the head-to-gimbal bond. This test will be performed in pattern of destructive test. HGAs will be tested with pushing slider away from flexure with tester until slider is peeled out from flexure. And then the maximum force that is used to push slider will be recorded as the bonding strength.

3) Roll Static Attitude (RSA) / Pitch Static Attitude (PSA)

RSA/PSA are important factors that will directly affect the fly performance and indirectly affect electrical performance of product because fly performance is sensitive to electrical performance. Due to this proposal is to eliminate smearing adhesive on the bond tab after applying one dot of adhesive on it and adhesive may flow to only one side of bond tab and results in unbalance of slider. In other word, slider may incline to only one side of HGA. And the reason why RSA/PSA is important factors of this study is to check the plane of slider. RSA/PSA, therefore, will be measured at SAAM operation in unit of degree because this measurement is to see the plane of slider in direction as Figure 2.11.

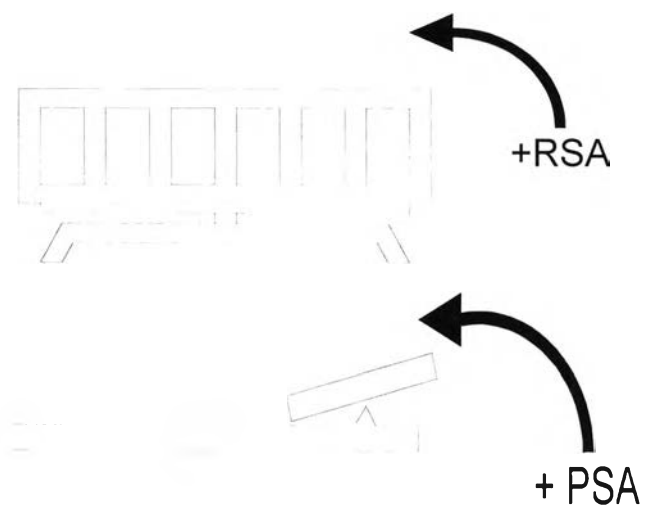

Figure 3.11 The static attitude of HGA in direction of Roll and Pitch.

RSA/PSA is one factor of this evaluation because there may be an impact from eliminating smearing adhesive on the bond tab. The thickness of adhesive at various area of bond tab may not be in the same plane and results in RSA/PSA change.

4) Fly test

This test is performed to test fly height of the heads while they are on operating media. They are tested on the fly tester. Due to Fly height is sensitive to storing and retrieving the data (electrical performance). Too low fly height may cause disc scratch that results in some track of information on media (disc) damaged. And too high fly height may cause low magnetic density to store and retrieve the data from media. RSA/PSA change is not only factor of fly performance but stiffness change from change in applying adhesive is also another one that may affect fly performance. But there is difficulty in measuring stiffness of gimbal therefore fly performance that is the end result of stiffness is measured to compare the performance between both groups. This study will focus on CRTE (Center Rail at Trailing End), sometimes called FH (Fly Height). CRTE is important parameter that is tested at Fly test because reader and writer are on the center rail trailing end. And this will be tested at both Inner Diameter of media called ID and Outer Diameter of media called OD.

5) Lifted flexure

The Pie wedge of JIT Tool that is laid on the load arm of flexure at Gimbal bond operation is to protect lifting of flexure when it is moved to next operation, Flex bond. But JIT Tool, actually, has two enough long locating pins on JIT Tool to align the flexure and slider and their length may protect flexure not miss its alignment and lift out from JIT Tool.

3.5.2 Evaluation Procedures

The evaluation is run to study effects of new applying method. The evaluation instructions are as followings;

1) Preliminary evaluation

This evaluation is to study the possibility of new method for applying adhesive to gimbal bond tab. Therefore, this evaluation is run by assembling 40 HGAs with new method for applying adhesive and inspecting the parts per gimbal bond criteria.

2) Functional effect evaluation

This evaluation will be performed after the result of the preliminary evaluation is accepted. Because this evaluation need to be run with more quantity of HGAs to compare the performance of three factors such as RSA/PSA, Fly test, and Shear test between current method and proposed method as the instructions below.

2.1) Build 250 pair of HGAs (250 up tab HGAs and 250 down tab HGAs) with current method through HGA assembly process. This group is celled "Control Group".

2.2) Build more 250 HGAs (250 up tab HGAs and 250 down tab HGAs) with new method for Gimbal bond operation and build them through other operations with current method. This group is called " Eval Group".

2.3) Separately record RSA/PSA data of both groups.

2.4) 100% Fly test of both groups and separately record fly test data.

2.5) Randomly select 70 HGAs of each group for Gimbal shear test. Because Gimbal bond shear test is destructive test, therefore, this test is performed on only 70 HGAs per group.

3) Mechanical effect for mass production

This evaluation is to study long term effect of new method of gimbal bond in term of mechanical defect. Therefore, this evaluation with proposed

method is performed on one HGA assembly line of Ultra4 product and collect the mechanical data for one week (six working days) and compare to the data from three weeks before. However, before this evaluation will be run, the result of functional evaluation must be summarized and be accepted already. Otherwise the parts produced in long run may not be usable.

3.6 Results of Evaluation

3.6.1 Evaluation Factors Effects

1) Preliminary result

From building 40 HGAs for preliminary evaluation, All of them were assembled through gimbal bond operation with new method of applying adhesive on the bond tab of flexure and all of them meet the gimbal bond specification per product criteria. Therefore, the functional evaluation will be allowed to run in next step.

2) Functional effect

There are four factors that will be studied the effect of new gimbal bond method. Furthermore, there are three of them that will be analyzed separately between Up tab HGA and Down tab HGA. Those are RSA, PSA and Fly test. In order to determine whether there are any differences in each factors, Minitab Software is an important tool that is used in statistical analysis. F-test in Homogeneity of variance is used to study effect of new gimbal bond method to standard deviation of each evaluation factors to know whether there is a significant difference between two populations' variance. And 2 Samples T-test is used to study effect of new gimbal bond method to Mean of each evaluation factors to know whether there is a significant difference between two populations' mean.

In determining whether there is a significant difference between the two populations' variances. The test begins by specifying Null Hypothesis and alternative hypothesis for testing *each evaluation factors* as followings;

H_0 : New Gimbal bond method does not effect standard deviation of evaluation factor.

Ha : New Gimbal bond method DOES effect standard deviation of evaluation factor.

The Hypothesis above can be transformed to statistical sentences as followings;

$$H_0 : 6_{Old} = 6_{New}$$

$$Ha : 6_{Old} \neq 6_{New}$$

As same as the Hypothesis testing of standard deviation, In order to know whether there is a significant difference between two populations' means, the test begins by specifying Null hypothesis and alternative hypothesis for testing each evaluation factor as followings;

H_0 : New Gimbal bond method does not effect mean of evaluation factor.

Ha : New Gimbal bond method DOES effect mean of evaluation factor.

The Hypothesis above can be transformed to statistical sentences as followings;

H_0 : Mean Old = Mean New

Ha : Mean Old $\neq$ Mean New

Result of Testing;

Homogeneity of Variance

By applying the statistical test, Homogeneity of variance test, to all evaluation factors of both groups, current gimbal bond method and proposed gimbal bond method, the result of Homogeneity of variance test are summarized and shown in Table3.2. The details of the tests are shown in Appendix A.

Factors	F-Test	P-Value	Result
RSA_UP	1.160	0.241	Not Significant
RSA_DN	1.090	0.499	Not Significant
PSA_UP	1.037	0.775	Not Significant
PSA_DN	1.045	0.730	Not Significant
FHID_UP	1.077	0.559	Not Significant
FHID_DN	1.078	0.554	Not Significant
FHOD_UP	1.008	0.949	Not Significant
FHOD_DN	1.009	0.946	Not Significant
Shear Test	1.321	0.250	Not Significant

Table 3.2 Summarized Results of Homogeneity of variance test.

Decision making on the results is performed on P-Value of each evaluation factor. For Hypothesis testing, the Confidential Interval of each factor was set at 95%(0.95). Therefore, P-Value of Homogeneity of variance test of each evaluation factor will be compared to 0.05 that is shown that difference is out of 95% Confidential Interval. From review each P-Value of each test of each factor, all of them are above 0.05. The result of F-Test of each evaluation factor shows that H0 are accepted while Ha are rejected. This implies there are **no significant difference** between two populations' variances of each evaluation factors. The statistical testing results conclude that the proposed gimbal bond method does not impact to *variances* of current HGA performances.

Two Sample T-Test

By applying the same statistical test to all evaluation factors of both groups, current gimbal bond method and proposed gimbal bond method, the result of T-Tests are summarized and shown in Table3.3. The details of the tests are shown in Appendix A.

Factors	T-Test	P-Value	Result
RSA_UP	0.370	0.710	Not Significant
RSA_DN	-0.780	0.440	Not Significant
PSA_UP	-1.300	0.200	Not Significant
PSA_DN	-0.970	0.330	Not Significant
FHID_UP	0.350	0.730	Not Significant
FHID_DN	0.360	0.720	Not Significant
FHOD_UP	0.070	0.940	Not Significant
FHOD_DN	0.070	0.940	Not Significant
Shear Test	1.180	0.240	Not Significant

Table 3.3 Summarized Results of two samples T-test.

Decision making on the results is performed on P-Value of each evaluation factor. For Hypothesis testing, the Confidential Interval of each factor was set at 95%(0.95). Therefore, P-Value of Two samples T-Test of each evaluation factor will be compared to 0.05 that is shown that difference is out of 95% Confidential Interval. From review each P-Value of each test of each factor, all of them are above 0.05. The result of T-Test of each evaluation factor shows that H0 are accepted while Ha are rejected. This implies there are **no significant difference** between two populations' means of each evaluation factors. The statistical testing results conclude that the proposed gimbal bond method does not impact to *means* of current HGA performances.

3) Mechanical effect

To study the effect in term of mechanical defect, new gimbal method is provided to gimbal operators in one cell and then start collecting data of gimbal defect per gimbal bond criteria for one week (six working days). The data will be compared to data of three weeks before. The result of collecting gimbal bond defect is shown in Table 3.4.

Result from implement new gimbal bond method on one cell for one week, **%Gimbal bond defect and mechanical yield look comparable with old gimbal method.**

	Current Method			Proposed Method
	WW43	WW44	WW45	WW46
Loading	63456	63066	63234	63270
Defect	7	9	8	8
%Defect	0.01%	0.01%	0.01%	0.01%
Mech Yield	99.35%	99.33%	99.36%	99.34%

** Defect in table means gimbal defect only.

Table 3.4 Gimbal defects that are detected on each day compared to three weeks before.

Lifted flexure is suspected to occur while the part is transported to next operation. Therefore, this evaluation factor will be monitored at next operation. Flex bond operation, that is the next operation to Gimbal bond operation, is assigned to focus on lifted flexure that should be found at this operation. Lifted flexure will be monitored at flex bond operation in parallel.

3.6.2 New Standard UPH

After the result of new gimbal bond method shows no significantly different to old gimbal bond method, motion and time study is performed again to measure time that is used for each new element performed at gimbal bond operation. And new motion and time standard are shown in Table3.5

Product	Ultra4
Operation	GIMBAL BOND
Date	May 18, 1999
Location	C52, C53, C83
Prepared by	TASBONGKOT D.

Element No.	Element	FREQ.	AVG. Time	Select Time	Rating	Normal Time
1	Pick up JIT Tool tray from Kanban	5	1.60	0.32	100.00%	0.32
2	Load JIT Tool to Flipper	1	2.11	2.11	100.00%	2.11
3	Load flexure to flipper arm	1	2.17	2.17	100.00%	2.17
4	Apply epoxy on flexure	1	3.18	3.18	100.00%	3.18
5	Flip flipper arm	1	1.45	1.45	100.00%	1.45
6	Support Pie wedge	0	0.00	0.00	0.00%	0.00
7	Unload JIT Tool to tray	1	2.32	2.32	100.00%	2.32
8	Pick up tray	5	2.20	0.44	100.00%	0.44
9	Move flipper out	5	2.00	0.40	100.00%	0.40
10	Inspect & send JIT tool tray to conveyor	5	5.80	1.16	100.00%	1.16
11	Record data	5	1.80	0.36	100.00%	0.36
12	Open flexure tray	30	12.30	0.41	100.00%	0.41
		Summation time (sec)				14.32
		Hour per piece				0.004
		UPH				251
		Capacity				14,232

Table 3.5 New motion and time that are performed at gimbal bond operation.

3.7 Conclusion of Evaluation and Control Plan

3.7.1 Conclusion of evaluation

1) Preliminary evaluation from 40 HGAs that were built with new method to study the possibility of new method that will be performed at gimbal bond operation with no defect. The result shows **no defect found per Gimbal bond criteria.**

2) Functional evaluation from building 250 pairs of HGAs is run to study the effect of new gimbal bond method to functional factors such as RSA, PSA, Fly performance, and Gimbal bond shear strength. The result of each factor was run through Minitab Software with Homogeneity of Variance test and Paired T-Test to see difference in each factor of both old method and new method. Decision making was performed through P-Value of each test by considering them with 95% Confidential Interval and all of them are above 0.05. **That means no significantly different between old method and new method.**

3) Mechanical effect evaluation from implementation new gimbal bond method on one assembly line for one week (six working days) to monitor mechanical effect in term of gimbal bond defect. The result from each day will be compared to data of that assemble line from three weeks before. From monitoring gimbal bond defect every day, **% gimbal bond defect was running around 0.01% and mechanical yield was running around 99.34% that are comparable to data of old method between three weeks before.**

4) Motion and time study is performed again by Industry Engineer to measure time that is used for each new element performed at gimbal bond operation. Motion and time of new standard of both old method and new method are compared as shown in Table3.6. Table show time used for performing each element and also show standard UPH and operation capacity. From this study, new method can improve standard UPH from 195 to 251 and also increase operation capacity from 11,063 units loading per cell per day to 14,254 units loading per cell per day.

		Old Method		New Method	
Element No.	**Element**	FREQ.	Normal Time	FREQ.	Normal Time
1	Pick up JIT Tool tray from Kanban	5	0.32	5	0.32
2	Load JIT Tool to Flipper	1	2.11	1	2.11
3	Load flexure to flipper arm	1	2.17	1	2.17
4	Apply epoxy on flexure	**1**	**5.63**	**1**	**3.18**
5	Flip flipper arm	1	1.45	1	1.45
6	Support Pie wedge	**1**	**1.68**	**0**	**0.00**
7	Unload JIT Tool to tray	1	2.32	1	2.32
8	Pick up tray	5	0.44	5	0.44
9	Move flipper out	5	0.40	5	0.40
10	Inspect & send JIT tool tray to conveyor	5	1.16	5	1.16
11	Record data	5	0.36	5	0.36
12	Open flexure tray	30	0.41	30	0.41
Summation time (sec)			18.45		14.32
Hour per piece			0.0051		0.0040
UPH			195		251
Capacity			11,057		14,232

Table 3.6 Compared data of time used for each element performed at gimbal bond operation.

3.7.2 Process Control Plan

From the results of evaluation, there is no significantly effect of new gimbal bond method to all evaluation factors of this study. Therefore, this new method is proposed to all 30-series HGAs with PCA (Process Change Authorization) official document. However to control the quality, process control plan is included in that PCA that is stated as following :

"Apply exactly one dot of adhesive to the center area of the bond tab, biased away from the horizontal strut. Do not spread or smear the adhesive dot. See Figure3.12 below."

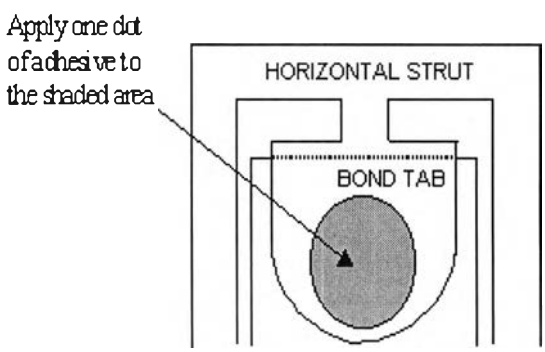

Figure 3.12 The center area of the bond tab that will be applied with exactly one dot of adhesive.