LEAN MANUFACTURING FOR THE HEAD GIMBAL ASSEMBLY (HGA) PRODUCTION

by

Mr. Norachet Saetang

A Final Report of the Three - Credit Course
CE 6998 Project

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
in Computer and Engineering Management
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Project Title	Lean Manufacturing for the Head Gimbal Assembly (HGA) Production
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The Graduate School of Assumption University has approved this final report of the three-credit course, CE 6998 PROJECT, submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer and Engineering Management.

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ABSTRACT

This project concentrates on how to apply the lean manufacturing concept with Head Gimbal Assembly (HGA) production by eliminating wastes and non-value-added (NVA) activities in the manufacturing process. For lean manufacturing, the wastes elimination concepts are fundamental to operation improvement by eliminating wastes. This project focuses on the work in process (WIP) reduction and elimination of non-value-added activities in production.

Seagate's strategies are geared toward creating world-class manufacturing processes with which lean manufacturing is adopted as part of the improvement endeavor. Currently, Seagate is producing the Head Gimbal Assembly (HGA) in Thailand. The HGA is the heart of hard disk drivers to read, write and transfer signals from the processing unit. To support Seagate's strategies, its production facility in Thailand needs to implement lean manufacturing concepts.

We eliminate wastes to reduce WIP in the production line and apply a statistical tool which is the Six-sigma technique to get rid of non-value-added activities in production. We reduce the unnecessary WIP by conducting a feasibility study and setting up the new standard level for WIP without an impact to capacity per line.

After applying the WIP reduction and elimination of non-value-added activities by a statistical tool, Six-sigma. The WIP can be reduced from 2,155 units to 1,671 units. Furthermore, the tooling costs per cell were slashed by 26,654 US$ or 1,039,526 bahts (1 US$ = 39 bahts). Seagate can also reduce 2 operators per cells at the Autogramer operation.

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I. INTRODUCTION

1.1 Introduction

Dynamic changes are underway with the hi-technology products such as Hard disks. Fundamental shift in the operations from manufacturing to product design to sales are being dictated by the owners need to evolve into a company that will lead and shape the market for hi-technology product.

Seagate Technology Company operates in a single industry segment by designing, manufacturing and marketing products for storage, retrieval, and management of data on computer and data communications systems. Seagate products include disc drives and disc drive components, tape drives and software. The company designs, manufactures and markets a broad line of rigid magnetic disc drives and disc drives components for use in computer systems ranging from notebook computers and desktop personal computers to workstations and supercomputers as well as in multimedia applications such as digital video and video-on-demand. Teparuk plant is a division of Seagate Company that its product is Head Gimbal Assembly (HGA). HGA is the heart of hard disk drivers, to read, write and transfer signals from the processing unit.

The computer has become one important factor as a basic need that provides convenience for every level of human kinds. Now, hard disk drivers are higher in demand and also high competitive in the current market. Seagate believed cost and customer were king; low cost manufacturing cost was the formula for success and also time-to-market.

Through innovation, Seagate already is achieving recognition in the industry for its advances in technology and its new proactive operating strategies. Innovation, led by the lean manufacturing strategy and employees worldwide, will transform Seagate to the world-class manufacturing company. Consistently successful, efficient, and the leader that the competition struggles to catch up with.

The ways in which a business can grow and increase its profitability are by increasing its productivity and decreasing its unnecessary costs. Productivity improvement refers to the increase in output per resource put into that activity. The resource include land, building, material, machine, tool and labor. For labor intensive manufacturing, the company's productivity often refers to the increase in output of goods divided by total work-hour or number of workers employed. The cost reduction refers to decrease the inventory of raw material, work in process (WIP) reduction, the tooling cost equipment cost and Labor cost by eliminating non value added activity etc.

This project is a part of many projects which Seagate has adopted and adapted for the lean manufacturing concept to implement with the current and future production line. Seagate expects to gain a big productivity by takeing advantage to reduce throughput time of HGA, to support time-to-market in supply chain, to reduce work in process (WIP) in production line, tooling cost investment, and to eliminate non-value-added (NVA) activity from this project.

1.2 Objectives

(1) To reduce throughput time of HGA to support time-to-market in supply chain.

(2) To reduce work in process (WIP) in production line.

(3) To eliminate non-value-added (NVA) activity by Six Sigma statistical tool.

1.3 Scope of Project

The project scope is aimed to study and apply the lean manufacturing concept to the production line of HGA assembly. The project will focus on work in process (WIP) reduction of production line of HGA and the example of eliminated non-value-added

(NVA) activity by statistical tools. The WIP reduction can be classified into 3 phases as Feasibility phase, Evaluation phase and Implement phase. The elimination of non-value -added (NVA) can be classified into 4 phases including Measurement phase, Analysis phase, Improvement phase and Control phase.

1.4 Deliverables

(1) To reduce throughput time of HGA assembly and reduce working in process (WIP) manufacturing line to support supply chain.

(2) To reduce tooling investment per cell.

(3) Eliminate non-value-added (NVA) operation.

II. LITERATURE REVIEW

Lean production started as Toyota's answer to the American assembly that it could not afford to replicate. Also, the Japanese had no wish to import, along with the technical know-how, the problem that plagued U.S. mass production, such as a high number of defective parts, huge inventories, and badly organized human and material resources. The new system, with its highly measurable improvements reduction of waste, lower inventories, sophisticated benchmarking, and a productivity rate of 20 to 30 percent higher for Japanese workers compared to their European or American counter parts- was soon copied everywhere. Now adopted by the world motor industry, Lean production can mean using about half the traditional factory space and about one-tenth the inventories. With faster product development and dramatically improved quality and productivity, lean organizations also find a payoff in lower cost and the ability to bring out different models faster, at higher volumes, and with higher quality.

The method does come under heavy criticism, especially from unions, which see it as a mean to undermine them. Yet integrating efficiency with quality resembles the principle of constant improvement that the Japanese call Kaizen, "The never-ending quest for perfection" (Peter 1987).

Lean production depends on such practices as just-in-time (JIT) manufacturing, the cycle time management in which a precise number of part are delivered to the assembly line right before they are needed. JIT can be a powerful inventory system, but it depends on a supplier/manufacturer relationship base on trust: small supplier that has to bend over backward to accommodate a client- usually a large corporation- will often ask to be the sole supplier. The manufacturer, on the other hand, needs to be able to call on other sources when the habitual one fail.

Cycle time reduction (CTR), also called time-based management is an effective way of making sure that actual work is being done during the time spent to make a product. At AlliedSignal, one of the corporations that has made spectacular use of CTR, managers found that actual work was being done only 10 to 20 percent of the time of entire process. For instance, it was taking two weeks far apart to go from receiving dock to storeroom and the time reduced now to two hours! Through mapping out, and time-consuming steps, or downtime, such as waiting for work order to be signed, can be eliminated.

2.1 Eliminating Waste

2.1.1 Waste

Fujio Cho of Toyota defines waste as "anything other than the minimum amount of equipment, materials, parts, space, and worker's time, which are absolutely essential to add value to the product" (Peter 1987).

As early as the 1920s Henry Ford was concerned with the problem of waste. He discussed it specifically in his book Today and Tomorrow, which Toyota people diligently studied later. To put it in simple terms, "If it doesn't add value, it's waste."

When we review the time people spend in the factory, for example, we often find that more than 95 percent of an operator's time is not being utilized to add value to the product. Rather, it is adding cost to the product. When we measure the material being processed in the factory, we may also find that, during more than 95 percent of the time, that material is in storage, waiting to be transferred, processed, or inspected. Similarly, a machine may be producing unnecessary or defective products, or it may be broken down or may require maintenance. In either case, it is obviously not being used to add value to the product.

People may say, "We know all of that." But the questions we should ask ourselves are, "Then what are we actually doing to reduce this waste?" "How much of our time is spent on eliminating this waste?" "Do we really know how much of this waste can be eliminated?" "Do we really know how much dollar savings can be achieved through such efforts?"

Unfortunately, most of us cannot answer these questions. One thing we should remember is that a lot of work requires immediate action. The urgency of such matters can keep us from analyzing and planning our work. We may feel we have accomplished more when we spend time on urgent work and exhaust ourselves. But is it really a productive way of using our time? The following portion of this chapter is devoted to answering these questions.

2.1.2 Seven Wastes

What we are talking about here is the need to introduce production improvement practices where the action is taking place, that is, on the shop floor. By diligently practicing problem solving with as many people as possible, many of our current problems will disappear.

While each person's ideas will be used to facilitate the improvement of factory operations, the most powerful results can be obtained by implementing improvement activities in the most integrative fashion so that each island of improvement can be tied together with the others. Also, we want to develop certain approaches to facilitate these improvements so that the improvement process becomes effective. In order to achieve such goals, we need to understand more about waste in the factory.

While products made in each factory may be different, the typical wastes found in factories are very similar. After years of improvement activities, Toyota identified the following seven types of waste as the most prominent ones. The Wastes can be classified as follows:

(a) Waste from overproduction

(b) Waste of waiting time

(c) Transportation waste

(d) Processing waste

(e) Inventory waste

(f) Waste of motion

(g) Waste from product defects

Waste from overproduction. Toyota concluded that overproduction was one of the worst wastes commonly found in factories. This waste is created by producing goods over and above the amount required by the market. When the market is in an upswing, this waste may not be prominent. However, when market demand slows, the effects of overproduction are compounded and companies often get into trouble carrying unsold goods as extra inventory.

Overproduction waste is typically created by getting ahead of the work. When this happens, more raw materials are consumed and wages are paid for unneeded work, thereby creating unnecessary inventory. This in turn requires additional handling of materials, additional space to hold inventories, and additional interest paid to the bank for money used to carry the inventories. It may also require additional people to monitor inventories, additional paperwork, extra computers, more forklifts or warehouse space, and so on.

Furthermore, excessive inventory leads to confusion about what needs to be done first. It also distracts people and prevents them from focusing on immediate objectives or tasks. As a result, for additional production control, people are required. Since operators seem busy and machines are occupied unnecessarily, additional equipment may be purchased on the mistaken assumption that it is needed.

Since overproduction creates difficulties that often obscures more fundamental problems, it is considered one of the worst wastes and should be eliminated. In order to do so, we first need to understand that machines and operators do not have to be fully utilized, as long as market demands are met. (This may seem odd to many people, but it makes sense.

Operators at each stage of production should think of the next process as their "customer" simply because the next process involves working on the product produced in the previous process. We should make sure that only the amount required by the customer is produced, at high quality, low cost, and at the time needed.

Waste of waiting time. While waste from overproduction is not always easy to identify because the operators appear to be busy (even though their work does not add value to the product), waste of waiting time is usually easy to identify.

In fact, waste in the form of waiting should be exposed, so that corrective action can be taken. For example, instead of occupying machines to overproduce good, operators should remain idle when the required amount of work is finished. With this practice in place, supervisors can thus better assess the capacity and control the situation more readily.

If we look around the factory, we also find operators simply watching machines run. Some may say that machines must be watched so that corrective action can be taken quickly whenever a problem arises. But is that not already too late for an operator to take action? Shouldn't there be a mechanism that automatically stops the machine and buzzes or lights up to alert an operator when an abnormal condition occurs?

Another way to look at this is that there will be no initiative to eliminate the causes of such problems because these problems are not being exposed clearly to the supervisor's eyes; instead they are often resolved by operators without a supervisor's knowledge. Even though some supervisors may prefer to ignore such problems as long as production schedules are met, should such practices be allowed?

Transportation waste. Transportation waste and double or triple handling are also commonly observed wastes in most factories. For example, incoming material may be stored in the warehouse before it is brought to the line. With such a practice, a tracking person has to be informed where to pick up the material, where to store it in the warehouse, where and when to pick it up again, and where to deliver the material down the line. He may even have to bring materials left over from the line back to the storage area if there is a lack of coordination.

Ill-planned layouts may make long-distance transportation necessary. They can also result in double or triple handling of parts that have been put away in a disorderly manner and then kept in temporary storage and switching storage locations. Often we are amazed to discover how many miles a product must travel through the factory before it is completed.

In order to eliminate this waste, improvement in layout, coordination of processes, methods of transportation, housekeeping, and workplace organization need to be considered.

Processing waste. The processing method itself may be a source of problems, resulting in unnecessary waste. For example, a certain die-casting operation may require additional labor to file and finish the surface. But a finishing operator may be quite unnecessary if the die is maintained well or if manufacture ability has been considered in the product design.

Also, in manufacture of the products, certain aspects of the painting, sealing, or bolt-tightening processes may be unnecessary in meeting product requirements.

When fixtures are not well maintained or prepared, operators may have to use extra effort in processing the materials. Certain defects may be produced by these inappropriate processing procedures.

Certain fixture may be added or modified to facilitate operation of a machine. For example, the use of an air cylinder or chain and sprocket may help to automate the machine drilling operation. Similarly, the power of the drill machine motor may be used to eject the finished product automatically. Also, the combination of a gravity chute and fixture may make automatic loading possible, thereby totally eliminating operator involvement.

<u>Inventory waste.</u> As discussed above in connection with waste of overproduction, excess inventory increases the cost of a product. It requires extra handling, extra space, extra interest charges, extra people, extra paperwork, and so on.

Because of the problems associated with unnecessary inventory, we should consciously try to reduce inventory levels.

(a) Dispose of obsolete materials (housekeeping/workplace organization).

(b) Do not produce items not required by the subsequent process (line balance).

(c) Do not purchase or bring in items in large lot sizes (savings achieved through volume discounts, may be more than offset by inventory waste).

(d) Manufacture products in small lots (reduced setup time/more changeovers).

As we are going to reduce inventory levels, we may find more problems that need to be addressed before the inventory level can be reduced further.

Because of many problems associated with inventory, we need to pay more attention to clearing out the waste associated with inventory. To emphasize this point, let's just say that excess inventory is the root of all evil.

Waste of motion. Whatever time is not spent in adding value to the product should be eliminated as much as possible. One fact we should constantly bear in mind is that "move" does not necessarily equal "work":

An operator may keep "busy" for three hours looking for tools all around the factory without adding even a penny of worth to the product. Instead, he has increased the cost of the product by three hours of his wages together with three hours of production lead time before delivery of the product to the customer.

We can find many other examples of this kind of waste. *Pick and place* is another example of movement that can be reduced by keeping parts or tools closer to where they are used -or even eliminated by using chutes and other fixtures.

Walking is another kind of wasteful movement, especially when one person is responsible for operating several machines. Machines should be placed so that the operator's walking time is minimized.

Waste from product defects. When defects occur at one station, operators at subsequent stations waste time waiting, thereby adding cost to the product and adding to production lead time. Furthermore, rework may be required or the defective products are scrapped. If a defect has occurred in the assembly operation, additional labor is required for re-assembly. Obviously, schedules must be adjusted to accommodate these changes.

Sorting out bad parts from good parts also requires additional labor. There is a waste of both the materials and the value of work already added to the parts.

An even worse case exists when customers find defects after product delivery. Not only are warranty costs and additional delivery costs incurred, but future business with the customer as well as market share may be lost.

To eliminate these problems, a system must be developed to identify the defects or the conditions that produce defects so that anyone present can take immediate corrective action. Without such a system, other time-saving advances are futile. Highly industrialized countries are introducing more automated machines that are capable of producing products in a short time period. However, these machines will also produce defective products at a very fast rate unless a better preventive system is developed.

2.1.3 Simplify, Combine, and Eliminate

The difficulty in eliminating waste is that most of us have not directed our efforts to finding waste and eliminating it. But with more conscious effort, everybody should be able to practice this, After all, it is said that 90 percent of improvement comes from common sense. Most improvement seems so basic after the fact that people wonder why they did not think of it before. In order to acquire these skills, however, certain principles of improvement will help so that we do not have to reinvent the wheel.

Industrial engineering techniques can be basic to improving operations. But though some people may feel that improvement activity should be left to the industrial engineers because "they are paid to do it," this is not the case. We can all contribute to the improvement process. After all, who knows better about the work areas than the operators? The basic idea of improvement is simple. We want to do our work easier, faster, cheaper, better, and safer. To do so, a basic approach to improve our operations is to simplify, combine, and eliminate.

2.2 Six Sigma

Six sigma is a statistical tool that is an approach to improve our operations to simplify, combine, and eliminate without quality effected and based on the statistical data that also is to improve the quality tool for our production.

2.2.1 What Is Six Sigma Product Quality?

The six sigma concept is a relatively new way to measure how "good" a product is. When a product is six sigma it tells us that product quality is excellent. It says the probability of producing a defect is extremely low.

In order to make more understanding as to how six sigma tells us that a product is excellent, let us define what the term "sigma" actually means in terms of quality. Essentially, a sigma is a statistical measuring device that tells us how good our products are. Using this device, we can directly measure the quality with confidence we would have in a given product or process and then compare it to another like product or process. To make things nice and simple we will substitute the symbol "a" for the word "sigma".

To apply this concept, we must first determine how many opportunities there are for a nonconformity or defect to occur, as related to a particular product. Then, we must count the actual number of defects associated with that during manufacture. With this information we are now able to determine how many defects there are per million opportunities for a defect. For example, if there are 1,000,000 opportunities for a defect to occur within each of our five ratios and we observe five defects (one defect per ratio) then there will be one defect per million opportunities or, expressed as a fraction, 0.000001 nonconformities per million opportunities (npmo). Note that this also may be expressed as parts per million (ppm.)

When the number of sigma units or "a's" is small, say two, product quality is not very good. The number of defects per million opportunities for a defect would be intolerable. When the number of σ's is large, say six, quality would be excellent. The number of defects per million opportunities would be extremely small.

In general, when we say that a product is 6o, what we are really saying is that any given product exhibits no more than 3.4 ppm at the part and process step level. This number takes typical sources of variation into account. That is to say, the 66 quality concept recognizes that a small amount of variation will be present as a result of slight fluctuations in environment conditions; differences between operators, parts, materials; and so forth. If the fluctuations can be sufficiently controlled such that a product or process characteristic stay centered on its ideal condition, there will be only 0.002 non-conformities per million opportunities. However, nothing can be perfectly controlled to an ideal condition, some shifting and spread will be presented over the long haul. When such variation is taken into account, there would only be 3.4 ppm.

In order to help ensure that typical forms of variation — shifts and drifts in the average — do not cause excessive differences between and within units of product, there are several things that can be done.

(1) First, Designers configure a product in such a manner that its performance is "shielded" against variation. By doing this, the organization can ensure that its products will consistently perform to the specified levels; i.e. all of the product will be on target with minimum differences between units of product. When designers do this, we say they are "designing for product ability".

(2) Second, The thing that can be done is related to the manufacturer's process as well as the process of its suppliers. By systematically tracking down,

controlling and ultimately eliminating the root causes of variation through the application of statistical process control (SPC) methods, the "spread" and "centering" of processes can be significantly improved.

When these things are done and the end result is the product whose opportunity for the error at the part and process step levels is, on the average, no more than 3.4 ppm, we say that the product is 66.

To better understand this concept, let us look at Table 1 so that we can see how many nonconformities, or defects per million opportunities, there would be for several different 6's under two different conditions.

Table 2.1. Sigma (a) Quality Levels: before and after a 1.56 Change in the Average.

Sigma	ppm	
	Without change	With change
1	317,400	697,700
2	45,400	308,733
3	2,700	66,803
4	63	6,200
5	0.57	233
6	0.002	3.4
7	0.000003	0.019

2.2.2 How to Achieve 66 Quality?

In order to achieve 66 quality, we must recognize that product variation results from insufficient design margin, inadequate process control, and less than optimum parts and material. These are the three primary sources of product variation. If we are to achieve 66 quality in everything we do, including administrative things such as filing, typing, and documentation, we must isolate, control and ultimately eliminate the variation.

To defeat the variation, we must recognize that any deviation from an ideal condition, no matter how small, represents a potential loss to our customers, as well as to ourselves. There are some of the tools that can help us conquer this variation which includes:

(a) Short cycle time manufacturing (SCM)

(b) Design for product ability

(c) Statistical process control (SPC)

(d) Supplier SPC (SSPC)

(e) Participate management practices (PMP)

(t) Part standardization and supplier qualification

(g) Computer simulation

Not only do these tools help us remove the variation while the product is being built, but they also help us detect the presence of the variation before we go into production. In this manner, we are able to prevent product casualties before they happen. We call this "a prior" control — control that is gained before the fact, not after something goes wrong. If we do not do these things, chance is in charge; by doing them, we are in charge.

There are three basic strategies for winning the variation. First, we must gain a prior control during the product and process design cycle. To do this, we must:

(1) Define 66 tolerances on all-critical products and process parameters.

(2) Minimize the total number of parts in the product and minimize steps that comprise all processes.

(3) Standardize the parts and processes we use.

(4) Use SPC principles and computer tools during the design and prototype phases.

The second strategy involves using SPC to continually isolate, control, and eliminate variation resulting from people, machines, material and environment. The third strategy involves the supplier. Our supplier must also continually strive to eliminate variation in the parts and materials we purchase by:

(1) Instituting a supplier qualification program that is, in part, based on SPC principles.

(2) Requiring process control plans from our suppliers

(3) Minimizing the total number of suppliers that are used.

(4) Ensuing a long-term "win-win" partnership with the suppliers that are used.

2.2.3 Six Sigma Process Steps

If we believe that a product design should be judged on the basis of how well it integrates various elements to achieve some output, in the most efficient and cost effective manner possible, then a manufacturing process should likewise be assessed. In reality, there is no real difference between a "design" and a manufacturing "process" from an analytical point of view. Both things have elements, sub-elements, sub-subelements, and so on, ad infinitum. In both cases, there exists a hierarchy of causation. Even though the "nuts and bolts" are different, they both process a form of order. This order may be expressed using the following relation:

$$Y\ f\ (X_i \ldots\ldots X_N)$$

Where Y is a certain output parameters and X_1 XN are the various input and process factors. The relationship defined in above relation is to say that Y is dependent upon the Xs. The value of Y must wait upon the value of X. In short, Y is dependent upon the condition of the Xs and, conversely, the Xs are independent of Y condition. From a design point of view, a product performance requirement (Y) is dependent upon the nominal values and specification limits of the components assigned to the design. So, it goes with manufacturing.

The overall ability of a manufacturing process to consistently produce a high-quality end item is highly dependent on the capability of the individual steps that comprise that process. In turn, the capability of any given process step is determined by the degree of capability related to and the subsequent control of, the underlying factors or " variables" as they are often referred to. For example, soldering is a function of such variables as flux specific gravity, solder machine chain speed, solder temperature, and copper mass, just to mention a few. As we are all aware, not all process steps or variables equally impact the quality of the product; some are more influential than others. In the same manner those design engineers strive to isolate the quality-sensitive components that exert an undue influence on product performance, the manufacturing, process, and quality engineers must isolate those process steps and related variables that exert undue influence on the various characteristics and performance requirement tied to the product. Once the critical steps and related variables are known, the engineers must then strive to establish 6a control.

Essentially, 6a process capability can be realized through a relative simple four - phase approach; Measure, Analysis, Improve and Control phase. The first phase, Measure, is related to process definition. This involves physically defining the limits of the process — where it begins and ends in relation to the total manufacturing flow. Figure 2.1 illustrates the nature of such a flow. By doing this, the limits of the battlefield are defined. Also during this phase, all of the key inspection and test parameters are identified. In addition, by means of brainstorming, all of the known independent parameters are established. In turn, these factors are formed into a Cause and Effect (C&E) matrix in order to provide process "scorecard" see Figure 2.2.

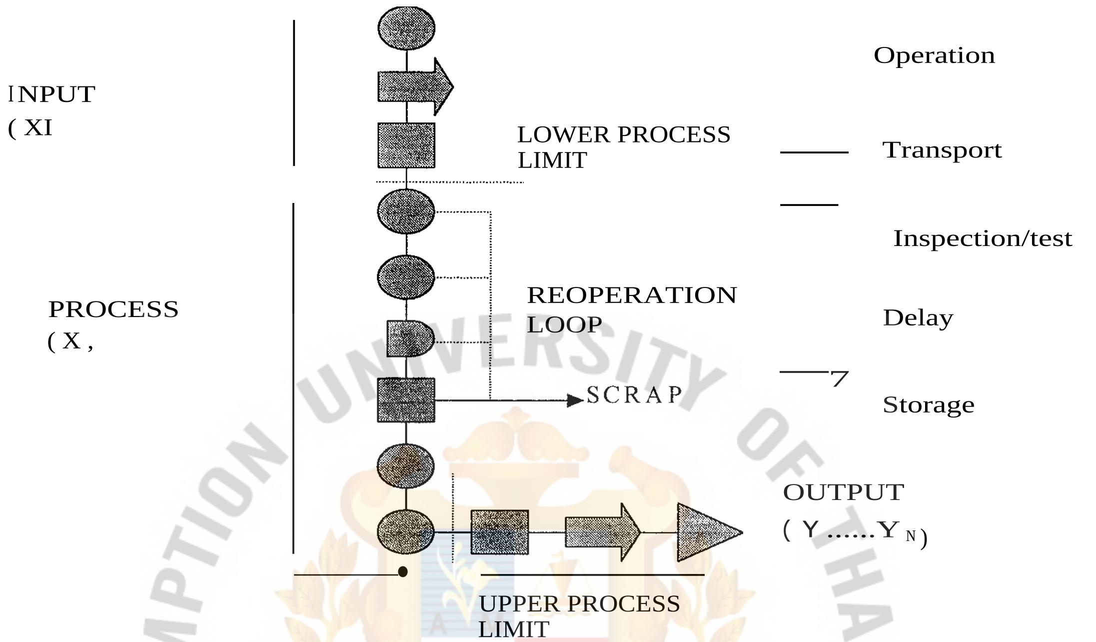


Figure 2.1. Sample Process Flow Diagram Showing the Process Limits.

EFFECT:

EFFECT: PRODUCT PARAMETERS

(IMPROVEMENT OPPORTUNITIES)

PRODUCT PARAMETERS (CASUAL VARIABLES)

	YI	Y2	Y3	YN
x1	4	3	-	1
x2	-	2	2	6
x3	5	7	10	4
x4	3	5	-	3
XN	-	4	5	9

Figure 2.2. Sample Cause and Effect Matrix.

Phase two, Analysis phase, establishes the capability of the process to attain a certain level of quality with respect to the key product parameters. Such analyses are performed at two levels. First, a macro, or global, capacity study is undertaken using discrete or attribute data. This establishes the overall process by expressing process performance in a units and C_p. In addition, such indices provide a means to benchmark the process under consideration against like processes. When this is done, more informed process engineering decisions can be made with regard to future process design efforts. Should the outcomes of the macro capability study provide undesirable result, a microanalysis is undertaken. Basically, a microanalysis involves stratifying the product quality data using Pareto diagrams in order to prioritize subsequent optimization efforts during phase three. Also, it is possible that at this point, there may be a need for collecting continuous data at the variable or "knob" level so that such things as " parameter control efficiency" can be assessed in relation to the 66 model.

Phase three, Improve phase, is related to the optimization of those characteristics identified during the micro capability study. The intent here is to improve quality performance by reducing the influence of the underlying cause system. This is accomplished by deriving realistic operating tolerances for the "vital few" variables within the cause system. To do this, the engineer must first determine which variables, as related to the key process steps, are "leverage" in nature. In other words, the engineer must first determine which of the factors are variations sensitive. Such identification is most often accomplished through the use of multi-vari charts, statistical graphs, brainstorming techniques, fractional factorial experiments, Taguchi style arrays, etc. In short, the tools of statistical process control (SPC) are applied to track down the sources of product and process variation.

Next, the functional limits (LFL and UFL, respectively) must be defined for each of the vital few factors. Usually this is accomplished with statistically designed experiments such as full factorial and response surface matrices. The reason for this is in order to adequately improve a process, existing nonlinear and interactive effects must he surfaced in order to know how to best prescribe settings for the critical process parameters. One must be able to take advantage of such things if an improvement is to occur. The classical one factor-at-a-time approach will not do. This approach is inefficient and cost prohibitive and often not capable of surfacing optimum conditions. The end result of this step is a set of "predictions limits" for each of the vital few variables. In other words, the optimization experiments allow the required functional limits, or realistic tolerance, to be defined such that a product characteristic behaves to the desired.

Following this step, the engineer must match the new performance capability related to the vital few factors to the 66 performance model. This step is most often achieved by comparing real time performance data, normally displayed in the form of a histogram, to the experimentally defined realistic tolerance width. If the +/-3G range of histogram only consumes 50 percent of the realistic tolerance, then the variable would be said to be "capable of 6c7 control". Given this condition, $C_p = 2.0$. If $C_pk < 1.5$, then the variable would be expended to adjust the parameter mean back on the target such that $C_pk > 1.5$. If this is done, then one would expect the parameter to exceed the UFL and LFL only 3.4 times, or fewer, out of every 1,000,000 manufacturing cycles, assuming a cause system that exhibits typical shift and drifts.

If the criteria for 6o capability is not met by this point in time, the engineer has three choices which are:

(1) Track down and eliminate the sources of variation if the parameter displays a great deal of nonrandom variation, assuming it would be economical to do so.

(2) Replace or otherwise modify the technology if the parameter does not meet the criteria but is free of " assignable causes".

(3) Alter the process to " desensitize" the critical variables, therein allowing the functional limits (UFL and LFL) of those variables to be redefined such that the +/-66 limits of the natural process distributions are compatible with their respective realistic tolerances. In this sense, the 66 manufacturing model would be achieved by:

   (a) Desensitizing the leverage factors.

   (b) Establishing guard-bands on those factors that still exhibit a moderate form of leverage.

   (c) Opening the functional limits of the "trivial many" factors which are relative non-influence.

A manufacturing strategy along these lines is far more efficient, not to mention more cost effective, than simply "guard-banding and automating everything in sight". Obviously, a fourth option would involve some combination of the alternative just mentioned.

Phase four, Control phase, is most tied to the classical uses of SPC — parameter monitoring and control. Once the vital few variables have boon optimized, they must be controlled within their realistic tolerances. If this is not done, the attribute control charts associated with the product performance characteristics will display unfavorable variation, In this sense, the charts will signal the alarm when a problem is about the surface. As may be apparent, the primary issue related to this control phase that is one of a prior control—discovering signs of future problems and correcting them before they occur as the corrective action plan.

III. HEAD GIMBAL ASSEMBLY (HGA) MANUFACTURING PROCESS

3.1 What Is the HGA?

Head Gimbal Assembly (HGA) is a disc drive components whose function is to read and write data from the storage device. An HGA is composed of three main components which are Slider, Flexure and Flex on suspension (FOS), as illustrated in Figure 3.1. Cheetah 36 is one kind of HGAs product that was developed for the high-end product.

Figure 3.1. HGA Components.

3.2 HGA Manufacturing Process Flow

HGA manufacturing has many process steps and operations to produce part. The process flow of HGA is shown in Figure 3.2.

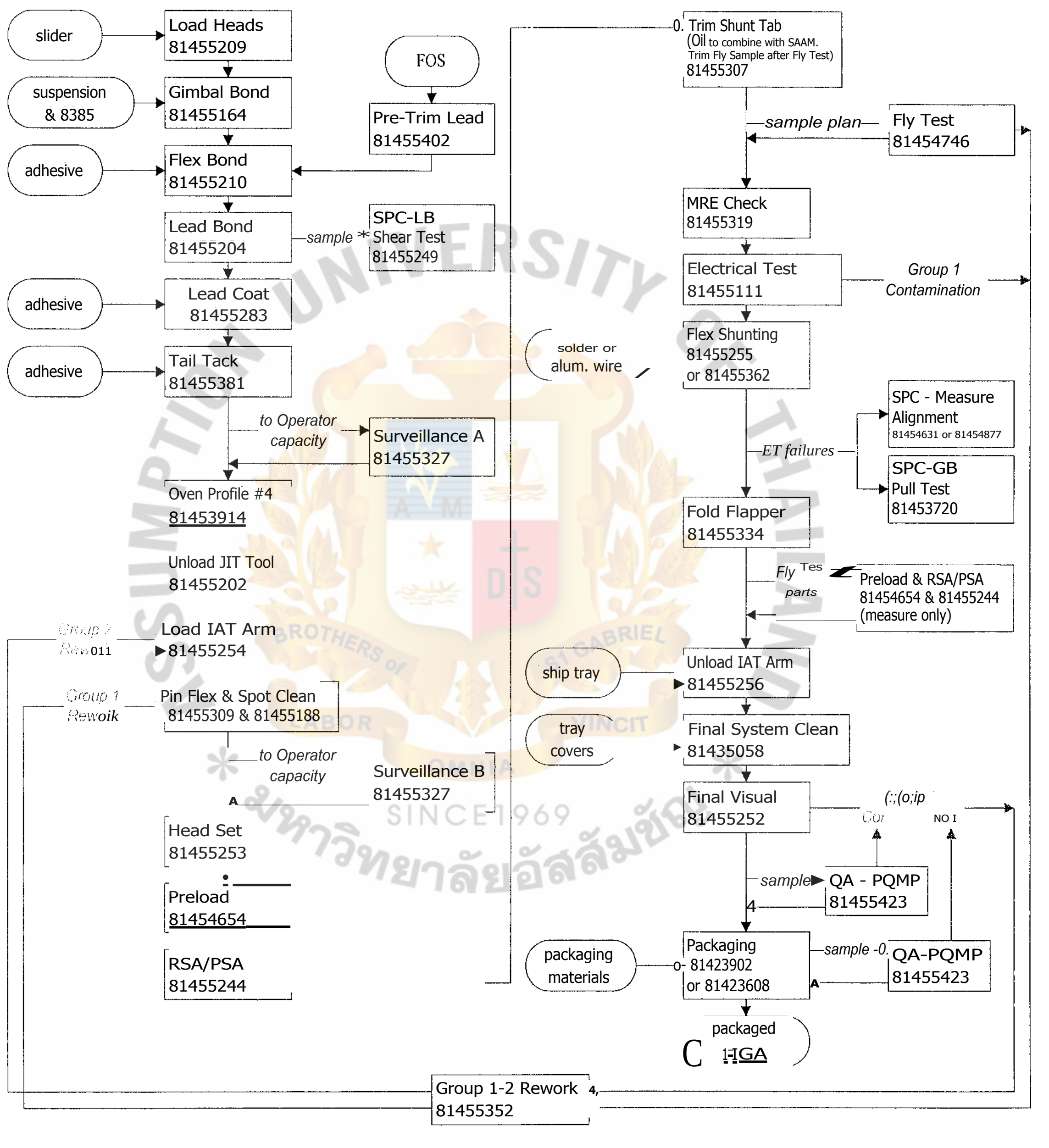


Figure 3.2. HGA Manufacturing Process Flow.

3.3 HGA Manufacturing Process

HGA Manufacturing Process is the process to assemble sub-assembly parts, which compose of Slider, FOS and Flexure, to be a HGA or Recording head. The process is operated manually and it mainly uses an epoxy to adhere the components. The description of each operation of this process is provided below:

3.3.1 Pretrim Operation

Pretrim Operation is the operation that is to cut the lead capture of an incoming FOS before an assembly process. Its procedure is provided as below:

(1) Position the flex on the fixture inserted by placing the front tooling hole and the back slot of the flex on the guiding pins

(2) Cut the lead capture by pressing the blade handle

(3) Remove the flex from the fixture

(4) Place the flex back into the tray and stage for the next operation.

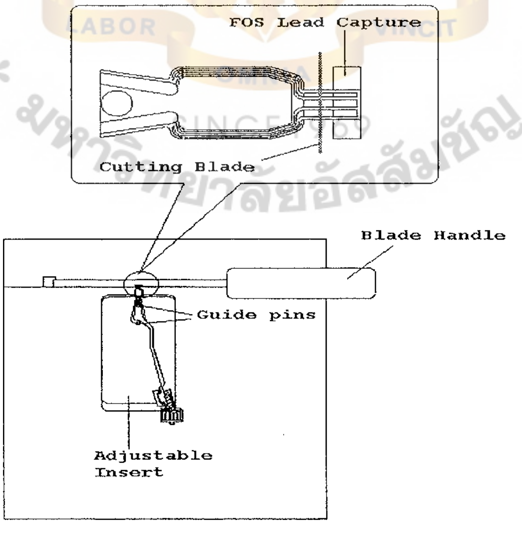


Figure 3.3. Pretrim Fixture.

3.3.2 Head Load Operation

Head load operation is the first operation of HGA assembly process whose purpose is to load slider into the jit tool which is one kind of jig for caning the component part along with it. Its processes are as below:

(1) Turn the jit tool upside down (suspension Clamp/Flex clamp down) and place the jit tool in between the jit clamp and the alignment pins. The slider pocket of the jit tool should be on the table of the inverted head loader.

(2) Actuate the toggle switch. This will close the jit clamp and then open the template.

(3) Using an Electro Static Discharge (ESD) safe plastic tweezers, pick up a slider — Air Bearing Surface (ABS) up- and place it into the pocket of the jit tool.

(4) With the end of the tweezers apply a light pressure on the trailing end of the slider. While holding the slider in place actuate the toggle switch to clamp the slider and release the jit tool clamp. This will ensure that the slider is seated in the X-direction.

(5) Remove the jit tool from the inverted loader. Turn it right side up (suspension clamp/Flex clamp up) and place it in the oven tray.

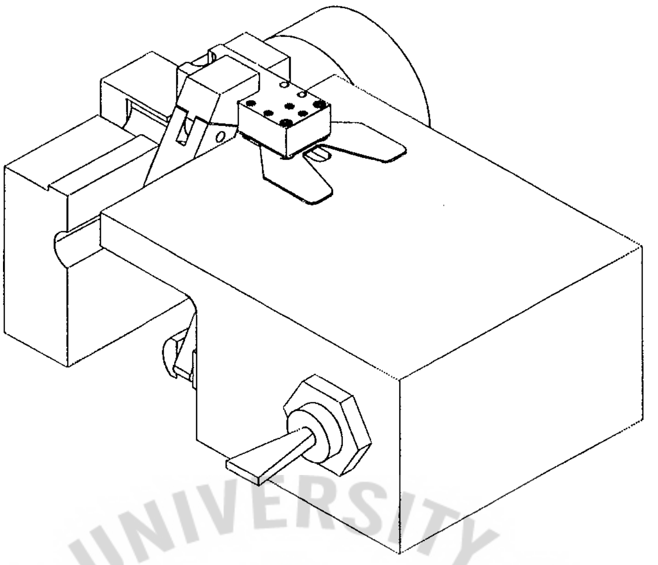


Figure 3.4. Head Load Components.

3.3.3 Gimbal Bond Operation

The purpose of Gimbal Bond Operation is to attach the slider to Flexure by using an adhesive, Ablebond 8385, as a bonder. The processes of this operation are provided below:

(1) Obtain Flexure for bonding.

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

(3) Using the vacuum tweezers only, pick up a spring and place it onto the flipper. No fingers should be used to manipulate the spring into position on the flipper.

(4) 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.

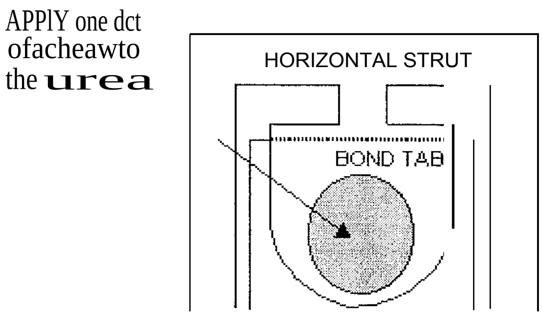


Figure 3.5. Adhesive Application Procedure.

3.3.4 FOS Bond Operation

The purpose of FOS Bond Operation is to attach FOS to Flexure by using an adhesive, LD227. The procedures of this operation are as follows:

(1) Obtain the FOS for bonding.

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

(3) Using the vacuum tweezers only, pick up a FOS and place it onto the flipper. Do not use fingers to manipulate the FOS into position on the flipper.

(4) Apply the adhesive to the correct flex locations.

(a) Dot 1 should be located between the tooling hole and the gimbal widow. Apply a dot of adhesive approximately 10 mils in diameter.

(b) Dot 2 should be located on the FOS over the vacuum hole in the FOS flipper fixture. Apply a dot of adhesive approximately 75% the diameter of the vacuum hole.

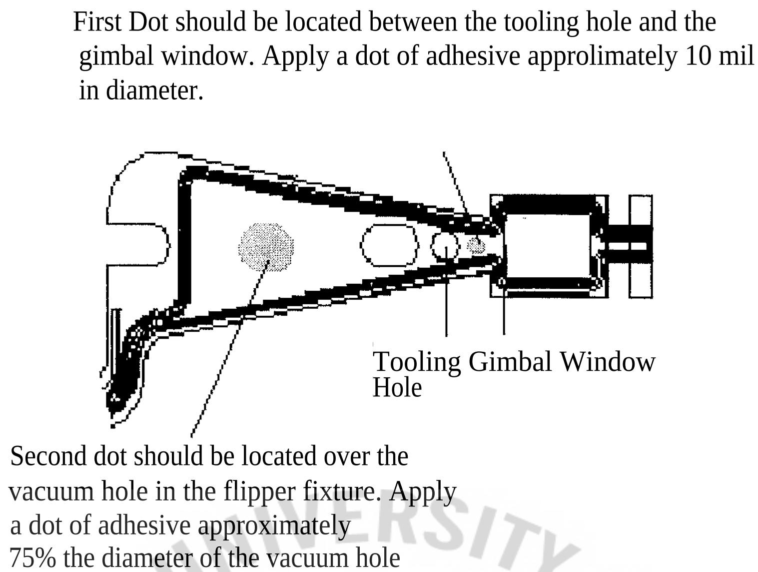


Figure 3.6. FOS Bond Procedure.

(5) Rotate the flipper counter-clockwise and release vacuum on the part, allowing the FOS to fall onto the alignment pins of the tool. Then rotate flipper clockwise to start position.

(6) Using a pin vise, place the Flex Clamp onto the spring. The correct placement of the Flex Clamp is aligned over the alignment pins on the jit tool.

(7) Release the cam, remove the jit tool and place the tool into the carrier tray.

3.3.5 FOS Lead Bond Operation

The purpose of Lead Bond Operation is to bond lead to the slider pad by using an ultrasonic. The procedures of this operation are provided as below:

(1) Install the loaded jit tool on lead bond holding fixture. Secure in place with fixture toggle switch.

(2) Locate the lead form roller on top of the left holding fixture arm. Form leads by pushing it to the right.

(3) With the manipulator handle, position the bonding tip completely over the lead. Locate the bond tip relative to the end of slider pad.

(4) Visually inspect if any leads have lifted. If none of the leads have lifted, the HGA may be sent to the next operation.

(5) Release the jit tool from the holding fixture.

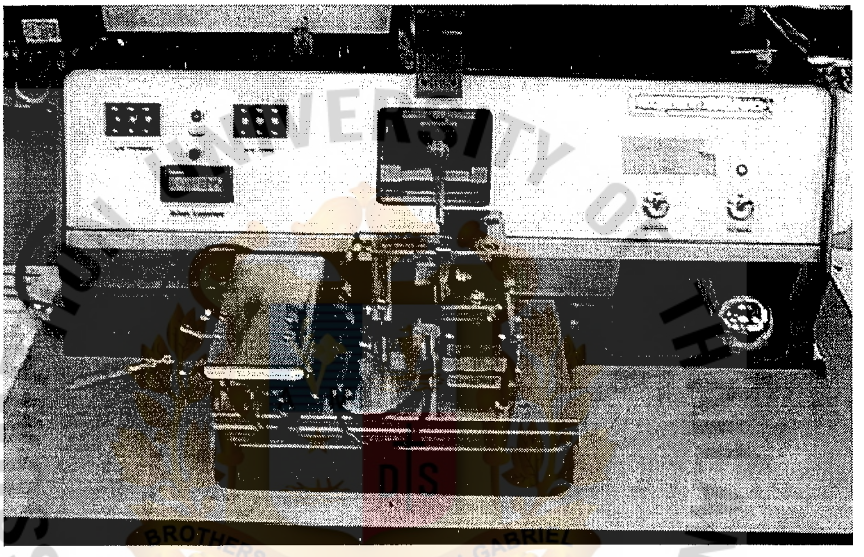


Figure 3.7. Lead Bonder.

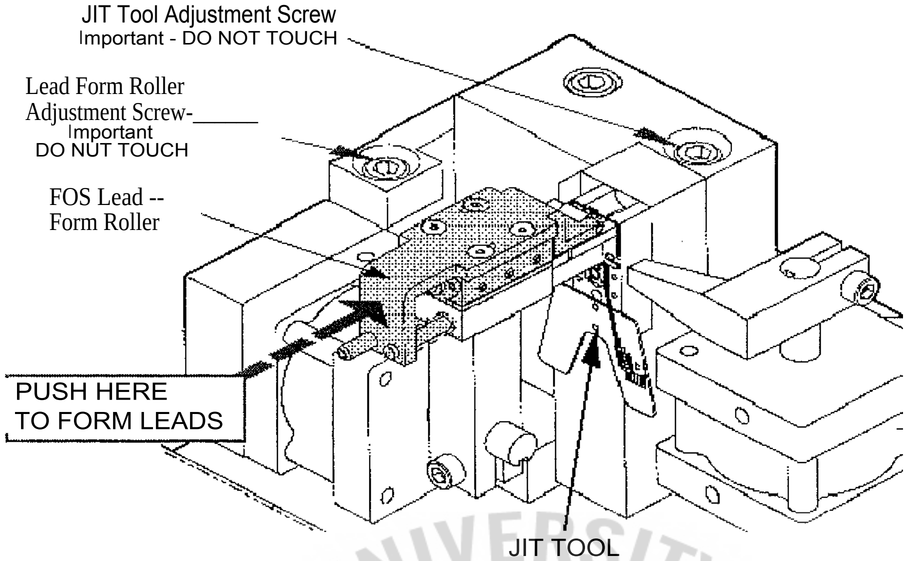


Figure 3.8. Lead Bonder Components.

3.3.6 Coating Operation

The purpose of Coating Operation is to coat the lead after the bond by using an adhesive, LD227. The coating will ensure that the lead will not lift when shipped or used by the customer. The procedures of this process are described as follows:

(1) Position the loaded jit tool in wire coat nest under microscope. Focus on trailing end of the head.

(2) Check lead bonds & gimbal bond under microscope (10X-40X). Inspect for Lifted Leads, damaged leads, bridged leads and gimbal bond adhesive on the TE.

(3) Dispense and spread a thin layer of adhesive over all lead bonds (from the cross in the X to the bond heel). The adhesive must flow to the slider on both sides of the lead. The adhesive does not need to coat the end of the lead or lead tail.

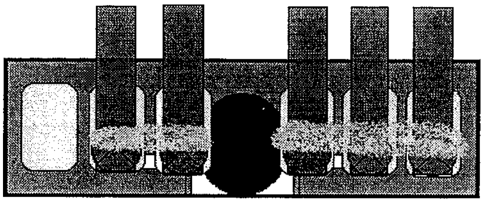


Figure 3.9. Conformal Coating.

3.3.7 Tail Tacking Operation

Tail Tacking operation is to attach FOS tail to Flexure tab by using an adhesive, LD227, as a bonder. The purpose of this operation is to increase the reliability of the product when it is working at Drive or Customer level. The procedures of this process are provided as below:

(1) Apply adhesive to the FOS in the area which covers the formed tab.

(2) Weave the FOS with a rubber tip pin vise and a round tip tweezers under the formed tab.

(3) After the tail is weaned, align the FOS tail with the edge of the tab by pushing gently on the corner of the FOS.

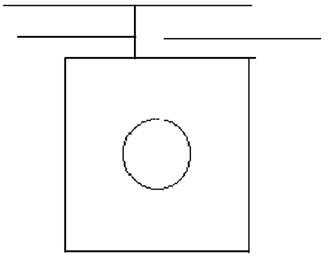


Figure 3.10. Tail Tacking.

3.3.8 Unload HGA Operation

The purpose of Unload HGA Operation is to unload HGA from the jit tool by using a vacuum tweezer. The processes of this operation are provided as below:

(1) Clamp the JIT tool using the cam-lock.

(2) Actuate the toggle switch to release the slider.

(3) Using a J-hook, lift up the U-Clamp/Flex Clamp, turn the U-Clamp/Flex Clamp counter-clockwise until the Flex Clamp is completely off the jit tool.

(4) Raise the load beam assist. Using a vacuum tweezers only, remove the HGA from the jit tool and place in the in-process tray.

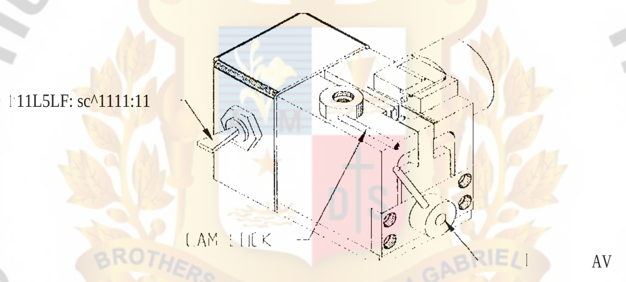


Figure 3.11. Unloading Fixture.

3.3.9 Load Integrated Assembly Test (IAT) Operation

The purpose of Load IAT Operation is to prepare HGA for testing by loading HGA to the IAT arm. The procedures of this process are described as below:

(1) Place the test arm on the Suspension Load Fixture with the serial number face down. Mount the suspension to the front actuated hole.

(2) Open the test arm boss clamp by actuating the toggle switch to the up position.

(3) Pick up the HGA from the in process tray with a duck bill tweezers. Grasp

the suspension by the load beam.

(4) With the HGA ABS up, slide the flex tail under the test arm wing and position the suspension locating slots over the Suspension Load Fixture Alignment pins.

(5) Locate the suspension boss in the front boss clamp. Use index finger to press the suspension boss and apply light pressure to the boss until it is seated properly.

(6) Close the test arm boss clamp by actuating the toggle switch to the down position.

(7) Remove the Test Arm/Wing assembly and inspect the loaded HGA. Visually verify that the suspension base plate is seated along the test arm.

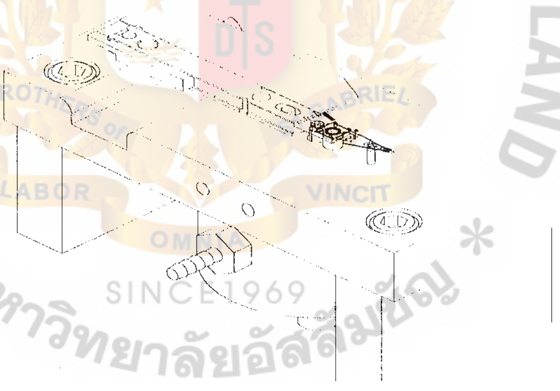


Figure 3.12. Load IAT Fixture.

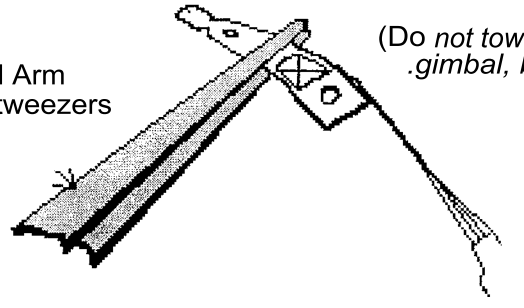


Figure 3.13. HGA Handling.

3.3.10 Spot Cleaning Operation

Spot cleaning Operation is the inspected operation which mainly focuses on contamination on HGA, including Slider, FOS and Flexure, and Front line defect, such as Crack slider, Bent Flexure, etc. If contamination is found, it will be cleaned off by spot clean operator. For the mechanical defect, it will be reworked or rejected according to the specification. The procedures of this operation are described as below:

(1) Inspect all front line defects such as Crack slider, Lifted lead bond, Bridge bond pad, etc. Rework or Reject based on the specification.

(2) Inspect contamination on HGA, including Slider, FOS and Flexure. All contamination will be cleaned off by using cotton swab dampened in IPA.

3.3.11 Head Set

The purpose of Head Set operation is to align the magnetic direction in the slider layer. The procedures of this operation are provided as below:

(1) Place test arm on the head setter track with the head pointed toward the housing, ABS facing up.

(2) Lay the test arm FLAT against the track slowly, Do not drop/slam the test arm since it will cause dimple separation.

(3) Gently push the slide of fixture forward until the head of HGA is encased in the head setter.

(4) Slide fixture back and remove test arm assembly.

(5) Place the Test Arm/Wing assembly back into the FOS Wing Tray.

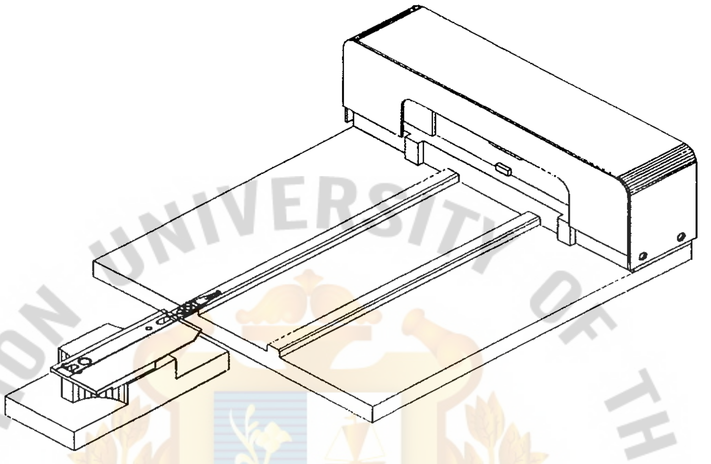


Figure 3.14. Head Setter.

3.3.12 Autogram Operation

The purpose of Autogram operation is to measure and adjust an incoming gram of HGA to the product target or specification. For the Cheetah 36 product, the specification is as below:

Table 3.1. The gramload Specification of Cheetah 36 Product.

< 1.5 grams	Reject as is, do not attempt to adjust
1.5 to < 2.53 grams	Adjust to target of 2.65 grams
2.53 to 2.77 grams	Accept as is, no further adjustment required or allowed
>2.77 to 3.5 grams	Adjust to target of 2.65 grams
>3.5 grams	Reject as is, do not attempt to adjust

3.3.13 Static Attitude Adjust Machine (SAAM) Operation

The Static Attitude Adjust Machine (SAAM) measures and adjusts HGA static attitude. The definitions of positive Pitch Static Adjust (PSA) and Roll Static Adjust (RSA) are illustrated below. Positive PSA rotates the trailing edge closer to the disk. Positive RSA is counter clockwise rotation as viewed from the trailing end.

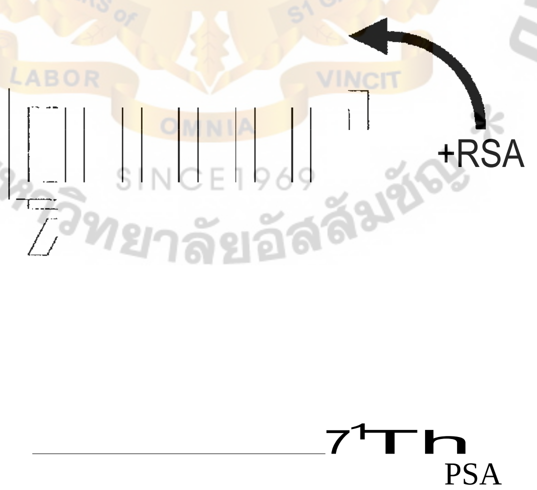


Figure 3.15. PSA/RSA Illustration.

For Cheetah 18 product, the specification of PSA and RSA +/-1.0 degrees and +/-0.8 degrees, respectively.

For Cheetah 18 product, the specification of PSA and RSA are +/-1.0 degrees and +/-0.8 degrees, respectively.

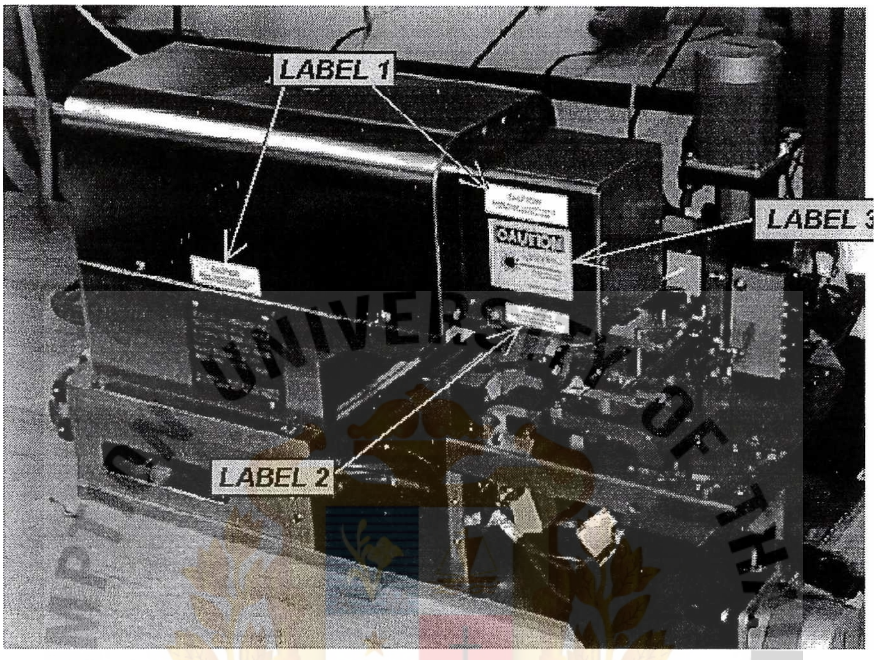


Figure 3.16. SAAM.

3.3.14 Cut Shunt Operation

Cut shunt Operation is the process that cuts the shunt tab at FOS tail off before testing and its procedures are as follows:

(1) HGAs will be located in FOS Wing Tray.

(2) Under a 30X scope, using a tweezers-scissors, trim the FOS tail off

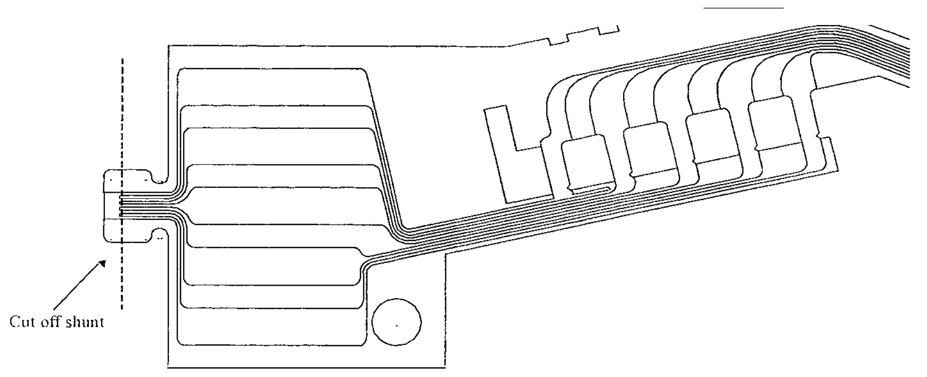


Figure 3.17. FOS Trimming Location.

3.3.15 Magnetic Resistance Electrical (MRE) Test Operation

MRE is the operation for testing the resistance of Head, the procedures are:

(1) Locate the hole in the flex tail and align it with the pin of the test wing.

(2) Using a metal tweezers, lock the flex tail into the test wing.

(3) Place the test arm/wing assembly into the FOS/wing tray.

3.3.16 Electrical Test Operation

Electrical Test is a dynamic test operation that simulates for testing Read and Write performance of HGA on a media. All specification is tighter than the working condition.

3.3.17 Fly Test Operation

Fly test is a dynamic operation that tests the fly height performance of HGA on glass disc. Fly height unit is in micro-inch, Cheetah 18 specification is 1 micro-inch.

3.3.18 Flex Shunting Operation

Flex shunting operation is the process that the FOS tail is re-shunted after testing in order to ensure the problem of ESD. The process of this operation is illustrated as below:

(1) Place the test arm with ABS down on the FOS Tail Shunt Fixture and position the test wings tooling hole on the pins.

(2) Set the soldering iron at 550 - 580 °F.

(3) Melt a small amount of solder on the soldering tip.

(3) Under microscope (30X), apply solder in given area in product criteria.

Figure 3.18. Flex Shunting Area..

3.3.19 Unload IAT Operation

Unload TAT Operation is the operation that unloads HGA from the IAT arm before cleaning. Its procedures are illustrated as below.

(1) Place the test arm on the Suspension Unload Fixture with the serial number facing down. Mount the suspension to the front actuated hole.

(2) Grasp the suspension by the load beam with a tweezers.

(3) Open the test arm boss clamp by actuating to toggle switch to the up position.

(4) Remove HGA from the test arm.

3.3.20 Final System Clean

Final system clean is the automated cleaning whose purpose is to clean all HGA components before shipping to the customer.

3.3.21 Final Visual Operation

Final Visual Operation is the operation that requires to inspect all the mechanical works related of HGA which includes contamination, slider defects, FOS defects and Flexure defects.

IV. HGA PROCESS TRADITIONAL PERFORMANCE

Seagate has many models of HGA production to support variance specification of hard drive. Each individual model has a specified type of computer and the capacity of hard drive. Currently, Seagate has about 7 models of HGA production, Barracuda 36, Barracuda 50, Ultra 4, Ultra 8, Cheetah 18 and Cheetah 36 are running the mass production.

Currently, Cheetah 36 program is the highest volume and the project was run based on this program. The benefits and advantages of the project will be measured by the following criteria:

(a) Work in process (WIP) of Cheetah 36 HGA

(b) Throughput time of Cheetah 36 HGA

(c) Tooling investment of Cheetah 36

(d) Non value added (NVA) activities

4.1 Work In Process (WIP) of Cheetah 36 HGA

With the just-in time concept, each operator is allowed to have only 1 tray for operation and 1 tray to fulfill the Kanban. Totally maximum 2 trays per operator follow the pull system. There are 3 types of tray used to carry the assembly part to go along through the whole process to start. The types of tray are jit tool tray, test arm tray and HGA tray. The current standard number of lot size of tit tool tray and test arm tray are 5 units per tray and the lot size of HGA tray is 30 units per tray.

With the current condition, the number of total work in process (WIP) of the Cheetah 36 programs is 2,155 HGAs.

The detail of standard WIP is shown in Table 4.1.

Table 4.1. Standard WIP of Cheetah 36 Program.

OPERATION	% Sampling	STD UPH	STD H/C	Kanban Size	WIP HGA
PRE-TRIM LEAD	100.0%	873	--Ncncncn--.—NN	5	10
LOAD HEAD	100.0%	340		5	20
GIMBAL BOND	100.0%	251		5	30
FLEX BOND	100.0%	232		5	30
FLEX LEAD BOND	100.0%	262		5	30
SPC BOND PULL	3.5%	30		-	-
SERVILANCE # 1	25.0%	160		-	5
COAT LEAD	100.0%	427		5	20
TAIL ATTACHED	100.0%	365		5	20
OVEN	100.0%	698		-	320
UNLOAD HGA FROM JIT TOOL	100.0%	382		10	40
LOAD IAT TEST ARM	104.0%	372		10	40
PUSH FLEX & CLEAN	110.0%	165		5	50
SURVEILLANCE#2	25.0%	160		5	5
HEAD SETTER	100.0%	730		5	10
PRELOAD	100.0%	156		5	50
STATIC ATTITUDE ADJUST	104.0%	188		5	40
MRE & REMOVE PRE-SHUNT	100.0%	296		5	20
ET TESTER	104.0%	88.1		50	800
SPC ALIGNMENT	7.6%	66		5	5
SPC GIMBAL BOND	5.0%	100		-	-
SHUNT LEAD	100.0%	5.62		5	10
FLY TESTER	5.0%	50		5	10
UNLOAD TEST ARM & FOLD FLAPPER	104.0%	331		5	20
FINAL INSPECTION	100.0%	170		30	240
CLEANING				240	240
QC	10.0%	128		-	-
PACK	100.0%	1500		90	90
TOTAL			58		2155

4.2 Throughput Time of Cheetah 36 HGA

The throughput time is calculated based on 3 factors, Standard hour per units, Standard number of lot Size and Standard of WIP. The Cheetah 36 throughput time is 3.29 hours or 197.7 minutes. The detail is shown in Table 4.2.

Table 4.2. The Throughput Time of Cheetah 36 HGA.

OPERATION	STD UPH	STD H/C	STD Unyield	Kanban Size	WIP HGA	Time used Hour	Time used (min)
PRE-TRIM LEAD	873	1	0.0011	5	10	0.0115	0.6873
LOAD HEAD	340	2	0.0029	5	20	0.0294	1.7647
GIMBAL BOND	251	3	0.0040	5	30	0.0398	2.3904
FLEX BOND	232	3	0.0043	5	30	0.0431	2.5862
FLEX LEAD BOND	262	3	0.0038	5	30	0.0382	2.2901
SPC BOND PULL	30	1	0.0012	5	-	-	-
SERVILANCE # 1	160	1	0.0016	5	5	0.0156	0.9375
COAT LEAD	427	2	0.0023	5	20	0.0234	1.4052
TAIL ATTACHED	365	2	0.0027	5	20	0.0274	1.6438
OVEN	698	-	-	-	300	0.4298	25.7880
UNLOAD HGA FROM JIT TOOL	382	2	0.0026	10	40	0.0524	3.1414
LOAD IAT TEST ARM	372	2	0.0027	10	40	0.0538	3.2258
PUSH FLEX & CLEAN	165	5	0.0061	5	50	0.0606	3.6364
SURVEILLANCE#2	160	1	0.0063	5	5	0.0625	3.7500
HEAD SETTER	730	1	0.0014	5	10	0.0137	0.8219
PRELOAD	156	5	0.0064	5	50	0.0641	3.8462
STATIC ATTITUDE ADJUST	188	4	0.0053	5	40	0.0532	3.1915
MRE & REMOVE PRE-SHUNT	296	2	0.0034	5	20	0.0338	2.0270
ET TESTER	88.1	8	0.0120	50	800	1.2032	72.1907
SPC ALIGNMENT	66	-	0.0011	5	5	-	-
SPC GIMBAL BOND	100	-	0.0005	-	-	-	-
SHUNT LEAD	562	1	0.0018	5	10	0.0178	1.0676
FLY TESTER	50	1	0.0200	5	10	0.1000	6.0000
UNLOAD TEST ARM & FOLD FLAPPER	331	2	0.0032	5	20	0.0319	1.9135
FINAL INSPECTION	170	4	0.0059	30	240	0.3529	21.1765
CLEANING	-	-	-	-	240	0.4167	25.0000
QC	128	1	0.0008	-	-	-	-
PACK	1500	1	0.0007	90	90	0.1200	7.2000
TOTAL						3.29	197.68

4.3 Tooling Cost per Cell of Cheetah 36 HGA

The major of HGA production cost is the tooling cost because the HGA tooling itself needs high precision specification which makes tooling expensive especially jit tool block and test Arm. A number of jit tool block and test arm are required more than hundreds to support the current line capacity. The standard requirements of jit tool and test arm are calculated based on the line balancing at 13 K loading per day as shown in Tables 4.3 and 4.4 respectively. The HGA tooling cost is 130,395 US$. The details of the tooling cost are shown in Table 4.5.

Table 4.3. Jit Tool Requirement per Cell.

JIT TOOL REQUIREMENT WITH CURRENT CONCEPT
MODEL : CHEETAH 36
LINE LOADING : 13 K DAY

				Cheetah 36	13 K			
Opn #	Operation description	% Sampling	Standard UPH	H/C 13	Number of Jit tool Operator	Operation	Tray	Remarks
1	Pre-trim	100%	873	1	0	0		
2	Head loader	100%	340	2	5	10	2	
	Wait for Gimbal bond				5	15	3	
3	Gimbal bond	100%	251	3	5	15	3	
	Wait for Flex bond				5	15	3	
4	Flex bond	100%	232	3	5	15	3	
	Wait for lead bond				5	15	3	
5	Lead bond	100%	262	3	5	15	3	
6	SPC lead bond	5%	30	1	5	6	1	4 units/shift/machine
7	Servilance # 1	100%	160	5	5	25	5	
	Wait for Coating				5	10	2	
8	Coat Lead	100%	427	2	5	10	2	
	Wait for Tacking				5	10	2	
9	Tail Tacking	100%	365	2	5	10	2	
	Thermal Oven				5	320	64	
	Wait for Unload HGA				5	10	2	
10	Unload HGA	100%	382	2	5	10	2	
	Screen Jit tool				5	5	1	
	Return Jit tool				5	5	1	
	Total Jit tool Block for MFG					521		
	Cleanning jit tool (6 %)					31		
	Jit tool For ME (6 %)					31		
	Total Standard Jit Tool per Cell					584		
	Total Jit tool Tray per cell						110	

Assumption			
Working Hour	21	Jit tool Cleaning	6%
Ultilisation	93%	Jit tool Spare	6%
Jit tool per tray			5
Jit tool per tray for Tail tracking,Oven, Unload			5

Table 4.4. Test Arm Requirement.

TEST ARM REQUIREMENT WITH CURRENTCONCEPT
MODEL : CHEETAH 36
LINE LOADING : 13 K PER DAY

				Cheetah 36	13 K		
Opn #	Operation description	% Sampling	Standard UPH	H/C 13	Number of Test Arm Operator	Operation	Tray
	Wait for load IAT Arm				5	10	2
11	Load IAT Arm	104%	372	2	5	10	2
12	Serveilance # 2	25%	160	2	5	10	2
	Wait for Push Flex and spot clean				5	5	1
13	Push Flex and spot clean	104%	165	5	5	25	5
	Wait for Head Setter				5	5	1
14	Head Setter	100%	730	1	5	5	1
	Wait for Preload Adjust				5	25	5
15	Preload Adjust	100%	156	5	5	25	5
	Wait for SAAM & Cut Flex				5	20	4
16	SAAM & Cut Flex	104%	188	4	5	20	4
	Wait for ET & Fly				5	5	1
17	Fly tester	5%	50	1	5	5	1
18	ET	104%	88.1	8	50	400	80
	Wait for Shunting				15	30	6
19	Shunting	100%	562	2	5	10	2
	Wait for Unload HGA & Flapper				5	15	3
20	Unload HGA & Flapper	104%	331	3	5	15	3
	Return to Load Test arm					10	2
	Total Jit tool Block for MFG					650	
	SAAM,Autogramer and Auto-shunting					62	
	Cleanning jit tool (6 %)					39	
	Jit tool For ME (6 %)					39	
	Total Standard Jit Tool per Cell					790	
	Total tray per cells						177

Assumption			
Working Hour	21	Test arm cleaning	6%
Ultilisation	93%	Test arm spare	6%
Test Arm per tray			5
Test Arm per ET			50

Table 4.5. Cheetah 36 HGA Tooling Cost.

HGA TOOLING COST PER CELL
MODEL : CHEETAH 36
LINE LOADING : 13 K

Items	Operation description	Qty/cell	Cost(US$)		Remarks
		Cheetah 36		13 K	
		13	Unit	Cell	
1	Pre-trim Firture	2	156.0	312.0	
2	Jit tool block	584	104.0	60,686.1	
3	Jit tool tray	110	6.5	717.9	
4	Head loader Fixture	2	569.0	1,138.0	
5	Gimbal bond Fixture	3	358.0	1,074.0	
6	Flex bond Fixture	3	358.0	1,074.0	
7	Lead bond Fixture	3	927.0	2,781.0	
8	Damper Fixture	3	67.0	201.0	
9	In-tray damper application fixtur	3	54.0	162.0	
10	Tail Tacking Fixture	2	67.0	134.0	
11	Unload HGA Fixture	2	1689.0	3,378.0	
12	Load IAT Arm	2	540.0	1,080.0	
13	Test arm	790	30.0	23,700.0	
14	Test arm wing do	395	33.0	13,035.0	
15	Test arm wing up	395	33.0	13,035.0	
16	Test Arm Tray	177	5.3	936.0	
17	Spot clean Fixture	1	108.0	108.0	
18	Head Setter	1	730.0	730.0	
19	Head setter receiver	1	25.0	25.0	
20	Preload Receiver	4	221.0	884.0	
24	Autogram cal. Block	2	132.0	264.0	
21	Wafer code fixture	10	17.0	170.0	
22	Wafer code lense	10	147.0	1,470.0	
23	Wafer code adater	10	144.0	1,440.0	
24	Light shield	10	24.0	240.0	
25	Unload IAT Arm Fixture	3	540.0	1,620.0	
	Total cost of tooling per cell			*130,395.0*	

Assumption

Working Hour	21	Jit tool Cleaning	6%
Ultilisation	90%	Jit tool Spare	6%
		Test arm cleaning	6%
		Test arm spare	6%

4.4 Value and Non-Value-Added Operations of Cheetah 36 HGA

The HGA process of Cheetah 36 product is required total 58 operator per cell. There are only 14 out of 58 classified as the value-added operation and the remaining is classified as the non-value-added. The value added operation is 24 % on the other hand, the non-value add is 76 %. Details are shown in Table 4.6.

Table 4.6. Value and Non Value Added Operations Classification.

OPERATION	STD H/C	Class	Value		Non-value	
			H/C	%	H/C	%
PRE-TRIM LEAD	1	N			1	1.7%
LOAD HEAD	2	V	2	3.4%		
GIMBAL BOND	3	V	3	5.2%		
FLEX BOND	3	V	3	5.2%		
FLEX LEAD BOND	3	V	3	5.2%		
SPC BOND PULL	1	N			1	1.7%
SERVILANCE # 1	1	N			1	1.7%
COAT LEAD	2	N			2	3.4%
TAIL ATTACHED	2	N			2	3.4%
UNLOAD HGA	2	V	2	3.4%		
LOAD IAT TEST ARM	2	N			2	3.4%
PUSH FLEX & CLEAN	5	N			5	8.6%
SURVEILLANCE#2	1	N			1	1.7%
HEAD SETTER	1	N			1	1.7%
PRELOAD	2	N			2	3.4%
SAMM	4	N			4	6.9%
MRE	2	N			2	3.4%
ET TESTER	8	N			8	13.8%
SPC ALIGNMENT	0	N	-	-	-	
SPC GIMBAL BOND	0	N	-	-	-	-
SHUNT LEAD	1	N			1	1.7%
FLY TESTER	1	N			1	1.7%
UNLOAD HGA FROM TEST AR & FOLD FLAPPER	2	N			2	3.4%
FINAL INSPECTION	4	N			4	6.9%
QC	1	N			1	1.7%
PACK	1	V	1	1.7%		
MH & LEAD GIRL	3	N			3	5.2%
TOTAL	58		14	24%	44	76%

V. CYCLE AND WIP REDUCTION

The WIP of HGA productions consists of operating, testing, cleaning, curing inspection units, Kanban units , and waiting units.

The waiting units are hidden in every operation. It was set up to fulfill standard lot size that originally fixes based on the carrier capacity or gravity just as j it tool tray is fixed at 5 units per tray, test arm tray is fixed at 5 units per tray and HGA tray is fixed at 30 units.

The waiting units can be classified into necessary waiting units and unnecessary waiting units. The necessary waiting units are required for flexibility, smooth production line, fulfilling the package and increasing the UPH in element of the material handing. The unnecessary waiting units are required to fulfil carrier or tray capacity or gravity.

The operator can operate the HGA unit by unit at each workstation: However; operators need to fulfill the tray capacity or gravity before sending out to next operations.

The work in process of Cheetah 36 HGA production line is 2155 HGAs and it's cause is waste of the waiting time from the current lot size and it's results are long throughput time and high investment tooling cost. To reduce work in process(WIP) as mush as possible the WIP reduction is applied to eliminate unnecessary WIP in production line.

The procedure of WIP reduction by eliminating unnecessary waiting of WIP and it's details are illustrated on next pages.

5.1 Feasibility Study

The carrier of the WIP in HGA production line can be classified into 3 groups. There are oven tray or jit tool tray , test arm tray and HGA tray or clean and ship tray.

(1) The oven tray or jit tool tray is carrier for the front line assembly and it carries the HGA WIP by the jit tool block. The HGA component part is assembled to be the HGA in this state. The tray gravity is maximum 5 units per tray.

(2) The test arm tray is carrier for the back line or testing line and it carries the HGA WIP by the test arm. The HGA part will be the test to follow the specification in this state. The tray capacity is maximum 10 units per tray.

(3) The HGA tray is finished good tray. Its feature also is cleaning and shipping tray. It is named clean and ship tray. It carries the HGA WIP after testing process for cleaning, inspection and packaging. The tray has 30 gravity.

The WIP reduction feasibility will be studied in each process based on the WIP carrier. The number of WIP can be reduced to the minimum number as long as the line capacity is not effected.

5.1.1 Oven Tray or Jit Tool Tray

The oven tray or jit tool tray carries the part by jit tool block through the HGA assembly process. It carries over the component part from the beginning operation through the last operation of the HGA assembly process. The jit tool tray is passed by the following operations:

(a) Load head operation

(b) Gimbal bond operation

(c) Flex bond operation

Flex lead bond operation

SPC bond pull operation

Surveillance # 1 operation

Coat lead operation

Tail attached operation

Thermal oven

Unload HGA from jit tool

All operation except the Thermal oven, the number of the jit tool block can be reduced to 2 jit tool blocks per tray without the significant effect to the unit per hour of each operation and that means it does not effect the line capacity as well.

The critical and focal point in the front line assembly is the Thermal oven because to maintain the line capacity the jit tool tray must carry 5 jit tool block per tray; otherwise, the line capacity will be effected. It's cause is the number of the jit tool per cycle reduced. With the same number of cycle per day, the capacity will be reduced depending on the number of jit tool reduced per cycle time with the number of cycle per day. Therefore, when the jit tool tray passes the oven, it requires 5 jit tool per tray as the original to maintain the capacity per line.

With the Thermal oven constraint, the jit tool tray will carry 2 jit tools per tray to start with the first operation (Load head operation) until before the jit tool tray passes the oven. The Trail tracking operation has been the previous operation before the oven needs to contain 5 jit tools per tray and then sends to the oven. Also, the HGA unload operation must have 5 j it tools per tray automatically.

The number of WIP on jit tool block is 425 Units for the Front line assembly after having reduced the number of WIP per jit tool tray. The detail is shown in Table 5.1

Table 5.1. Total Number of WIP for the Jit Tool Block.

OPERATION	% Sampling	STD UPH	STD H/C	Kanban Size	WIP HGA
PRE-TRIM LEAD	100.0%	873	1		
LOAD HEAD	100.0%	340	2	2	8
GIMBAL BOND	100.0%	251	3	2	12
FLEX BOND	100.0%	232	3	2	12
FLEX LEAD BOND	100.0%	262	3	2	12
SPC BOND PULL	3.5%	30	1	-	
SERVILANCE # 1	25.0%	160	1		5
COAT LEAD	100.0%	427	2	2	8
TAIL ATTACHED	100.0%	365	2	2	8
OVEN	100.0%	698	-	-	320
UNLOAD HGA FROM JIT TOOL	100.0%	382	2	10	40
TOTAL			20		425

5.1.2 The Test Arm Tray

After having completed assembly the HGA part, every single HGA part will pass from the Unload HGA from Jit tool operation to the Laod IAT test arm operation, and the HGA part, will be mounted on the test arm at this operation. Then the HGA and WIP will be carried on the test arm by the test arm tray. The test arm tray carries the HGA part for the back line or testing line. It carries over the HGA part from the Load IAT test arm operation along though the testing process until Unload test arm & flod flapper operation. The Jit tool tray is passed though the following operations:

(a) Load IAT test arm operation

(b) Push flex and spot clean operation

(c) Surveillance # 2 operation

(d) Head setter operation

(e) Preload operation

(f) Static attitude adjust operation

(g) MRE & Remove pre-shunt operation

(h) Electrical testing operation

(i) SPC alignment operation

(j) SPC gimbal bond operation

(k) Shunt Lead operation

(1) FLY tester Operation

(m) Unload test arm & flod flapper operation

For all operations except the Electrical operation, the number of the test arm can be reduced to 3 test arms per tray without the significant effect to the unit per hour of each operation and that means it does not effect the line capacity as well.

The critical and focal point in the test line or back line is the Electrical operation because the electrical tester is located out of the assembly line. The operator needs to carry the part by hand from the assembly line to test at the tester which sometimes need to be located far from the assembly line. Therefore, to optimize the total distance per day for the operator to carry the part from assembly line to the HGA line, the test arm tray must carry 5 test arms per tray.

Therefore, before the operator sends the test arm to the Electrical tester operation, the operator must perform the lot so as to optimize transfer batch which is 30 test arms per time

With the Electrical tester constraint, the test arm tray will carry 3 test arms per tray start with Load IAT test arm operation until the MRE & remove shunt pre-shunt operation. The MRE & remove shunt pre-shunt operation need to contain 5 test arms per tray and perform transfer batch and its 1 lot is 30 test arms.

The number of WIP on Test Arm after reducing the number of WIP per Test arm tray is 652 units. The detail is shown in Table 5.2.

Table 5.2. Total Number of WIP for the Test Arm.

OPERATION	% Sampling	STD UPH	STD H/C	Kanban Size	WIP HGA
LOAD IAT TEST ARM	104.0%	372	2	5	20
PUSH FLEX & CLEAN	110.0%	165	5	3	30
SURVEILLANCE#2	25.0%	160	1	3	5
HEAD SETTER	100.0%	730	1	3	6
PRELOAD	100.0%	156	5	3	30
STATIC ATTITUDE ADJUST	104.0%	188	4	3	24
MRE & REMOVE PRE-SHUNT	100.0%	296	2	3	12
ET TESTER	104.0%	88.1	8	30	480
SPC ALIGNMENT	7.6%	66	-	5	5
SPC GIMBAL BOND	5.0%	100	-	-	
SHUNT LEAD	100.0%	562	1	5	10
FLY TESTER	5.0%	50	1	5	10
UNLOAD TEST ARM & FOLD FLAPPER	104.0%	331	2	5	20
TOTAL			32		652

5.1.3 The HGA Tray

The HGA tray is carrier for the HGA part after having completed assembly process. Its feature also can be used as cleaning tray with cleaning machine and used as the shipping tray for HGA finished good as well. It also is named clean and ship tray. The HGA tray or clean ship tray has 30 gravity. The HGA tray is required to support the operation that has no jit tool or test arm to carry the HGA part. It consists the following operations:

(a) Unload HGA operation

(b) Load IAT teat arm operation

(c) Unload IAT arm operation

(d) Final inspection operation

(e) Cleaning operation

(f) Packing operation

According to the oven capacity constraint, the number of the WIP in the jit tool tray must be 5 units per tray when loaded to the oven and it automatically covers the Unload HGA from the jit tool operation. After that the operator unloads the HGA from the jit tool and loads to the HGA tray. The WIP for the HGA tray is 5 units per tray following the number of the jit tool tray for WIP. So the WIP of HGA tray is 5 units per tray for the Unload HGA from the jit tool operation and Load IAT arm operation.

Therefore, the current number of WIP in the HGA tray cannot be reduced for these 2 operations.

The HGA tray contains 30 units for the Unload IAT arm operation, final inspection operation and packing operation and cleaning operation because of the specified constraint of the individual operation as follows:

(a) The standard packing is 90 units per pack and 1 pack consists of 3 trays and 1 tray needs to contain 30 units. Therefore, the HGA tray at packing operation must contain 30 units.

(b) Because the HGA tray must contain 30 units per tray for packing. If the WIP number per tray is reduced, the operator needs to fulfil the HGA at the last operation by picking and placing the finished good parts that is the cause of the handling defect. Therefore the Process Engineer does not allow to reduce the number of the HGA per tray for the Unload IAT arm operation and Final inspection operation.

(c) Because the cleaning machine is the capital equipment, its cost is about 250,000 US$. All cleaning machines need to be utilized as mush as possible. To fully utilize the Cleaning machine capacity, the single HGA tray used as the cleaning tray must be full of the HGA part which is 30 units per tray. Therefore, the HGA WIP of the cleaning operation cannot be reduced.

With constraints of individual operations, The number of WIP in the HGA tray cannot be reduced.

5.2 Evaluation

The evaluation is designed on 1 HGA production line on Cheetah 36 product. The evaluation line is sampling from skilled operation, which has 100 % learning curve. All 3 shifts of the operators of this line are trained with the Kanban concept (Pull system) for 2 days and 1 day for the new standard number of WIP in the production line. The Operator of cell number A22 is picked up and was trained for 3 days.

The evaluation period is 1 week between October 18, 1999 to October 23, 1999. The condition of number of WIP is performed following the feasibility analysis information. General condition, such as the conveyor speed ,and other utility is set up as normal.

The evaluation result is measured by the capacity per line per shift and per day. Basically, The normal Cheetah 36 line capacity is 13,000 units per day and the capacity per shift is 4,334 units per day.

Table 5.3 shows the condition and the result of evaluation by shift by line.

Table 5.3. Evaluation Results of the WIP Reduction.

Product	: Cheetah 36
Location	: A22
Evaluation period	: October 18-23, 1999
HGA line loading /line/Day	: 13000 Units per day
HGA line loading /line/Shift	: 4334 Units per shift
Operator	: 100 % learning curve

Date	Shift	Standard	Actaul /Shif	Actual/day	Remark
18-Oct-1999	Shift A	4334	3900	12150	Set up WIP & operator skill
	Shite B	4334	4050		Operator Skill
	Shift C	4334	4200		Operator Skill
19-Oct-1999	Shift A	4334	4050	12600	Operator Skill
	Shite B	4334	4200		Operator Skill
	Shift C	4334	4350		
20-Oct-1999	Shift A	4334	4350	13020	
	Shite B	4334	4350		
	Shift C	4334	4320		
21-Oct-1999	Shift A	4334	4380	13080	
	Shite B	4334	4320		
	Shift C	4334	4380		
22-Oct-1999	Shift A	4334	4380	13110	
	Shite B	4334	4410		
	Shift C	4334	4320		
23-Oct-1999	Shift A	4334	4380	13170	
	Shite B	4334	4380		
	Shite C	4334	4410		

5.3 Conclusion

The evaluation is set up on HGA line and operator of location A23. The operators are skilled operators having 100% learning curve and passed Kanban training concept class for 2 days and 1 day for new standard WIP. The evaluation is performed between October 18-23, 1999. The general condition is set as normal except the WIP condition, performed following the feasibility analysis information. The success is defined based on the line capacity by shift by line. The result in Shift A of the first day shows that the line capacity drops from the normal about 10% because of the operator not familiar with the standard WIP and the decreased set up the WIP in the First shift. The line loading of shift B and C in the first day decease about 5% because the operator were not familiar with the new WIP. The second day result still missed the capacity about 3%. It was better than the first day. Operators got familiar with the new standard of WIP. The results after the third day were positive. The operator of all 3 shifts could achieve the target capacity as normal and could maintain it as usual.

With the positive result, The management agrees to implement across the product and across the plant respectively.

5.4 Implementation

The evaluation results are positive and the management has the direction to implement 100% across the plant starting with Cheetah 36 product. The implementation plan is scheduled to implement across products without the capacity effect to the customer demand. With the evaluation result, the capacity will have average drop of 5% in first 2 days which is based on the current demand, we can implement 2 cells per time or 6 cells per weeks. For the Cheetah 36 product, Seagate currently has 14 cells built at this time. It takes about 2 and half weeks for 100% implementation. The detailed schedule is shown at Table 5.5.

Table 5.5. The WIP Implementation Time Line for Cheetah 36 Product.

Cell #	Location	Implementation plan																				
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	07-Nov	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14-Nov	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cell # 1	A22																					
Cell # 2	A24																					
Cell # 3	A25																					
Cell # 4	A32																					
Cell # 5	A23																					
Cell # 6	A35																					
Cell # 7	A34																					
Cell # 8	A33																					
Cell # 9	A42																					
Cell # 10	A44																					
Cell # 11	A46																					
Cell # 12	A43																					
Cell # 13	A52																					
Cell # 14	A53																					

Train KANBAN concept

Train the New WIP

Implementation

VI. NVA ELIMINATION OF PRELOAD OPERATION

An autogrammer is a machine/ tester for adjusting preload of HGA to target limits before fly and electrical testing on HGA process. Every single HGA will first measure the preload and compare it to 2.65+/- 0.05 grams. If any of HGA preload is out of this range, that HGA will be adjusted by an autogrammer. However, if any of HGA preload is between this range, that HGA will automatically pass to next operation. The measurement and adjustment process may be repeated from 1 to 9 times, depending on preload value after adjusting. Final measurement at the tenth will be last and compared to HGA preload specification at 2.65+/-0.2 grams, and any HGA preload out of this range will be scrapped.

Total 76% of Preload First Yield has been lost at the autogrammer which results in high NVA (Non-value-added) time, adjusted time. To improve HGA Preload First Yield from 24% to 50%, the Six sigma concept is adopted and applied to eliminate non-value-added load of which the details are illustrated on the following pages.

6.1 Measure Phase

6.1.1 Process Mapping

Process Map started at the beginning of HGA process and showing details of operations which affect the autogrammer operation. Each operation that prior to the autogrammer operation included Hidden factory, Key process input variables and Key process output variables as detailed in Figure 6.1.

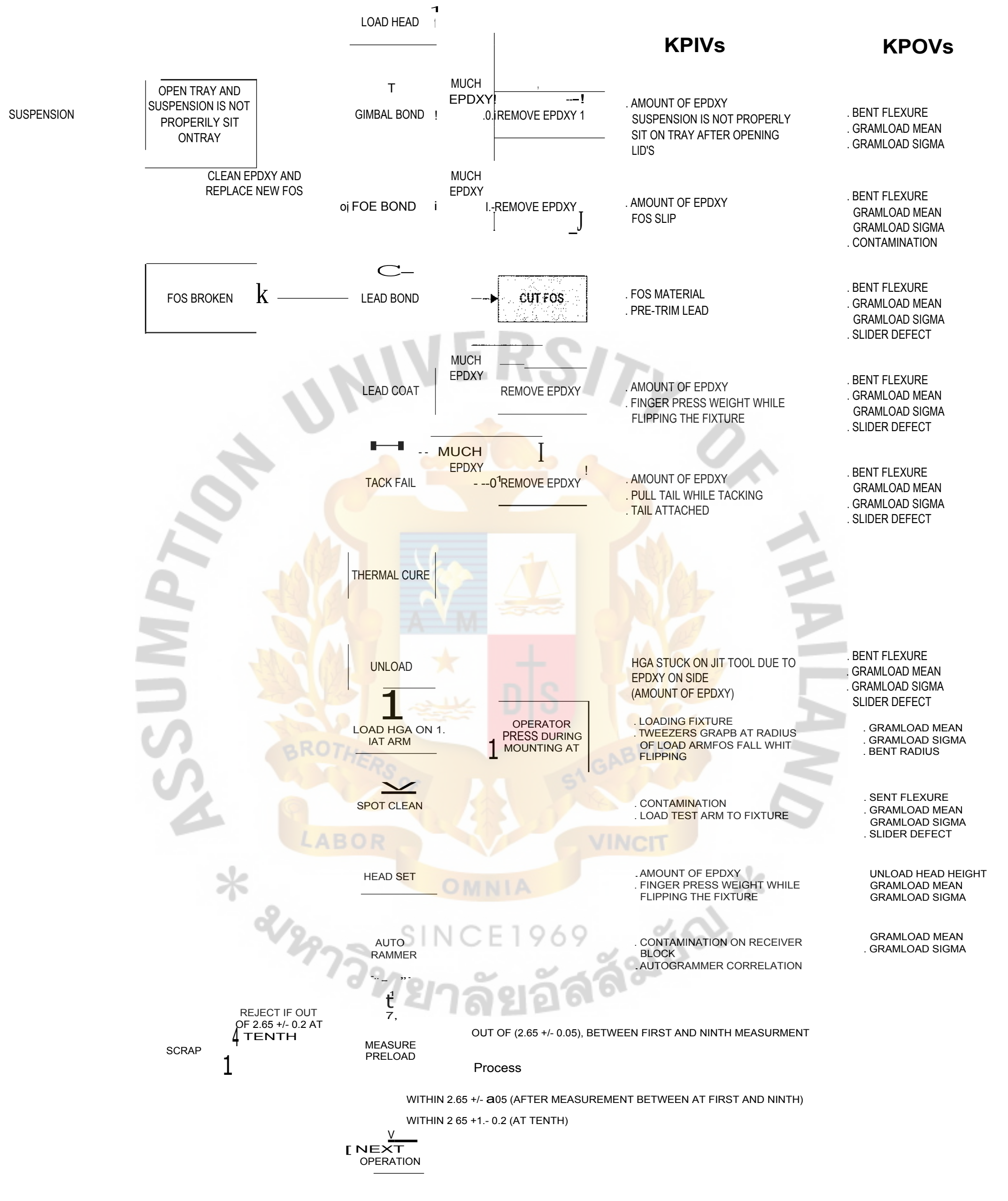


Figure 6.1. Process Mapping of Preload.

6.1.2 A Cause & Effect Diagram

A Cause & Effect Diagram is to identify, explore and graphicalling display increasing details, all the possible causes related to a problem or condition to discover. Cause & Effect diagram of preload is illustrated in Figure 6.2.

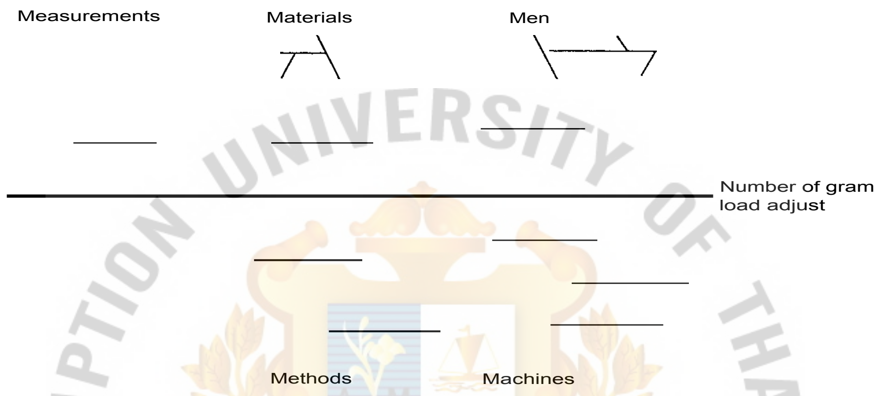


Figure 6.2. Cause & Effect Diagram of Preload.

6.1.3 Rolled Throughput Yield

The rolled throughput yield is the number of percentage of the real good part which does not require the adjustment from the machine. For this operation, 2,897 units is measured and 702 units are the part which need not adjust. Therefore the rolled tthroughput yield = 24% (Out = 702/ In = 2897)

Table 6.1. Number of Adjustments at the Autogrammer

	Count	Pass
First Measurement	2897	702
Bend 1	2195	1198
Bend 2	997	636
Bend 3	361	280
Bend 4	81	61
Bend 5	20	8
Bend 6	12	6
Bend 7	6	1
Bend 8	5	5
Bend 9	0	0

6.1.4 Cause and Effect Matrix

Cause & Effect Matrix is used to relate and prioritize X's, scored as to relationship to outputs, to customer and Y's, scored as importance to customer, through numerical ranking by using the process map as a primary source. For preload Cause & Effect Matrix is illustrated at Table 6.2.

Table 6.2. The Cause and Effect Matrix.

Process step	Process input	Preload mean (10)	Preload sigma (40)	Total (50)
Tail attached	Tail attached	9	16	25
Autogrammer	Correlation	2	20	22
Spot clean	Clean contamination	5	16	21
Autogrammer	R&R	3	16	19
Lead bond	Lead bond	5	12	17
Load IAT	IAT mounting	3	8	11
Unload HGA	HGA stuck on Jit tool	1	8	9
Fos bond	Fos slip	5	4	9
Gimbals bond	Open flexure tray's lid	1	4	5
Gimbals bond	Amount of epoxy	1	4	5
Load IAT	Hold HGA at radius	1	2	3
Head set	Load HGA	1	2	3

6.1.5 Gage of Repeatability and Reproduce (R&R)

Gage R&R did on autogrammer that was already confirmed on Correlation and Calibration. Operators who measured the parts were well trained as well. One autogrammer and two operators measured the preload of 10 HGAs, repeated 2 times/HGA. The procedure is explained below:

(1) Sample 10 HGAs (on IAT) and measure preload by operator #1 and record preload.

(2) Measure preload the same 10 HGAs by operators #2 and record preload.

(3) Re-measure preload the same 10 HGAs by operators #1 and record preload.

(4) Re-measure preload the same 10 HGAs by operators #2 and record preload.

Result in 27% of P/T ratio, 1.37% of contribution, 12.05% of Disc Inx and 2.50% of Process. 27% of P/T ratio was very high and this was the best of P/T ratio we used to get when compared with preload adjustment limits at target +/-0.05. The graphical result is illustrated below:

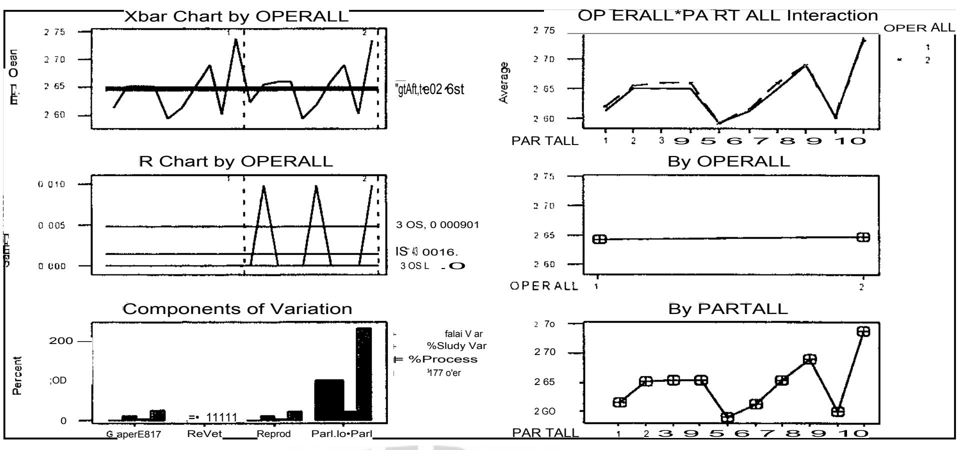


Figure 6.3. Graphical Result of Preload Gage R&R.

6.1.6 Process Capability Analysis

Process Capability was first analyzed and observed at 700,000 DPMO and preload first yield were equal to 24% as the baseline on Cheetah 36 product. In addition, the special causes were observed at the high end of distribution. These special causes were suspected due to the amount of epoxy at FOS bond operation, autogrammer correlation and raw flexure material lot to lot variation. Normal distribution observed an DPMO reducing to 665,760 after suggesting operators to apply an epoxy at FOS bond operation, building material only one shipment and ensuring autogrammers were in good condition. The analysis result is illustrated in Figure 6.4.

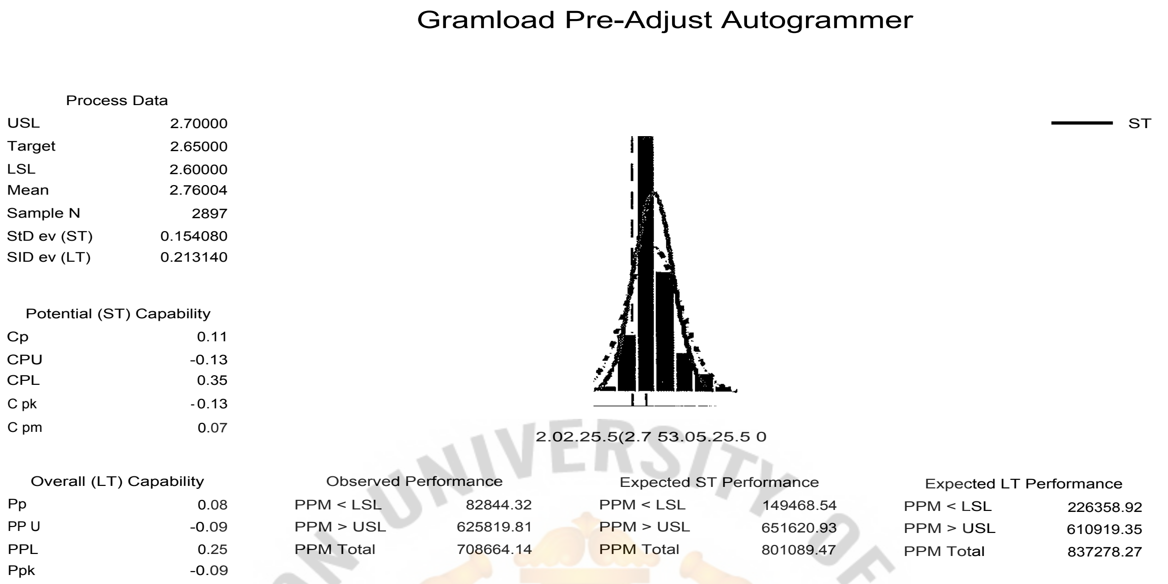


Figure 6.4. Preload Process Capability Analysis.

6.1.7 Phase Conclusion

According to Gage R&R showed 27% of P/T ratio, it means that the current preload window adjustment is too tight when compared to current Process gage standard deviation, which is the best that we can achieve. So, in order to improve preload first yield, the appropriate preload adjustment window is taken into account.

6.2 Analysis Phase

6.2.1 Demographics Matrix for Key Process Input Variable (KPIV)

The KPIV's need to be defend and analysis to improve the Key Process Output Valuable (KPOV).

The analysis of KPIV's effect to the KPOV's is shown in Figure 6.5.

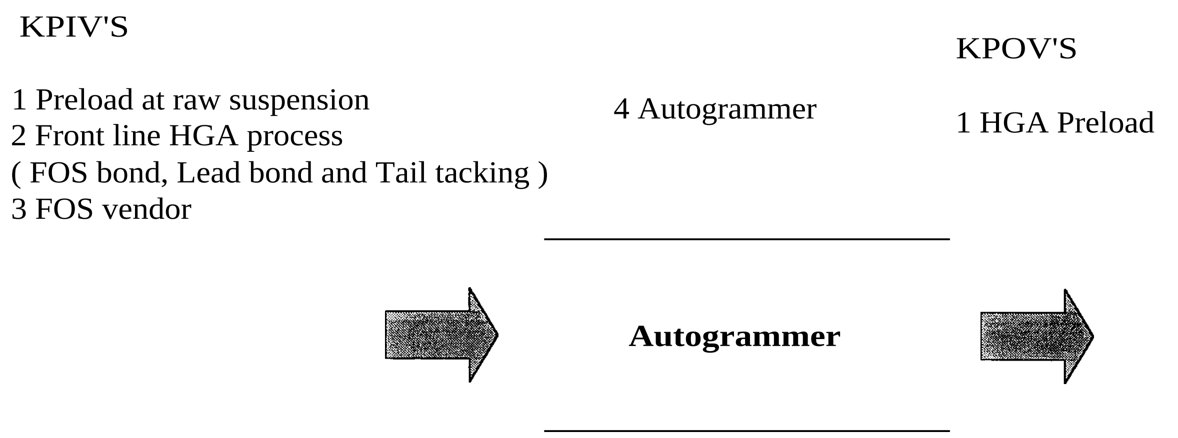


Figure 6.5. Demographics Matrix for KPIV's.

6.2.2 Multi-Variance Analysis

Multi-Variance chart was analysed by comparing among FOS bond application, FOS vendor and Tail Tack epoxy application. The result is as below:

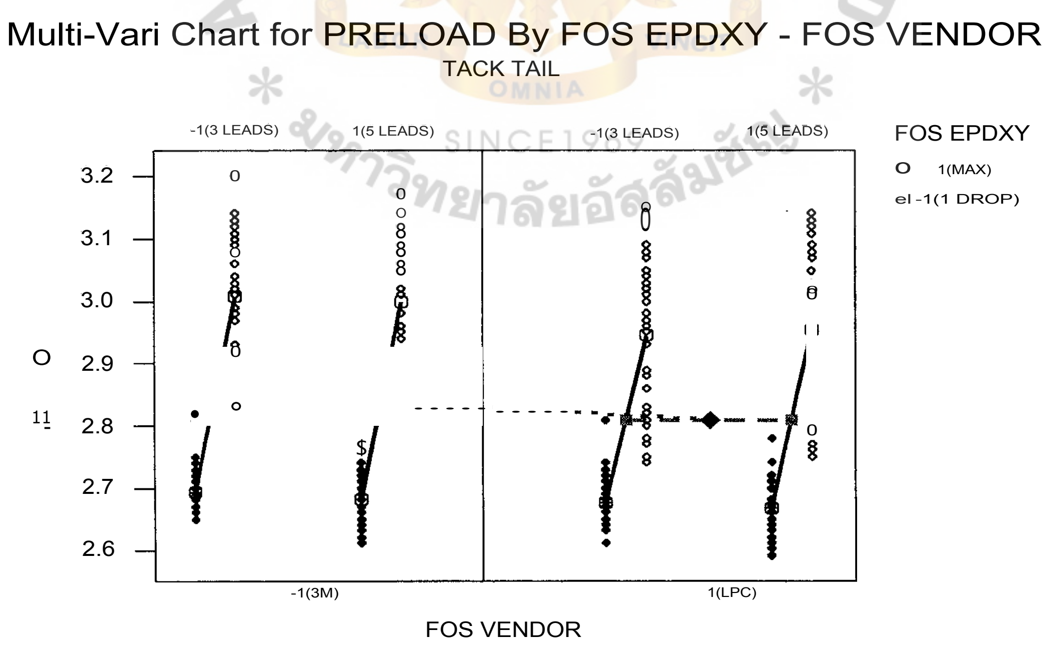


Figure 6.6. Muti-Variance Analysis.

According to this analysis, we can obtain that:

(a) High standard deviation of preload was observed at high epoxy level at FOS bond operation.

(b) Mean of preload was higher at high epoxy level at FOS bond operation.

(c) Preload is slightly different between FOS vendors.

(d) No difference is observed of preload between tail tack on 3 leads and 5 leads.

6.2.3 Hypothesis Testing

An evaluation was analyzed in order to understand what operation gave effect to preload by building HGA and measuring preload on each operation. Hypothesis testing had reported that FOS bond and Tail Tacking operation do impact to preload value which is illustrated in Figure 6.7.

```
Analysis of Variance for Gramload
Source      DF        SS        MS
Operation    6   3.23824   0.53971   114.70    0.000
Error      413   1.94332   0.00471
Total      419   5.18156
                                       Individual 95% CIs For Mean
                                       Based on Pooled StDev
Level        N      Mean     StDev      - - - - -
1RAW FLE    60    2.5418    0.0539      (-*--)
2GIMBAL     60    2.5470    0.0518      (--*-)
3FOS BON    60    2.6033    0.0900
4COAT/TA    60    2.7348    0.0740                            (--*-)
5UNLOAD     60    2.7358    0.0697                            ( --*-)
6LOAD IA    60    2.7408    0.0688                             (--*-)
7SPOT CLEAN60    2.7388    0.0647                             (_*__)
                                        - - - - -+ - - - - + - - -   + - - -
Pooled StDev =   0.0686                        2.590     2.660     2.730
```

Figure 6.7. The Result of the Analysis of Variance Test.

In addition, there were several evaluations on preload Hypothesis testing on cell to cell, shift to shift, between up and down tab. The results are illustrated in Figure 6.8 to Figure 6.13.

(a) Hypothesis Testing of Preload among Cells

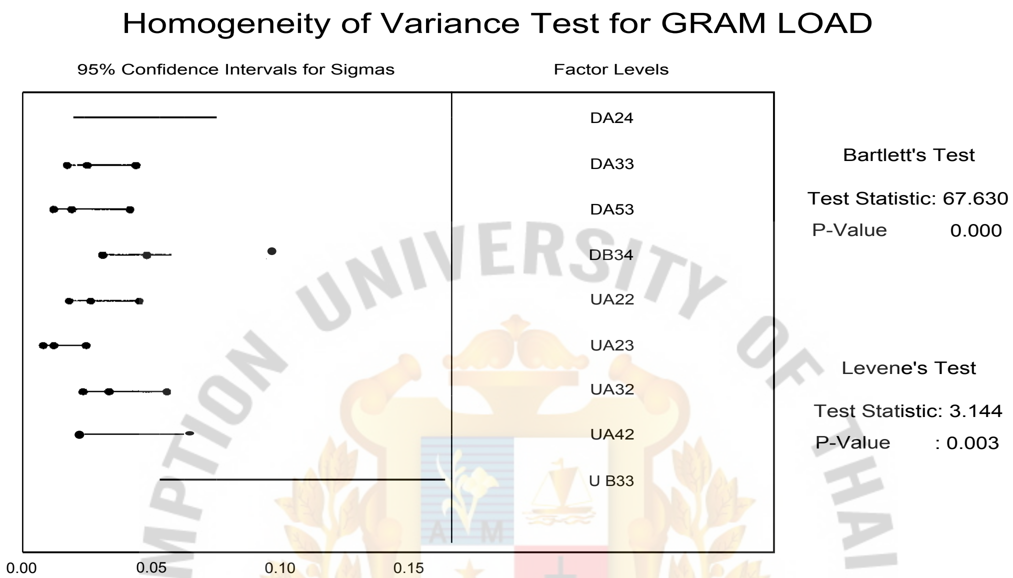


Figure 6.8. Homogenety of Variance Test for Gramload.

The result of the homogeneity of variance test for gramload is explaned in Figure 6.9.

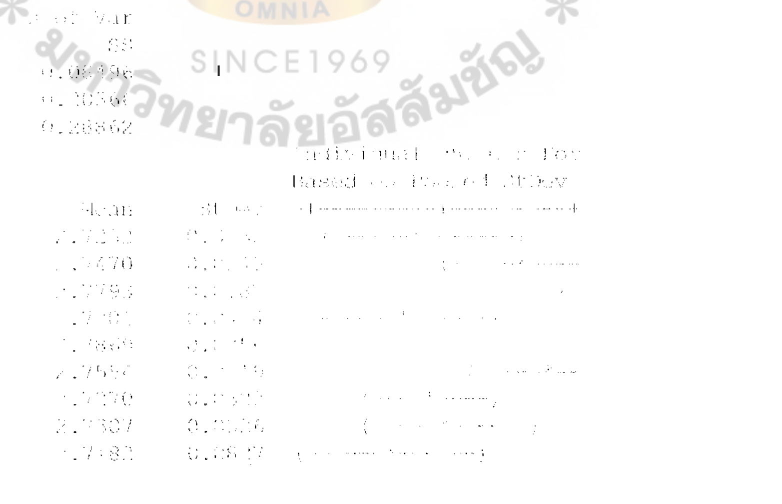


Figure 6.9. The Result of the Analysis of Variance Test.

According to these analyses, we can conclude that there are significant differences of mean and sigma of preload among cells.

(b) Hypothesis Testing of Preload among Shifts

After getting the result of the hyperthesis testing of the preload among cells, the hypthesis testing of preload among shifts is required and the result of the testing is shown in Figures 6.10 and 6.11.

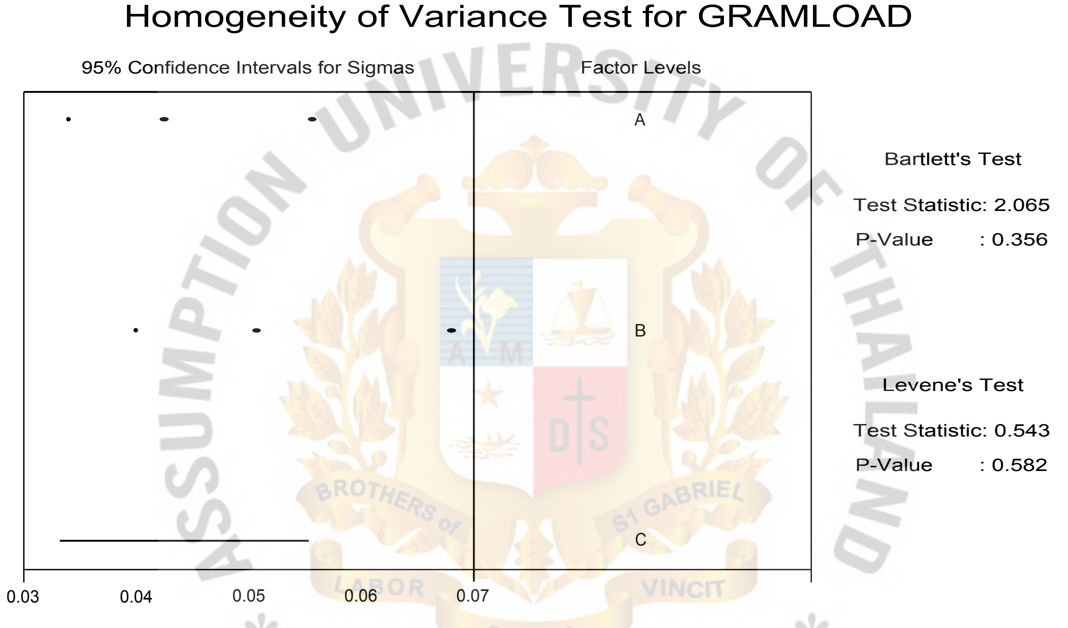


Figure 6.10. The Homogeneity of Variance Test for Preload among Shift.

Figure 6.11. The Result of Variance Test for Preload Among Shift.

Based on these analyses, we can conclude that there are no significant differences of mean and sigma of preload between shifts.

(c) Hypothesis Testing of Preload between Up and Down Tab

After getting the result of the hypothesis testing of the preload among cell and the hypothesis testing of preload among shift, the hypothesis test of preload between up and down also is the important factor that we need to test. The result of the testing is shown in Figures 6.12 and 6.13.

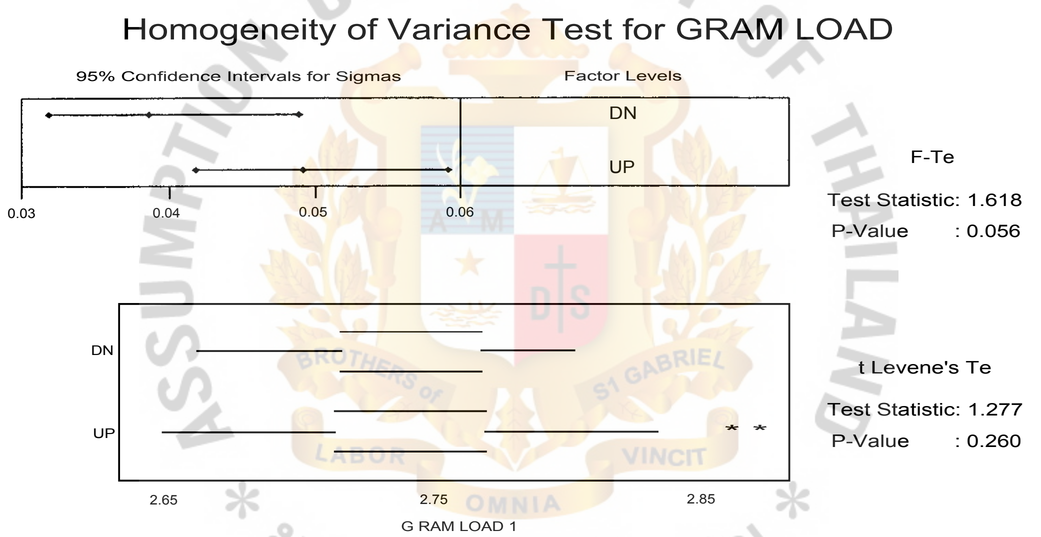


Figure 6.12. The Result of Variance Test for Preload between Up and Down Tab.

Figure 6.13. The Result of Variance Test for Preload between Up and Down Tab.

Base on these analysis, we can conclude that there are no significant differences of mean and sigma of preload between tabs.

6.2.4 Phase Conclusion

The results showed variation at raw suspension, FOS bond and Tail Tacking operation in testing of ANOM and Homogeneity on the same HGAs. Moreover, the variation among cells and shifts were observed as well.

6.3 Improve Phase

6.3.1 Design of Experiment (DOE) Planing Sheet

The DOE was designed for 3 factors, 2 levels, 10 repetitions and 4 replications for which the details are provided in Table 6.3.

Table 6.3. Preload DOE.

Control variables	Level -1	Level+l
1 Amount of epoxy at FOS bond	ldrop of needle tip and smear to 75%	Release epoxy all time and smear to 75%
2 Amount of epoxy at Tail Tack	Cover 3 leads	Cover 5 leads
3 FOS Materail Vendors	3M	LPC

6.3.2 DOE Result

After we have defined DOE, The result needs to be analyzed step by step as shown below:

(a) Main Effect Plot: Data Mean of Preload

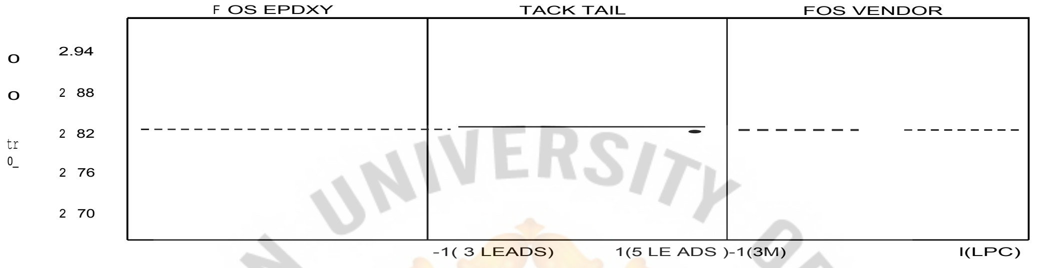


Figure 6.14. Main Effect Result of DOE.

(b) Interaction Plot: Data Mean of Preload

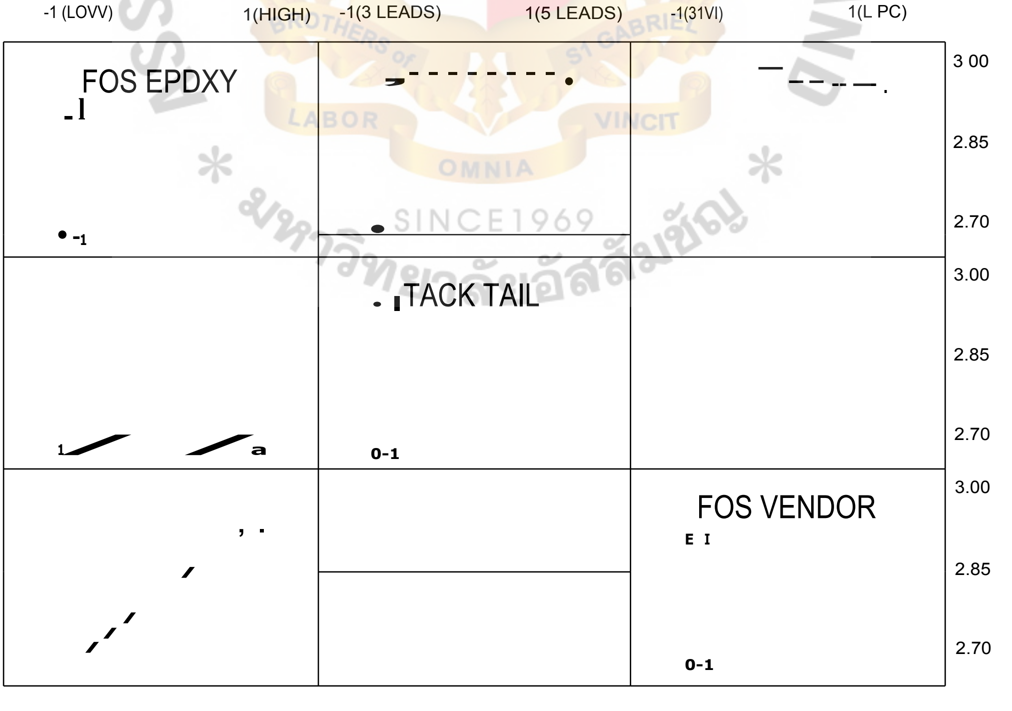


Figure 6.15. Interaction Effect Result of DOE.

(c) Fractional Factorial

Term	Effect	Coef	StDev Coef	T	P
Constant		2.82788	0.004492	629.58	0.000
	0.29650	0.14825	0.004492	33.01	
TAIL TACK	-0.00525	-0.00262	0.004492	-0.58	0.559
	-0.03575	-0.01787	0.004492	-3.98	
FOS EPDXY*TAIL TACK	0.00550	0.00275	0.004492	0.61	0.541
	-0.01850	-0.00925	0.004492	-2.06	
TAIL TACK*FOS VENDOR	0.00500	0.00250	0.004492	0.56	0.578
FOS EPDXY*TAIL TACK*FOS VENDOR	0.00425	0.00212	0.004492	0.47	0.636

Analysis of Variance for PRELOAD (coded units)

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Main Effects	3	7.13743	7.13743	2.37914	368.52	0.000
2-Way Interactions	3	0.03180	0.03180	0.01060	1.64	0.180
3-Way Interactions	1	0.00144	0.00144	0.00144	0.22	0.636
Residual Error	312	2.01428	2.01428	0.00646		
Pure Error	312	2.01428	2.01428	0.00646		
Total	319	9.18496				

Figure 6.16. Fractional Factorial Result.

(d) Pareto Chart of Standardize Effects

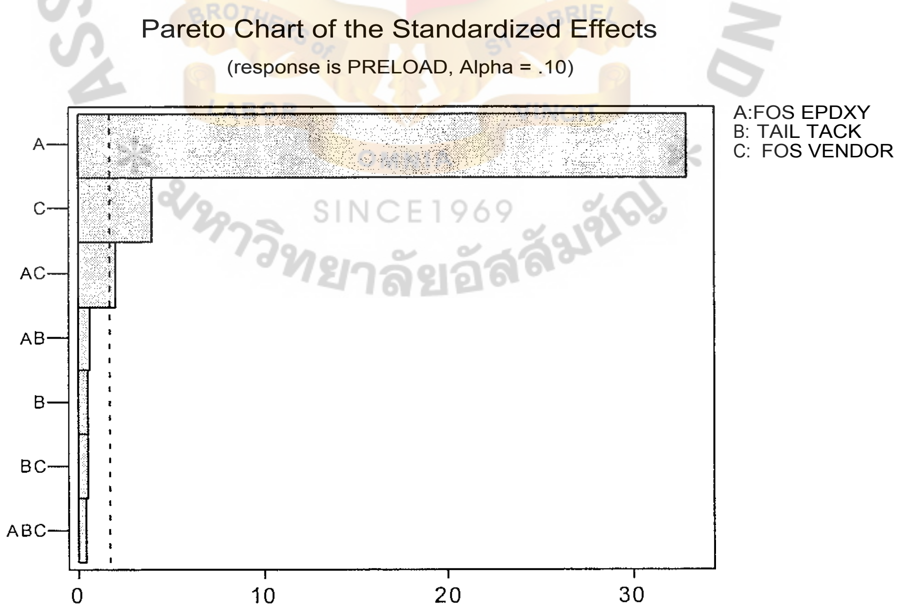


Figure 6.17. Pareto Chart of DOE.

(e) Regression Analysis

The regression equation is
[illegible]
[illegible]

Predictor	Coef	StDev	T	P
Constant	2.82787	0.00447	632.34	0.000
FOS EPDXY	0.148250	0.004472	33.15	
FOS VENDOR	-0.017875	0.004472	-4.00	
FOS EPDXY*VENDOR	-0.009250	0.004472	-2.07	

S = 0.08000 R-Sq = 78.0% R-Sq(adj) = 77.8%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	3	7.1626	2.3875	373.06	0.000
Residual Error	316	2.0224	0.0064		
Total	319	9.1850			

Figure 6.18. Regression Analysis of DOE.

(f) Revise Process Setting

According to Multi variable analysis reported very high standard deviation of preload when applied to much more amount of epoxy. So, process setting should be at low amount of epoxy. Not only the amount of epoxy needs to be adjusted but also raw flexure preload should be adjusted if HGA preload before adjustment is not on the target. The following graph shows preload comparing between raw suspension preload versus HGA eload before adjustment.

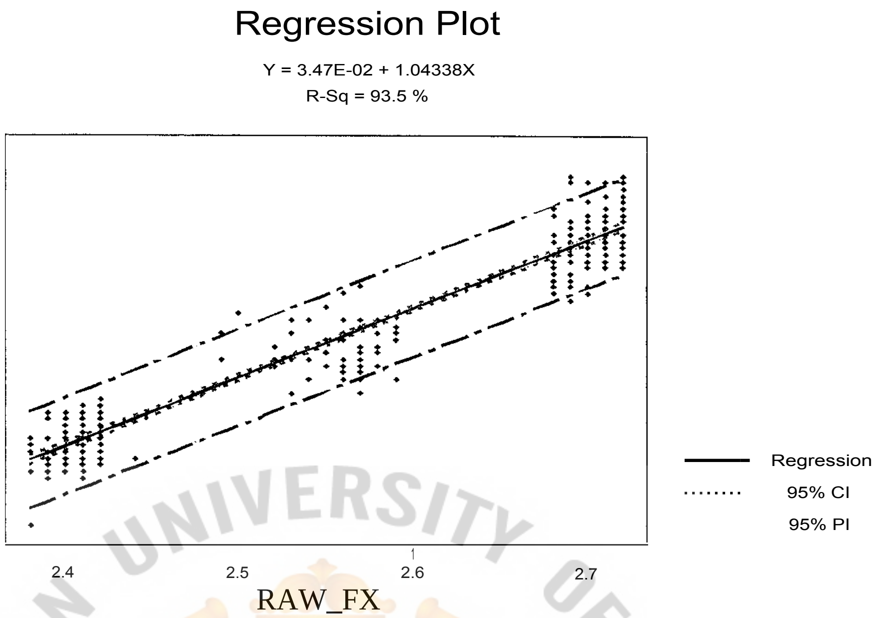


Figure 6.19. Regression Analysis Result.

(g) Appropriate Preload Window Adjustment

After studying the front line variations, the appropriate preload window adjustment has been evaluated by opening the preload window to be 3 groups, which are +/-0.05, +/-0.10 and +/-0.12. The results are provided in Figure 6.20.

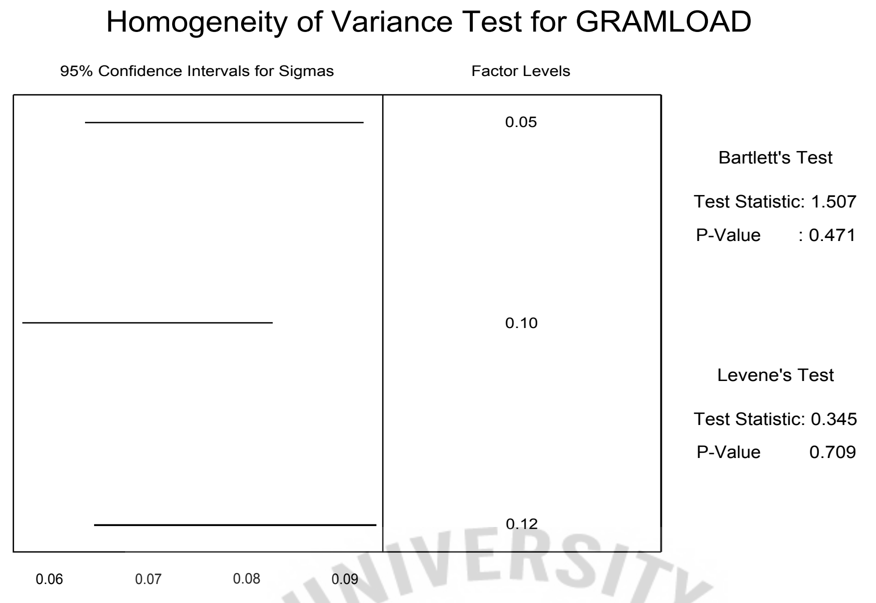


Figure 6.20. One-way Analysis of Variance.

```
Analysis of Variance for GRAMLOAD
Source     DF        SS        MS        F        P
RANGE       2   0.01561   0.00780     1.45    0.236
Error     267   1.43542   0.00538
Total     269   1.45103
                                   Individual 95% CIs For Mean
                                   Based on Pooled StDev
Level       N      Mean     StDev   - - - - -

0.05       90    2.6592    0.0755              ( -       *         )
0.10       90    2.6409    0.0678   ( -       *           )
0.12       90    2.6529    0.0764          ( - -       *          )
                                              + -       + -       +---
Pooled StDev =   0.0733                     2.640     2.655     2.670
```

Figure 6.21. Result of Analysis of Variance.

Conclusion: There are no significant difference of preload between these three groups. So, the preload window adjustment group +/-0.12 has been selected for the current process.

(h) Correlation between HGA and HSA Preload

Correlation between HGA and HSA preload has been studied by selecting HGA parts from OQA, in order to get the appropriate range of preload performance, and control build to HSA level. The result of this evaluation is illustrated in Figure 6.22 and Figure 6.23.

CORRELATION BETWEEN HGA VS HSA (UPTAB)

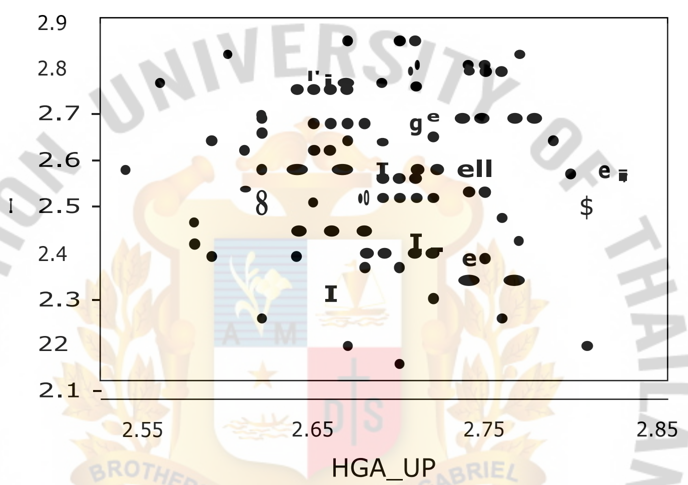


Figure 6.22. Correlation between HGA vs HAS.

Regression Analysis

```
The regression equation is
HSA DN = 2.03 + 0.178 HGA DN

Predictor         Coef       StDev          T        P
Constant        2.0301      0.9430       2.15    0.033
HGA DN          0.1777      0.3531       0.50    0.616

S = 0.1797      R-Sq = 0.2%      R-Sq(adj) = 0.0%

Analysis of Variance

Source            DF          SS          MS         F        P
Regression         1     0.00818     0.00818      0.25    0.616
Residual Error   118     3.80921     0.03228
Total            119     3.81739
```

Figure 6.23. Regression Analysis Result of HGA_DN.

Regression

```
The regression
HSA UP = 3.22 -

Predict            Coef              T
Constant         3.2220         0.7214
HGA UP          -0.2440         0.2676

S = 0.1633    Sq= 0.7%     Sq(ad)  -

Analysis of

Source                DF         SS          MS
Regression             1    0.02216     0.02216
Residual Error       118    3.14580
Total                119
```

Figure 6.24. Regression Analysis Result of HGA UP.

Conclusion: There are no correlations between HGA and HSA preload. So, the in-control chenaged of HGA preload will not have any effect to HSA preload.

6.3.3 Phase Conclusion

DOE analysis reported 78% R-Squared and FOS bond epoxy impact to HGA preload as the main effect. This lead to a suggestion as to how to apply epoxy at FOS bond operation in Control phase. Moreover, evaluation of raw suspension preload versus preload _1 before adjustment reported 93.5% R-Squared after suggesting operators to apply epoxy at FOS bond operation. Besides, 0.15 gram of preload at raw suspension should be lower than Preload 1 before adjustment regarding to regression equation.

However, the preload target had been changed during the evaluation due to the Drive issue that required the preload target to be up-gram in order to get the fly height to be lower. So, the preload target had been changed from 2.65 gram to be 2.75 gram and the incoming flexure preload had been changed from 2.50 gram to 2.65 gram regarding to regression equation.

Finally, the autogrammer adjustment window has been changed from target +/-0.05 to +/-0.12 gram based on the frontline process variation reduction, and the preload window adjustment evaluation and correlation between HGA and HSA preload result.

6.4 Control Phase

6.4.1 Metrics to Be Reported and Interval

Preload times adjusted per unit will be reported by weekly, daily and shiftly basis on Microsoft Intranet Explorer.

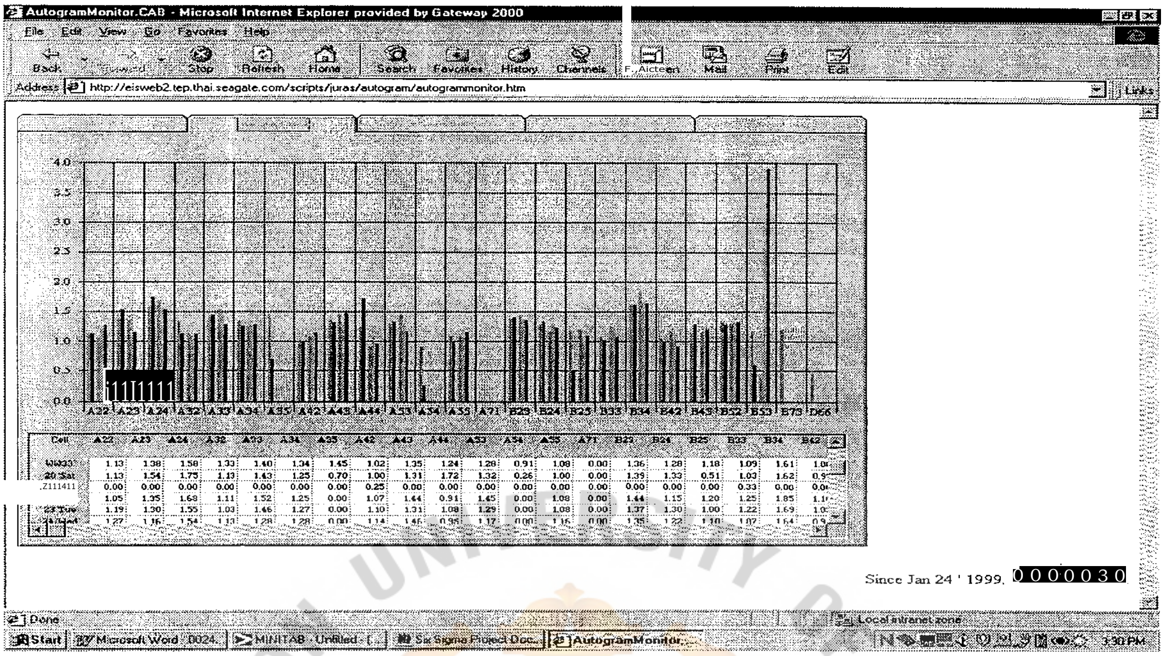


Figure 6.25. Report Preload by Weekly and Daily Basis.

6.4.2 Product and Tester SPC Status by Cell

Product and Tester SPC have been set up for each manufacturing cell. Mean, Sigma, Control limits and Input of corrective action when out of control occuring are provided automatically in the system. The sample of this is illustrated below.

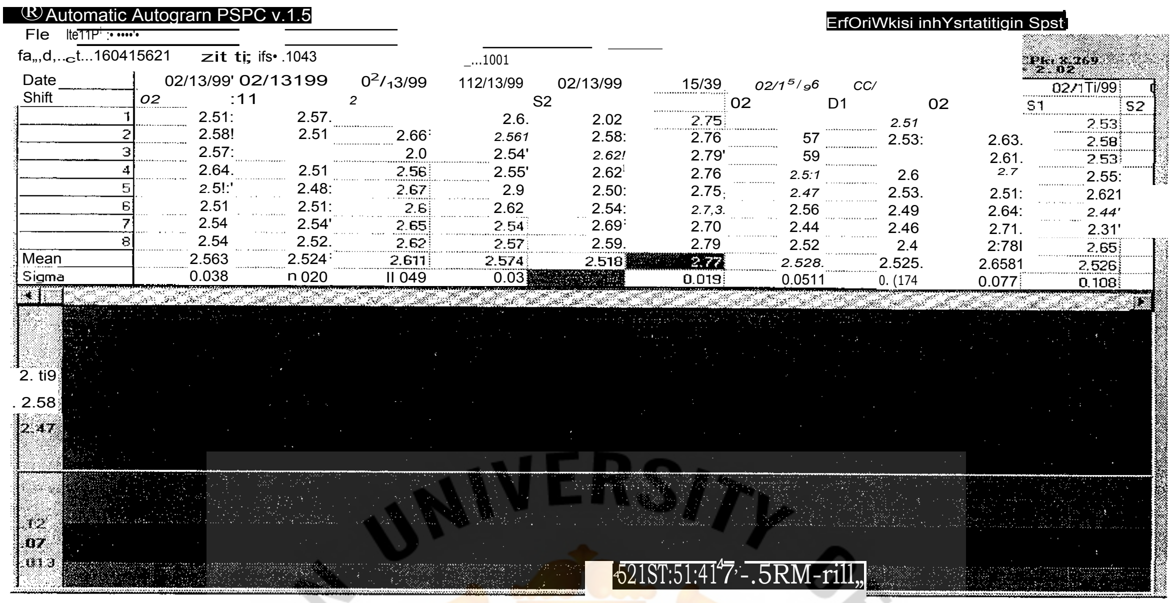


Figure 6.26. Automate PSPC.

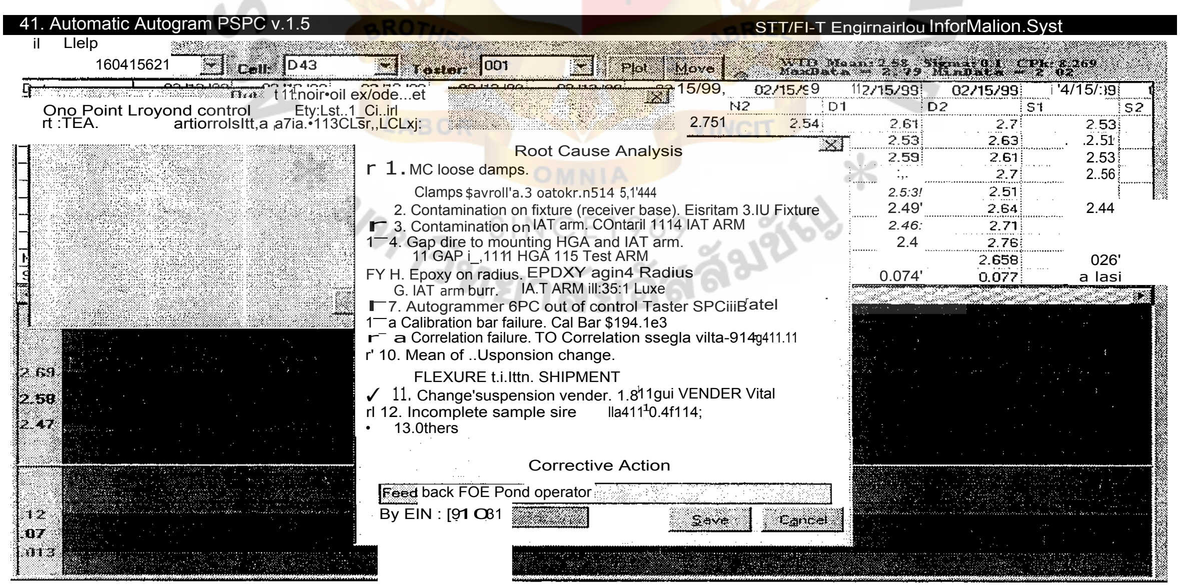


Figure 6.27. Automate PSPC.

6.4.3 Preload SPC Procedure and Root Cause Analysis

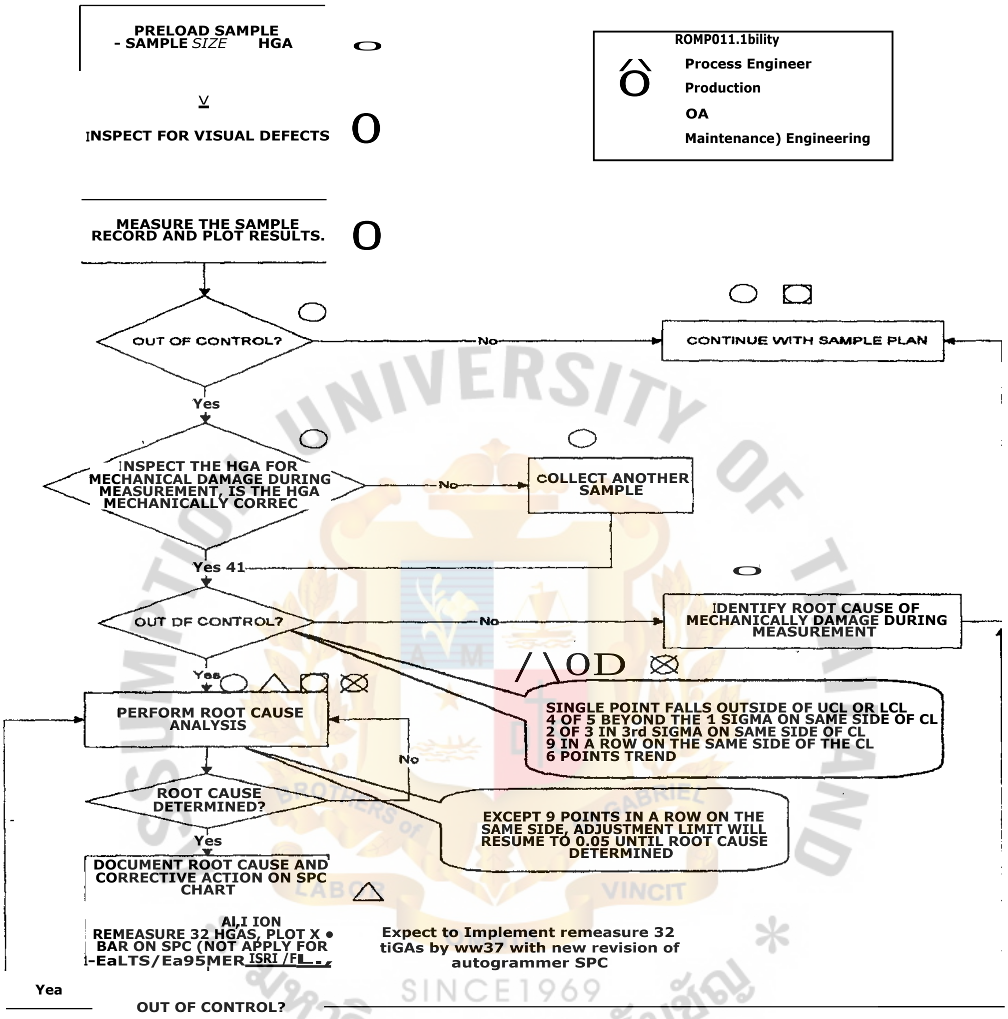
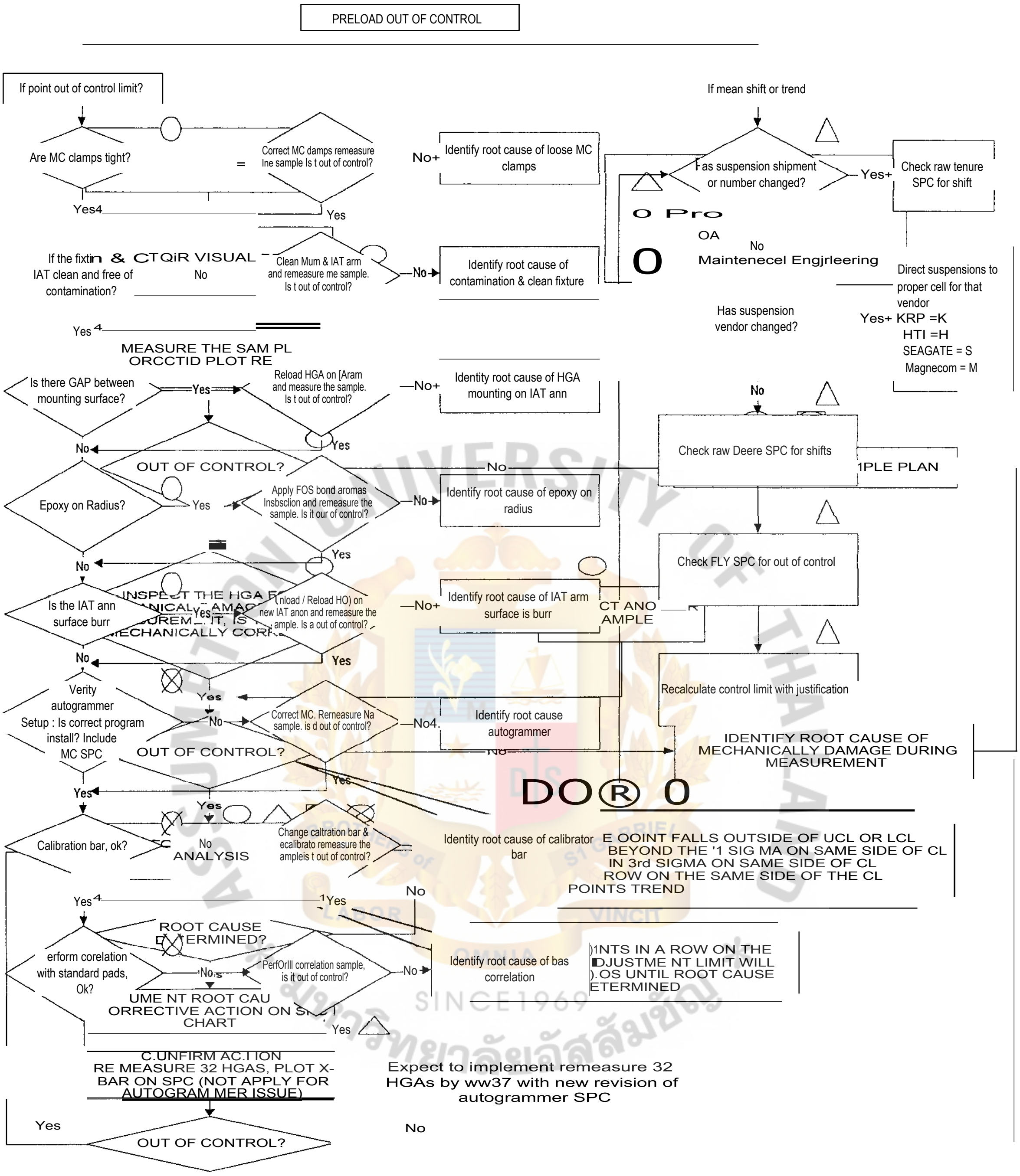


Figure 6.28. Process Control Loop.



Preload SPC Procedure and Root Cause

Figure 6.29. Loose Cause Analysis Loop.

6.4.4 Phase Conclusion

(1) Raw suspension preload should have been controlled at vendor. Need vendor control process by using SPC.

(2) Train Trainers, Supervisors and Operators about how to apply epoxy at FOS bond operation. In addition, visual aid of this is provided by Process engineer.

(3) Tester SPC have been changed from 1 HGA/day to 5 HGAs/shift in order to ensure that autogrammer is under controlled all the time.

(4) Preload SPC has been established before adjustment in order to feedback to the frontline when the process is out of control. In addition, there are a few monitoring charts on EIS/WEB such as SPC, Autogrammer Times Adjusted/Unit by cell or by shift and Real time Out of Control monitoring.

VII. CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

By applying the Cycle time and WIP reduction to our current process, The number of WIP is reduced from each carrier without the capacity per line per shift effect. The number of WIP can be reduced from 2,155 units to 1,671 units. Also the tooling cost per cell is reduced from 130,395 US$ to 103,740.5 US$ which saves 26,654 US$ or 1,039,526 bahts per cell (1 US$ = 39 bahts). Totally, Seagate can save about 373,163 US$ or 14,553,357 bahts from 14 cells of Cheetah 36 product.

The details of the number of WIP and the tooling costs are shown in Tables 7.1 and 7.2, respectively. The tooling requirement calculation is shown in Appendix A.

Also the Six sigma concept applied increased the percent of First Yield at autogramer operation, the results shows significant improvements from 24% to 60%. and the unit per hour (UPH) has been improved from 159 to 230 which causes the capacity of this operation to improve from 3,005 to 4,347 units/day/machine. Based on this improvement, with 13,000 units capacity per day, the number of operators of this operation can be reduced from 5 to 3 operators. Thus, 2 operators for NVA can be eliminated. The UPH calculation is shown in Appendix A.

Both of WIP reduction and the Six Sigma concept are adopted and applied to eliminate waste for Seagate Manufacturing. Although it can eliminate 7 kinds of wastes in business which are wastes from overproduction, transportation waste, waste of waiting time, inventory waste, processing waste, waste of motion and waste from product defects, it still furthers improvements on the NVA elimination. This project has shown only 1 out of 19 for the NVA elimination. Seagate needs to apply Six Sigma concepts to eliminate the remaining NVA as well.

Table 7.1. The Number of WIP in the Cheetah 36 Production Line after WIP Reduction.

OPERATION	% Sampling	STD UPH	STD H/C	Kanban Size	WIP HGA
PRE-TRIM LEAD	100.0%	873	1	2	4
LOAD HEAD	100.0%	340	2	2	8
GIMBAL BOND	100.0%	251	3	2	12
FLEX BOND	100.0%	232	3	2	12
FLEX LEAD BOND	100.0%	262	3	2	12
SPC BOND PULL	3.5%	30	1	-	-
SERVILANCE # 1	25.0%	160	1	-	5
COAT LEAD	100.0%	427	2	2	8
TAIL ATTACHED	100.0%	365	2	2	8
OVEN	100.0%	698	-	-	320
UNLOAD HGA FROM JIT TOOL	100.0%	382	2	10	40
LOAD IAT TEST ARM	104.0%	372	2	10	40
PUSH FLEX & CLEAN	110.0%	165	5	3	30
SURVEILLANCE#2	25.0%	160	1	3	5
HEAD SETTER	100.0%	730	1	3	6
PRELOAD	100.0%	156	5	3	30
STATIC ATTITUDE ADJUST	104.0%	188	4	3	24
MRE & REMOVE PRE-SHUNT	100.0%	296	2	3	12
ET TESTER	104.0%	88.1	8	30	480
SPC ALIGNMENT	7.6%	66	-	5	5
SPC GIMBAL BOND	5.0%	100	-	-	-
SHUNT LEAD	100.0%	562	1	5	10
FLY TESTER	5.0%	50	1	5	10
UNLOAD TEST ARM & FOLD FLAPPER	104.0%	331	2	5	20
FINAL INSPECTION	100.0%	170	4	30	240
CLEANING			-	240	240
QC	10.0%	128	1	-	-
PACK	100.0%	1500	1	90	90
TOTAL			58		1671

Table 7.2. The Cheetah 36 Tooling per Cell after WIP Reduction.

HGA TOOLING COST
MODEL : CHEETAH 36
LINE LOADING : 13 K

		Cheetah 36		13 K
Items	Operation description	Qty/cell	Cost(US$)	
		13	Unit	Cell
1	Pre-trim Firture	2	156.0	312.0
2	Jit tool block	487	104.0	50,668.8
3	Jit tool tray	109	6.5	709.9
4	Head loader Fixture	2	569.0	1,138.0
5	Gimbal bond Fixture	3	358.0	1,074.0
6	Flex bond Fixture	3	358.0	1,074.0
7	Lead bond Fixture	3	927.0	2,781.0
8	Damper Fixture	3	67.0	201.0
9	In-tray damper application fixture	3	54.0	162.0
10	Tail Tacking Fixture	2	67.0	134.0
11	Unload HGA Fixture	2	1689.0	3,378.0
12	Load IAT Arm	2	540.0	1,080.0
13	Test arm	526	30.0	15,770.4
14	Test arm wing do	263	33.0	8,679.0
15	Test arm wing up	263	33.0	8,679.0
16	Test Arm Tray	179	5.3	948.4
17	Spot clean Fixture	1	108.0	108.0
18	Head Setter	1	730.0	730.0
19	Head setter receiver	1	25.0	25.0
20	Preload Receiver	4	221.0	884.0
24	Autogram cal. Block	2	132.0	264.0
21	Wafer code fixture	10	17.0	170.0
22	Wafer code lense	10	147.0	1,470.0
23	Wafer code adater	10	144.0	1,440.0
24	Light shield	10	24.0	240.0
25	Unload IAT Arm Fixture	3	540.0	1,620.0
	Total cost of tooling per cell			103,740.5

Assumption

Working Hour	21	Jit tool Cleaning	6%
Ultilisation	90%	Jit tool Spare	6%
		Test arm cleaning	6%
		Test arm spare	6%

7.2 Recommendations

This project covers and focuses only on the production line, which is one part of the Seagate manufacturing. Seagate still adopts and adapts many techniques and tools for applying to other manufacturing areas such as storage and shipping to get the perfect lean manufacturing and meet Seagate's objectives which are shown below:

(1) Lead the industry in key technologies.

(2) Improve time to market for all product.

(3) Create world-class manufacturing processes.

(4) Develop strategic supplier relationships.

(5) Provide best-in-class product and process quality.

(6) Develop strategic relationships with key customers.

(7) Become an employer of choice.

There are many tools or techniques that are recommended at HGA assembly line for effectively increasing production capacity as follows:

(a) Methods analysis and design. Methods analysis or work design should be simplified and effective of manual work based on the principle of motion economy and ergonomic design.

(b) Time study. Before the observed time, the Industrial engineer should consider, "Is this operation ready for a time study?" It might be observed by the learning curve operator. Rating of operator's performance and allowance should be factored to be the standard time.

(c) KAIZEN or Continuous improvement, Productivity improvement is a good example that is implemented into our HGA production line. To increase capacity effectively, we always improve to be better than ever such as simplifying the necessary operation, sampling testing operation and improving quality circle.

(d) Lean manufacturing. To minimize the usage of resources. To reduce work in process (WIP), reducing amount of carriers for increased number of cycle loops that will be back into production line. The result is HGA will be completed in each operation faster than previously because there is minimized idle time to waiting for WIP carrier, and able to utilize carriers for other products. It helps the company to increase production capacity and also save tooling order cost.

APPENDIX A

TOOLING REQUIREMENTS AND UNITS PER HOUR (UPH) CALCULATION

OVEN CAPACITY CALCULATION

DESPATCH OVEN 18 "

18"

L.BLK

48" 13"

68 "

CURING TRAY 5 UNITS

DIMENSION = 2.4"x7.5"

L.BLK LENGTH OF BLOC

L.B : LENGTH OF BELT

<u>CONDITION</u>

W / H : WORKING HOUR PER DAY	1260	MINUTES
% UTIL % UTILIZATION	95%	
LOT SIZE = I BLOCK	35	UNITS
LENGTH OF BLOCK	7.50"	

AT OVEN SPEED 2.5 INCH / MINUTE

MAXIMUM OUT PUT = $\frac{\text{W/ H X\% UTIL X SPEED X LQT SI}}{\text{L BLK}}$

13965 UNITS / DAY

MAXIMUM JIT TOOL ON OVEN'BELT = $\frac{\text{L , B X LOT SIZE}}{\text{L BLK}}$

317 UNITS

Table A.1. Jit Tool Requirement per Cell.

JIT TOOL REQUIREMENT WITH CURRENT CONCEPT
MODEL : CHEETAH 36
LINE LOADING: 13 K DAY

Opn #	Operation description	% Sampling	Standard UPH	Cheetah 36 H/C 13	13 K Number of Jit tool Operator	Operation	Tray	Remarks
1	Pre-trim	100%	873	1	0	0		
2	Head loader	100%	340	2	5	10	2	
	Wait for Gimbal bond				5	15	3	
3	Gimbal bond	100%	251	3	5	15	3	
	Wait for Flex bond				5	15	3	
4	Flex bond	100%	232	3	5	15	3	
	Wait for lead bond				5	15	3	
5	Lead bond	100%	262	3	5	15	3	
6	SPC lead bond	5%	30	1	5	6	1	4 units/shift/machine
7	Servilance # 1	100%	160	5	5	25	5	
	Wait for Coating				5	10	2	
8	Coat Lead	100%	427	2	5	10	2	
	Wait for Tacking				5	10	2	
9	Tail Tacking	100%	365	2	5	10	2	
	Thermal Oven				5	320	64	
	Wait for Unload HGA				5	10	2	
10	Unload HGA	100%	382	2	5	10	2	
	Screen Jit tool				5	5	1	
	Return Jit tool				5	5	1	
	Total Jit tool Block for MFG					521		
	Cleanning jit tool (6 %)					31		
	Jit tool For ME (6 %)					31		
	Total Standard Jit Tool per Cell					584		
	Total Jit tool Tryper cell						110	

Assumption			
Working Hour	21	Jit tool Cleaning	6%
Ultilisation	93%	Jit tool Spare	6%
Jit tool per tray			5
Jit tool per tray for Tail tracking,Oven, Unload			5

Table A.2. Test Arm Requirement per Cell.

TEST ARM REQUIREMENT WITH CURRENT CONCEPT
MODEL : CHEETAH 36
LINE LOADING : 13 K PER DAY

Opn #	Operation description	% Sampling	Standard UPH	Cheetah 36 H/C 13	13 K Number of Test Arm Operator	Operation	Tray	Remarks
	Wait for load IAT Arm				5	10	2	
11	Load IAT Arm	I 04%	372	2	5	10	2	
12	Serveilance 4 2	25%	160	2	5	10	2	
	Wait for Push Flex and spot clean				5	5	1	
13	Push Flex and spot clean	104%	165	5	5	25	5	
	Wait for Head Setter				5	5	1	
14	Head Setter	100%	730	1	5	5	1	
	Wait for Preload Adjust				5	25	5	
15	Preload Adjust	100%	156	5	5	25	5	
	Wait for SAAM & Cut Flex				5	20	4	
16	SAAM & Cut Flex	104%	188	4	5	20	4	
	Wait for ET & Fly				5	5	1	
17	Fly tester	5%	50	1	5	5	1	
18	ET	104%	88.1	8	50	400	80	
	Wait for Shunting				15	30	6	
19	Shunting	100%	562	2	5	10	2	
	Wait for Unload HGA & Flapper				5	15	3	
20	Unload HGA & Flapper	104%	331	3	5	15	3	
	Return to Load Test arm					10	2	
	Total Jit tool Block for MFG					650		
	SAAM,Autogramer and Auto-shunting					62		
	Cleanning jit tool (6 %)					39		
	Jit tool For ME (6 %)					39		
	Total Standard Jit Tool per Cell					790		
	Total tray per cells						177	

Assumption			
Working Hour	21	Test ann cleaning	6%
Ultilisation	93%	Test arm spare	6%
Test Arm per tray			5
Test Arm per ET			50

Table A.3. HGA Tooling Cost per Cell.

HGA TOOLING COST PER CELL
MODEL : CHEETAH 36
LINE LOADING : 13 K

Items	Operation description	Cheetah 36 Qty/cell 13	13 K Cost(US$) Unit	Cell	Remarks
1	Pre-trim Firture	2	156.0	312.0	
2	Jit tool block	584	104.0	60,686.1	
3	Jit tool tray	110	6.5	717.9	
4	Head loader Fixture	2	569.0	1,138.0	
5	Gimbal bond Fixture	3	358.0	1,074.0	
6	Flex bond Fixture	3	358.0	1,074.0	
7	Lead bond Fixture	3	927.0	2,781.0	
8	Damper Fixture	3	67.0	201.0	
9	In-tray damper application fixtur	3	54.0	162.0	
10	Tail Tacking Fixture	2	67.0	134.0	
11	Unload HGA Fixture	2	1689.0	3,378.0	
12	Load IAT Arm	2	540.0	1,080.0	
13	Test arm	790	30.0	23,700.0	
14	Test arm wing do	395	33.0	13,035.0	
15	Test arm wing up	395	33.0	13,035.0	
16	Test Arm Tray	177	5.3	936.0	
17	Spot clean Fixture	1	108.0	108.0	
18	Head Setter	1	730.0	730.0	
19	Head setter receiver	1	25.0	25.0	
20	Preload Receiver	4	221.0	884.0	
24	Autogram cal. Block	2	132.0	264.0	
21	Wafer code fixture	10	17.0	170.0	
22	Wafer code lense	10	147.0	1,470.0	
23	Wafer code adater	10	144.0	1,440.0	
24	Light shield	10	24.0	240.0	
25	Unload IAT Arm Fixture	3	540.0	1,620.0	
	Total cost of tooling per cell			*130,395.0*	

Assumption

Working Hour	21	Jit tool Cleaning	6%
Ultilisation	90%	Jit tool Spare	6%
		Test arm cleaning	6%
		Test arm spare	6%

Table A.4. HGA Requirement per Cell with Lean Concept.

JIT TOOL REQUIREMENT WITH LEAN MANUFACTURING CONCEPT
MODEL : CHEETAH 36
LINE LOADING : 13 K DAY

Opn#	Operation description	% Sampling	Standard UPH	Cheetah 36 11/C 13	13 K Number of lit tool Operator	Operation	Tray	Remarks
1	Pre-trim	100%	873	1	C	0		
2	Head loader	100%	340	2	D	4	2	
	Wait for Gimbal bond				N	6	3	
3	Gimbal bond	100%	251	3	N	6	3	
	Wait for Flex bond				N	6	3	
4	Flex bond	100%	232	3	N	6	3	
	Wait for lead bond				N	6	3	
5	Lead bond	100%	262	3	N	6	3	
6	SPC lead bond	5%	30	1	NM	6	2	4 units/shift/machine
7	Servilance # 1	100%	160	5	Nkr)	10	5	
	Wait for Coating				kr)	10	2	
8	Coat Lead	100%	427	2	kr)	10	2	
	Wait for Tacking				kr)	10	2	
9	Tail Tacking	100%	365	2	r)	10	2	
	Thermal Oven				r)	315	63	
	Wait for Unload HGA					10	2	
10	Unload HGA	100%	382	2	kr)	10	2	
	Screen Jit tool				N	2	1	
	Return Jit tool				N	2	1	
	Total Jit tool Block for MFG					435		
	Cleanning j it tool (6 %)					26		
	Jit tool For ME (6 %)					26		
	Total Standard Jit Tool per Cell					487		
	Total Jit tool Tray per cell						109	

Assumption			
Working Hour	21	Jit tool Cleaning	6%
Ultilisation	93%	Jit tool Spare	6%

Table A.5. Test Arm Requirement per Cell with Lean Concept.

TEST ARM REQUIREMENT WITH LEAN MFG CONCEPT
MODEL : CHEETAH 36
LINE LOADING : 13 K PER DAY

Opn#	Operation description	% Samplin	Standard UPH	H/C 13	Cheetah 36 13 K Number of Test Arm: Operator	Operation	Tray	Remarks
	Wait for load IAT Arm				3	6	2	
11	Load IAT Arm	104%	372	2	3	6	2	
12	Serveilance # 2	25%	160	2	3	6	2	
	Wait for Push Flex and spot clean				3	3	1	
13	Push Flex and spot clean	104%	165	5	3	15	5	
	Wait for Head Setter				3	3	1	
14	Head Setter	100%	730	1	3	3	1	
	Wait for Preload Adjust				3	15	5	
15	Preload Adjust	100%	156	5	3	15	5	
	Wait for SAAM & Cut Flex				3	12	4	
16	SAAM & Cut Flex	104%	188	4	3	12	4	
	Wait for ET & Fly				15	15	5	
17	Fly tester	5%	50	1	3	3	1	
18	ET	104%	88.1	8	30	240	80	
	Wait for Shunting				15	30	10	
19	Shunting	100%	562	2	3	6	2	
	Wait for Unload HGA & Flapper				3	9	3	
20	Unload HGA & Flapper	104%	331	3	3	9	3	
	Return to Load Test arm					6	2	
	Total Jit tool Block for MFG					414		
	SAAM,Autogramer and Auto-shunting					62		
	Cleanning jit tool (6 %)					25		
	Et tool For ME (6 %)					25		
	Total Standard Jit Tool per Cell					526		
	Total tray per cells						179	

Assumption			
Working Hour	21	Test arm cleaning	6%
Ultilisation	93%	Test arm spare	6%

Table A.6. HGA Tooling Cost per Cell with Lean Concept.

HGA TOOLING COST
MODEL : CHEETAH 36
LINE LOADING : 13 K

Items	Operation description	Qty/cell	Cost(US$)		Remarks
		Cheetah 36		13 K	
		13	Unit	Cell	
1	Pre-trim Firture	2	156.0	312.0	
2	Jit tool block	487	104.0	50,668.8	
3	Jit tool tray	109	6.5	709.9	
4	Head loader Fixture	2	569.0	1,138.0	
5	Gimbal bond Fixture	3	358.0	1,074.0	
6	Flex bond Fixture	3	358.0	1,074.0	
7	Lead bond Fixture	3	927.0	2,781.0	
8	Damper Fixture	3	67.0	201.0	
9	In-tray damper application fixture	3	54.0	162.0	
10	Tail Tacking Fixture	2	67.0	134.0	
11	Unload HGA Fixture	2	1689.0	3,378.0	
12	Load IAT Arm	2	540.0	1,080.0	
13	Test arm	526	30.0	15,770.4	
14	Test arm wing do	263	33.0	8,679.0	
15	Test arm wing up	263	33.0	8,679.0	
16	Test Arm Tray	179	5.3	948.4	
17	Spot clean Fixture	1	108.0	108.0	
18	Head Setter	1	730.0	730.0	
19	Head setter receiver	1	25.0	25.0	
20	Preload Receiver	4	221.0	884.0	
24	Autogram cal. Block	2	132.0	264.0	
21	Wafer code fixture	10	17.0	170.0	
22	Wafer code lense	10	147.0	1,470.0	
23	Wafer code adater	10	144.0	1,440.0	
24	Light shield	10	24.0	240.0	
25	Unload IAT Arm Fixture	3	540.0	1,620.0	
	Total cost of tooling per cell			103,740.5	

Assumption

Working Hour	21	Jit tool Cleaning	6%
Ultilisation	90%	Jit tool Spare	6%
		Test arm cleaning	6%
		Test arm spare	6%

Table A.7. Autogrammer Unit per Hour Calculation before Implement Six Sigma.

ELEMENT	QTY.	% ADDJUST OE EACH MODE	STANDARD TEST TIME (SEC)	SUMMATION STANDARD TIME (SEC)	AVERAGE TEST TIME (SEC)
LOAD TEST ARM TO TRAY			2	2	2.00
NOT BEND	702	24.2%	6.6	6.6	1.60
BEND 1	1198	41.4%	7.4	14	5.79
BEND 2	636	22.0%	7.8	21.8	4.79
BEND 3	280	9.7%	7.8	29.6	2.86
BEND 4	61	2.1%	6.1	35.7	0.75
BEND 5	8	0.3%	6.1	41.8	0.12
BEND 6	6	0.2%	6.1	47.9	0.10
BEND 7	1	0.0%	6	53.9	0.02
BEND 8	5	0.2%	6	59.9	0.10
BEND 9	0	0.0%	6	65.9	0.00
UNLOAD TEST ARM TO TRAY			2		2.00
TOTAL	2897	100.0%			
SUMMATION TIME					20.12
STANDARD TIME WITH ALLOWANCE 11 %					22.61
HOUR PER UNIT					159.21
CAPACITT PER OPERATOR PER DAY					3009.14

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