CHAPTER I
INTRODUCTION

1.1 Background

Filters used in hard disk drive are 3M products that are categorized as products in automotive and chemical markets group. Usually, filters can be classified by their usage as:

1. Breather filter is used for catching the dust that will get into the hard disk drive.
2. Desiccant filter is used for absorbing chemical vapor and dehumidifying inside hard disk drive.
3. Recirculation filter is used for preventing any damage on the disc surfaces by the dust while hard disk drive is operating. Because, during its operation, the disc must rotate at very high speed. The air in the hard disk drive will circulate at very high velocity also. Thus any dust inside or very small particles cracked during rotation can scratch the disc surface and the data stored on the disc may be lost. By using recirculation filter, the air that circulate inside hard disk drive will be filtered and the small particles will be caught and the possibility of disk drive failures will be reduced. Figure 1-1 shows the position of recirculation filter in hard disk drive.

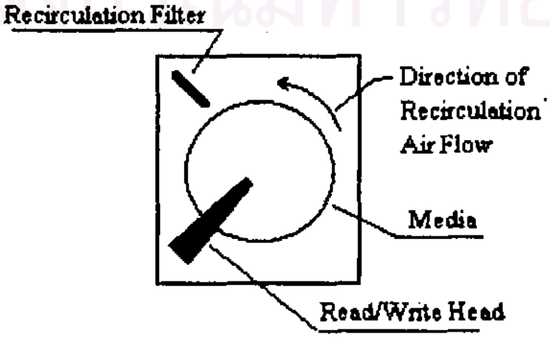

Figure 1-1 : Recirculation in hard disk drive

3M Thailand manufactures only the recirculation filter. The steps of its manufacturing process can be described as follows:

1. Raw materials, called " Filtrete™ Media ", is baked at 80 °C for 2 hours in order to reduce vaporized organic contaminants.
2. Filtrete™ Media is cut to the required size by the process called "Die-cutting process".
3. The visual inspection is used to detect the dust or other contaminants in the filter.
4. If the visual inspection results are satisfactory, then filters will be packed for delivering to the customers. In this stage, filters must be vacuum packed to prevent any electrical charge that will cause damage while using.

The manufacturing process flow chart of recirculation filter can be shown as figure 1-2.

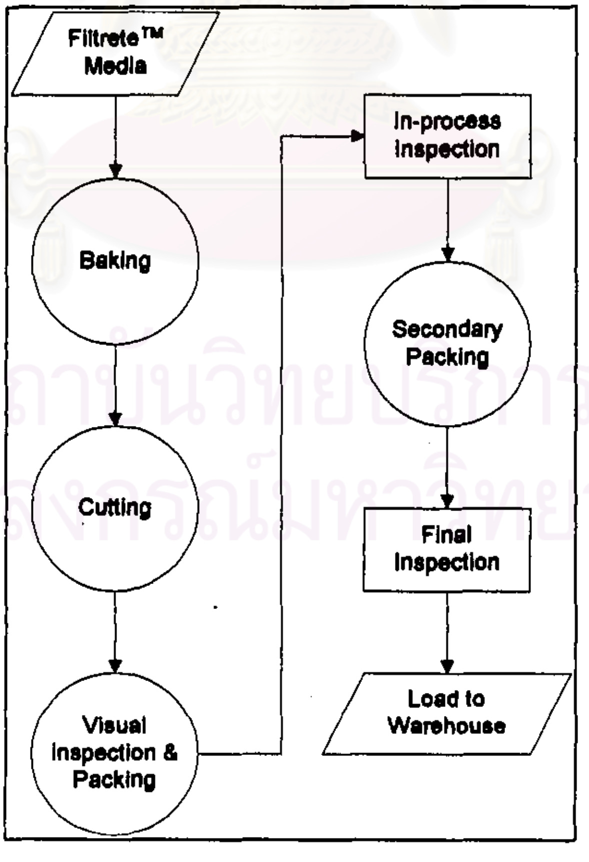

Figure 1-2 : Recirculation Filter Converting's Process Chart[2]

1.1.1 The Manufacturing Process

1. Material used is 100% polypropylene which is divided into 2 types by material weight per square meter. The two types of material are GSB-70 and G-100 which consisted of polypropylene 70 g/m^2 and 100 g/m^2 respectively. The selection of material to be used depends on customer's requirements.

2. Each model of recirculation filter is manufactured by exactly the same processes. But they differ only in terms of sizing.

3. Before going to the cutting process, the machine tool (die) needs to be set up. The supporting panel, including die, needs to be paralleled set up to the sonotrode surface so that the sonotrode surface will eventually touch the die, not touch only one side of the die. At this stage the operator can adjust three adjustable springs to make the die balance. The measurement of die balancing is by using feeler gage so that the operator's skill is very important.

4. Focusing on the cutting process, actually it consists of two integrated activities; they are sealing and cutting. To do these activities, 3M use machine called " Microprocessor Controlled Ultrasonic Welding Press ". The microprocessor - controlled welding press is a new standard set for the application of Ultrasonic to join thermoplastic components.

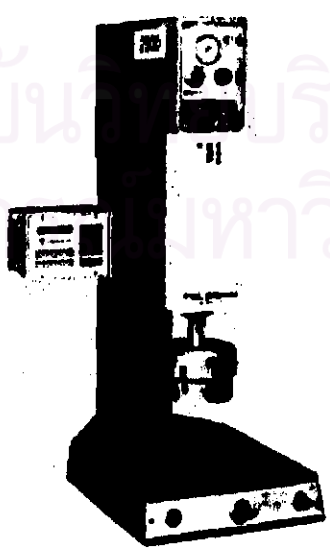

Figure 1-3 : Ultrasonic Welding Press

1.1.2 Principle of Ultrasonic Welding[1]

During the ultrasonic welding process, oscillation energy is supplied to the part to be welded by the welding tool, called " sonotrode ". The very briefly occurring friction of the material particles causes the material to plasticise very quickly in the desires areas. If this process is supported by a defined mechanical pressure, a tight joint of material is obtained.

The oscillation energy transfer is done through touching of the sonotrode with the plastic. The workpiece begins to oscillate in the standing transverse wave train, and the maximum begins to form itself on the contact surfaces of the two pieces of plastic to be connected. Under the influence of a set pressure, superimposed by ultrasonic, a secondary friction of a high frequency begins to heat up the contact surfaces of the parts to be connected. The plastic melts immediately and after cooling off a sturdy and homogeneous welding is obtained.

The magnitude of the plasticizing depends upon the amount of ultrasonic energy supplied. This application is almost impossible for the material to be detrimentally affected in any way in areas outside the welding zone. It is depend upon the type of plastic material that the different solidification times are required for the " at the joint plasticized material " to resolidify under the effect of the still present mechanical pressure. This process is called the cooling or holding time.

After that the surplus at the welding seam can be cut at the same time. In such a case the supporting metal only needs to be equipped with the die which has a cutting edge in a defined position, which then cuts the surplus off every time a weld is done. See figure 1-4 below:

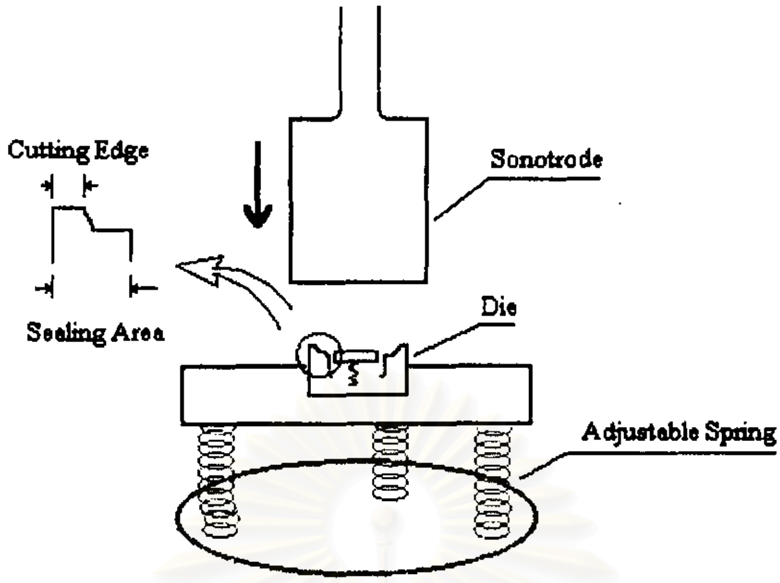

Figure 1-4 : Construction of the die and the supporting metal.

The sequence of an ultrasonic - weld is as follows:

1. The machine moves the surface of the sonotrode to very close contact with the component to be oscillated.
2. The ultrasonic pulse starts immediately. Fast plasticizing now takes place at the points of contact of the parts to be welded.
3. When the optimum degree of plastification has been reached, the mechanical pressure first applied.
4. When the ultrasonic impulse has stopped, as soon as the sonotrode touch the die (metal to metal) even it is reach the pre set time or not, the mechanical pressure is further intensified but only to a minimal extent.
5. The cooling time begins. And at the end of this process the machine returns to its starting position; the welding and cutting process is completed.

The whole cycle takes a very relatively short period of time. The individual cycle times for a complete welding process vary from 0.1 up to 5 seconds, depending on the application. In general the cycle times are between 0.5 and 2 seconds.

1.2 Statement of the Problem

Since starting to manufacture recirculation filter, there was a problem that the recirculation filter came off from its slot while the hard disk is operating. From the customer point of view, this problem is caused by either the size of filter is not correct and/or filter is too soft.

Since the raw materials can not be changed and the same model of filters which made by other 3M sources have not face this problem, the concentrated factor for the study will be on the size of the filter. From the study, shrinkage of the filter after die-cutting process is inevitable. The percentage of the shrinkage is not yet predictable. Therefore, the correct size of the die can not be determined. Resulting from the filter shrinkage, the die has to frequently be reworked, normally, at least twice per die.

The lead-time for submitting the First Article (Prototype, Dimensional Check and Cleanliness Test Results) after customer requested is 2 weeks. 3M has 5 working days to make the die, after cut off another 5 working days for the dimensional check and test result. Reworking the die causes many adverse effects because 3M can not meet the customer's request while the competitors may. From the records, 30 times of FA submission, the lead-time of submitting FA is 2 months in average.

It can be concluded that the causes of problems came from two reasons as follows:

1. How much percentage of shrinkage ?
2. Do operator crew, cutting edge, amplitude and area of edge seal have any affect on the material shrinkage ?

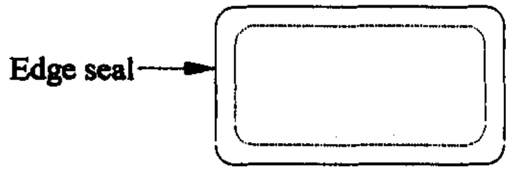

Figure 1-5 : Recirculation Filter

1.3 Objective of Study

To study the relationship between percent shrinkage of filter and potential factors that might affect it.

1.4 Scope of Study

1. Potential factors of study are as follows:
   - width of cutting edge (sharpness of cutting edge)
   - percentage of amplitude of energy
   - area of sealing

2. Study percentage of filter shrinkage in two direction; width and length.

3. Studying on 2 types of material basis ; GSB-70 and G-100.

1.5 Procedure

1. Study various causes of occurring shrinkage of recirculation filter by using Cause-and-Effect diagram. The study is considered the factor in five areas; men, materials, machines, methods and measurement.
2. Study the constraint in each aspect.
3. Preliminary conclusion on potential causes to study and design an experiment by using the information from the previous steps.
4. Collect data according to the experimental design.

5. Evaluate the effect of each factor on percent shrinkage of recirculation filter by hypothesis testing approach: ANOVA method.
6. Analysis and conclusion.

1.6 Benefits of the Study

1. Save cost in reworking the die.
2. Reduce lead-time of making the die.
3. More competitive.

1.7 Literature review

1. More orderly molecular packing, more shrinkage [12]

For crystallize polymers (include polypropylene) , the more orderly molecular packing leads to much greater shrinkage. In molding process, the main factors which cause an increase in shrinkage are:

1. An increase in mould temperature (which allows more time for crystallization to occur at reasonable rate).
2. A decrease of injection time - up to a limit - would allow more material to be packed into the mould).
3. A decrease of injection pressure (an increase of pressure will cause greater packing of material).

Moreover, shrinkage is often different along the line of flow and perpendicular to the flow stream line. Volumetric shrinkage is unaffected by melt temperature.

2. The shrinkage is resulted from loss of moisture of plasticizer[13]

" In thermoplastic materials , shrinkage may result from the loss of moisture of plasticizer, or may simply be a process of relieve internal stress introduced by molding or forming. "

3. The shrinkage is resulted from suddenly change of temperature[14]

When plastic material is solidified in the molding process , the shrinkage will occur due to the suddenly change of temperature.

4. The amount of shrinkage depends on types of plastic[15]

The shrinkage in crystalline thermoplastic is higher than amorphous plastic. The transition from room temperature to a high processing temperature may decrease a plastic's density by up to 25 percent. Cooling process cause possible shrinkage (up to 3 percent) and may cause surface distortions or voiding with internal frozen strains. The control of shrinkage is made to meet design requirements by factors such as the design of mold or die shape, the processing-machine controls, the change of product shape, and the type of plastics.

5. Basic concept of ultrasonic welding[16]

The basic of ultrasonic welding is two surfaces are rubbed together vigorously, which produces frictional heat. At the joint between two material faces, ultrasonic energy, which resulted from the conversion of mechanical vibration into heat, is transmitted and the temperature across the interfaces will rise.

An ultrasonic welder basically consists of a generator, which converts electrical main frequency to the required ultrasonic frequency. A typical layout for an ultrasonic welder is illustrated in figure 1-6.

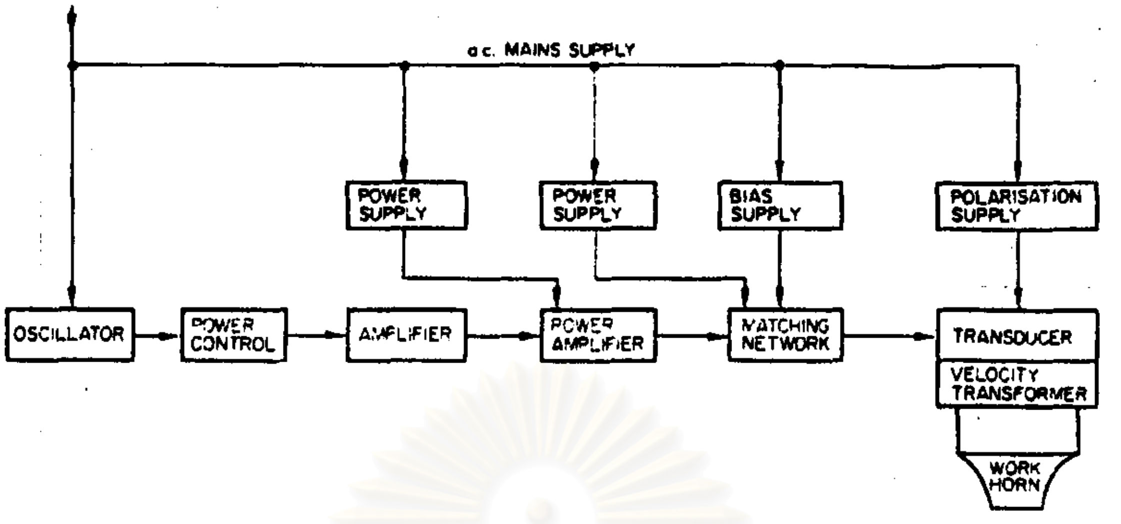

Figure 1-6 : Block diagram of a typical ultrasonic generator and transducer[16]

" There are two types of transducer, the piezoelectric or crystal type and the magnetostrictive type. Crystal transducers use natural or synthetic materials that will change in physical dimension if an electrical charge is applied across opposite faces. The disadvantage of transducers using quartz crystals or synthetic crystals is that if the temperature rises above the point known as the Curie point, it can have an effect on the life span of the crystal. Magnetostrictive transducers use the property of certain metals, such as nickel, where a changing magnetic field produces the change in the physical dimensions of the laminate stack which, whilst losing some efficiency if heated above the Curie point, will return to normal on cooling.

A transducer is similar to a small transformer. Two coils of wire are wound onto a nickle lamination stack. The work horn is screwed to one end of a stub, the other end of which has been bonded to the nickel stack. The assembly, together with a cooling fan, is mounted into a small press head which allows vertical pressure, normally under 10 kgf/cm^2, to be applied by the applicator or work horn to the work. The applicator can be changed for undertaking different applications such as spot, ring or bar welds or more complex shapes.

Two types of ultrasonic seal are possible, i.e. contact or near field such as with high frequency welding, where the electrode or applicator is applied directly to the material where the weld is to be made, and remote or far field which is suitable for joining rigid moldings. With the latter, the tip of the work horn is applied to a point of the work which may be some inches away from the faces to be welded, and the vibrations are transmitted through the material.

If the dimensions from the top of the work horn to all parts of the faces to he welded are equal. a single application will suffice. If there are gross differences from the tip to the weld face, the work horn may have to he applied more than once, in different places. "