

# CHAPTER V

## CONCLUSION AND RECOMMENDATION

### 5.1 Conclusion

The study of potential factors that have an effect on percent shrinkage of recirculation filter was done by measuring actual percent shrink of filter in length and width directions with the three existing dies. The factors that were concerned during the study are:

- types of material
- amplitude of the energy applied
- characteristics of the die (edge seal, cutting edge)

By applying the analysis of variance on the collected data, the results showed that all factors, except inner length and inner width, had an influence on the percent shrinkage of recirculation filter. Although in some conditions the test failed to reject the null hypothesis, but it may be caused by other influential factors that were not considered and were beyond the scope of this study.

To predict the size of die, the multiple regression analysis was applied in order to determine the relationship between percent shrinkage and those factors.

From the analysis, the relationship of the percent shrinkage per types of material and other factors that can be explained by linear regression equation are shown as following:

- % shrinkage in length direction for material G-100

$$M100 \%SHL = 2.72 + 0.00606 \text{ Amp} + 1.16 \text{ Cutting Edge} - 2.82 \text{ Edge Seal} \quad (\text{Eqn.4-1})$$

$$M100 \%SHW = 2.02 + 0.0187 \text{ Amp} - 2.34 \text{ Cutting Edge} + 3.55 \text{ Edge Seal} \quad (\text{Eqn.4-2})$$

- % shrinkage in width direction for material GSB-70

$$M70 \%SHW = 1.38 + 0.0113 \text{ Amp} - 6.56 \text{ Cutting Edge} + 11.1 \text{ Edge Seal} \quad (\text{Eqn.4-4})$$

From the equations, the percent shrinkage can be explained by these multiple regression equations except the shrinkage in length direction of GSB-70 that the coefficient of determination is very low. It may be caused by other factors such as the variation within lot of material that is inherit properties of woven material, variation of input amplitude, and uniformity of ultrasonic energy throughout the sonotrode's surface (horn). Thus, the further study should be done in order to clarify which additional factors are over looked. Nevertheless, the above three equations show that the factors (material types, amplitude and die's characteristic (edge seal and cutting edge)), which are considered in this study, affect the percent shrinkage of the filter.

The equations from this study can be applied during design stage to determine the compensation of the filters' size that the shrinkage may occur. It has many benefits in the filter production as follows:

1. Save cost in reworking the die.

As discussed previously, the die size can be calculated by the equations from this study. It is different from the past that the die size was determined by trial and error and the die needed to be reworked many times to get the appropriate size.

2. Reduce lead-time in making product prototype.

Due to reduction of die's reworking process, the lead time for producing the product prototype will be also reduced.

3. More competitive.

Because of reduction in cost and production lead-time, the competitive potential will be increased.

## **5.2 Recommendation**

1. From the study, it is indicated that the type of material affects percent shrinkage of recirculation filter. Thus, the performance and other specification test should be performed in order to specify the type of material before manufacturing the die. It

can minimize the loss due to manufacture new die if the size of filter from changing material is not satisfied as previous.

2. The equation from the regression analysis can be used in order to predict the size of the die in die's design stage. However, the linear regression equation of the shrinkage in length direction of GSB-70 has very low coefficient of determination and is not recommended for use. Thus, further study should be performed.
3. As discussing above, there might be other factors that affect the percent shrinkage. Thus, the company should proceed the study in those factors whether they have an effect on percent shrinkage. The following actions should be proceeded:
  - The weight variation within a lot of material should be checked. It may be checked through the Filtrete™ supplier.
  - The output of amplitude from the ultrasonic welding machine should be calibrated and controlled for its variation. Moreover, a person should be assigned to coordinate with the machine manufacturer in Switzerland. In addition, the training for maintenance staffs about operation principle of the machine should be organized with the manufacturer.
  - During actual manufacturing, the spring underneath die's foundation is periodically adjusted or changed, so the period that the spring becoming unbalance should be recorded. Also, the effect due to unbalance of the spring should be studied. Thus, more operating time is needed to investigate for further study.
  - The die wearing should be further study to investigate life cycle.