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OPTIMIZATION OF PACKAGE SAW PARAMETERS USING FULL FACTORIAL DESIGN IN QFN PACKAGES

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ABSTRACT

Quad Flat No-lead (QFN) presents an excellent example of a complex substrate composed of both ductile (copper) and brittle (plastic molding compound) materials, showing clear trends of reduction in package size and the combination ductile and brittle materials in the same sawing process which creates real challenges in term of sawing quality, blade life and throughput. This paper discussed on the effect of different blade rotation and cutting speed process parameters in package saw singulation. The objective of this study is to screen the effect on the output quality by increasing the throughput using existing blade. The design of experiment on singulating processes is evaluated for this study to get the optimal parameters for the process. The type of sawing process used was the single-pass tape saw method. The package shifting and burr level analysis were measured by using Smartscope Optical Gaging. The results showed that at higher cutting speed and lower blade rotation, less chipping, burr level and side smear were observed.

INTRODUCTION

Singulation of packages is an important step in the manufacturing of IC semiconductor packaging. Presently, the most widely used technique is abrasive sawing [1]. Due to the combination of different materials used in QFN packages such as die attach material (DAF) and mold compound the parameter in saw singulation process need to be optimized or new techniques to be explored to produce good output.

One of the latest developments in packaging technology is the QFN (Quad Flat No-lead) package. QFN packages have many advantages over conventional leadframe package, such as low cost, small size, low profile, high thermal and electrical performance and good production yields [2]. QFN package is manufactured in a molded array format that maximizes product throughput. Beside that, QFN is also an excellent example of a complex substrate composed of both ductile (copper) and brittle (plastic molding compound) materials, showing clear trends towards package size reduction. Combination of these factors poses a real challenge to the sawing process's, in terms of sawing quality, blade life and throughput [3].

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Many studies have been conducted to investigate the quality risks during package saw process and the main risks are found to be package chipping, lead burrs and plating smears. These risks increase with faster feed rates during sawing process [1-3]. In all of the above studies, the statistical methods such as full factorial design proved to be useful in the determining the cutting speed and blade rotation process parameters. Consequently this also helps to reduce fire risk in production line. No studies involving how the full factorial design can contribute to the cutting speed and blade rotation (spindle) optimization process parameter in saw singulation has been done yet.

In this study, the type of sawing process used is the tape saw method with single pass cut. Fig. 1 shows the type of instrument used in the saw singulation process. Therefore, in this research the burr level and package shifting were measured by using Smartscope Optical Gaging. The aim of this study is to see the effect of two selected factors and to determine the optimized parameter for package saw. The results of burr level, side smear and package shifting using statistical method and the effect of the cutting speed and blade rotation (spindle) parameters on package saw has been studied.

Figure 1: Package saw machine.

METHODOLOGY

In this study, the package used is QFN package with package size of 7 mm x 7 mm with 48 leads. All the samples are subjected to the normal manufacturing process of a QFN package before the final saw singulation process. For sub package saw process flow chart is shown in Figure 2. Before the sawing process, the package must be mounted and after the package saw was completed, the package was placed

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under the UV lights machine. In this process, the type of sawing process used is the tape saw method with single pass cutting.

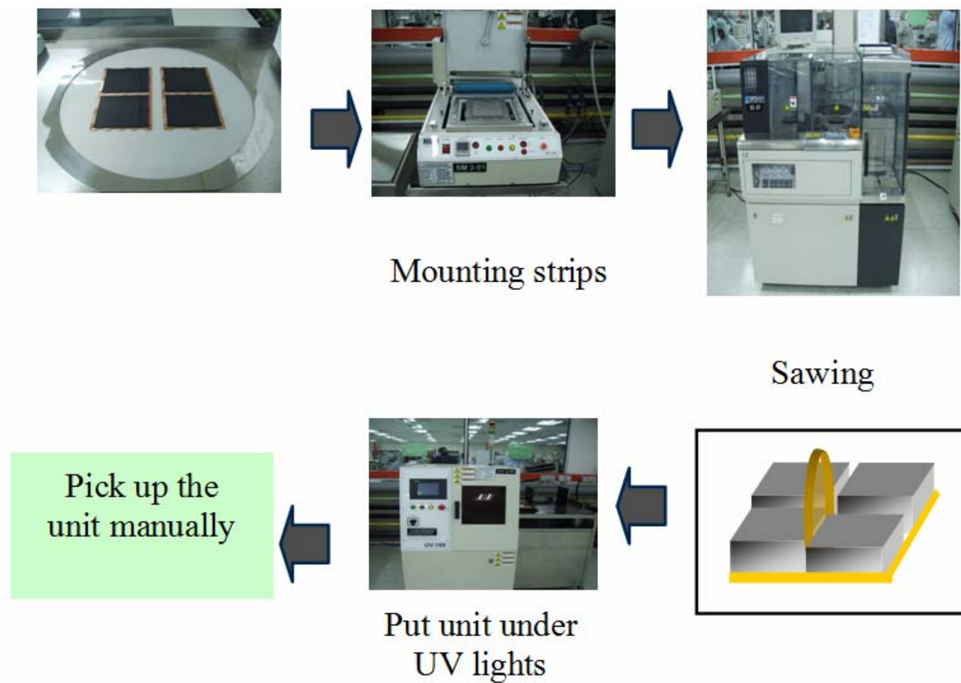

Figure 2: Process flow package saw sub process QFN package.

Full Factorial Design
In this study, full factorial designs was used to observed the effect of two selected factors on the package saw and to defined the optimized parameters saw singulation process. Table 1 shows the selected factor with different combination of run.

Table 1: Design of experiment using full factorial design.

	Factors	
Run	Cutting Speed (mm/s)	Blade rotation (rpm)
1	25	25000
2	25	30000
3	25	35000
4	30	25000
5	30	30000
6	30	35000
7	35	25000
8	35	30000
9	35	35000

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In these experiments, the unit of measurement used is millimetre (mm) for package size and micrometer (µm) for top burr and side smear. The runs for these experiments are based on the different combination as referred to the table above. These experiments consist of five replications for each run. Package shifting, burr level and side smear was measured by using a measurement tool, Smartscope Optical Gaging. The data were collected after each run was completed. Fig. 3 shows that the image of the measurement of the burr level.

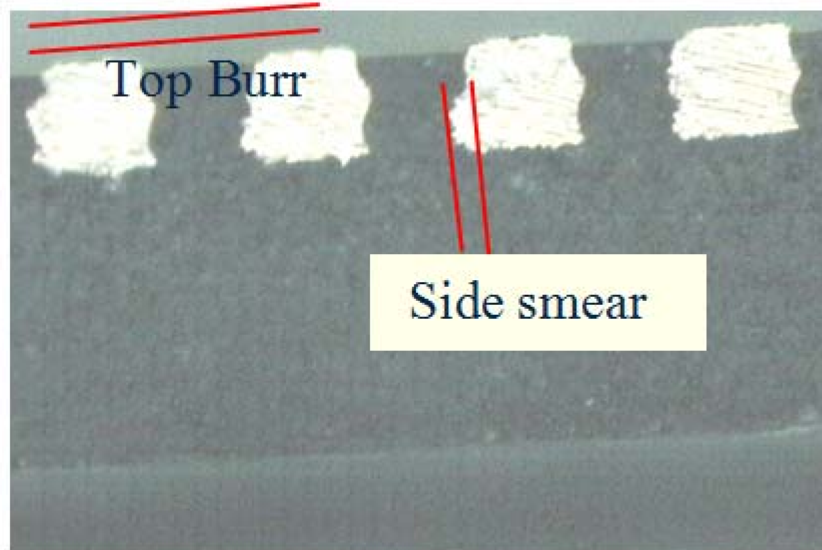

Figure 3: The image show measurement for top burr and side smear.

Package size measurement for x-axis and y-axis is shown in Figure 4. After the data collections were completed, they were analyzed using statistical method to determine the significant factors that affect the parameter for the package saw process.

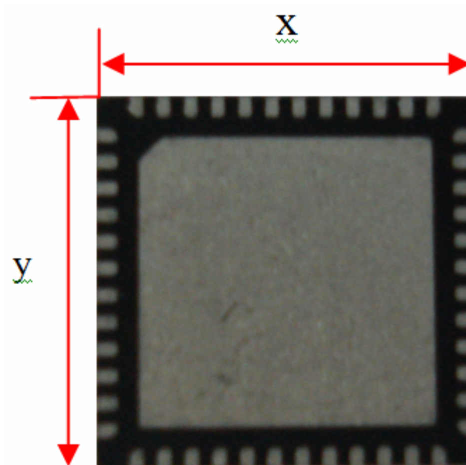

Figure 4: The image show package size measurement for axis –x and axis-y.

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RESULTS AND DISCUSSIONS

Package shifting for each QFN package 7mm x 7mm run was analyzed by full factorial experimental design. For results of package size, table analysis of variance for x-axis and y-axis are shown on Table 2 and Table 3.

Table 2: Table Analysis of Variance for X.

Source	DF	Seq SS	Adj SS	Adj MS	F	P
speed	2	0.0053744	0.0053744	0.0026872	15.33	0.000
Spindle	2	0.0070513	0.0070513	0.0035257	20.11	0.000
speed*spindle	4	0.0147554	0.0147554	0.0036889	21.04	0.000
Error	36	0.0063105	0.0063105	0.0001753		
Total	44	0.0334916				

Table 3: Table Analysis of Variance for Y.

Source	DF	Seq SS	Adj SS	Adj MS	F	P
speed	2	0.0075234	0.0075234	0.0037617	36.94	0.000
Spindle	2	0.0095441	0.0095441	0.0047720	46.86	0.000
speed*spindle	4	0.0194231	0.0194231	0.0048558	47.68	0.000
Error	36	0.0036664	0.0036664	0.0001018		
Total	44	0.0401569				

The main effects plot in Fig. 5 and Fig. 6 show that the package sizes are greatly influenced by both parameters in package saw i.e. speed and blade rotation (spindle). When higher cutting speed is used, the measurement of package size increased. It means that the package is within specification 7 mm x 7 mm and chippings are reduced. For blade rotation (spindle), when the low blade rotation is used, the package size is better than used the higher blade rotation parameter. The combination of the low blade rotation and high cutting speed can give the good package.

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From the previous study, the main problem were package chipping, lead burrs and plating smears and they were found to be limited to blade selection and process parameter optimization [4]. Beside that, the adhesive strength between the mold compound and the leadfinger, which in other case is plated with silver, cannot withstand the mechanical stress coming from the rotating resin bonded blade. It can also cause cutting quality issues [5]. With lower speed package chipping is increased.

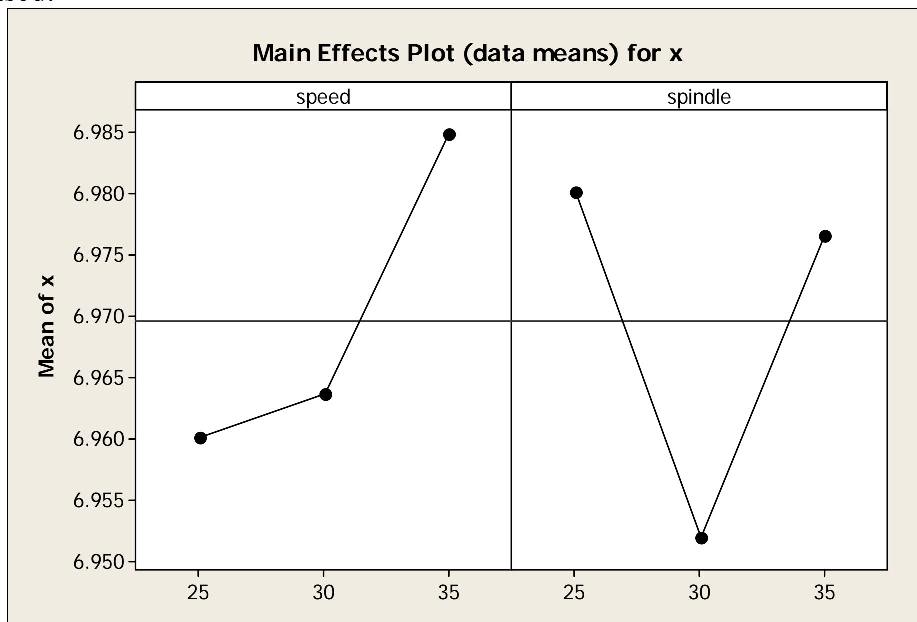

Figure 5: The graph show the main effect plot for X.

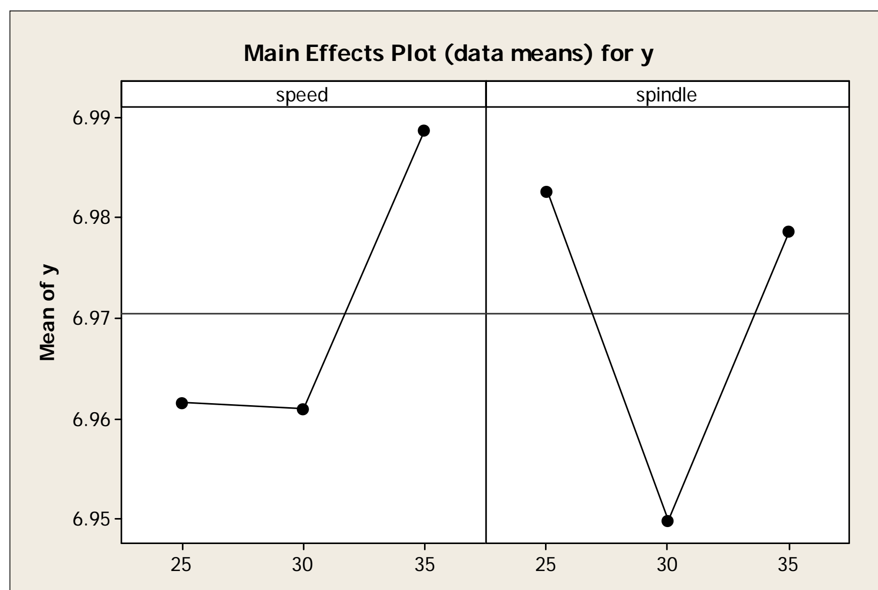

Figure 6: The graph show the main effect plot for Y.

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Figure 7 shows that the result of average of top burr for each run. It is shown that the average values the top burr give the low value and all of the run are in specification. For top burr specification, the package only reject if there is any burr more than 50 µm vertically.

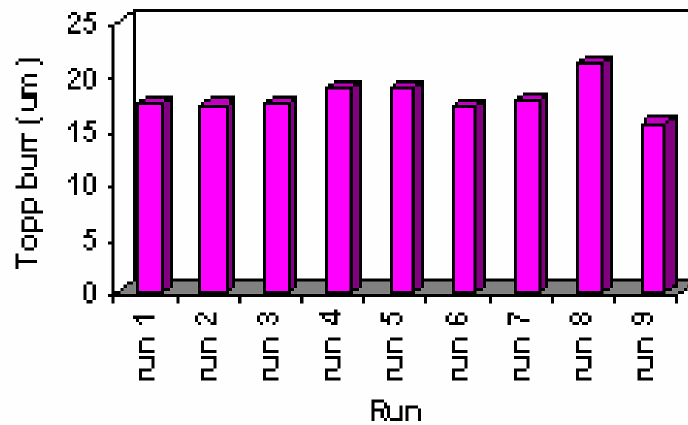

Figure 7: The graph show the average of top burr for each runs for QFN package.

Referring to Figure 8, the average value for side smear for each run is within specifications. The results showed that, side smear for run 7 has lower average value and run 8 has higher value of side smear. The higher speed and the lower spindle parameter give the lower value. This means that, the good package is produce in order the package chipping also are reduced.

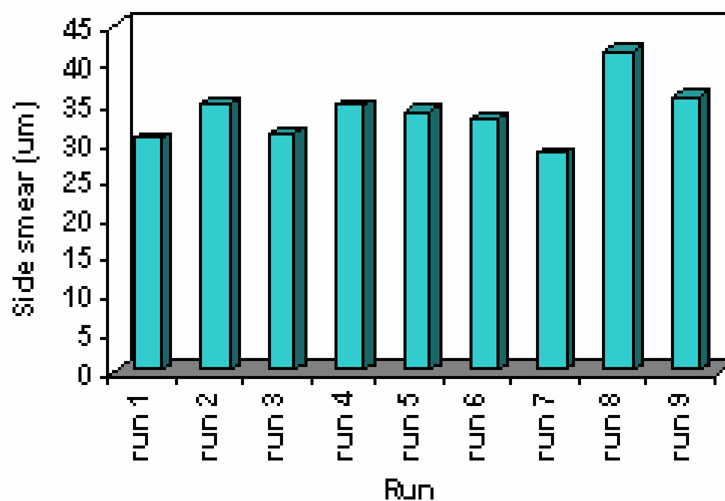

Figure 8: The graph show the average of side smears for each runs for QFN package.

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There are some critical variables that affect the saw performance. Factors like blade clogging, flow rate, spindle rpm, feed rate and package condition are some critical parameters to control and lock [4].

CONCLUSION

In this study, full factorial design has been used to observe the effect of two selected factors on the package saw and to define the optimized parameter saw of singulation process. Statistical method is used to analyses the data to identify the significant factors that affect the process parameters. In addition to that, the results of package size burr level and side smear were analyzed and the results shows that run 7 is the best combination parameter. When higher speed and lower spindle rotation are used, a better product will be produced. Beside that, package chipping, lead burrs and plating smears are also reduced. For top burr and side smear, the results are similar. The results for each run showed that all average values are within specification.

From the QFN package size study, it can be observed that, both factors of speed and spindle parameter give a significant effect in package saw process. The effects of speed and spindle rotation are an important parameter in the singulation process and must be considered to produce the good units. Beside that's, the results showed that when higher cutting speed and lower blade rotation parameters were applied, less chipping, burr level and side smear were observed.

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