VOL. 11, NO. 12, JUNE 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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IMPROVEMENT OF UNIVERSAL PARTS FOR PICK AND PLACE MACHINE IN SEMICONDUCTOR INDUSTRY USING QFD APPROACH

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ABSTRACT

Continuous improvement is one of the core strategies for excellence in production. In semiconductor industries, they manage to be more competitive by increasing their productivity and producing a variety of products in a large quantity at a low processing time. The goal of this study is to develop the universal parts on pick and place (PnP) machine and reduce on the setup time that impacted to the overall output of the products. The Quality Function Deployment (QFD) method as a supported tool was used for the development of this universal part. Then, production rate of three different products before and after improvement of the parts were recorded. The results revealed that the overall rate of production was improved up to 13.3 %. In addition, total errors from the PnP machine between the current and the new parts design significantly can be reduced up to 6 %.

Keyword: quality function deployment, house of quality, voice of customer, semiconductor industry.

INTRODUCTION

In order to survive, international companies have to manufacture high quality product, develop an effective organization and improve new product designs to meet customers' need and to succeed in the global market. One method to organize the design and development of product is the Quality Functional Deployment (QFD) method.

QFD has been employed successfully by car manufacturing companies including Toyota (Lochner and Matar, 1990) and Ford Motor Company (Miller, 1994).Bergmen and Lelevsjo, (1994) also reported that Toyota can reduce costs of design and product development time over one third after they started to use QFD.

QFD method has been used in the food industry since 1987 as mentioned by Hofmeister, (1991).However, an application of QFD in the food industry is more complicated when involved with the specific characteristic of food ingredient taken into account (Benner *et. al*., 2003). In additions, Griffin and Hauser, (1993) reviewed that QFD is a successful tool used in product and services including cars, computers, software, cameras, airline services, paints, surgical, instrument tool, movie, theatre and electrical services.

An advance QFD model that beyond the House of Quality is the Four-Phase model was explained by Sullivan, (1986), Hauser and Clausing, (1988), Hauser, (1993) and Cohen, (1995).This model consists of

(i) the product planning or the House of Quality
(ii) the product design matrix (product design and innovation)
(iii) the manufacturing planning matrix (process planning and manufacturing)
(iv) the process control matrix (production and operation control)

Currently, semiconductor industries, use multiple parts on the pick and place machine (PnP) to produce a variety of products. With regard to this matter, the aim of this study is to design and produce new universal parts of plate attached to the pick and place (PnP) machine that can be used to manufacture three different products. The QFD method was then employed in a case study to develop the universal parts. It is focused on improvement and increasing overall productivity of the products.

METHOD

QFD was used for the development in the new design of manufacturing parts. It consists of the collection of voice of customer requirement ranking and product matrix planning analysis, House of Quality (HOQ). Then, details of product improvement are discussed as follows:

Customers need analysis

The random sampling data questionnaire was collected from ten technical employees, who were directly involved with the PnP machined. All of them were responsible to perform the setup process task on the PnP machine at least four shifts per week. They were given an evaluation choice on the scale between 1 to 9, with 1 being less important and 9 being most important. Figure-1 shows a Pareto diagram for the number of respondents against customer requirements from the questionnaire used in this survey. As can be seen from the figure, easy to assemble was recorded as the highest rating of customer's need. In addition, easy to assemble, good product pickup, universal parts, faster to set up and high safety features represented more than 70% of the customer's requirements and should be focused on the new design. In contrast lighter, high quality, easy maintenance and low cost were considered as the less important features of the new parts.

VOL. 11, NO. 12, JUNE 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

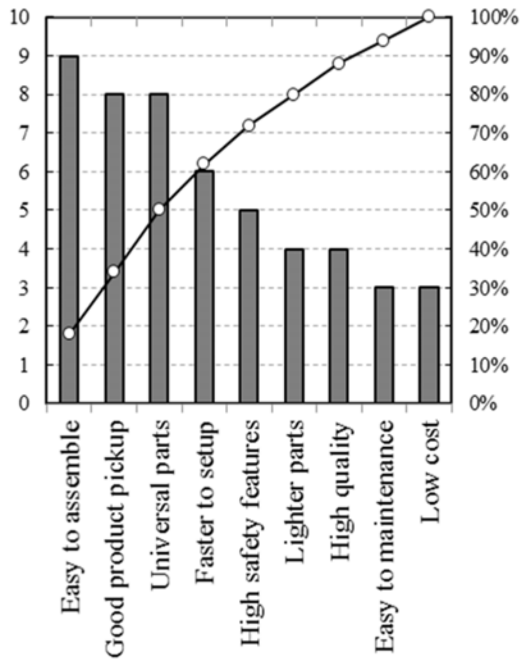

Figure-1. Pareto diagram for the number of respondents against customer requirements.

The House of quality (HOQ)

Vairaktarakis, (1999) reported that the first planning matrix needed to be developed in QFD method was known as House of Quality (HOQ). It consisted of 6 basic steps. The HOQ was constructed to translate the customer's requirements (What's) into technical specifications (How's).

Step 1: The customer's desire and the technical parameters including design of vacuum cup, power, weight, material, size, number of conversion setup and surface finish are shown in Figure-2. It can be seen that these technical requirements are closely related to the top five of important customer requirements as discussed above.

Step 2: The result of group brainstorming with various levels of technical personnel in this factory including engineer, technician and designer was conducted to analyse the technical requirement that fulfilled the customer's needs.

Step 3: Scale rating of 1, 3 and 9 is represented by ●,○and△respectively. The rating scale of ● representing a strong relationship, ○representing moderate relationship and △standing for weak relationship. Rating and clustering of the relationship between customer and technical requirements were determined by the group of product technical teams.

Step 4: The level of satisfaction of the new design with the current design was compared and depicted on the right hand side of Figure-2. Again, a group discussion was conducted to determine the direction of the goal of improvement. In can be seen from the Figure-2 that the new design offered an outstanding performance as compared to the current design.

Step 5: The technical rating and target of the new design placed at the bottom of HOQ as shown in Figure 2. It used to determine the direction for improvements of the How's (Benner *et. al*., 2003). In addition, technical competitor's assessment was measured to analyse the target of technical requirement for new design.

Step 6: (Benner *et. al*., 2003) mentioned that the relationship between the How's should be assigned in the roof of HOQ. These How's element relationships were represented by the sign '+' for a positive correlation and '-' for a negative correlation. Again, results were drawn from group brainstorming.

Improvement of new design

Figure-3(a) shows the current design of gripper and lifter parts that used in production of P1, P2 and P3.In order to produce each of products, customer needs to perform of the setup process for individual and different gripper and lifter. On average, it's taken more than 45 minutes for every single setup process.

Figure-3(b) presents of the photos of new design universal parts after QFD method was employed. It consists of 6 and 12 mm diameter of vacuum cup for the gripper. This improvement was made to fulfil the priority of customer and technical needs from HOQ.

Figure-4 shows the schematic diagram of suction cup for the lifting of universal parts. It has been shown that 280mm length of plate was attached with the 20 mm diameter of suction cup. It is suitably used to pick up all types of top plate with the perfect vacuum suction area. In contrast, the current design was being stuck with 270mm length of the plate and can cause a loss sucking power because of the imperfection design of suction area.

RESULT AND DISCUSSIONS

Figure-5 presents output versus working shift for product P1, P2 and P3 before and after improvement of the pick and place parts. It is clear that the productivity for all types of products increase after improvement of the parts. Here, the output product increased by approximately 13.0% for P1. Similar observations were also being made for the P2 and P3 where the total productivity was found to have increased 13.3 and 13.2 % respectively. By this evidence, it shows that, it is important to study the customer's need and use a specific tool in the design of the parts to increase the productivity.

Figure-6 indicates total productivity of product P1, P2 and P3 before and after improvement of the parts. In general, a significant increase in output was observed with the new parts. The value of output for the P1, P2 and P3 were increased approximately 67 000, 84 000 and 10 500 units respectively. These findings shows that with a proper design of the parts, it can be reduced an operational time at the pick and place machines and finally raise output of the products.

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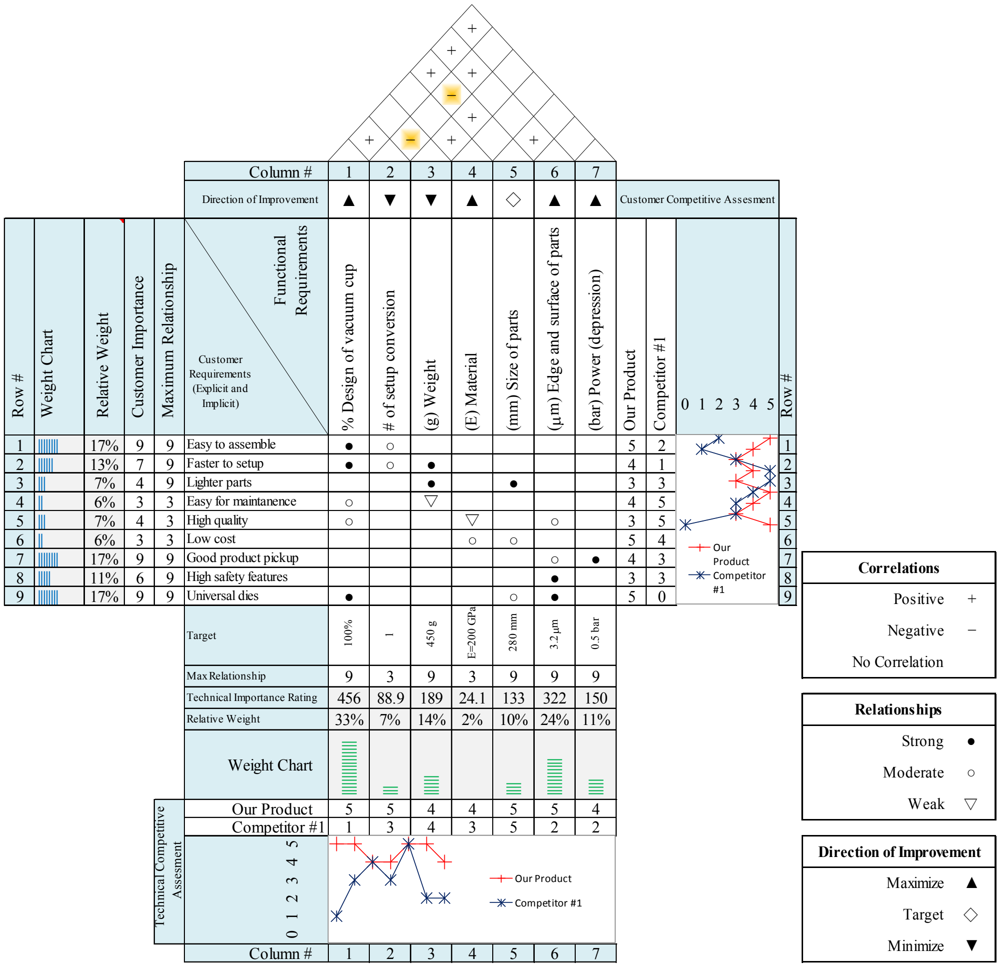
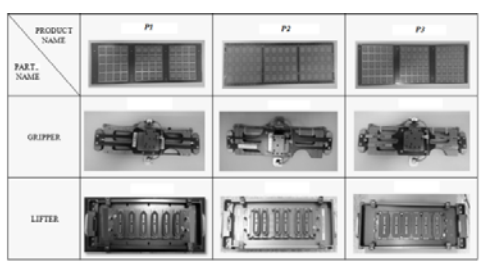


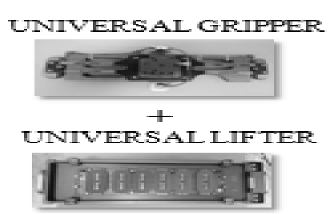
Row #	Relative Weight	Customer Importance	Maximum Relationship	Customer Requirements	1	2	3	4	5	6	7	Our Product	Competitor #1
1	17%	9	9	Easy to assemble	●	○						5	2
2	13%	7	9	Faster to setup	●	○	●					4	1
3	7%	4	9	Lighter parts			●		●			3	3
4	6%	3	3	Easy for maintanence	○		▽					4	5
5	7%	4	3	High quality	○			▽		○		3	5
6	6%	3	3	Low cost				○	○			5	4
7	17%	9	9	Good product pickup						○	●	4	3
8	11%	6	9	High safety features						●		3	3
9	17%	9	9	Universal dies	●				○	●		5	0

Column #	1	2	3	4	5	6	7
Direction of Improvement	▲	▼	▼	▲	◇	▲	▲
Target	100%	–	450 g	E=200 GPa	280 mm	3.2 µm	0.5 bar
Max Relationship	9	3	9	3	9	9	9
Technical Importance Rating	456	88.9	189	24.1	133	322	150
Relative Weight	33%	7%	14%	2%	10%	24%	11%
Our Product	5	5	4	4	5	5	4
Competitor #1	1	3	4	3	5	2	2

Figure-2. House of quality (HOQ) for the universal parts.



(a)



(b)

Figure-3. Photos of (a) current and (b) universal parts to produce components P1, P2 and P3.

 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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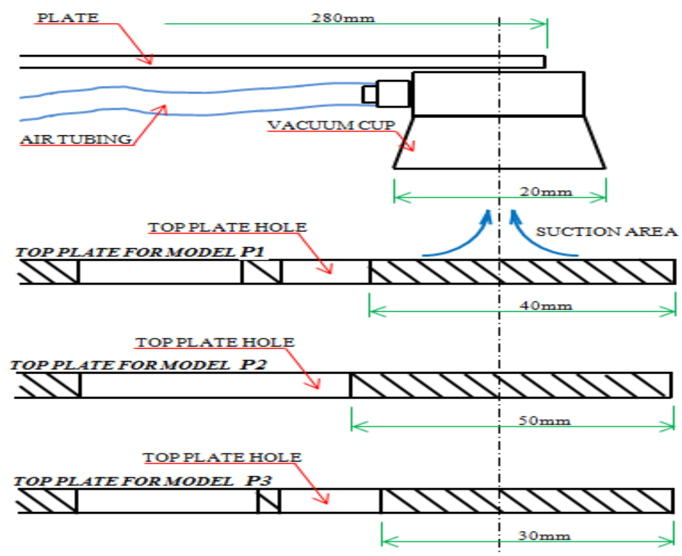

Figure-4. Schematic design of suction cup for universal parts.

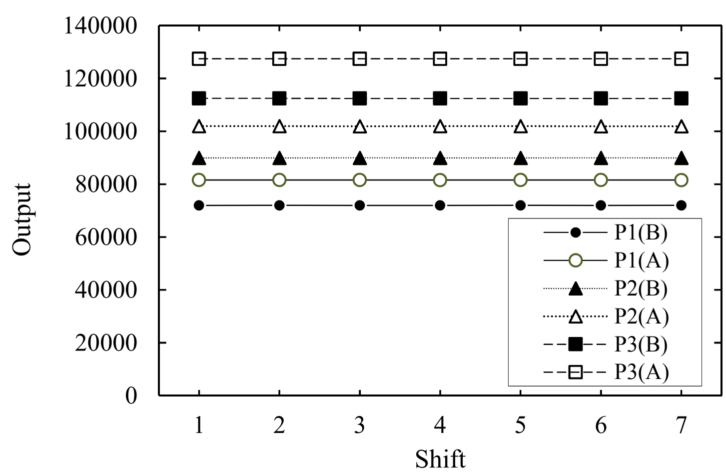

Figure-5. Summary of the output versus shift traces for PI, P2 and P3 products.

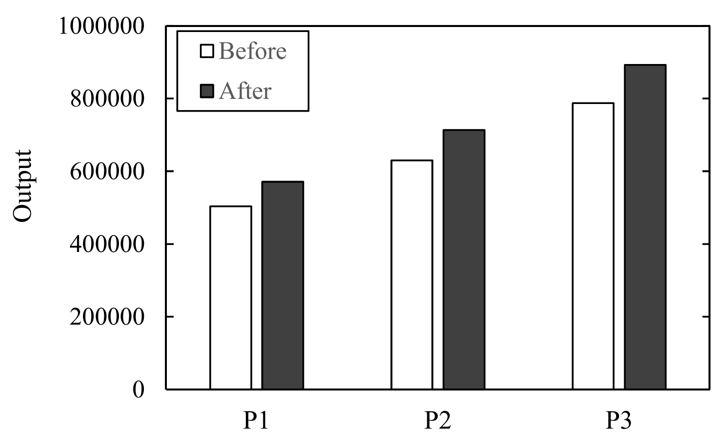

Figure-6. Comparison of the output of P1, P2 and P3 products before and after improvement of parts.

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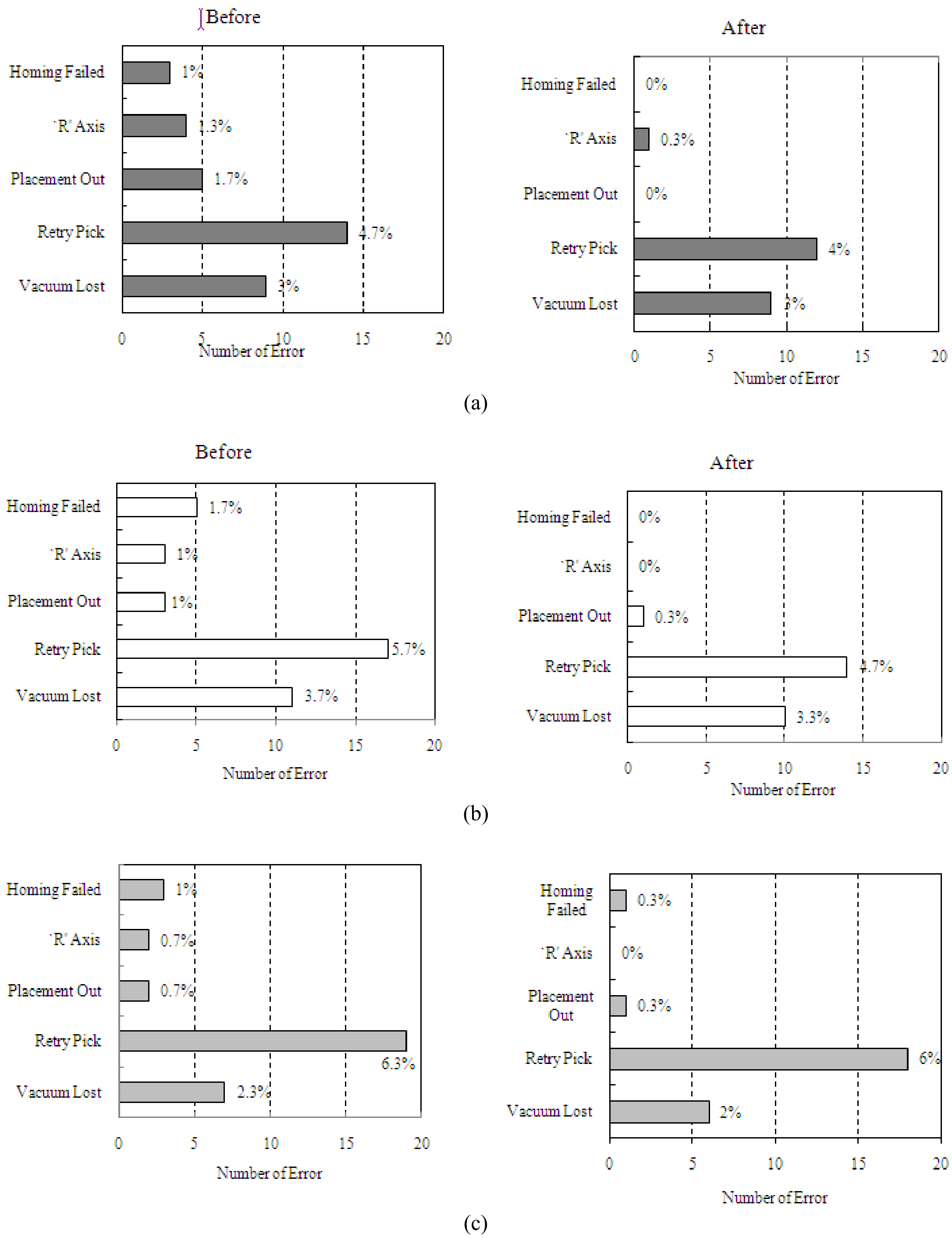

Figure-7. Comparison massage of machine errors before and after improvement of plates for (a) P1, (b) P2 and (c) P3 products.

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Figure-7 shows representative error messages from the machine for products P1, P2 and P3. These errors recorded after 300 units of products were manufactured. As observed from the figure, placement out, homing failed and ‘r’ axis errors were highly reduced for P1, P2 and P3 products. Pressure lost error decreased for products P2 and P3 resulted from the redesign of the vacuum cup, however no evidence on product P1 was recorded.

CONCLUSIONS

This study presents an investigation of using QFD for design tool for fabricating new universal parts of pick and place machine. Customer needs analysis was transformed into the House of Quality. The new designed and improvements of gripper and lifter parts were developed based on functionality, shape and quality of the material. The new design of parts was evaluated by comparing the output of the product P1, P2 and P3. The findings revealed that the average production rate for all products increased over 13%. Error analysis on the PnP machine between current and new designs was found to significantly decrease over than 6%.

ACKNOWLEDGEMENT

The authors are grateful to the Minister of Education (MOE) and Universiti Teknologi Malaysia, Kuala Lumpur for aids financial through Potential Academic Staff (PY/2014/03023) and Tier 2 (PY/2014/03706) grants scheme during this research.

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