DESIGN FOR MANUFACTURING AND ASEMBLY (DFMA) OF INDUSTRY PRODUCT

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"I hereby declare that the thesis is based on my original work except for questions and citations, which have been duly acknowledgement"

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ABSTRACT

The main purpose of the design for manufacturing and assembly is to simplify one product during manufacturing and assembly. The research of design for manufacturing and assembly (DFMA) has been undertaken a lot in the industrial field currently as it is potential in reducing a lot of time in develops the product. The applications of design for manufacturing and assembly (DFMA) also have widely been explored and many potentials field has been discovered for its usage. Boothroyd method is used to improve product design of a standing fan. The Bothrooyd analysis consentrate on product handling and insertion until completely assemble. Analysis was done on each part to identify function, its weakness and strength of the product. After the design was improved on the analysis on the process and material selection was made. This is to find out the best materials and the suitable processes. Through this method a few concepts have been developed and the best concept have selected by consider the screening and scoring value. There were about 60 parts in the old product and it was reduce to 33 parts .This is reflected also in production. The number of operator was reduced 11 to 6. The result from the analysis shows that efficiency of the design is improved from 18 to 31.

ABSTRAK

Rekabentuk untuk pembuatan dan pemasangan adalah bertujuan untuk memudahkan produk dalam semasa proses pembuatan dan pemasangn. Kajian diatas rekabentuk untuk pembuatan dan pemasangan (DFMA) telah dibuat pada industry semasa dan ia sangat berpotensi dalam mengurangkan masa dan cost sesuatu produk. Kaedah ini telah dikai secara meluas dan ia terbukti dan sangat berguna.Kaedah Boothroyd digunakan untuk memperbaiki rekabentuk kipas berdiri yang telah saya pilih. Analisis Boothroyd memberi tumpuan kepada cara pengendalian dan pemasukan sesuatu kompenen sehingga menjadi satu produk yang lengkap.Ia juga mengkaji tentang tentang fungsi ,kelemahan dan kekuatan dalam produk tersebut. Beberapa konsep telah dibuat untuk mendapatkan rekabentuk terbaik dengan mengambil kira nilai skrin dan skor. Analisis untuk proses dan pemilihan bahan dibuat selepas analisis rekabentuk siap dibina. Ia bertujuan untuk mencari bahan yang terbaik dan proses yang sesuai. Terdapat 60 komponen pada produk lama dan ia telah dikurangkan sehingga 33 komponen dan ia telah mempengaruhi susunan aliran pengeluaran pekerja .Terdapat 11 operater pada produk lama, ia menjadi 6 operater untuk produk baru. Hasil daripada analisis yang dilakukan kecekapan rekabentuk dipertingkatkan dari 13 peratus kepada 31 peratus.

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LIST OF ABBREVIATIONS

DFA	: Design for assembly
DFM	: Design for manufacturing
DFMA	: Design for manufacturing and assembly
AEM	: Assembly Evaluation Method
DSG	: Destructive solid Geometry
PAWs	: Producibility Assessment Worksheets
FBM	: Feature base model
TM	: operation time
CM	: operation cost
TH	: Handling time per item
TI	: Insertion time per item
TA	: Total operation time
CA	: Total operation cost

CHAPTER 1

INTRODUCTION

1.1 Background

Manufacture is process to build up the component part while the assembly is the way to join or add the part to produce a perfect product. Assembly will not approach the manufacturing process. Design for manufacturing (DFM) is to set ease style of manufacture. The collection of the part will generate the product after assembly and design for assembly DFA means the design of the product ease of assembly.

From there, many kind of method have been used to build that their product. Much of the early and significant work on DFM and DFA was done in the early 1970s .Product development was essentially done in several stages. The designer should have very good knowledge of materials and mechanisms. They must construct the prototype first. Once the prototype was tested and approved, the manufacturing team would then construct manufacturing plans for the product, including the tooling. Check out using the different material, thickness and also the different sheet material. They also must used different components example different sized screws to find the best way. Their goal was to achieve the same functionality, but make mass production more efficient. It is depend on manufacture engineer because it would effect some functional requirement.

The DFMA (*Design for manufacturing and assembly*) is also a setup of production line which designing for the process of manufacturing in the industry. The better performance of manufacturing process, the shorter line in every department, the safest cost reduction and safest time estimation resulted for the company. Soon, the product will probably manufacture faster than the existing product as the improve after implementing the DFMA approaches. (Boothroyd, 1991)

1.2 DFMA study

DFMA is The Design for Manufacture and Assembly. DFMA is combination from (DFA) Design For assembly and (DFM) design for manufacturing. This method is develop to build a perfect product while consider the manufacture and assembly.

There were detail design of the part and assemblies, part features, dimension and tolerance must be making neatly to get want important fact. A design engineer need a DFA tool to effectively analyze the ease of assembly of products and subassemblies of their design. This way should provide quick result and be simple and easy to use. It also should ensure consistency and completeness in its evolutions of product assembly. Product assimilability must consistency and completeness. A few thing should be consider eliminate subjective judgment from design assessment, allow free association of ideas, enable easy to comparison of alternate designs, ensure that solution make logically, identify assembly problem area and suggest alternate approaches for improving the manufacturing and assembly of product.

By using this DFMA tool it can develop communication between manufacturing and design engine, share new ideas, reasoning and from it will come out with good result. (Boothroyd, 1991)

1.3 Advantages

DFMA method serves many of advantage such as:

- Its make the production lines process more simple. There will less opportunity to make mistake in develop the product.
- Increases the quality of the product because it increase the reliability.
- By using the DFMA it will provide the systematic plan to do analysis about a product design from the point of view of manufacture and assembly. The result from of using this tool it will give a simpler and more reliable product which are less expensive to manufacture and assembly. Therefore there are no drawing and specification that is no needed after reduce part of the product. This will leave much important effect on overhead that in many cases larges proportional of the total cost effect of the product.
- Collaboration between the designer and the manufacturing will generate after the dialogue between them. Not enough the other individual also will take part from that and it will give more benefit of simultaneous or concurrent engineering can be achieved.

1.4 Objectives

The objective of this project is to:

- Analyse industry product (stand fan) using DFMA.
- Develop new design based on analysis made.
- The project is focusing on how to design the simplest structure of the product, so that it will ease manufacturing and assembly process.
- Relate to goal of the industry to reduce on manufacturing and assembly cost.

1.5 Scope of Study

The studies concentrate on DFMA of a study fan. The product has been disassembled and it have been assembled back to know the way of the insertion and handling. From that, we can find the time of insertion and handling. The design of the product also has been consider in order determining the best design. Concept scoring and the screening was used. In the manufacture analysis it is more on the selection material and the process of the product. \

1.5.1 Product review

There were many type of fan such as ceiling fan, wall fan, stand fan and ventilation fan. Most of this fan design of combination electrical and mechanical system. The standing fan that used in the study is shown in figure 1.1.

Figure 1.1: Stand fan

1.5.2 Stand Fan Assembly

Manual assembly used to assemble stand fan. Manual Assembly means that the process assembly used benches or simple conveyors. There were simple jigs and fixtures with manual clamping and simple, light tools (manual/pneumatic/electric screwdrivers, solder irons etc.).

For this product it almost used screwing tool, a few soldering, and snap clip. There were three section of assemble bottom, middle and upper. Bottom sections include the stand use to hold the fan. Control panel is the base part in the middle and it were assembles with upper and bottom section. The upper sections were a motor fan part. Combination of three sections develops complete stand fan.

Figure 1.2: Middle section assembles of stand fan.

Figure 1.3: Assembly of middle and upper section.

CHAPTER 2

LITERATURE REVIEW

2.1 DFMA Method

This chapter, we will review methods in Design for Manufacturing and Assembly (DFMA). This method is to show us on how to deal with the existing product before analyze the product to propose a new conceptual design. There were many type of the DFMA method such as Taguchi, Hitachi, Lucas, Nippondenso, Taguchi and other. Here, they will produce a different style method according to their research. Although we find out it is the different method but the objective DFMA is still the same. They make an analysis on the data such as the parameters of materials, the functions of calculations of cost and cycle time, the components that can or cannot be assembled into the database of their software, and let the computer find out all the possible selections to a certain mission. By comparing all these results, an optimal plan is picked out and put into effect. From the result they use to simplify the product, reduce the manufacture cost and time of manufacturing and assembly.

2.2 Boothroyd and Dewhurst method

This method has been developing by two guys. The research was done in 1970. DFMA have being their company trademark. From this all research they apply to their company. The method can be used for manual assembly, with robotic assembly, and with machining.

Three shortcomings should be highlighted of DFMA method. (Boothroyd, 1990).

- The consider on all part in detail. By using the software, it would show the optimal plan and put into effect.
- The main target is not focus on the conceptual design stage, where most of the product cost is fixed.
- Is to provide redesign suggestions to modify shapes in the case of an unsuitable design

2.2.1 DFMA on controller assembly using Boothroyd and Dewhurst method

This controller has almost 20 parts before the method progress on it.

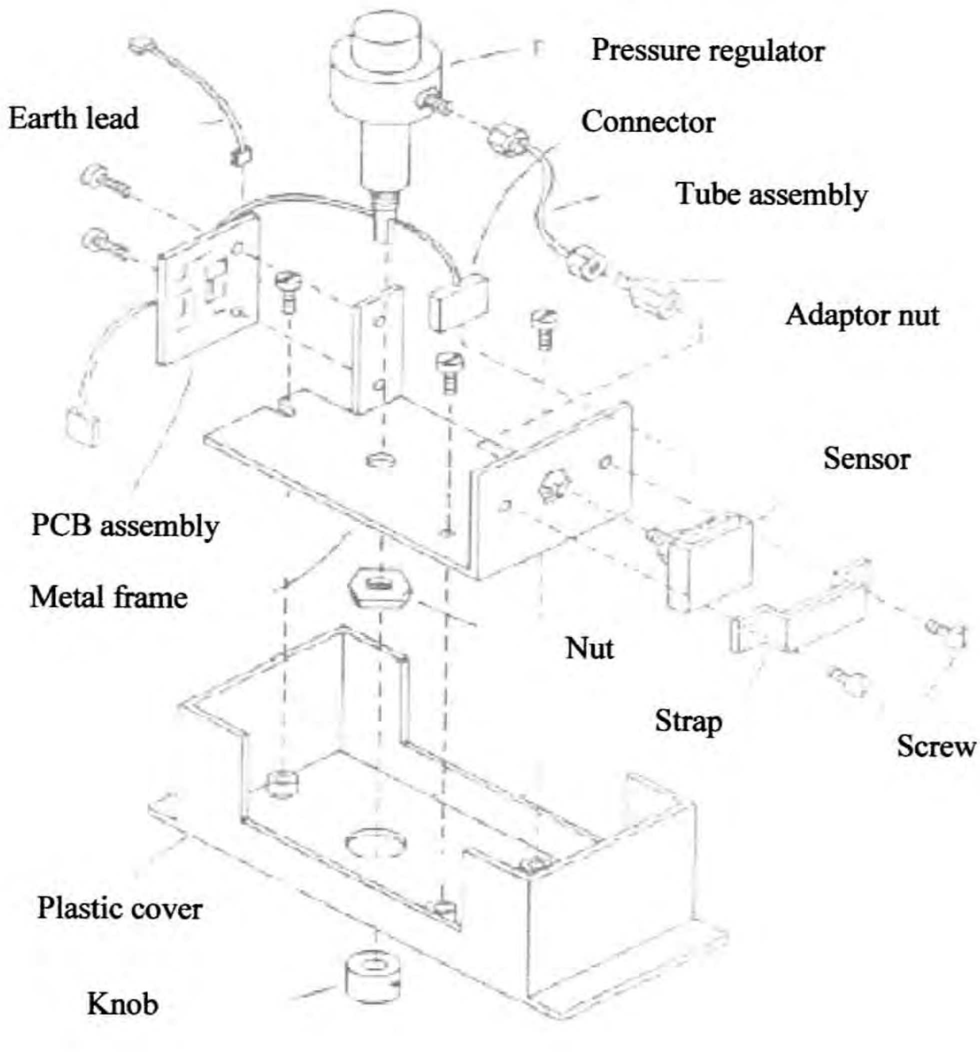


Figure 2.1: Before DFMA (David E. Lee and Thomas H. Hahn, 1996)

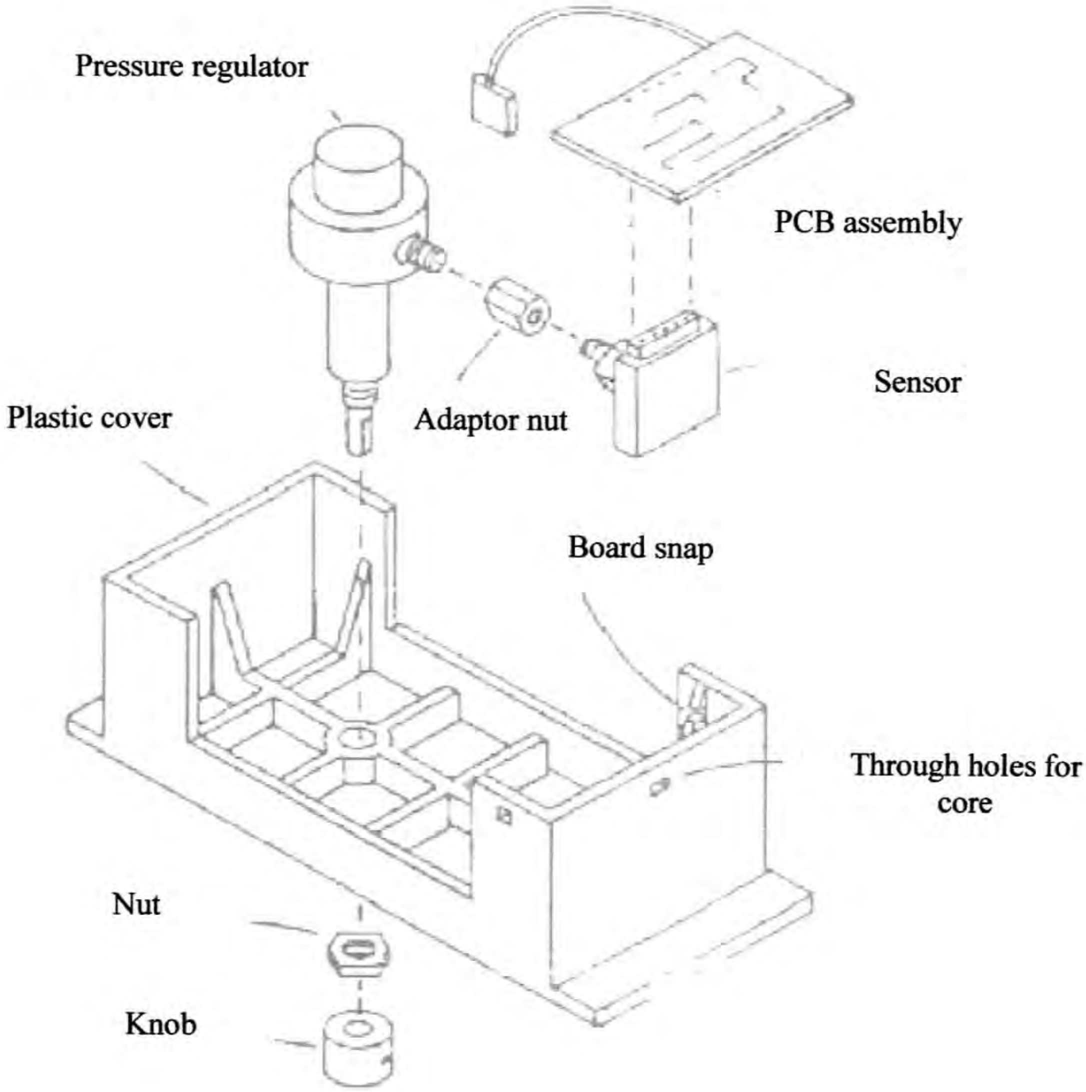


Figure 2.2: After DFMA (David E. Lee and Thomas H. Hahn, 1996)

The part was reduced into 7 parts. The sensor, hold was cut, simplify the regulator connector and cover plastic turn to give more contribute.

2.2.2 DFMA on the pneumatic piston

This piston used DFMA tool to reduce its parts. It has been done by the Boothroyd method in detail.

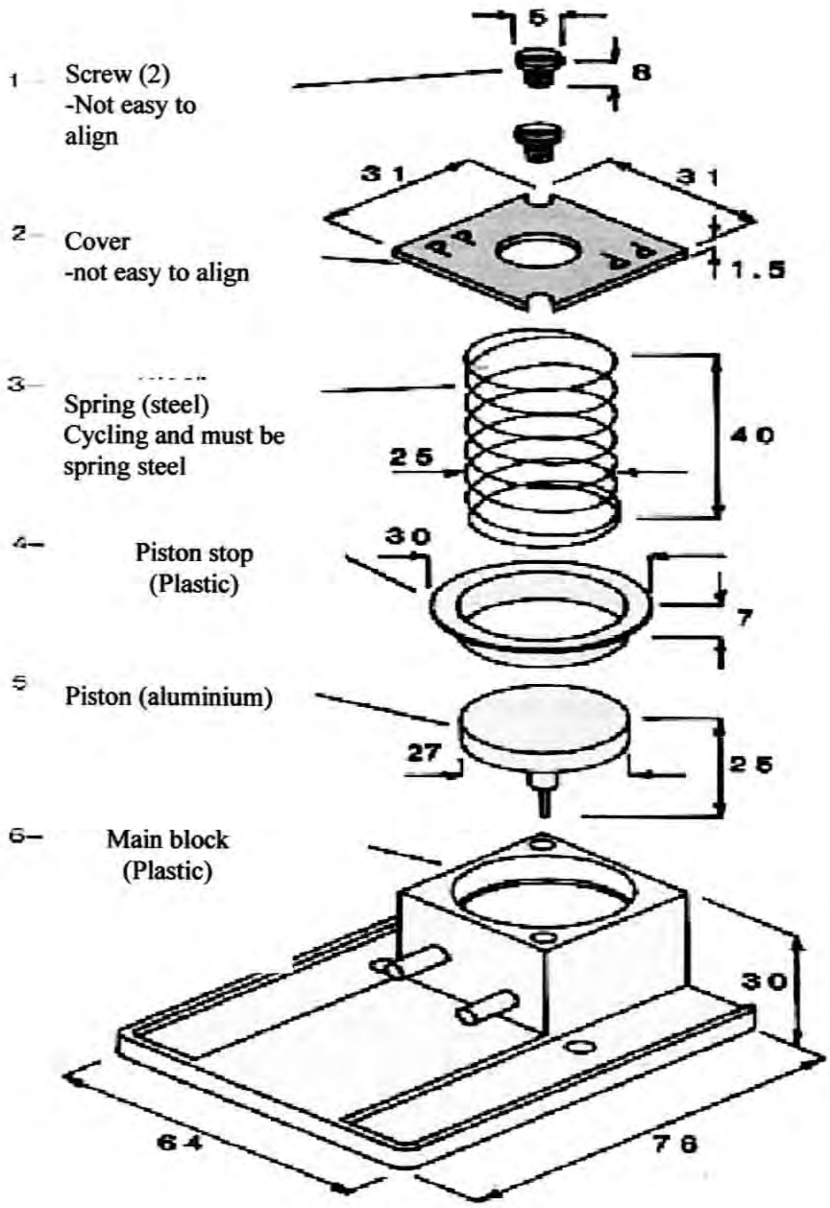


Figure 2.3: A piston-assembly design (Boothroyd 1991)

All the calculation has been done systematically used the table. Table used for computation of Design efficiency. The table lists the name of the part that shows the efficiency of the one part characteristic.

Boothroyd-Dewhurst method is estimation of the ideal product which translates to the method of filling up column 9 in the chart. They give the following guidelines:

Rule 1: During operation of the product, does the part move relative to all other parts already assembled.

Rule 2: Must the part be of a different material than the parts already assembled? [Only fundamental reasons associated with material properties are acceptable.]

Rule 3: Must the part be separate from all parts already assembled (because otherwise necessary assembly/disassembly of other parts would be impossible)?
If the answer to any of these questions is YES, a 1 is entered in column 9 (except if there are multiple parts in column 2, in which case the minimum number of separate parts required is entered in column 9.)

c1	c2	c3	c4	c5	c6	c7	c8	c9	Name of Assembly
Part ID	No of times the operation is carried out consecutively	Manual handling code	Manual handling time per part	Manual insertion code	manual insertion time per part	Operation time c2(c4 + c6)	Operation cost 0.4 c7	Estimation for theoretical minimum parts	PNEUMATIC PISTON
6	1	30	1.95	00	1.5	3.45	1.38	1	MAIN BLOCK
5	1	10	1.5	10	4.0	5.50	2.2	1	PISTON
4	1	10	1.5	00	1.5	3.00	1.2	1	PISTON STOP
3	1	05	1.84	00	1.5	3.34	1.34	1	SPRING
2	1	23	2.36	08	6.5	8.86	3.54	0	COVER
1	2	11	1.8	39	8.0	16.6	6.64	0	SCREW
					Total:	40.75	16.3	4	**Design efficiency** =
						TM	**CM**	**NM**	*3 NM/TM* = 0.29

Table 2.1: Evaluating the design efficiency of Pneumatic Piston (Boothroyd 1991)

2.2.3 Improving the design:

The following considerations are important:

STEP 1: Make sure that the column 9 < the number in column 2

If yes, there is an opportunity for reduction in number of parts.

STEP 2: Examine columns 4 and 6. These figures indicate potential for assembly time

reduction.

Based on these ideas, a redesign of the piston assembly is presented below. Notice how

the new design presents a design efficiency of 90%.

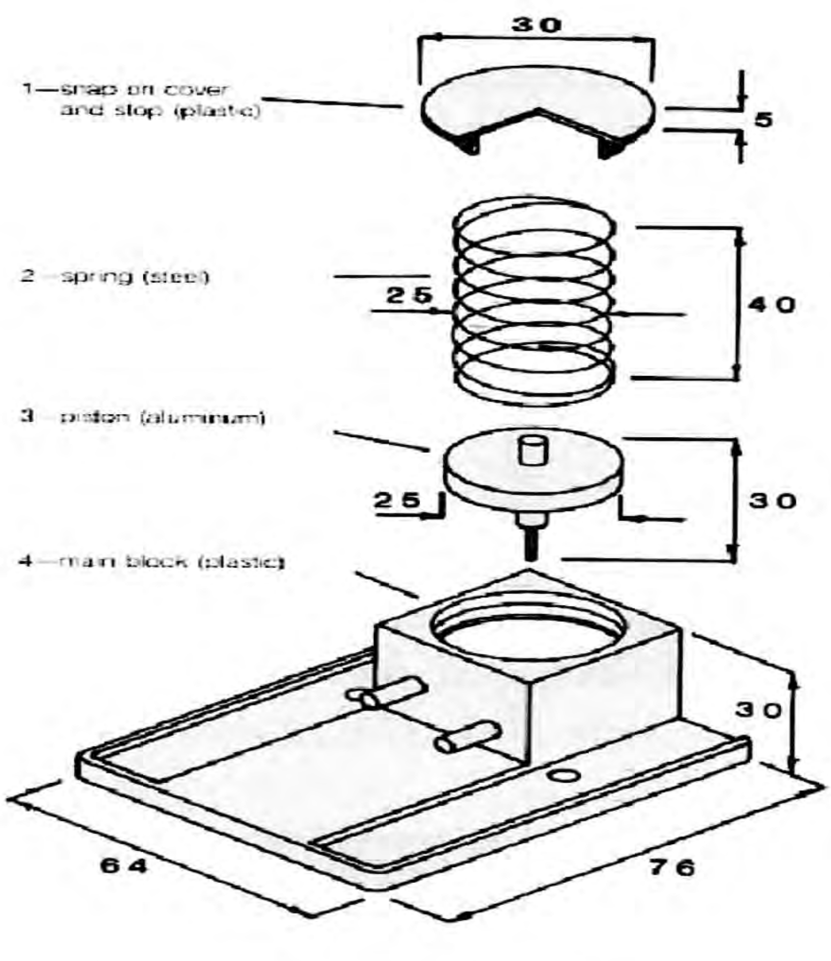


Figure 2.4: An improved piston design (Boothroyd ,1991)

c1	c2	c3	c4	c5	c6	c7	c8	c9	Name of Assembly NEW PNEUMATIC PISTON
Part ID	No of times the operation is carried out consecutively	Manual handling code	Manual handling time per part	Manual insertion code	manual insertion time per part	Operation time c2×(c4 + c6)	Operation cost 0.4 c7	Estimation for theoretical minimum parts	
4	1	30	1.95	00	1.5	3.45	1.38	1	MAIN BLOCK
3	1	10	1.5	00	1.5	3.00	1.2	1	PISTON
2	1	05	1.84	00	1.5	3.34	1.34	1	SPRING
1	1	10	1.5	30	2.0	3.50	1.40	1	COVER and STOP
					Total:	13.29	5.32	4	**Design efficiency =**
						TM	**CM**	**NM**	$3\ NM/TM = 0.90$

Table 2.2: Evaluating the design efficiency of the re-designed piston

2.3 Hitachi Method

This method come out from the Hitachi Corp, Tokyo, Japan and called Assembly Evaluation Method, AEM. All this done to facilitate design improvements by detect the weaknesses in the design at the earliest possible stage in the design process. This method was implementing by the use of two indices:

- **Assembly cost ratio (K) :** used to project elements of assembly cost.
- **Assimilability evaluation score ratio (E)** : used to assess design quality by determining the difficulty of operations

2.3.1 Hitachi's AEM procedure

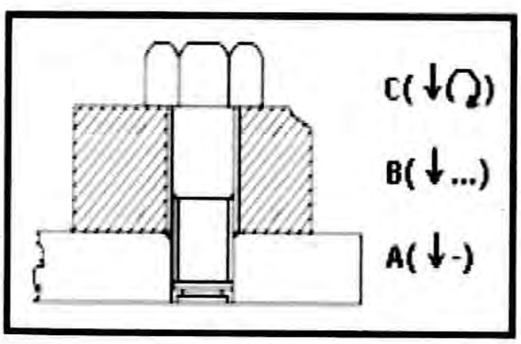
From the sum of assimilability scores for the individual tasks will divided with by the number of the tasks to get the total assimilability. This may be considered to be a measure of design efficiency where a score of 100 would represent a perfect design. Hitachi consider that an overall score E of 80 is acceptable and overall assembly cost ratio K of 0.7 is unacceptable.

Redesign of a simple product using AEM

The example of the simple redesign procedure is shown three steps below. The redesign starts from the original and on the chasis

Step 1: (Original design)

Here it is necessary to attach a small block B, to a chassis A. The initial method, shown in the figure below, involves the use of bolt C.



A = the part is can be cut

B = the can be arbitration

C = the part can be cut out

Figure 2.5: The original design of a block attachment to a chassis.

	Part assembly evaluation score	E, assemblability evaluation score	K, assembly cost ratio
Set chasis A	100		
Bring down B and hold it to maintain orientation	50	73	1
Fasten screw C	65		

Table 2.3: Evaluation score and the cost ratio of the original design

Step 2: (Redesign 1)

From the original the exam was done, the holding down to maintain orientation is the worst individual evaluation score and the suggestion is that the need for holding be removed by spot-facing the chassis shown in figure. This gives an improved evaluation score and cost ratio as a result of the table.

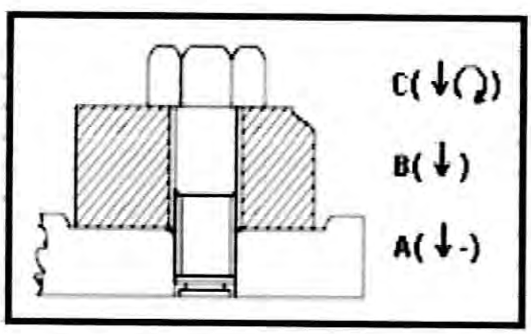


Figure 2.6: First redesign.

	Part assembly evaluation score	E, assemblability evaluation score	K, assembly cost ratio
Set chasis A	100		
Bring down B and hold it to maintain orientation	100	88	0.8
Fasten screw C	65		

Table 2.4: Evaluation score and the cost ratio of redesign 1

Step 3: (Redesign 2)

The bolt above has been removed and only the block attached onto the chassis by using a press fit. From that the assembly evaluation score for the press fit is less than that for simple block placement and reduces from 100 to 80 but, importantly, one part has been eliminated. As a result, although the product evaluation score has not significantly improved (89 compared with 88), the assembly cost ratio has significantly improved because of the reduced number of parts.

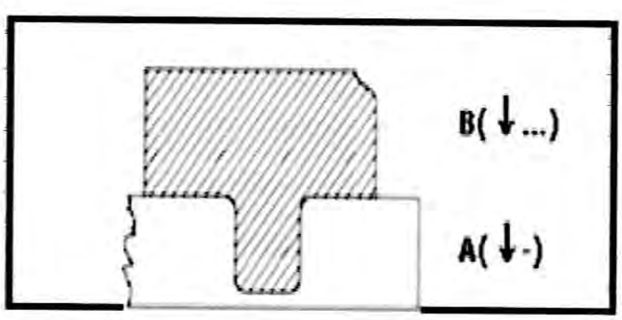


Figure 2.7: Second redesign

	Part assembly evaluation score	E, assimilability evaluation score	K, assembly cost ratio
Set chassis A	100	89	0.5
Bring down B and hold it to maintain orientation	80		

Table 2.5: Evaluation score and the cost ratio of redesign 2

2.4 Lucas

Lucas develops a basic DFA that similar is like to the DFA of BDI. It comes from it experimental between Lucas Organization and the University of Hull in U.K. It is combination with the engineering analysis software. He has divided the product design into three stages.

- Function Analysis
- Handling Analysis
- Fitting Analysis

The Product design specification held which change the need of the customs into engineering specification, then the manufacturing and assembly process. After that, the design engineers perform the design job according to this information. From that it change the engineering specification became a real design. This is a kind of process to change the engineering specifications into the real design, it should be all the requirements satisfied. Using his tool we have to separate all the parts of the product into the essential part and non important part that apply very standard used by BDI DFA. According to the function analysis, comes the analysis of handing. It almost same with the function analysis,(Lucas,1988)

DFA separated the handing analysis into the automatic handing analysis and themanual analysis. The sequence of parts assembly will be determined first, follow the fitting analysis. The assembly flow chat, analyze the will gripping and the fitting process. Finally the weakness of will be found, then the redesign will implement.(Lucas, 1988)

2.5 The Nippondenso Method

Nippondenso is a car products company in Japan that manufactures products such as radiators, anti-skid brake system, alternators and generators, Toyota being its chief customer. The huge orders that the company receives comprises various models of its products and different mixes as well. The company came up with the following response to remove the bottlenecks in production [Whitney, 1988]:

1. The combinatorial method of meeting model-mix production requirements.
2. In-house development of manufacturing technology.
3. Wherever possible, manufacturing methods that do not need jigs and fixtures.

The combinatorial method consists of dividing the product into generic parts or sub-assemblies and designing the parts for interchangeability, so a variety of products may be produced. The in-house manufacturing team helps in designing the parts. Avoiding the use of jigs and fixtures helps in economical batch-size-of-one production.

This method is derived, basically, from the DFM guidelines which are a set of rules used to optimize the manufacturing system with respect to productivity, cost and quality. DFM guidelines are a prescription whereas the Nippondenso method is a description. A sample of the DFM guidelines list follows [Bedworth et al, 1991]:

- Design parts to be multifunctional.
- Design parts or ease of fabrication.
- Minimize part variations.
- Avoid separate fasteners.

- Avoid flexible components; they are difficult to handle.
- Use parts of known capability.
- Emphasize standardization.
- Undertake engineering changes in batches.
- Use the simplest possible operations.
- Minimize setups and interventions.

These guidelines are nothing more than suggestions and the designer is at liberty to override them when necessary. The drawback of this method is that a general design or manufacturing strategy cannot be designed. Rules have to applied and modified based on different situations and conditions.

2.6 Feature Based Manufacturability Evaluation

This tool was creating by Gupta and Nau .This step was state as followed:

- First, generate all the possible features for the design part; each feature representing a machining operation and get rid of the parts which are not machinable.
- Create a FBM (Feature base model) which contains no redundant features.
- The process will yield again and again to get the best plan

CHAPTER 3

METHODOLOGY

3.1 Boothroyd Method

Boothroyd and Dewhurst had found DFM and DFA significant work was done in the early 1970s .Several stages done essentially in the product development. The designer who usually had very good knowledge of materials, mechanisms and other would design the product, and sometimes would construct working prototypes. Once the prototype was tested and approved, the manufacturing team would then construct manufacturing plans for the product, including the tooling etc. Often, different materials example different thickness or type of sheet metal, and different components example different sized screws etc), would be substituted by the manufacturing team. Their goal was to achieve the same functionality, but make mass production more efficient. However, the majority of the design remained unchanged, since the manufacturing engineers could never be sure whether a change would affect some functional requirement. (Boothroyd, 1970)

Bootrohroyd had said the idea of DFM and DFA were extended to include other aspects of better designs – including design for maintenance, design for environment, design for cost, etc. Often, this application of CE is referred to as DFX, where X is a variable selected from the set of manufacture or assembly. We shall restrict our study of manufacturing decisions to those related to fabrication and assembly.

This tool more concentrates on the manual assembly. This process used in the low volume that produces less than 1000 parts per year. There many to consider while using the manual assembly handling and insertion.

3.2 Design Efficiency.

Design efficiency is quantitative measure that base on analysis which produce by Boothroyd Dewhurst. The efficiency compares the total assembly time for a product with the total assembly time for an ideal product. The efficiency can be used to compare various designs in terms of their relative efficiencies used for manual assembly.

The design improvement is brought about by two considerations:

- A decision is made as to whether the part can be considered a candidate for elimination, or combination with other parts of the assembly
- An estimation of the time taken to grasp, manipulate, and insert the part.

3.3 Efficiency step

STEP 1: Build design details

Engineering drawings, or exploded 3-D views, or existing product, or prototype. Using Catia to develop drawing.

STEP 2: Take assembly apart or imagine doing so, assigning identification to each part as it is removed. Consider sub-assemblies as parts, and analyze them separately.

STEP 3: Begin re-assembly of the product. Start with the part with the highest Identification number, going all the way up to the part 1.Fill up the assembly worksheet as you go along.

STEP 4: Compute the design efficiency, given as:

EM = 3 x NM / TM

c1	c2	c3	c4	c5	c6	c7	c8	c9	Name of Assembly
Part ID	No of times the operation is carried out consecutively	Manual handling code	Manual handling time per part	Manual insertion code	manual insertion time per part	Operation time c2(c4 + c6)	Operation cost 0.4 c7	Estimation for theoretical minimum parts	
					Total:				**Design efficiency =**
						TM	CM	NM	*3 NM/TM =*

Table 3.1: Table for computation of Design efficiency (Boothroyd 1991).

From this table we have to make sure that estimation for theoretical minimum part is less than number of times the operation is carried out consecutively .It has an opportunity to reduce number of part. Examine columns 4 and 6. These figures indicate potential for assembly time. To get the operation time (TM) column 2 time (column 4 and column 6).Then count the operation cost (CM) and estimation for theoretical minimum parts (NM).Use the 3 NM/TM to get the design efficiency.

3.4 Design Concept selection for improved Design

Introduction

Concept selection is the process of evaluating concepts with respect to customer needs and other criteria, comparing the relative strength and weaknesses of the concepts, and selecting one or more concepts for further investigation, testing, or development.

3.4.1 Selection Criteria

The selection criteria that we identified are obtained from survey, literature review, journals and other references from books and website.

3.4.2 Design Concept Selection procedure

Concept Screening

Although we present a well- defined process, the team, not the methods, creates the concepts and makes the decisions that determine the quality of the product. Ideally, teams are made up of people from the difference functional groups within the organization. Each member bring unique views that increase the understanding of the problem and thus facilitated the development of a successful, customer-oriented product. The concept selection method exploits the matrices as visual guides for consensus building among team members. The matrices focus attention on the costumer needs and other decision criteria and on the product concepts for explicit evaluation, improvement, and selection. Concept screening is based on a method developed by the late Stuart Pugh in the 1980's and is often called Pugh concept selection .The purpose of this stage is to narrow the number of the concepts quickly and to improve the concepts. (Pugh, 1990).

Step 1: Prepare the selection matrix

To prepare the matrix, our team selected a physical medium appropriate to the problem at hand. Individuals and the groups with a short list of criteria may use matrices. For larger groups a larger a chalkboard or flip chart is desirable to facilitate group discussion.

Next, the inputs (concept and criteria) are entered on the matrix. Although possibly generated by different individuals, concepts should be presented at the same level of detail for meaningful comparison and unbiased selection. The concepts are best portrayed written description and a graphical representation. A simple one-page of each concept greatly facilitates communication of the key features of the concept. The concepts are entered along the top of the matrix, using graphical or textual labels of some kind.

Multivoting is a technique is a technique in which members of the team simultaneously voted for three to five concepts by applying 'dots' to the sheets describing their preferred concepts. The concepts with the most dots are chosen for concepts screening. It is also possible to use the screening concept matrix methods with a large number of concepts. This is facilitated by a spreadsheet and it is then useful to transpose the rows and columns.

The selection criteria are listed along the left-hand side of the screening matrix.. These criteria are chosen based on the customer needs the team has identified, as well as on the needs of the enterprise, such as low manufacturing cost or minimal risk of product liability. The criteria at this stage are usually expressed at a fairly high level of abstraction and typically include 5 to 10 dimensions. The selection criteria should be chosen to differentiate among the concepts. However, because each criterion is given equal weight in the concept screening methods, the team should be careful not to list many relatively unimportance criteria in the screening matrix. Otherwise, the differences among the concepts relative to the more important criteria will not be clearly reflected in the outcome.

After careful consideration, the team chooses a concept to become the benchmark, or *reference concept*, against which all other concepts are rated. The reference is generally either an industry standard or a straightforward concept with which the team members are very familiar. It can be a commercially available product, a best-in-class benchmark product which the team studied, an earlier generation of the product, any one of the concept under consideration, or a combination of subsystems assembled to represent the best features of different product.

	CONCEPT FOR BODY FASTENERS					
SELECTION CRITERIA	CONCEPT 1 SCREWS	CONCEPT 2 SNAP-FIT	CONCEPT 3 FOLD	CONCEPT 4 CLIPS	CONCEPT 5 CABLE TIGHT	CONCEPT 6 CLAMP
Ease of handling	0	0	+	0	0	0
Ease to maintain	0	0	0	-	-	+
Reliability	+	+	-	+	-	-
Durability	0	-	0	-	-	-
Ease to manufacture	0	+	+	+	+	+
Portability	+	+	+	+	-	-
Operating performance	0	+	-	-	-	-
Sum +'s	2	4	3	3	1	2
Sum 0's	5	2	2	1	1	1
Sum -'s	0	1	2	3	5	4
Net score	2	5	1	0	-4	-2
Rank	2	1	3	4	6	5
Continue?	Yes	Combine	Combine	No	No	No

Table 3.2: Example of The screening matrix.

For the example, the team rated the concept against the reference concept using a simple code (+ for "better than", 0 for "same as", - for "worse than") in order to identify the same concept for further consideration.

Step 2: Rate of the concept

A relative score of 'better than' (+), 'same as' (0), or 'worse than'(-) is placed in each cell of the matrix to represent how each concept rates in comparison to the reference concept relative to the particular criterion. It is generally advisable to rate every concept on one creation before moving to the next criterion. However, with a large number of concepts, it is faster to use the opposite approach to rate each concept completely before moving on to next concept.

Some people find the course nature of relative rating difficult to work with. However, at this stage in the finding design process, each concept is only a general notion of the ultimate product, and more detail rating is largely meaningless. In fact, given the impression of the concept description at this point, it is very difficult to consistently compare concepts to one another unless one concept (the reference) is consistently used as a basis for comparison.

When available, objective metrics can be used as the basis of the rating concept. Similarly, a good approximation of ease if use is the number of operations required to use the device. These objective metrics help to minimize the judgmental nature of the rating written description and a graphical representation. A simple one-page sketch of each concept greatly facilitated communication of the key features of the concept. The concepts are entered along the top of the matrix, using graphical or textual labels of some kind.

When available, objective metrics can be used as the basis of the rating concept. Similarly, a good approximation of ease if use is the number of operations required to use the device. These objective metrics help to minimize the judgmental nature of the rating process. Some objective metrics suitable for concept selection may arise from the process of establishing target specifications for the product. Absent objective metrics, ratings are established by team consensus, although secret ballot or other methods may also be useful. At this point the team may also wish to note which selection criteria need further investigation and analysis.

Step 3: Rank the concepts

After rating all the concepts, the team sum the number of "better than", "same as", and "worse than" scores and enters the sum for each category in the lower rows of the matrix. Once the summation is completed, the team ranked-orders the concepts. Obviously, in general those concepts with more plusses and fewer minuses are ranked higher. Often, at this point rating can identified one or two criteria distributing to differentiate the concept.

Step 4: Combine and improve the concept.

Having rated and ranked the concept, the team should verify that the result make sense and then considered if there are ways to combine and improve certain concepts. Two issues two consider are:

a) Is there a generally good concept which is degraded by one bad feature? Can a minor modification improve the overall concept and yet preserve a distinction from the other concepts?

b) Are there two concepts which can be combined to preserve the "better the" qualities while annulling the "worse than" qualities?

We combined and improved concepts are then added to the metrics, rated by our team, and ranked along with the original concept. Concept 3 was also considered for revision. So, we decided to change this product which can move automatically.

Step 5: Select one or more concept

Once the team members are satisfied with understanding of these concepts and its relative quality, we decided which concepts are to be selected for further refinement and analysis. Base upon previous steps, our team will likely develop a clear senses of which are the most promising concepts. The number of concepts selected for further review will be limited by team resources (personal, money and time). Having determined the concepts for further analysis, our team must clarify which issues needs to be investigated further before a final selection can be made.

Our team must also decide whether another round this concept screening will be performed or whether concepts scoring will be applied next. If the screening matrix is not seen to provide sufficient resolution for the next step of evaluation and selection, then the concept scoring stage with is weighted selection criteria and a more detail rating scheme would be used.

Step 6: Reflect on the result and the process.

All of us should be comfortable with the outcome. If an individual is not in agreement with the decision of the team, then perhaps one or more importance criteria are missing for the screening, or perhaps a particular rating is in error, or at least is not clear. An explicit consideration of whether the result makes sense to everyone reduces likelihood of making a mistake and increases the likelihood that the entire team will be solidly committed to the subsequence development activities

Concept Scoring

		CONCEPTS							
		1 (REFERENCE) 100% SCREW		2 100% SNAP-FIT		3 FOLD +SCREWS		4 SNAP FIT AND FOLD	
SELECTION CRITERIA	WEIGHT	RATING	WEIGHTED SCORE	RATING	WEIGHTED SCORE	RATING	WEIGHTED SCORE	RATING	WEIGHTED SCORE
Ease of handling	5%	3	0.15	3	0.15	3	0.15	3	0.15
Ease to use	15%	3	0.45	3	0.45	3	0.45	3	0.45
Reliability of setting	10%	2	0.2	1	0.1	1	0.1	3	0.3
Operating performance	25%	3	0.75	2	0.5	2	0.5	3	0.75
Durability	15%	3	0.45	1	0.15	2	0.3	3	0.45
Ease to manufacture	20%	3	0.6	2	0.4	2	0.4	3	0.6
Portability	10%	3	0.3	1	0.1	2	0.2	3	0.3
	Total Score Rank	1.9		2.85		2.1		3	
	Continue?	No		Develop		No		Develop	

Table 3.3: Concept Scoring Matrix

In this concept scoring matrix, we identified the most ranked concept to be developed in the next progress. From this table 3.4, the result can be conclude that concept #2 (100% snap fit) and concept #4 (snap fit and fold) to be analyze on the concept design selection consideration.

Design Concept Selection

		CONCEPTS			
		FOLD+SNAP-FIT		SNAP-FIT	
Selection Criteria	Weights %	Ratings	Weighted Score	Ratings	Weighted Score
Ease of Handling	5	3	0.15	3	0.15
Ease of Use	20	3	0.6	3	0.6
Durability	15	3	0.45	2	0.3
Portability	15	2	0.3	2	0.3
Ease of Manufacture	10	3	0.3	3	0.3
Readability of Settings	5	3	0.15	2	0.1
Ease of Maintenance	20	5	1	4	0.8
Ease of Operating	10	3	0.3	3	0.3
Total Score		3.25		2.85	
Rank		1		2	
Continue?		YES		NO	

Table 3.4: Design concepts Selection matrix.

Design concept selection had been done from the previous concept scoring analysis. From this table, we can see that concept #1 (new design) had been selected due to the scoring analysis that had been done.

3.5 Steps of DFM

The design for manufacturing step:

- STEP 1: Estimation from the old design

The estimation done on the cost of the process and material that use in the old product.

- STEP 2: Estimate the manufacturing cost

The process that chosen should be calculates to find the suitable.

- STEP 3: Reduce the cost of component (improvement)

The components have been cut while considering function and performance.

- STEP 4: Reduce the cost of assembly (improvement vs. Old design)

Calculation based on the design efficiency for old and new.

- STEP 5: Reduced the cost of supporting production

Consider the tooling, life cycle and labor payment cost.

- STEP 6: Results for the new design (improvement)

Comparison between the old and new design.

CHAPTER 4

ANALYSIS AND DISCUSSION

4.1 Boothroyd efficiency table

The analysis done by using the Bootroyd table to find out the efficiency of the product. There were 9 columns which have it own function. Column 1 is name of the part and column 2 number of part.

The quantitative base on analysis which produce by Boothroyd Dewhurst. Boothroyd Dewhurst compares the total assembly time for a product with the total assembly time for an ideal product. The efficiency can be used to compare various designs in terms of their relative efficiencies used for manual assembly.

The design improvement is brought about by two considerations:

- A decision is made as to whether the part can be considered a candidate forelimination, or combination with other parts of the assembly
- An estimation of the time taken to grasp, manipulate, and insert the part.

4.2 Stand fan part

This stand fan has about 60 parts. There was mechanical part and electronic part this product. There were three sections of this product upper part, middle and base. Here, got a few ways to install the product such as screw, snap fit, slot and clip.

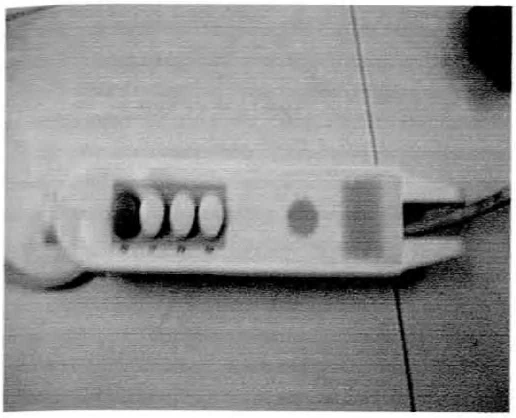


Figure 4.1: Fan cover panel and button

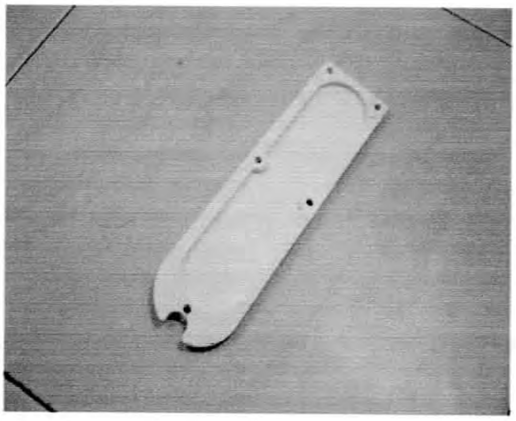


Figure 4.2: Back cover panel

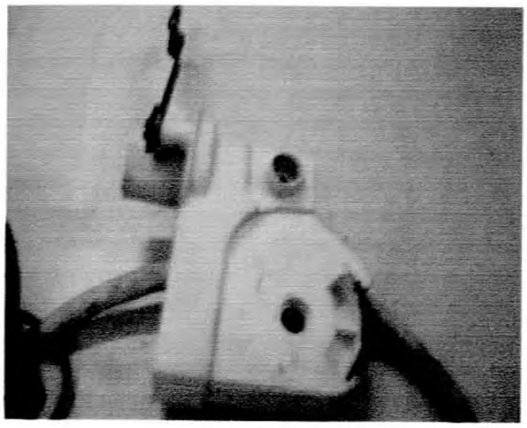


Figure 4.3: Adjustable and clip

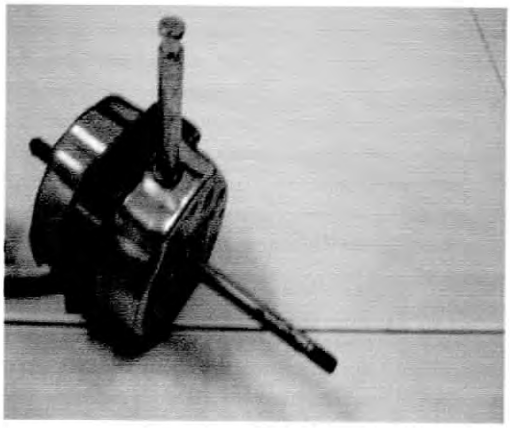


Figure 4.4: Motor

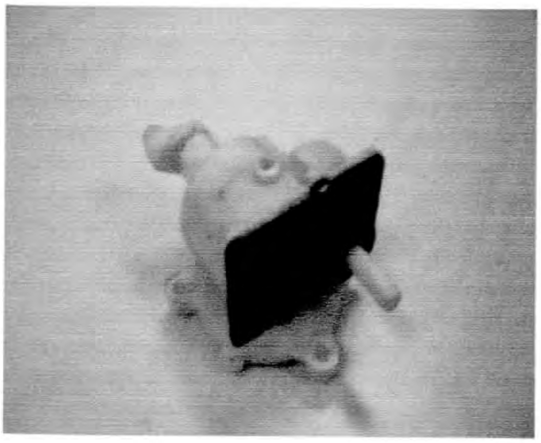


Figure 4.5: Gear box

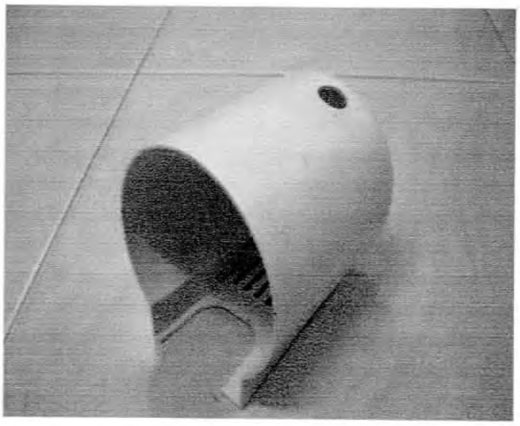


Figure 4.6: Back cover

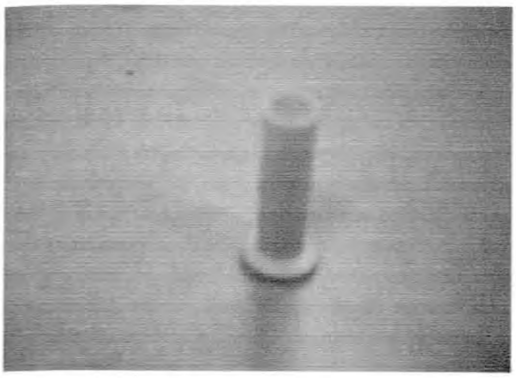


Figure 4.7: Button rotate

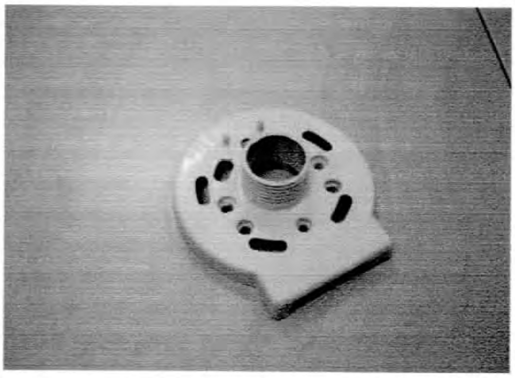


Figure 4.8: Front cover

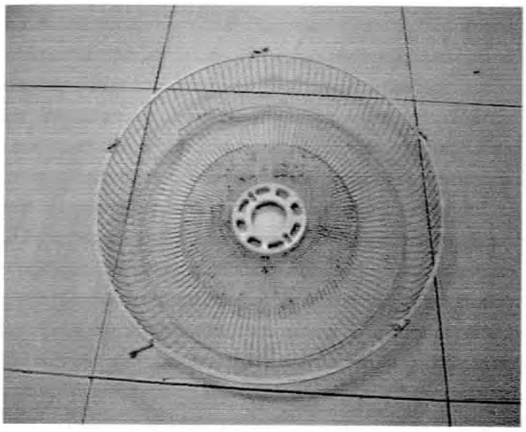


Figure 4.9: Back grill cover and clip

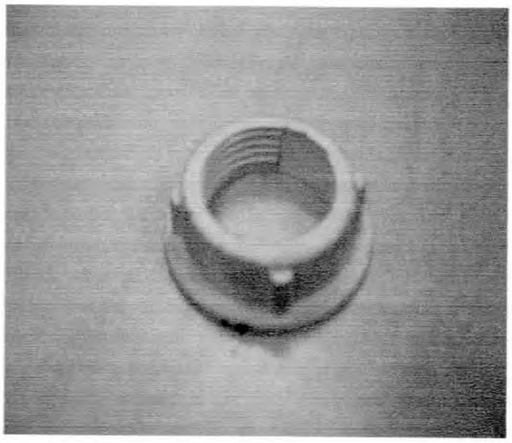


Figure 4.10: Grill lock

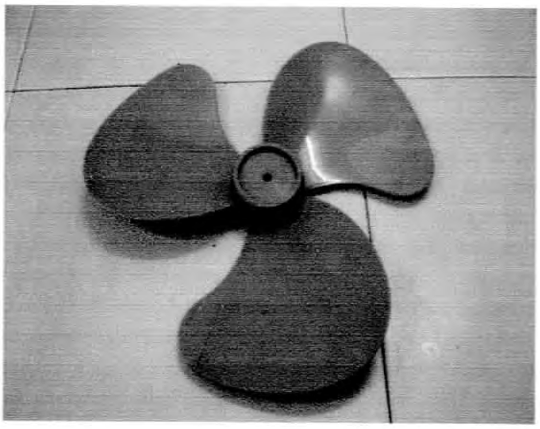


Figure 4.11: Fan blade

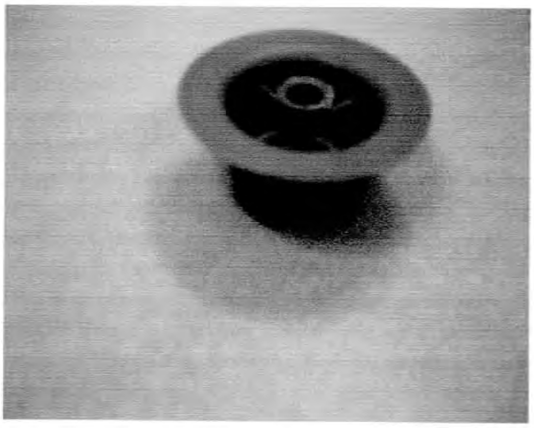


Figure 4.12: Fan blade cap

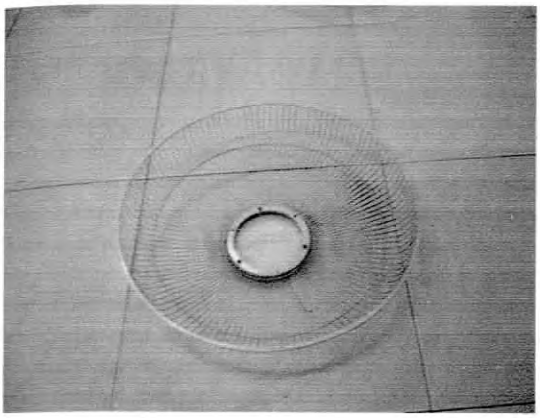


Figure 4.13: Front grill

Figure 4.14: Bottom base cover

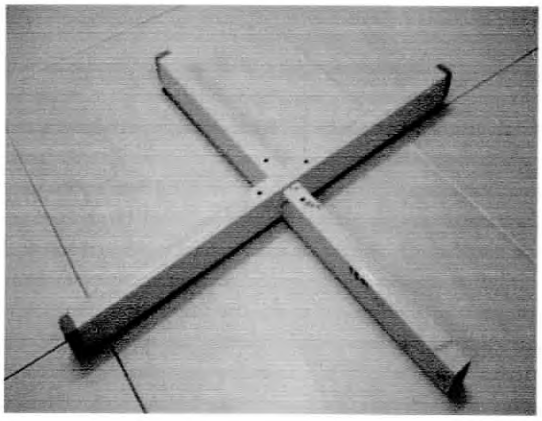


Figure 4.15: Stand A and stand B

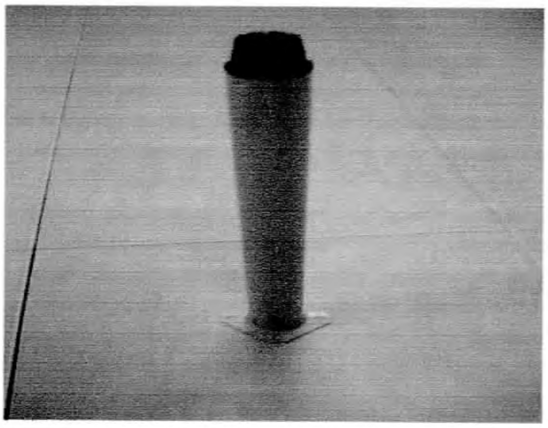


Figure 4.16: Outside pillar

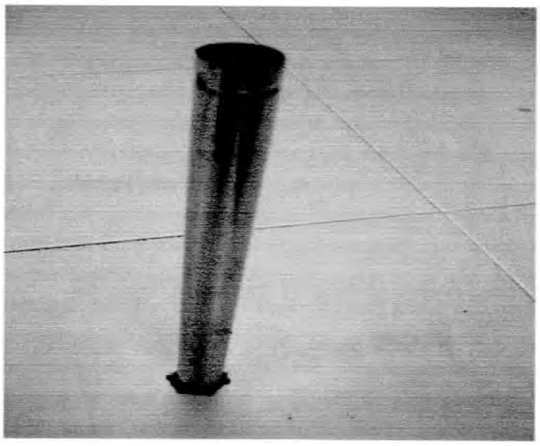


Figure 4.17: Inside pillar

Figure 4.18: Screw

4.3 Manual handling code column4 and time column5

Handling code

The insertion strap only have one way of the insertion according to the axis, therefore the alpha angle of the symmetry is 360°. While the strap is repeat t the angle axis of insertion and got to repeat the orientation in 180° and the beta angle of the symmetry. According to the table of handling time, if the strap can be grasped and manipulated using one hand without the aid of tools and alpha plus beta is 540°. Take first digit as 2 As an example the strap have no handling difficulties and have the thickness grater than 2 mm, the size greater than 15mm. We take the second digit is 0. The code is 20.

Handling time per item, TH

The control panel handling time (00) correspond to handling code 1.13s.All the code and the time reference on the Table 4 below:

4.4 Insertion code

Found the strap is not secured as part of the insertion process and since there are no restriction to access or vision, take 0 as a first code. Holding down is got in operations are carried out and it not easy to align because got no feature are served to the screw alignment holes. If there are no insertion resistances, 8 will take as a code. The code is 08.

Insertion time per item, TI

The control panel insertion time (30) correspond to insertion code 2s. All the code and the time reference on the Table 4.1 below:

ONE HAND			Parts are easily to grasp and manipulate					Parts present handling difficulties				
			Thickness > 2mm			Thickness $\leq$ 2mm		Thickness > 2mm			Thickness $\leq$ 2mm	
			Size > 15mm	6mm $\leq$ Size < 15mm	Size $\leq$ 6 mm	Size $\geq$ 6 mm	Size $\leq$ 6 mm	Size > 15mm	6mm $\leq$ Size < 15mm	Size $\leq$ 6 mm	Size > 6 mm	Size $\leq$ 6 mm
Parts can be grasp and manipulated by one hand without the aid of grasping tools			0	1	2	3	4	5	6	7	8	9
	$(\alpha+\beta) < 360^{0}$	0	1.13	1.43	1.88	1.69	2.18	1.84	2.17	2.65	2.45	2.98
	$360^{0} \leq (\alpha+\beta) \leq 540^{0}$	1	1.51	1.8	2.25	2.06	2.55	2.25	2.57	3..06	3	3.38
	$540^{0} \leq (\alpha+\beta) \leq 720^{0}$	2	1.8	2.1	2.55	2.36	2.85	2.57	2.9	3.38	3.18	3.7
	$(\alpha+\beta) = 720^{0}$	3	1.95	2.25	2.7	2.53	3	2.73	3.06	3.55	3.34	4

Table 4.1 Manual handling: One hand required for handling the component

ONE HAND with GRASPING AIDS				Parts need tweezers for grasping and manipulation								Parts need standards tools other than the tweezers	Parts needs special tools for grasping and manipulation
				Parts can be manipulated without optical magnification				Parts require optical magnification for manipulation					
				Parts are easily to grasp and manipulated		Parts present handling difficulties		Parts are easily to grasp and manipulated		Parts present handling difficulties			
Parts can be grasped and manipulated by one hands but only with the use of grasping tools				0	1	2	3	4	5	6	7	8	9
	$\alpha \leq 180^0$	$0^0 \leq \beta \leq 180^0$	4	3.6	6.85	4.35	7.6	5.6	8.35	6.35	8.6	7	7
		$\beta = 360^0$	5	4	7.25	4.75	8	6	8.75	6.75	9	8	8
	$\alpha = 360^0$	$0^0 \leq \beta \leq 180^0$	6	4.8	8.05	5.55	8.8	6.8	9.55	7.55	9.88	8	9
		$\beta = 360^0$	7	5.1	8.35	5.85	9.1	7.1	9.55	7.85	10.1	9	10

Table 4.2 Manual handling: One hand with Grasping Aids

TWO HANDS REQUIRED FOR LARGE SIZE		Parts can be handle by one person without mechanical assistance									
		Parts do not severely nest or tangle and not flexible								Parts severely nest or tangle or are flexible	Two persons or mechanical assistance required for parts manipulations
		Parts weight < 10lb				Parts are heavy (>10lb)					
		Parts are easily to grasp and manipulated		Parts present handling difficulties		Parts are easily to grasp and manipulated		Parts present handling difficulties			
Two hands, two persons or mechanical assistance required for grasping and transporting parts		α ≤ 180⁰	α = 360⁰	α ≤ 180⁰	α = 360⁰	α ≤ 180⁰	α = 360⁰	α ≤ 180⁰	α = 360⁰		
		0	1	2	3	4	5	6	7	8	9
	9	2	3	2	3	3	4	4	5	7	9

Table 4.3: Manual handling: Two hands required for large size

TWO HANDS FOR MANIPULATION	Parts present no additional handling difficulties					Parts present additional handling difficulties (e.g sticky, delicate, slippery . etc.) (1)				
	α ≤ 180⁰			α = 360⁰		α ≤ 180⁰			α = 360⁰	
	0	1	2	3	4	5	6	7	8	9
Parts severely nest or tangle or are flexible but can be grasped and lifted by one hand (with the use of grasping tools if necessary)	4.1	4.5	5.1	5.6	6.75	5	5.25	5.85	6.35	7

Table 4.4: Manual handling – Two hands for manipulation

MANUAL INSERTION - ESTIMATED TIMES (Seconds)

Part Added but Not Secured		After assembly no holding down required to maintain orientation and location				Holding down required during subsequent processes to maintain orientation or location			
		Easy to align and position during assembly		Not easy to align and position during assembly		Easy to align and position during assembly		Not easy to align and position during assembly	
		No resistance to insertion	No resistance to insertion (5)	No resistance to insertion	No resistance to insertion(5)	No resistance to insertion	No resistance to insertion (5)	No resistance to insertion	No resistance to insertion (5)
		0	1	2	3	6	7	8	9
Addition of any parts (3) where neither the parts itself nor any other parts is finally secured immediately: part are associated tool including hand(s) can easily reach the desired location	0	1.5	2.5	2.5	3.5	5.5	6.5	6.5	7.5
parts needs associated tools (including hands) cannot easily reach the desired location: due to obstructed access or restricted vision	1	4	5	5	6	8	9	9	10
parts needs associated tools (including hands) cannot easily reach the desired location: due to obstructed access and restricted vision	2	5.5	6.5	6.5	7.5	9.5	10.5	10.5	11.5

Table 4.5: Manual insertion: Part added but not secured

Part Secured Immediately				No screwing operation or plastic deformations immediately after insertion (snaps press fit, circlips, spire nuts)		Plastics deformations immediately after insertion								Screw tightening immediately after insertion (6)	
						Plastic bending torsion			Rivetting or similar operation						
				Easy to align and position with no resistance to insertion (4)'	No easy to align and position with no resistance to insertion (5)'	Easy to align and position during assembly (4)	Not easy to align or position during assembly		Easy to align and position during assembly (4)	Not easy to align or position during assembly				Easy to align and positioning with no torsion resistance (4)	Not easy to align and/or position with no torsion resistance (5)
							No resistance to insertion	Resistance to insertion (5)		No resistance to insertion	Resistance to insertion (5)				
				0	1	2	3	4	5	6	7			8	9
Additional of any parts (1) where the parts itself and/or other parts are being finally secured immediately	Parts and associated tools (included hands) can easily reach the desired location and the tools can be operated easily		3	2	5	4	5	6	7	8	9			6	8
	Parts and associated tools (included hands) cannot easily reach the desired location and the tools cannot be operated easily	Due to obstructed access or restricted vision (2)	4	4.5	7.5	6.5	7.5	8.5	9.5	10.5	11.5			8.5	10.5
		Due to obstructed access or restricted vision (2)	5	6	9	8	9	10	11	12	13			10	12

Table 4.5: Manual insertion: Part secured immediately

Separate Operation		Mechanical fastening processes (part(s)) already in place but not secured immediately after insertion				Non-Mechanical fastening processes (part(s)) already in place but not secured immediately after insertion				Non-Fastening process	
		None or localized plastic deformations			Bulk plastic deformation (large proportion of part is plastically deformed sharing fastening)	Metallurgical processes					
		Bending or similar process	Riveting or similar process	Screw tightening or other process		No additional material required (e.g resistance friction welding etc)	Additional material required		Chemical processes (e.g adhesive bonding etc.)	Manipulated of parts or sub-assembly (e.g orienting, fitting or	Other process (e.g liquid insertion, etc.)
							Soldering processes	Weld/brace processes			
		0	1	2	3	4	5	6	7	8	9
Assembly process where all solid parts are in place	9	4	7	5	3.5	7	8	12	12	9	12

Table 4.6: Manual Insertion: Separate Operation

4.5 Existing design of a standing fan.

Figure 4.19: Old product assembly drawing

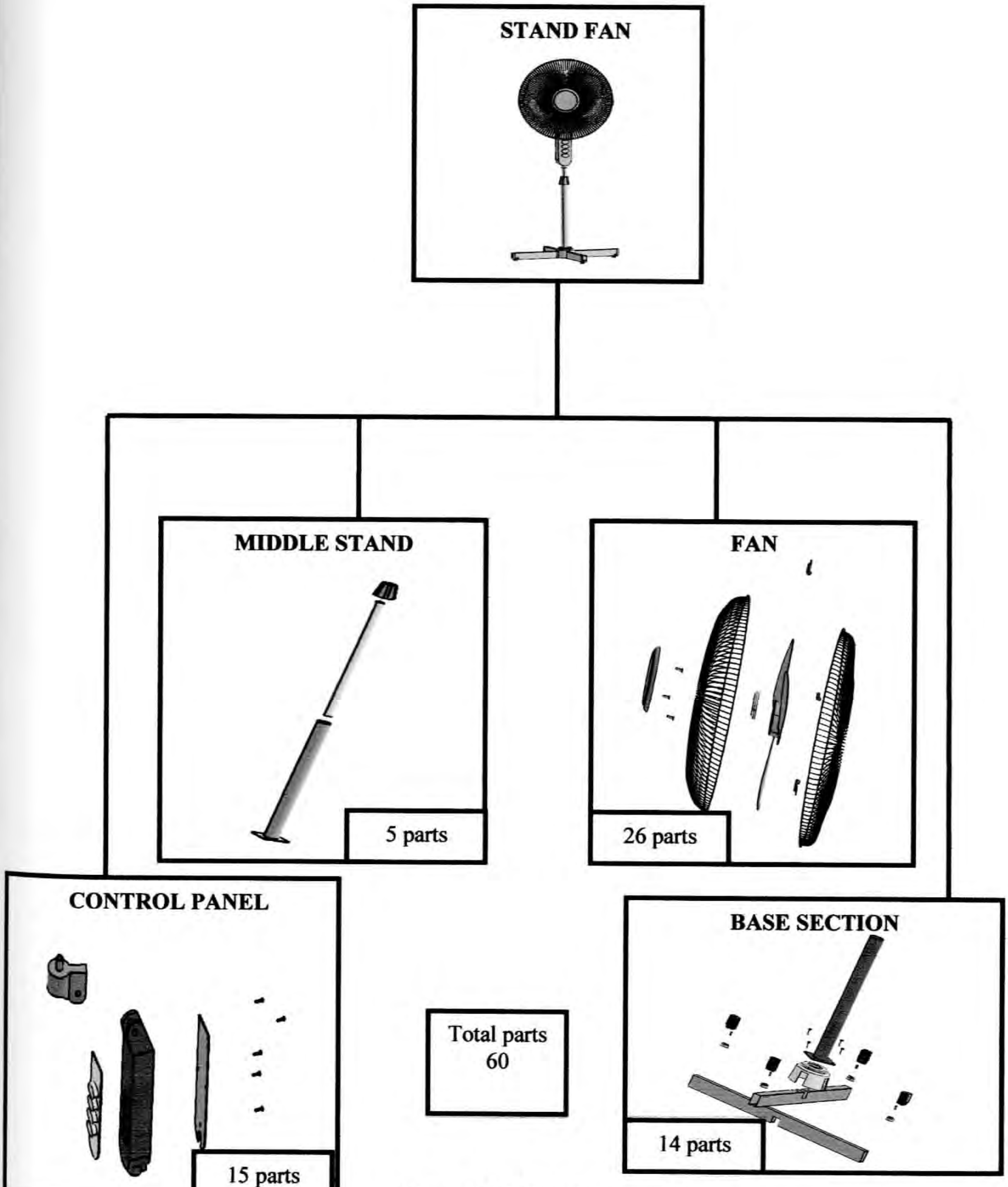


Figure 4.20: Function tree: old

4.5.1 Critics of each part

PART NAME	Critics
1 Fan cover panel	Necessary.To cover the electronic component inside
2 Button	Necessary but can be change into one part
3 Back cover panel	Necessary.To cover the electronic component inside
4 Screw	Necessary
5 Adjustable fan	Necessary
6 Screw	Necessary to hold the adjustable fan
7 Nut	Necessary to hold the adjustable fan
8 Clip	Not necessary
9 Screw	Not necessary
10 Motor	Necessary. Cannot be removed because of source rotation.
11 Gear box	Should be design to be more simple
12 Screw	Necessary to hold gear box
13 Back Motor cover	Necessary and must be separated prevent heat generated exposed to user and isolate motor from user
14 Screw	Not necessary can be improve
15 Button rotate	Control the button
14 Screw	Not necessary can be improve
16 Front motor cover	Necessary
17 Screw	Necessary to cover the motor
18 Back grillcover	Necessary for safety purpose
19 Screw	Necessary for safety purpose
20 Grill lock	Necessary
21 Fan blade	Necessary to create air flow
22 Fan Cap	Necessary
23 Clip	Not necessary, can be replace by snap fit.
24 Front grill cover	Necessary for safety purpose
25 Bottom base	Not necessary
26 Bottom base cover	Not necessary
27 Stand A	Necessary.The design can be improve
28 Stand b	Necessary.The design can be improve
29 Outside pillar	Necessary
30 Inside pillar	Necessary
31 Screw	Necessary
32 Stand Cap	Necessary
33 Pillar stand lock	Necessary
34 Screw	Not necessary

Table 4.7: Critics of each part

4.5.2 Weakness, strength and function of each part

Part	Weakness	Strength	Function
Fan cover panel	use many screw take long time to assemble	tight strong	hold the adjustable place the button
Button	3 buttons used	easy to assemble	control the fan level
Back cover panel	use many screw	tight strong	close the control panel
Screw	take long time to assemble not easy to assemble	easy to operate	tight the back panel
Adjustable fan	not easy to align	easy to operate	hold the upper part
Screw	take long time to assemble not easy to assemble	tight strong	hold the adjustable fan
Nut	easy to loss	easy to align	tight the screw
Clip	small function	easy to install	tight the wire
Motor	not easy to align heavy	tough	move the fan blade
Gear box	not easy to align not easy to install	tough	rotate the fan
Back Motor cover	not easy to align	hold itself	cover the motor
Button rotate	not easy to install		control the fan rotation
Front motor cover		easy to align	cover the motor hold the front grill
Back grill cover	not easy to align difficult to install	hold strong	protect the blade fan
Grill lock	big component	hold strong easy to install	hold the grill
Fan blade	not easy to align	changeable	
Fan Cap	not used able		hold the blade
Clip	easy to loose difficult to assemble	easy to used	clip the grill
Front grill cover	not easy to align difficult to install	hold strong	protect the blade fan
Bottom base	difficult to assemble useless component		as a base
Bottom base cover	tough less	stabilize	cover the base
Stand A	difficult to assemble	toughness	hold the fan
Stand B	difficult to assemble	toughness	hold the fan
Outside pillar	can't hold by itself	toughness	cover inside pillar
Inside pillar	slippery	toughness	adjustable high
Stand Cap	tough less	easy to install	cover the stand
Pillar stand lock	difficult to install	change able	tight the pillar
Screw	easy to broke	hold strong	tight the lock

Table 4.8: Weakness, strength and function of each part

4.5.3 Old design efficiency

c1	c2	c3	c4	c5	c6	c7	c8	c9	
Manual - Bench Assembly Name of Assembly - Stand fan Item Name : Part, sub or Pcb assembly or operation	No. of items	Manual handling code	Manual handling time per part	Manual insertion code	Manual insertion time per	Operation time c2(c4 + c6)	Operation cost 0.05c7	Estimation for theoretical	Operation rate OP : Description
1 Fan cover panel	1	00	1.13	30	2	3.13	0.1565	1	place in fixture
2 Button	4	00	1.13	95	8	36.52	1.826	1	add
3 Back cover panel	1	00	1.13	30	2	3.13	0.1565	1	add
4 Screw	5	11	1.8	38	6	39	1.95	0	add and screw
5 Adjustable fan	1	30	1.95	31	5	6.95	0.3475	1	add and hold down
6 Screw	1	10	1.5	38	6	7.5	0.375	1	add and screw
7 Nut	1	00	1.13	38	6	7.13	0.3565	1	add and screw
8 Clip	1	10	1.5	12	5	6.5	0.325	1	add and hold down
9 Screw	2	11	1.8	38	6	15.6	0.78	1	add and screw
10 Motor	1	83	5.6	30	2	7.6	0.38	1	add and hold down
11 Gear box	1	10	1.5	41	7.5	9	0.45	1	add
12 Screw	3	12	2.25	39	8	30.75	1.5375	1	add and screw
13 Back Motor cover	1	30	1.95	44	8.5	10.45	0.5225	1	add
14 Screw	1	11	1.8	38	6	7.8	0.39	1	add and screw
15 Button rotate	1	10	1.5	30	2	3.5	0.175	1	add
14 Screw	1	11	1.8	38	6	7.8	0.39	1	add and screw
16 Front motor cover	1	88	6.35	34	6	12.35	0.6175	1	add
17 Screw	2	11	1.8	38	6	15.6	0.78	0	add and screw
18 Back grillcover	1	85	5	02	2.5	7.5	0.375	1	add
19 Screw	2	11	1.8	39	8	19.6	0.98	0	add and screw
20 Grill lock	1	00	1.13	38	6	7.13	0.3565	1	add and fasten
21 Fan blade	1	15	2.25	02	2.5	4.75	0.2375	1	add
22 Fan Cap	1	10	1.5	39	8	9.5	0.475	1	add and screw
23 Clip	5	31	2.25	91	7	46.25	2.3125	0	add and rivet
24 Front grill cover	1	85	5	41	7.5	12.5	0.625	1	add and clip
25 Bottom base	4	01	1.43	34	6	29.72	1.486	1	add and snap
26 Bottom base cover	4	00	1.13	06	5.5	26.52	1.326	0	add and fit
27 Stand A	1	00	1.13	06	5.5	6.63	0.3315	1	add
28 Stand b	1	00	1.13	31	5.5	6.63	0.3315	0	add
29 Outside pillar	1	00	1.13	06	5.5	6.63	0.3315	1	add
30 Inside pillar	1	00	1.13	06	5.5	6.63	0.3315	1	add
31 Screw	4	11	1.8	38	6	31.2	1.56	0	add and screw
32 Stand Cap	1	30	1.95	30	2	3.95	0.1975	0	add
33 Pillar stand lock	1	10	1.5	30	2	3.5	0.175	1	add and fasten
34 Screw	1	11	1.8	39	8	9.8	0.49	1	add and screw
TOTAL						468.75	23.4375	28	Design efficiency =
						TM	CM	NM	3NM/TM =0,18

Table 4.9: Old product design effiency

4.9 New design effiency

c1	c2	c3	c4	c5	c6	c7	c8	c9	
Manual - Bench Assembly Name of Assembly - Stand fan Item Name : Part, sub or Pcb assembly or operation	No. of items	Manual handling code	Manual handling time per part	Manual insertion code	Manual insertion time per part	Operation time c2(c4 + c6)	Operation cost 0.05c7	Estimation for theoretical minimum parts	Operation rate OP : Description
1 Fan cover panel	1	0 0	1.13	30	2	3.13	0.1565	1	place in fixture
2 Button	1	0 0	1.13	95	2	3.13	0.1565	1	add
3 Back cover panel	1	0 0	1.13	30	2	3.13	0.1565	1	slot and snap fit
5 Adjustable fan	1	30	1.95	31	5	6.95	0.3475	1	add and hold down
6 Screw	1	10	1.5	38	6	7.5	0.375	1	add and screw
7 Nut	1	0 0	1.13	38	6	7.13	0.3565	1	add and screw
8 Clip	1	10	1.5	12	5	6.5	0.325	1	add and hold down
9 Screw	2	11	1.8	38	6	15.6	0.78	1	add and screw
10 Motor	1	83	5.6	30	2	7.6	0.38	1	add and hold down
11 Gear box	1	10	1.5	41	7.5	9	0.45	1	add
12 Screw	3	12	2.25	39	8	30.75	1.5375	1	add and screw
13 Back Motor cover	1	30	1.95	44	8.5	10.45	0.5225	1	add
14 Screw	1	11	1.8	38	6	7.8	0.39	1	add and screw
15 Button rotate	1	10	1.5	30	2	3.5	0.175	1	add
14 Screw	1	11	1.8	38	6	7.8	0.39	1	add and screw
16 Front motor cover	1	88	6.35	34	6	12.35	0.6175	1	add
18 Back grillcover	1	85	5	0 2	2.5	7.5	0.375	1	add
20 Grill lock	1	0 0	1.13	38	6	7.13	0.3565	1	add and fasten
21 Fan blade	1	15	2.25	0 2	2.5	4.75	0.2375	1	add
22 Fan Cap	1	10	1.5	39	8	9.5	0.475	1	add and screw
24 Front grill cover	1	85	5	41	7.5	12.5	0.625	1	add and clip
25 Bottom base	1	0 1	1.43	34	6	7.43	0.3715	1	add
26 Screw	4	11	1.8	39	8	39.2	1.96	1	add and screw
27 Outside pillar	1	0 0	1.13	0 6	5.5	6.63	0.3315	1	add
28 Inside pillar	1	0 0	1.13	0 6	5.5	6.63	0.3315	1	add
29 Pillar stand lock	1	10	1.5	30	2	3.5	0.175	1	add and fasten
30 Screw	1	11	1.8	39	8	9.8	0.49	1	add and screw
TOTAL						256.89 TM	12.8445 CM	27 NM	Design efficiency = 3NM/TM =0,31

Table 4.10: New product design efficiency

4.10 Concept selection

Design concept selection had been done from the previous concept scoring analysis. From this table, we can see that concept #1 (new design) had been selected due to the scoring analysis that had been done.

Assembly worksheet analysis of new design

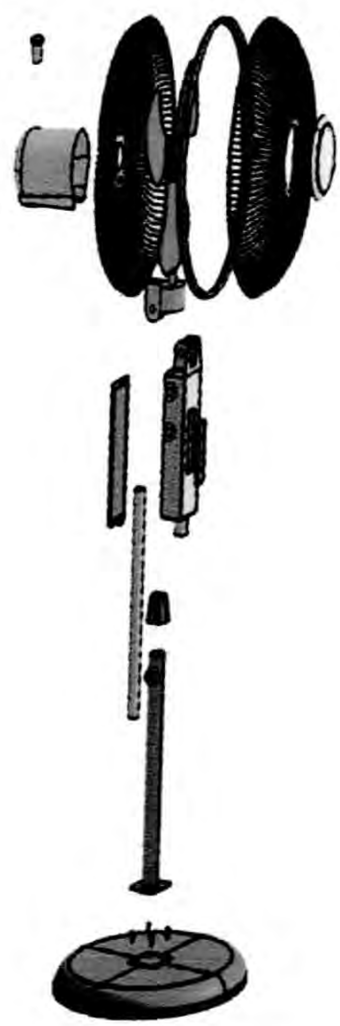


Figure 4.21: Assembly Drawing of New Concept Design

Discussions

Comparison between old and new design

- Percentage of part count reduction:
  = **45.76%**

- Percentage of assembly cost reduction:
  = **45.22 %**

- Percentage of assembly time reduction:
  = **45.23%**

- Percentage of design efficiency:

  old design: **18%**
  new design: **31%**
  Improving the product efficiency by **13%**

4.11 Part assembly drawing for old design

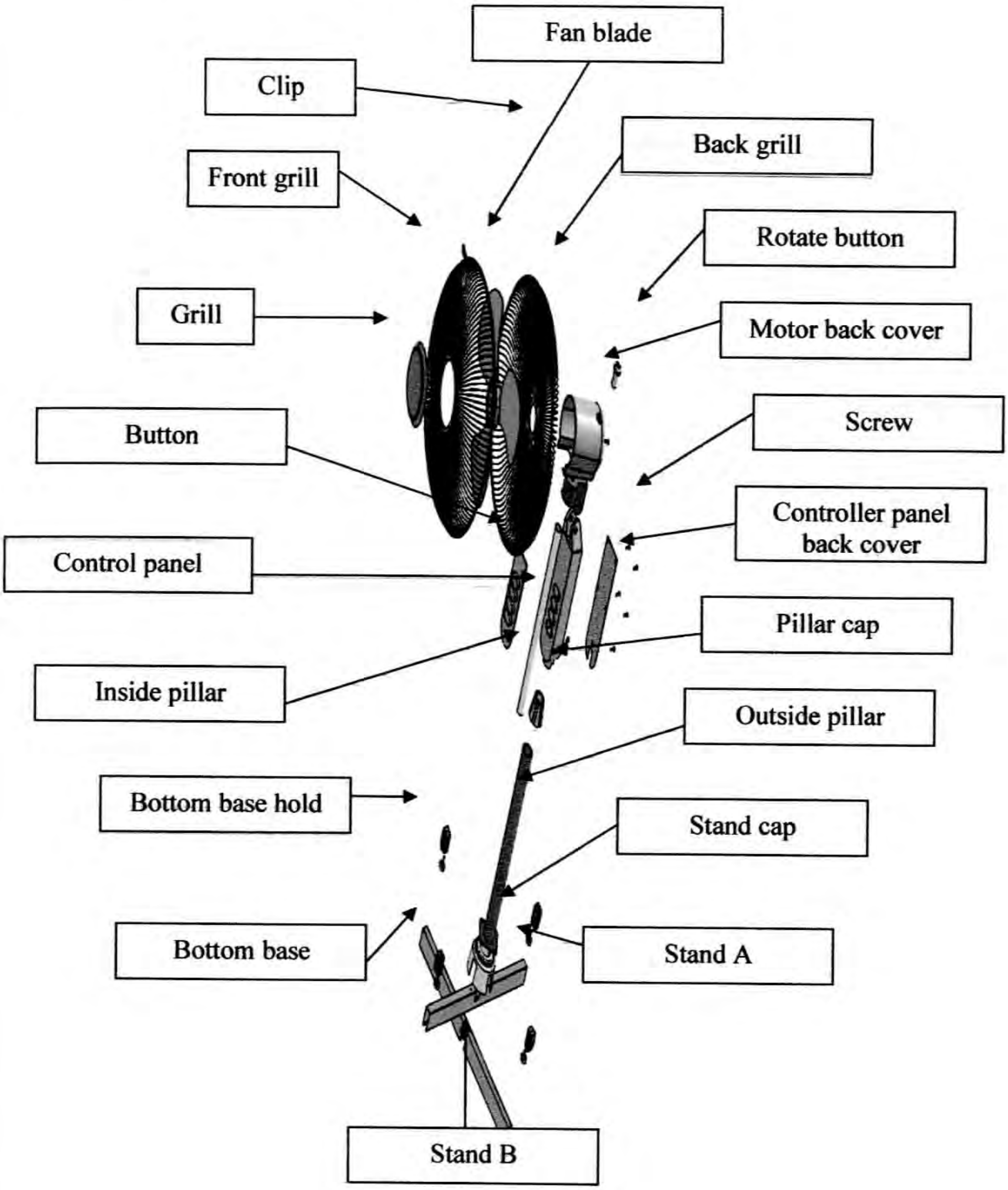
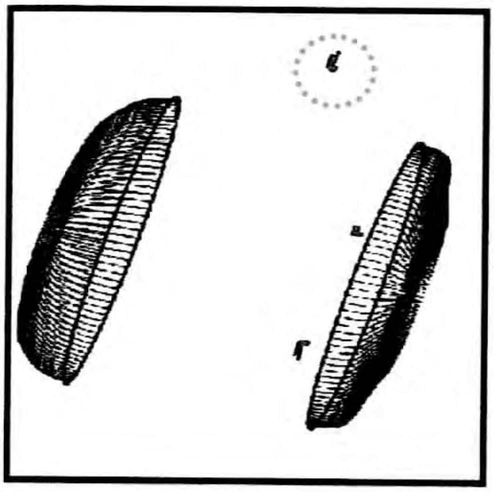


Figure 4.22: Part assembly

4.11.1 Concepts Selection

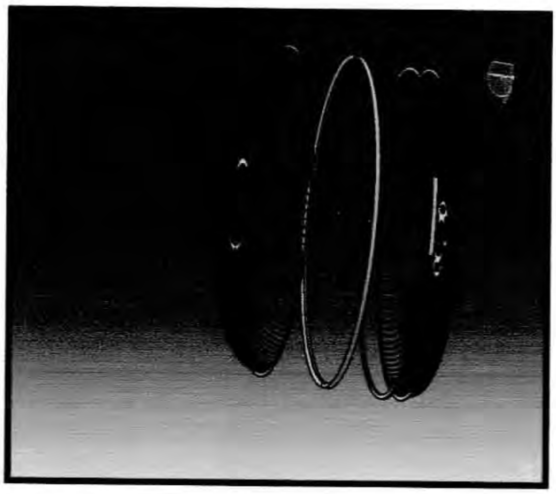
1. Fan grill

Concept 1



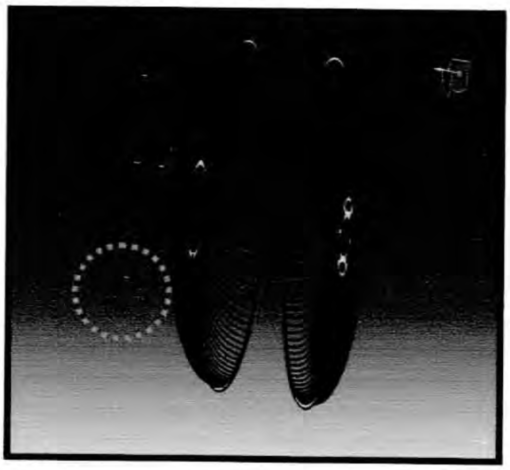
Clip Lock

Concept 2



Snap fit

Concept 3



Screw

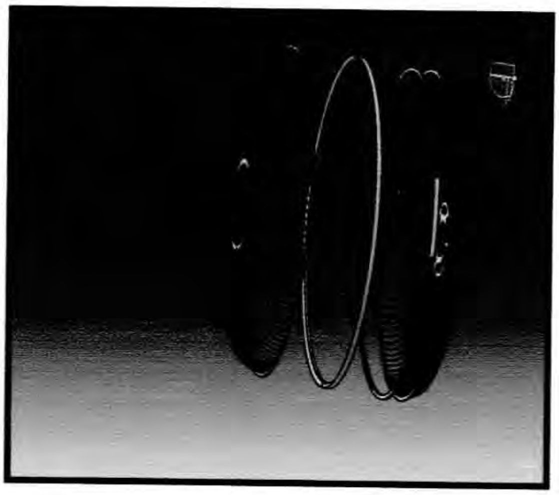
Figure 4.23: Concept selection for base grill

CONCEPTS			
SELECTION CRITERIA	1	2	3
	Clip Lock	Snap fit	Screw
Ease of Assembly	-	+	0
Easy to use	0	+	+
Reliability of setting	+	0	0
Durability	+	-	-
Ease of manufacture	-	0	-
Portability	0	+	0
Sum +'s	2	3	1
Sum 0's	1	2	3
Sum –'s	2	1	2
Net score	0	2	-1
Rank	2	1	3
Continue?	yes	yes	no

Table 4.11: Concept screening

	CONCEPTS				
		1		2	
SELECTION CRITERIA	WEIGHT	RATING	WEIGHTED SCORE	RATING	WEIGHTED SCORE
Ease of Assembly	30	3	0.9	3	0.9
Reliability of setting	15	2	0.3	3	0.45
Operating performance	25	3	0.75	3	0.75
Durability	5	2	0.10	1	0.1
Ease of manufacture	10	1	0.10	2	0.15
Portability	15	1	0.15	1	0.15
	Total Score	2.3		2.4	
	Rank	2		1	
	Continue?	no		yes	

Table 4.12: Concept scoring



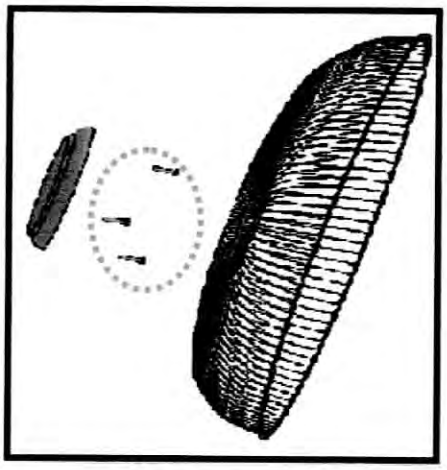
Selected Concept

Concept 2 (Snap fit)

2. Front grill cap

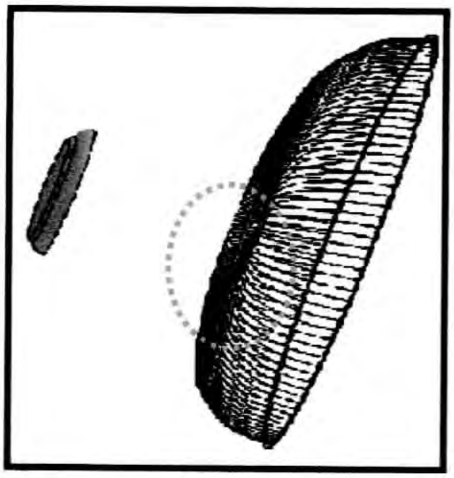
Concept Selection

Concept 1



3 screw

Concept 2



Glue

Concept 3

Snap fit

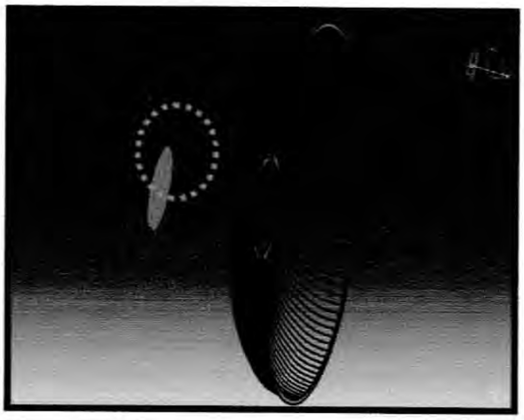
Figure 4.24: Concept selection for grill cap

CONCEPTS			
SELECTION CRITERIA	1	2	3
	3 screw	Glue	Snap fit
Ease of Assembly	-	0	+
Easy to use	0	0	+
Reliability of setting	+	-	+
Durability	+	-	0
Ease of manufacture	0	+	0
Portability	0	+	+
Sum +'s	2	2	4
Sum 0's	3	2	2
Sum –'s	1	2	0
Net score	1	0	4
Rank	2	3	1
Continue?	yes	no	yes

Table 4.13: Concept screening

	CONCEPTS				
		2		1	
SELECTION CRITERIA	WEIGHT	RATING	WEIGHTED SCORE	RATING	WEIGHTED SCORE
Ease of Assembly	30	1	0.3	3	0.9
Reliability of setting	15	1	0.15	1	0.15
Operating performance	25	1	0.25	2	0.5
Durability	5	1	0.05	2	0.1
Ease of manufacture	10	1.5	0.15	1.5	0.15
Portability	15	1	0.15	1	0.15
	Total Score	1.15		1.45	
	Rank	2		1	
	Continue?	no		yes	

Table 4.14: Concept scoring



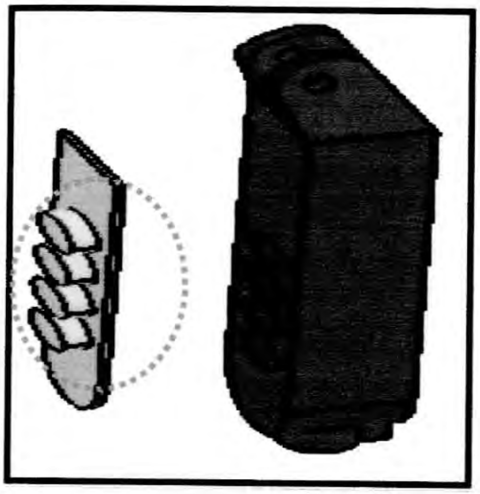
Selected Concept

Concept 3 (Snap fit)

4. Button

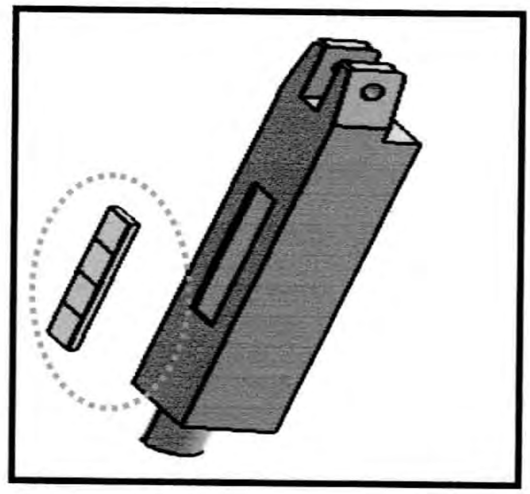
Concept Selection

Concept 1



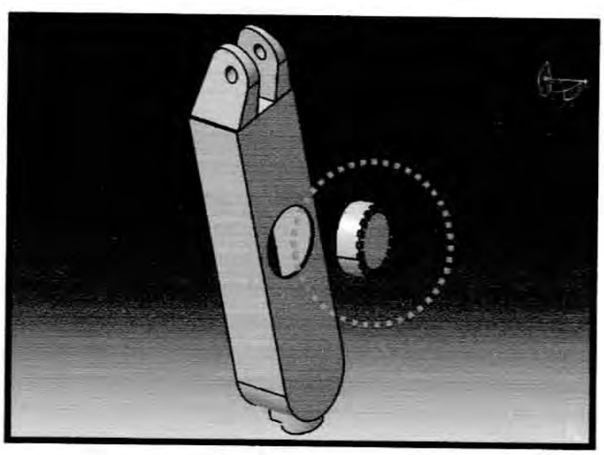
3 buttons

Concept 2



One row button

Concept 3



Rotating button

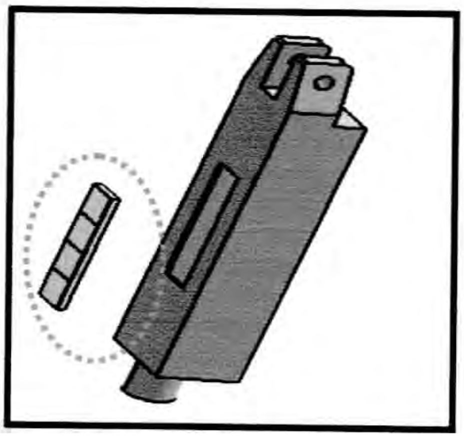
Figure 4.25: Concept selection for button

CONCEPTS			
SELECTION CRITERIA	**1**	**2**	**3**
	3 buttons	One row button	Rotating button
Ease of Assembly	-	+	-
Easy to use	+	-	+
Reliability of setting	+	-	0
Durability	0	0	-
Ease of manufacture	-	-	+
Portability	0	+	+
Sum +'s	2	2	3
Sum 0's	2	1	1
Sum –'s	2	3	2
Net score	1	0	1
Rank	0	-1	1
Continue?	yes	no	yes

Table 4.15: Concept screening

	CONCEPTS				
		1		3	
SELECTION CRITERIA	WEIGHT	RATING	WEIGHTED SCORE	RATING	WEIGHTED SCORE
Ease of Assembly	30	1	0.30	2	0.6
Reliability of setting	15	2	0.30	3	0.45
Operating performance	25	3	0.75	3	0.75
Durability	5	1	0.05	2	0.1
Ease of manufacture	10	1	0.10	3	0.3
Portability	15	2	0.3	1	0.15
	Total Score	1.8		2.2	
	Rank	2		1	
	Continue?	no		yes	

Table 4.16: Concept scoring



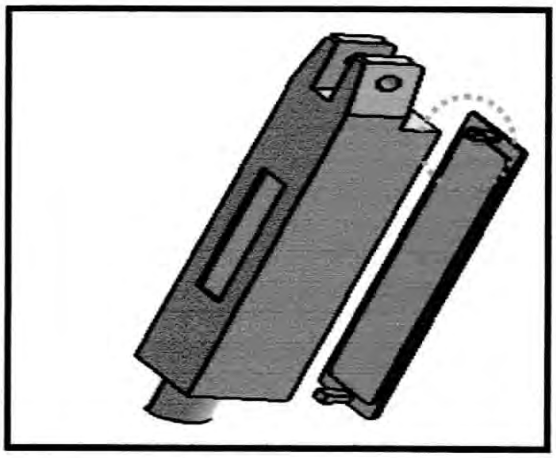
Selected Concept:

One row button (concept 2)

5. Back cover panel

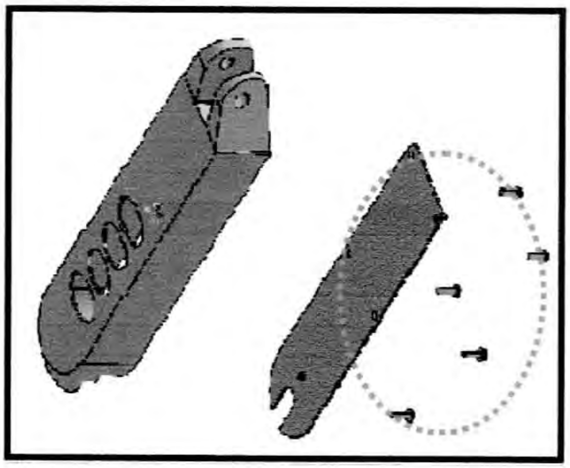
Concept Selection

Concept 1



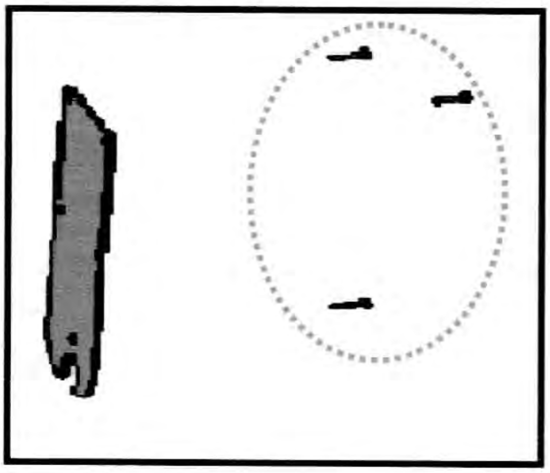
Snap fit

Concept 2



5 Screws

Concept 3



3 screws

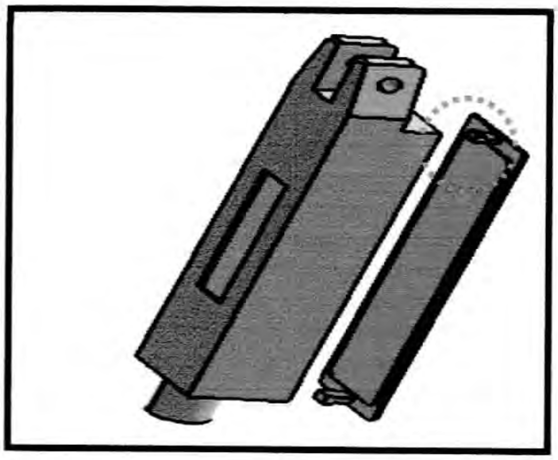
Figure 4.26: Concept selection for back cover panel

CONCEPTS			
SELECTION CRITERIA	**1**	**2**	**3**
	Snap fit	5 Screws	3 screws
Ease of Assembly	+	0	0
Easy to use	+	-	0
Reliability of setting	+	-	+
Durability	0	+	0
Ease of manufacture	-	0	0
Portability	+	0	0
Sum +'s	4	2	1
Sum 0's	1	2	4
Sum –'s	1	1	1
Net score	3	0	1
Rank	1	3	2
Continue?	yes	no	yes

Table 4.17: Concept screening

	CONCEPTS				
		1		3	
SELECTION CRITERIA	**WEIGHT**	**RATING**	**WEIGHTED SCORE**	**RATING**	**WEIGHTED SCORE**
Ease of Assembly	30	1	0.30	2	0.6
Reliability of setting	15	2	0.30	3	0.45
Operating performance	25	3	0.75	3	0.75
Durability	5	1	0.05	2	0.1
Ease of manufacture	10	1	0.10	3	0.3
Portability	15	2	0.3	1	0.15
	Total Score	1.8		2.2	
	Rank	2		1	
	Continue?	yes		no	

Table 4.18: Concept scoring



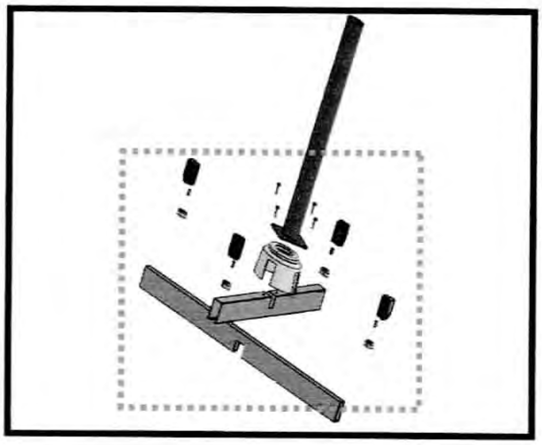
Selected Concept

Concept 3 (Snap fit)

6. Base

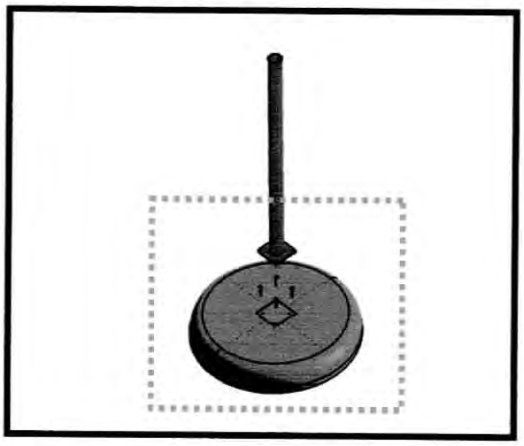
Concept Selection

Concept 1



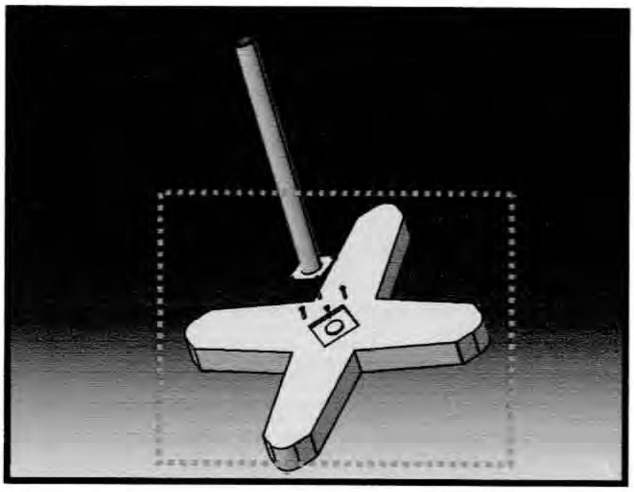
Slot and screws

Concept 2



Circle base and screws

Concept 3



Cross base and screws

Figure 4.27: Concept selection for base

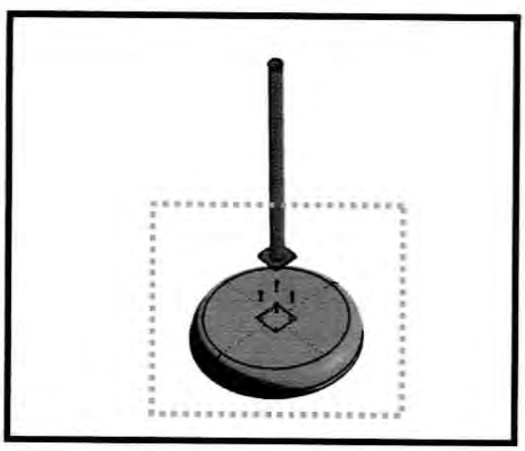
CONCEPTS			
SELECTION CRITERIA	**1**	**2**	**3**
	Slot and screws	Circle base and screws	Cross base and screws
Ease of Assembly	-	+	+
Easy to use	0	+	+
Reliability of	+	0	0

setting			
Durability	0	0	0
Ease of manufacture	-	-	+
Portability	-	0	+
Sum +'s	1	2	4
Sum 0's	2	3	2
Sum –'s	3	1	4
Net score	-2	-1	4
Rank	3	2	1
Continue?	no	yes	yes

Table 4.19: Concept screening

	CONCEPTS				
		2		3	
SELECTION CRITERIA	WEIGHT	RATING	WEIGHTED SCORE	RATING	WEIGHTED SCORE
Ease of Assembly	30	2	0.60	3	0.90
Reliability of setting	15	2	0.30	2	0.35
Operating performance	25	2	0.50	3	0.75
Durability	5	2	0.10	2	0.10
Ease of manufacture	10	2	0.20	2	0.20
Portability	15	2	0.30	3	0.45
	Total Score	2.0		2.75	
	Rank	2		1	
	Continue?	no		yes	

Table 4.20: Concept scoring



Selected Concept

Circle base and screws (Concept 2)

Summary

After all the concepts were identified, their advantages and disadvantages, I choose one of them for a final concept. This concept is the best one compared to the other concept. The final concept then was improving their to assemble. I designed the concept using all the information that we got by make a lot of survey and research to satisfy market needs. From the 60 parts, I have reduced the part until 33 parts. In this case a lot of time was reducing in assembly.

4.12 Weakness, strength, function

Part	Weakness	Strength	Function
Fan cover panel	use many screw take long time to assemble	tight strong	hold the adjustable place the button
Button		easy to assemble	control the fan level
Back cover panel		tight strong easy to assemble	close the control panel
Adjustable fan	take long time to assemble not easy to assemble	easy to operate	adjustable fan
Screw	not easy to align	easy to operate	hold the upper part
Nut	take long time to assemble not easy to assemble	tight strong	hold the adjustable fan
Clip	easy to loss	easy to align	tight the screw
Motor	not easy to align heavy	tough	move the fan blade
Gear box	not easy to align not easy to install	tough	rotate the fan
Screw	not easy to align	hold itself	tight the gear box
Back Motor cover	not easy to install	light	cover the motor
Screw		easy to align	tight the back motor
Button rotate	not easy to align difficult to install	hold strong	control the fan rotation
Front motor cover	easy to align	fast to assemble	cover the motor hold the front grill
Back grillcover	not easy to align difficult to install	hold strong	protect the blade fan
Grill lock		easy to used	lock back grill
Fan blade	not easy to align difficult to install	hold strong	produce the air
Fan Cap		fit tight	front grill cover
Front grill cover	not easy to align difficult to install	hold strong	protect the blade fan
Bottom base	make from plastic	toughness easy to assemble	hold the pillar stand
Screw	difficult to assemble	toughness	hold the stand
Outside pillar	can't hold by itself	toughness	cover inside pillar
Inside pillar	slippery	toughness	adjustable high
Pillar stand lock	tough less	easy to install	lock the pillar
Screw	difficult to install	change able	tight the pillar

Table 4.21: Weakness, strength, function

4.12.1 Part critique for new design

PART NAME	Critics
Fan cover panel	Necessary.To cover the electronic component inside
Button	Necessary
Back cover panel	Necessary.change to snap
Adjustable fan	Necessary
Screw	Necessary to hold the adjustable fan
Nut	Necessary to hold the adjustable fan
Clip	Not necessary
Motor	Necessary. Cannot be removed because of source rotation.
Gear box	Should be design to be more simple
Screw	Necessary to hold gear box
Back Motor cover	Necessary and must be separated prevent heat generated exposed to user and isolate motor from user
Button rotate	Control the button
Front motor cover	Necessary
Screw	Necessary to cover the motor
Back grillcover	Necessary for safety purpose
Screw	Necessary for safety purpose
Grill lock	Necessary
Fan blade	Necessary to create air flow
Fan Cap	Necessary. Used it propertly
Front grill cover	Necessary for safety purpose
Bottom base	Necessary
Outside pillar	Necessary
Inside pillar	Necessary
Screw	Necessary
Stand Cap	Necessary
Pillar stand lock	Necessary
Screw	Not necessary

Table 4.22: Part critique for new

Function tree (new)

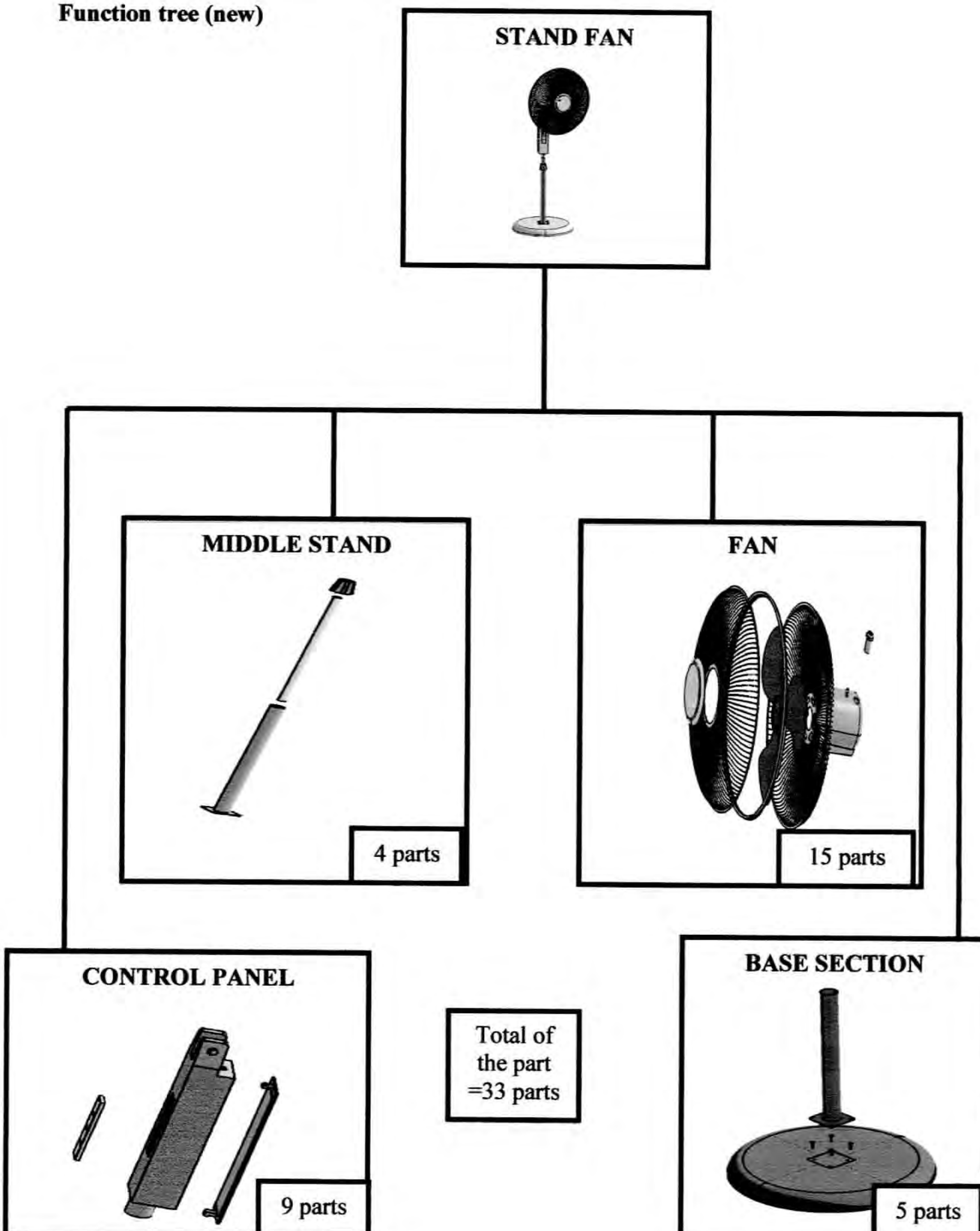


Figure 2.28: Function tree (new)

4.13 Design for manufacturing

STEP 1: Estimation from the old design

Component	Purchased Materials ($/kg)	Processing (machine+labor)	Assembly (labor)	Total unit variable Cost	Tooling and other (NRE), RM	Tooling Lifetime Unit	Tooling Unit fixed Cost	Total cost
SPINDLE SYSTEM:								
Fan grill carbon steel (using the machining)						15000		
Fan grill (2)	0.40	0.35	0.522	1.27			0.01	1.28
Injection Molding (Material:ABS)						500 000		
All	1.465	0.75	0.169	2.38			0.03	2.41
Stand and outside pillar made by carbon steel (using the machining)						15000		
Stand (2)	0.45	0.35	0.15	3.20			0.01	3.21
Outside pillar made stailess steel (using the machining)						10000		
Pillar (1)	1.65	0.25	0.1	2.00			0.01	2.01
Total Direct Cost	3.97	1.7	0.941	6.61			0.06	6.67
Overhead Charges	3.8	0.26	1.03	5.09				5.09
Total Cost								20.67

Table 4.23: Estimation from the old design

STEP 2: Estimate the manufacturing cost

Variable Cost		$
Materials Processing	1.1lb ABS at $1.25/lb	1.38
Injection Molding)	50unit/hr at 120/hr	0.7
Fixed Cost Tooling For Molding	$14 000 for 500K unit/tool	0.03
Total Direct Cost		2.11
Overhead Charges		0.62
Total Unit Cost		2.73

Table 4.24: Estimate the manufacturing cost

Estimating costs of manufacturing

Total manufacturing cost = Material + Tooling + Processing

Material cost per part, cm = M/q = cw(Wp + Ww)

= cw.wp(1 + α)

Tooling cost,ct = T/q

Processing cost per part,cp = ct

Cost per part, c = cw.Wp(1 +α) + T/q + ct

Section	Component	Part weight (lb)	Alpha	Material cost	Tooling cost rm,T	Production quantity	Cycle time (hrs/part)	Machine rate	Total cost
1	Part that made by the Abs (using the injection mold)	2	0.01	0.25	5000	10000	0.01	80	2.563
2	Fan grill carbon steel (using the machining)	1	0.25	0.28	1500	5000	0.2	30	6.65
3	Stand made by carbon steel (using the machining)	2	0.2	0.28	1500	5000	0.1	50	6.071
4	Inside and outside pillar made stailess steel (using the machining)	2	0.1	0.75	1500	5000	0.05	50	4.315

Table 4.25: Estimation cost for manufacturing

Old product

Total cost manufacture

= 23.067+13.3+12.142+8.63

= 57. 139

New design

DFA index = $\frac{27 \times 3}{256.86}$

= **0.31**

So the efficiency of the new design is better then the old design.

STEP 5: Reduced the cost of supporting production

- In new design we replaced the screw method into snap and fold method for the cover and eliminated unnecessary parts. It will effects on:
    - Number of Workers
    - Assembly Costing
    - Assembly Time
    -

STEP 6: Results for the new design (improvement)

Component	Purchased Materials ($/kg)	Processing (machine+labor)	Assembly (labor)	Total unit variable Cost	Tooling and other (NRE), RM	Tooling Lifetime Unit	Tooling Unit fixed Cost	Total cost
SPINDLE SYSTEM:								
Fan grill carbon steel (using the machining)						15000		
Fan grill (2)	0.40	0.35	0.522	1.27			0.01	1.28
Injection Molding (Material:ABS)						500 000		
All	1.465	0.75	0.169	2.38			0.03	2.41
Outside pillar made stailess steel (using the machining)						10000		
Total Direct Cost	1.87	1.1	0.691	3.66			0.04	3.70
Overhead Charges	3.2	0.26	1.03	4.49				4.49
Total Cost								11.88

Table 4.25: Results for the new design (improvement)

4.14 Shape Criteria

Example for: Base

Shape Attributes:

Depression	- Yes
Uniform wall	- Yes
Uniform Cross section	- Yes
Axis of rotation	- No
Regular cross section	- No
Capture cavity	- No
Enclosed cavity	- No
No draft)	- No

The shape that attributes with 'Yes' will eliminate those processes that are not capable of producing these features. Those features with 'No' will eliminate those processes that only not capable to producing parts with these features present.

4.14.1 Analysis on the material and process

Table selection of Material and process depend on shape generation capabilities of process.

	Cast iron	carbon steel	alloy steel	Aluminium and Alloys	Copper and alloys	zinc and alloys	Magnesium and alloys	Tatinium and alloys	Nickel and alloys	Refractory metals	Thermoplastics	Thermosets
Sand and casting												
Investment Casting												
Die Casting												
Injection Molding											X	
Structural Foam Molding												
Blow Molding												
Blow molding												
Rotational Molding												
Impact Extrusion												
Cold Heading												
Closed die forging												
Powder Metal processing												
Hot Extrusion												
Rotary Swaging												
Machining												
ECM												
EDM												
Wire EDM												
Sheet Metal												
Thermoforming												
Metal Spinning												

Normal Practise

Less Common

Not Applicable

Table 4.26: Analysis on the material and process

4.14.2 All part for selection material and process.

From the process and material the process that suit our product plastics is the injection molding. This class of material which always remain capable of being soft by heat and hardening on cooling. The material is Acrylonitrilebutadienestyrene with Yield strength 41MN/m²,elastic modulus 2100MN/m² and heat deflection temperature 99c is suitable one.

Then each of these parts will through the same process and material selection procedure. The standard parts are not required in this process flow.

No.	Name of assembly STAND FAN	Manufacturing process	material
1	Fan cover panel	Injection molding	thermoplastic
2	Button	Injection molding	thermoplastic
3	Back cover panel	Injection molding	thermoplastic
4	Adjustable fan	Injection molding	thermoplastic
5	Clip	Machining	cast iron
6	Gear box	Injection molding	thermoplastic
7	Back Motor cover	Injection molding	thermoplastic
8	Button rotate	Injection molding	thermoplastic
9	Front motor cover	Injection molding	thermoplastic
10	Back grillcover	Machining	cast iron
11	Grill lock	Injection molding	thermoplastic
12	Fan blade	Injection molding	thermoplastic
13	Fan Cap	Injection molding	thermoplastic
14	Front grill cover	Injection molding	cast iron
15	Bottom base	Injection molding	thermoplastic
16	Outside pillar	Injection molding	thermoplastic
17	Inside pillar	Machining	stainlesss steel
18	Pillar stand lock	Injection molding	thermoplastic
19	Stand	Machining	cast iron

Table 4.27: Selection material and process

4.15 Product assembly flow line (old product)

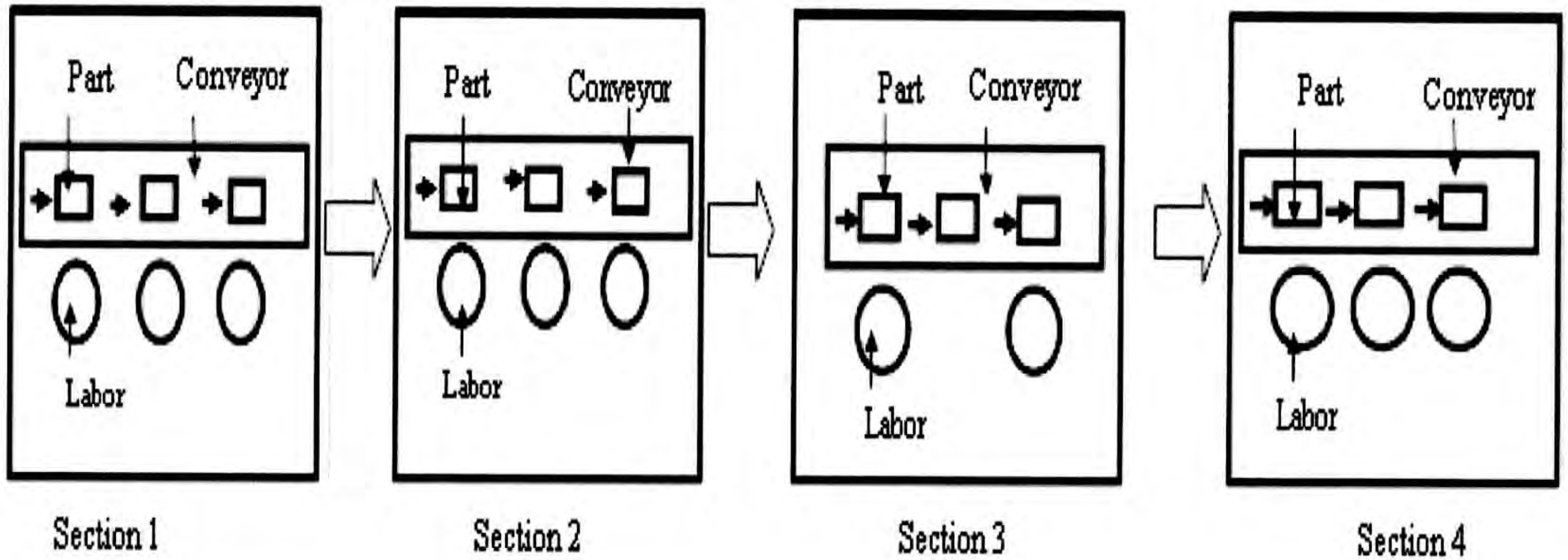


Figure 4.29: Product assembly flow line (old product)

Description:Old design

Section 1

1st labor: The assembly starts from the middle section, control panel was place in fixtures then add 4 buttons .The wiring done on the buttons connections.

2nd labor: Back panel cover use to close the control panel by using 4 screws.

3rd labor: Screw the adjustable on the top.

Section 2

1st labor: Start with install the motor into the back motor cover and screw it. The button rotate is install on the motor back cover and screw.

2nd labor: Snap the front cover then screw it.

3rd labor: Then install the back cover grill with 2 screws. Put the fan blade and the cap. Rivets the clip on the back grill then clip with the front grill

Section 3

Fix the stand, install bottom base and the base with the plastic deformation. Then snap that assemble on the stand 1 and 2. Two labor uses assemble on this section.

Section 4

1st labor: The stand assembles will combine the pillar stand with the 4 screws.

2nd labor: Add the inside pillar, and then put the stand cap. Lock the pillar with the combination of upper section

4.16 Product assembly flow line (new product)

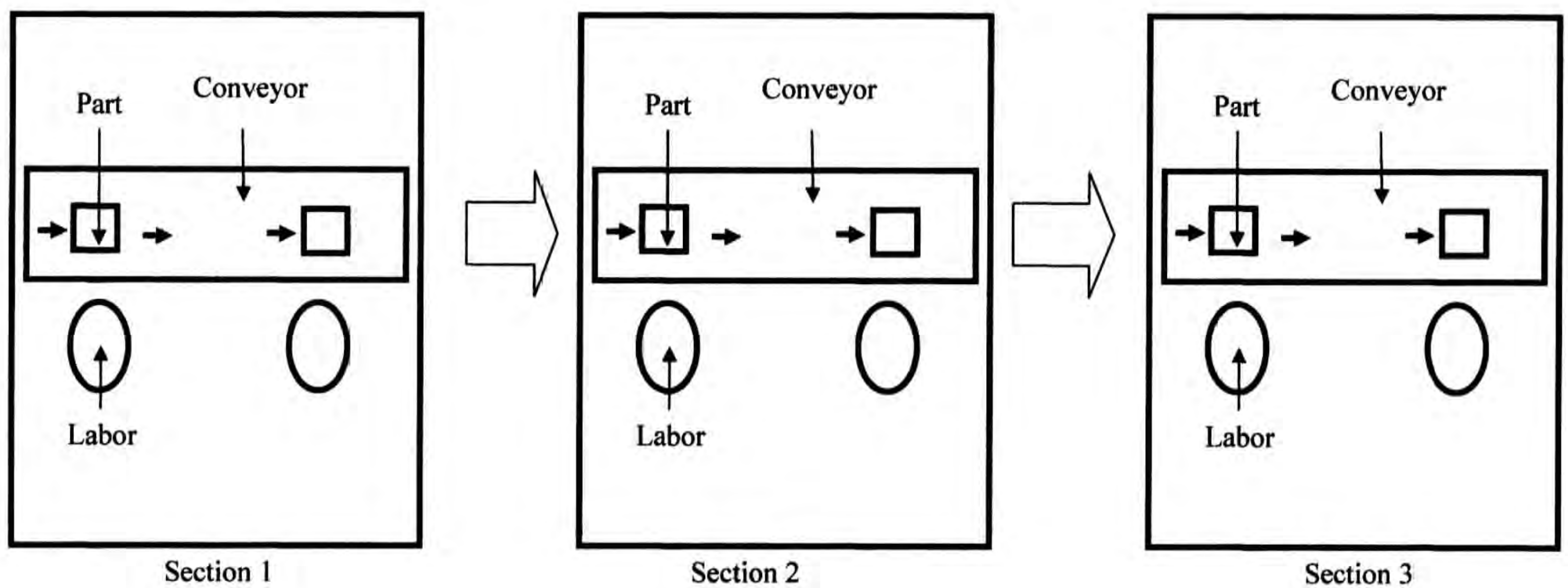


Figure 4.30: Product assembly flow line (new product)

Description: New design

Section 1

1st labor: Control panel was place in fixtures then add one row buttons .The wiring done on the buttons connections.

2nd Back: panel cover use to close the control panel by using snap fit. Screw the adjustable on the top.

Section 2

1st labor: Start with install the motor into the back motor cover and snap it. The button rotate is install on the motor back cover and screw.

2nd labor: Snap the front cover then screw it. Then install the ring on the back grill and snap it with the front grill.

.

Section 3

Here, there one labor use to assemble the pillar and the base use 4 screws. Then put the inside pillar into the stand pillar.

Discussions

From the flow line we can see there 12 labors used to assemble the old product. The new product only use 5 labors assemble the complete product. Here there save in pay to the labor. There are a lot of time reduce that we can save.

4.17 Process flow chart

Stand fan assembly process flow.

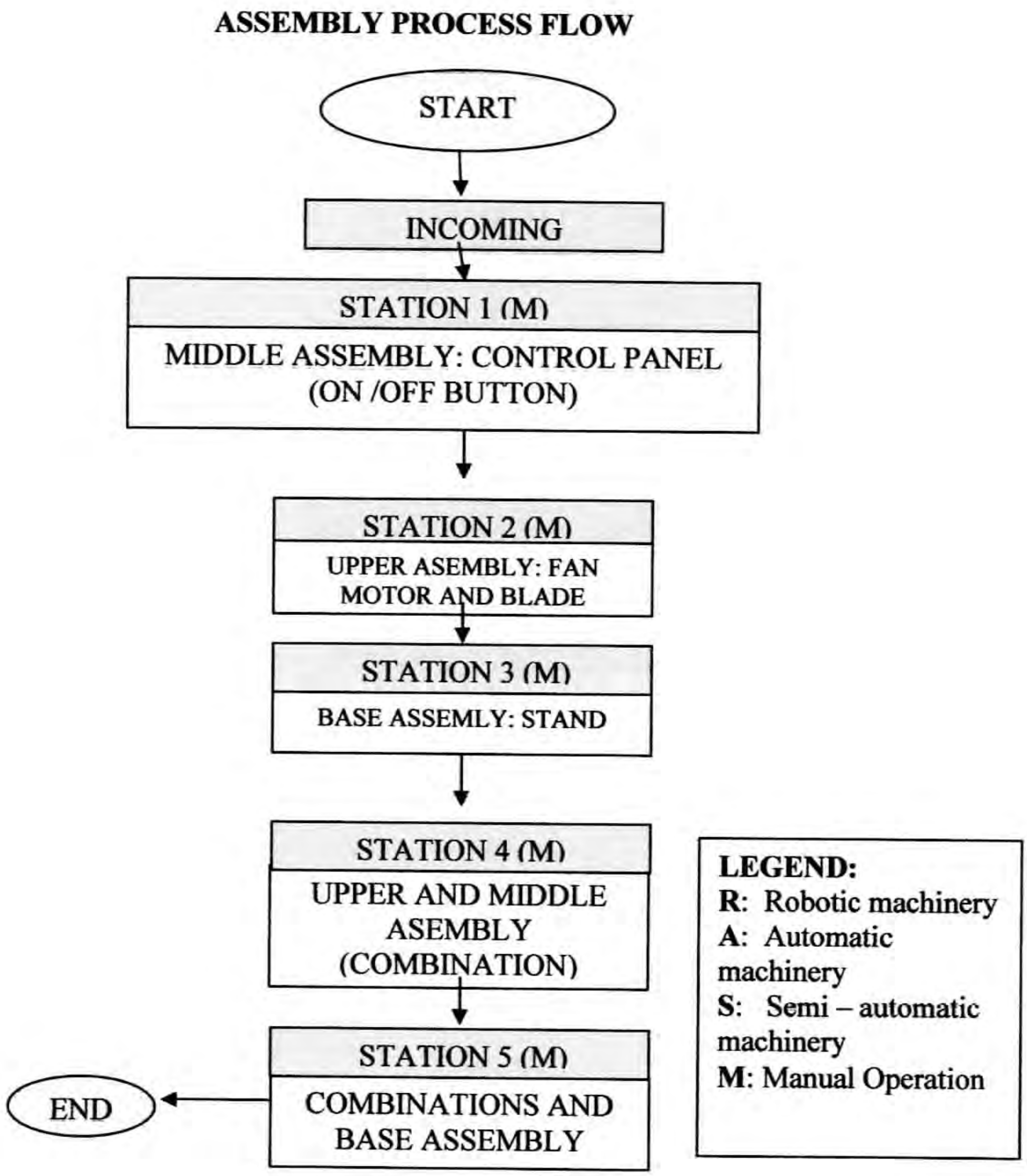


Figure 4.31: Assembly process flow

4.17.1 Station 1 Assemble.

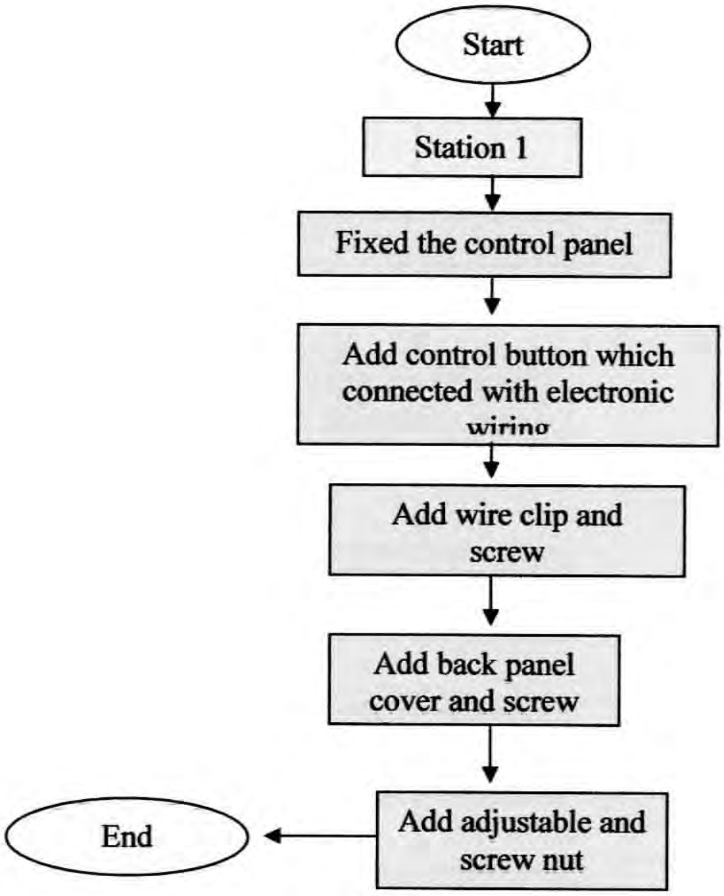


Figure 4.32: Flow station 1 assembly

4.17.2 Station 2 Assemble

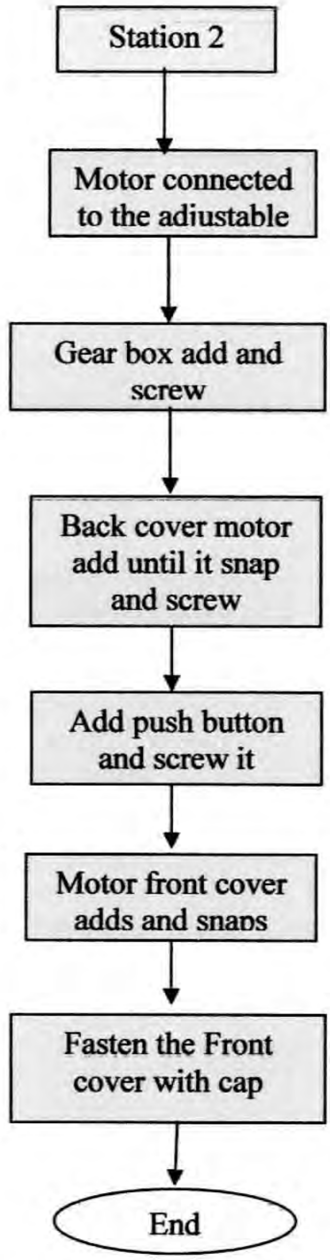


Figure 4.33: Flow station 2 assembly

4.17.3 Station 3

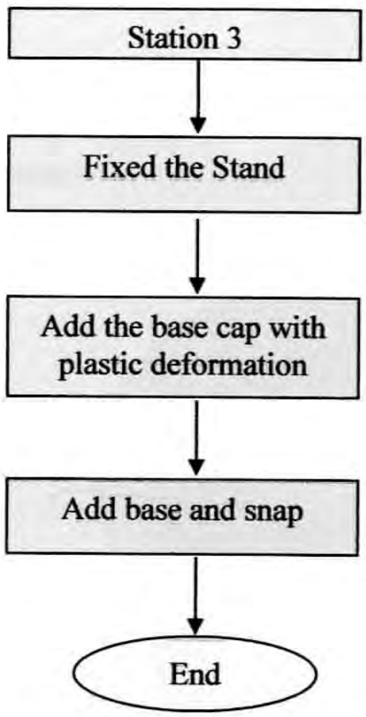


Figure 4.34: Flow station 3 assembly

4.17.4 Station 4 and station 5

Tight the combination with station 5 on the stand pillar with 4 screws and pillar lock in the middle.

4.18 New product assembly

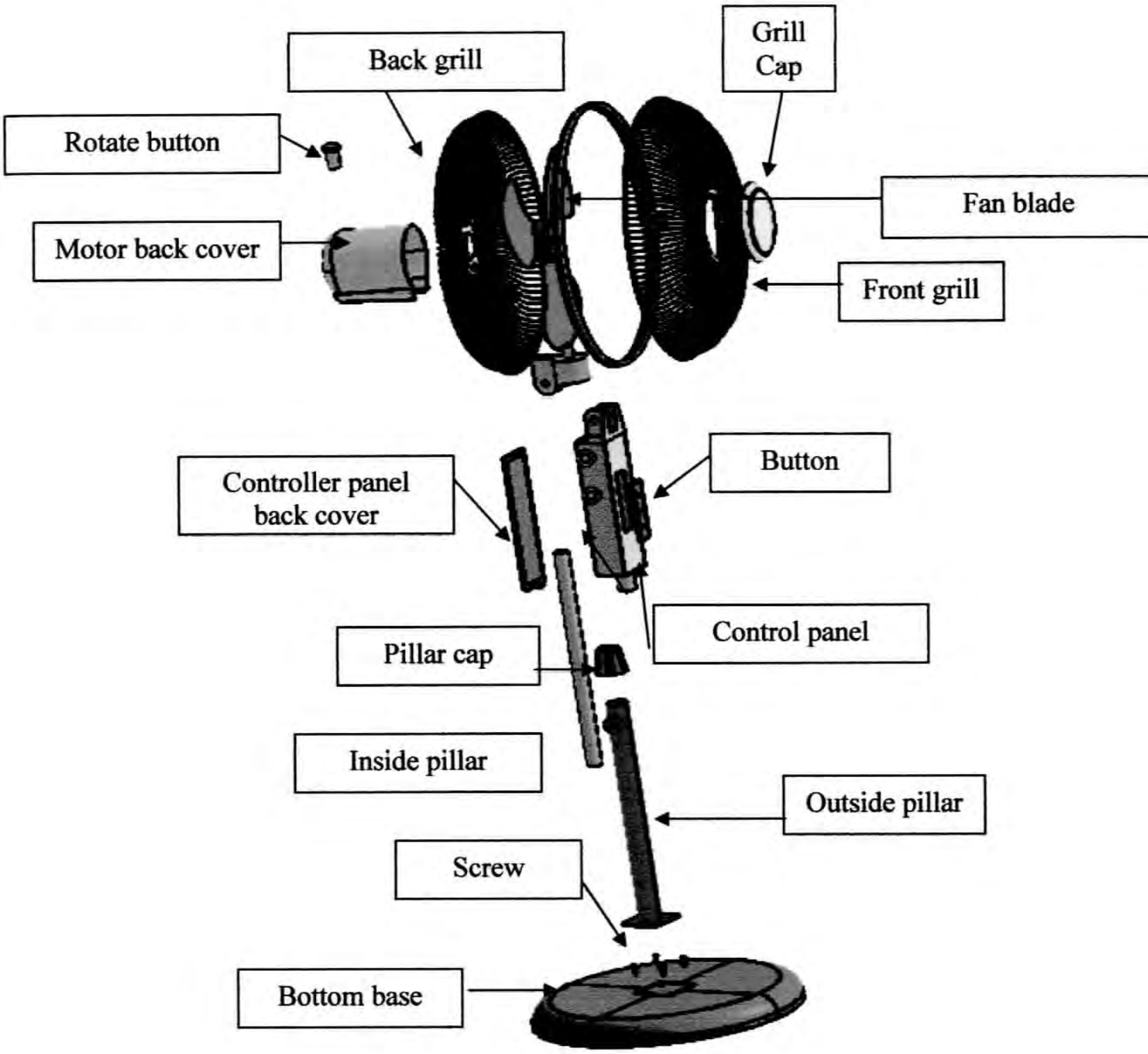


Figure 4.35: Part exploded

CHAPTER 5

CONCLUSION

5.1 Conclusions

Design for manufacturing and assembly guide us a lot in optimizing the product design. This method are required a lot of knowledge in design each of those product parts. Gaining the input of assembly guideline, time consuming, and cost in develop each of this product parts. From the current design and the new design that had been done, there will be the improvement that had been brought the differentiation between them. The design that had been created is to determine and get the recognition of a need of desire and terminate with availability of sources to fulfill the originality within some defined constraint. The redesign of the stand fan had reduced the time assembly, reduce the total assembly cost and also bring out the best material and process selection. Therefore, the efficiency of the design will also be increase.

The summarizing of the improvement of the project is stated as follows:

- Part count reduction = 45.76%
- Assembly time reduction = 45.23%
- Assembly cost reduction = 45.22%
- Improve Design efficiency = 13%
- Labor reduce = 55%

The implement of the DFMA in the product will also can be seen that the design will give the improvement to both the user and the manufacturer based on the reason stated which will bring the achievement of this objective of the PSM.

CHAPTER 6

FUTURE RECOMMENDATION

6.1 Recommendation for Further Works

After doing this DFMA project in two semesters, there will be some improvement that can be make to make the result of the project more efficient. These are the recommendation that I had suggest for the implement in future:

1) There still more parts to be reduced if the objective is more on ease of the assembly.
2) For further work the process for DFMA could reduce more parts and create new design.
3) If the constraint is lessen more we could design a new tower fan instead of redesigning.
4) The implementation of Rapid prototype of the product can make it easy to be compared to the current design.
5) The use of DFMA software is will increase the efficiency of the product redesign rather than manual calculation. The software should be applied in DFMA.

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APPENDIX

Appendix A

A.1 Calculation Estimating costs of manufacturing

A.2 Calculation for operation cost

A.3 Operation time

A.4 Design efficiency

Appendix B

B.1 Part drawing

APPENDIX A

A.1 Calculation Estimating costs of manufacturing

Calculate the material cost per part ,cm = Rm0.25/lb (2 1b/part)(1 + 0.01)

= Rm 0.738/part

Calculate the tooling cost, ct =Rm 5,000/10000 parts =Rm 7.000/part

Calculating the processing part cost per part ,cp =Rm 100/hr (0.03) hrs/part

= Rm 3.000/part

Summing the material, tooling and processing cost for each part:

cm + ct + cp = **$ 10.738/ part**

Old product

Section 1
9 x 2.563 = **23.067**

Section 2
2 x 6.65 = **13.3**

Section 3
2 x 6.071 = **12.142**

Section 4
2 x 4.315 = **8.63**

Total cost manufacture

= 23.067+13.3+12.142+8.63

= 57. 139

New product

Section 1
1 x 2.563 = **28.93**

Section 2
2 x 6.65 = **13.3**

Section 4
2 x 4.315 = **8.63**

Total cost manufacture

= 28.93+13.3+8.63

= 50.86

A.2 calculation for operation cost

Rm 1.80per hour

180 / 3600

= 0.05 cent per second.

A.3 Operation time

= c2 (c4 + c5)

= 1 (1.13+ 3.00)

= 4.13 cent/second

A.4 Design effiency

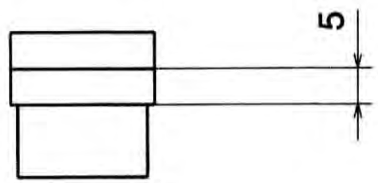
= 3nm / tm

= 3(27) / 256.89

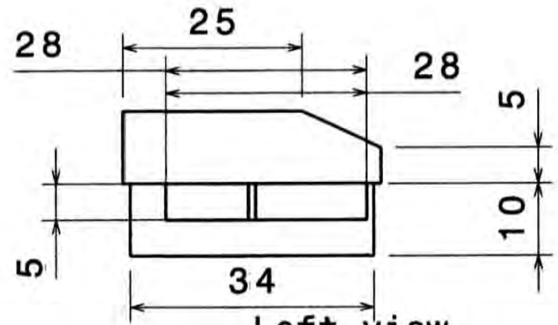
= 0.31

APPENDIX B

B.1 Part drawing



Front view
Scale: 1:1



Left view
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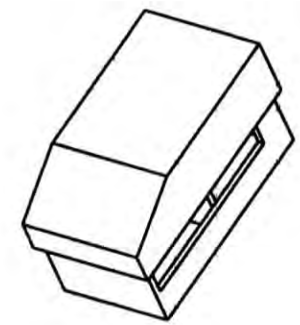
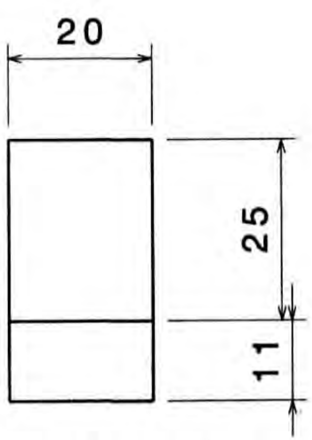
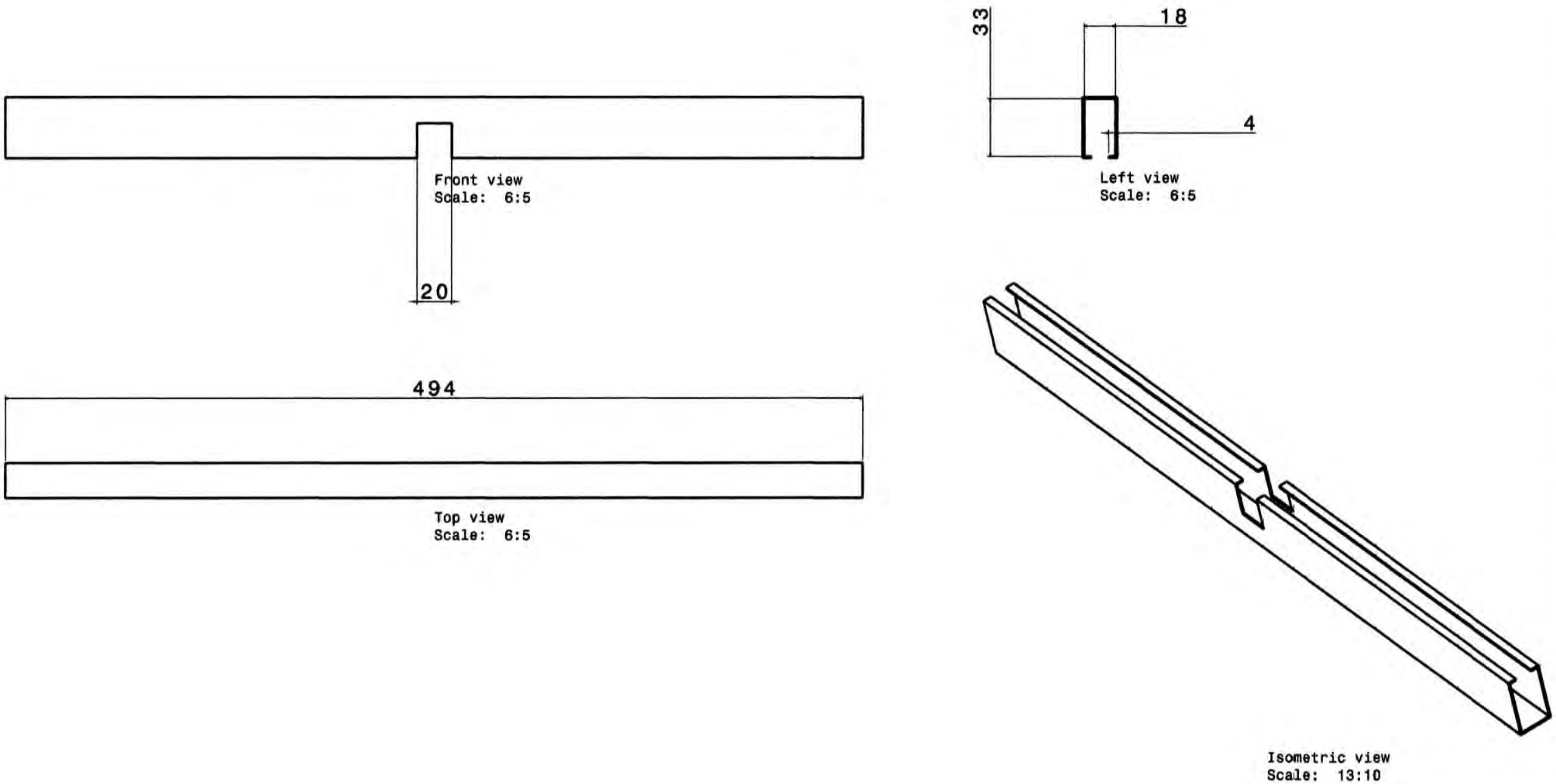


Isometric view
Scale: 1:1



Top view
Scale: 1:1

		STAND BASE CAP		
	DATE 5/5/2007	STAND FAN		
CHECKED BY XXX	DATE XXX	SIZE A4	MOHD IZWAN ZAINI	REV X
DESIGNED BY XXX	DATE	SCALE 1:1	WEIGHT(kg) 0.00	SHEET 1/1



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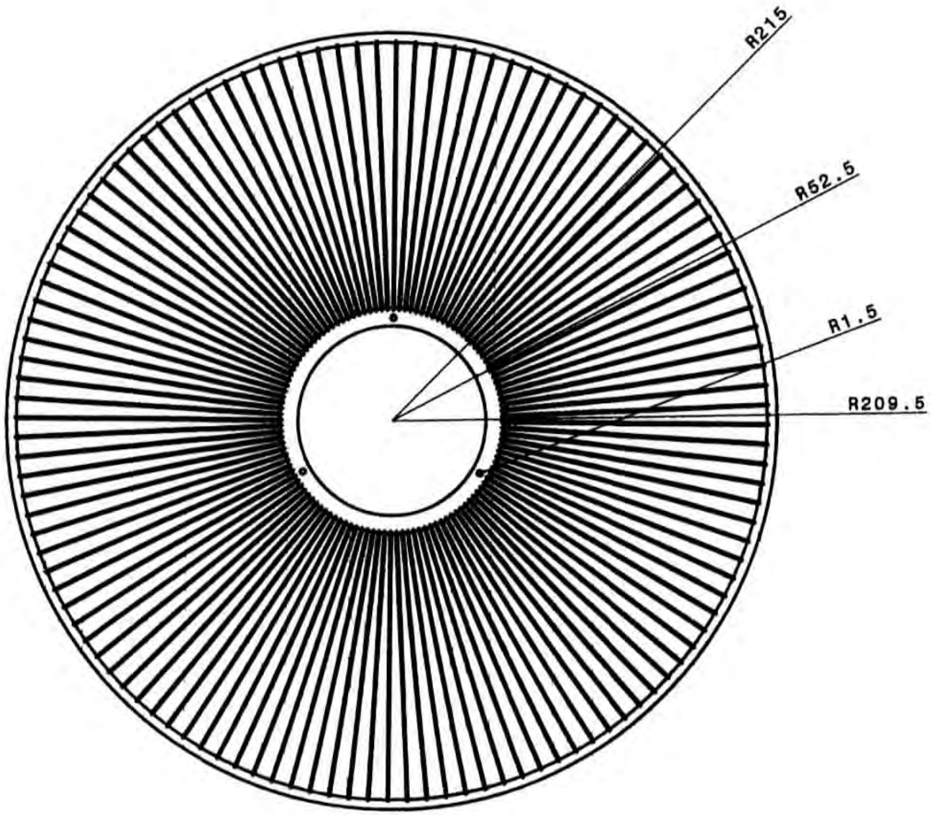
STAND

STAND FAN



Front view
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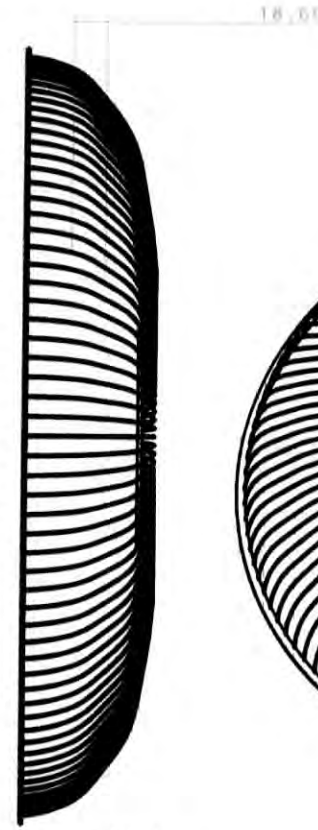

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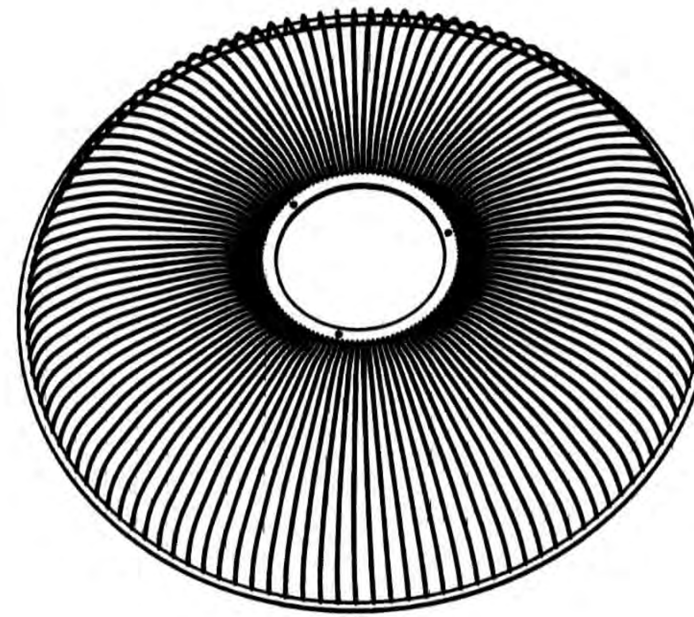

Isometric view
Scale: 9:10

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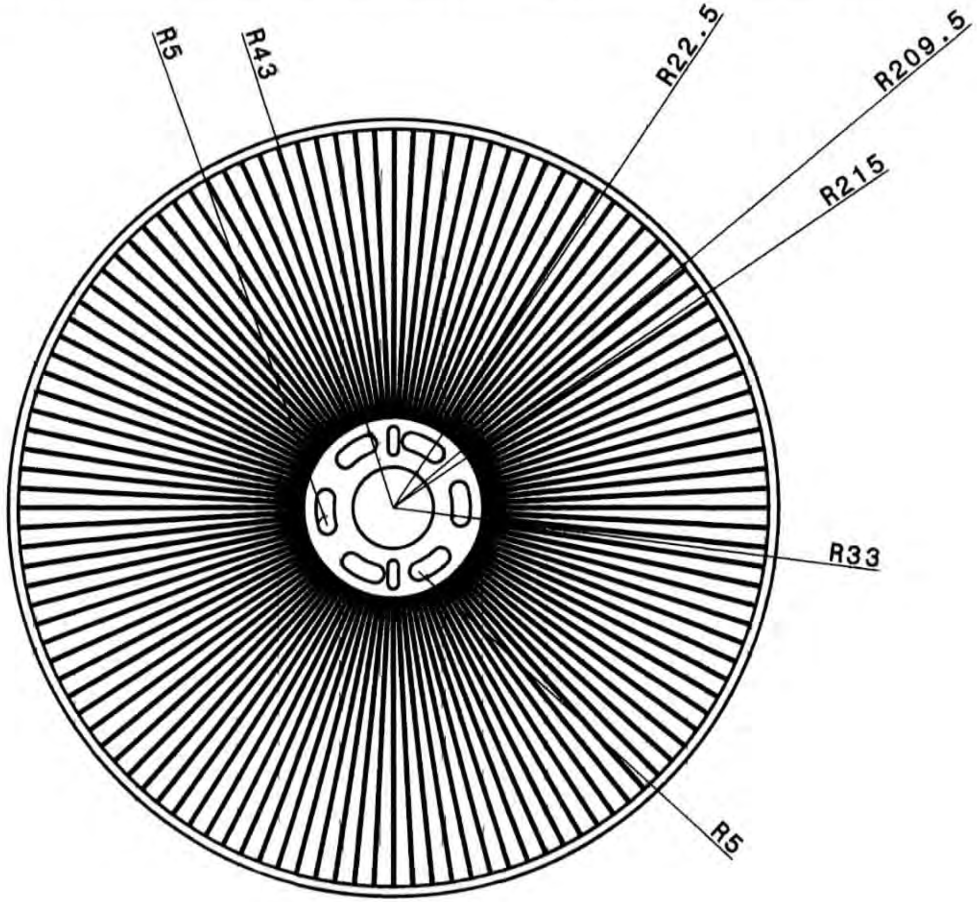
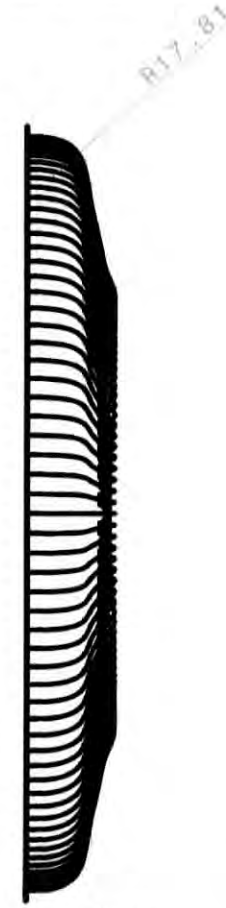
CHECKED BY: XXX		
DATE: XXX		
SIZE A0	STAND FAN	E – D –



Front view
Scale: 1:1



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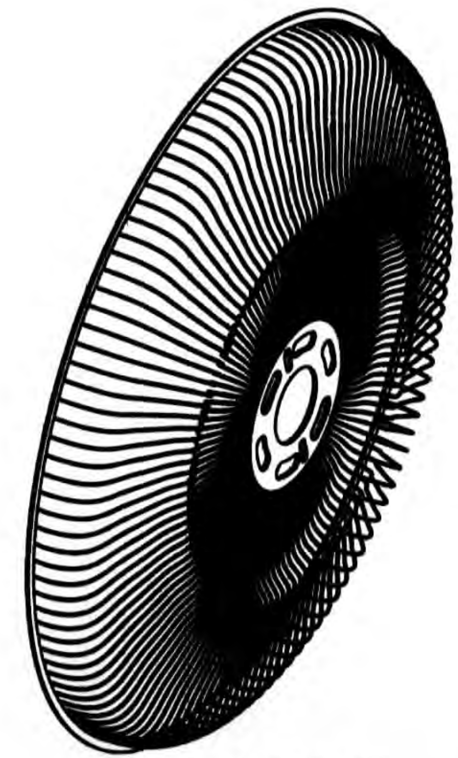
Isometric view
Scale: 1:1

DATE: 5/4/2007	BACK GRILL	I	-
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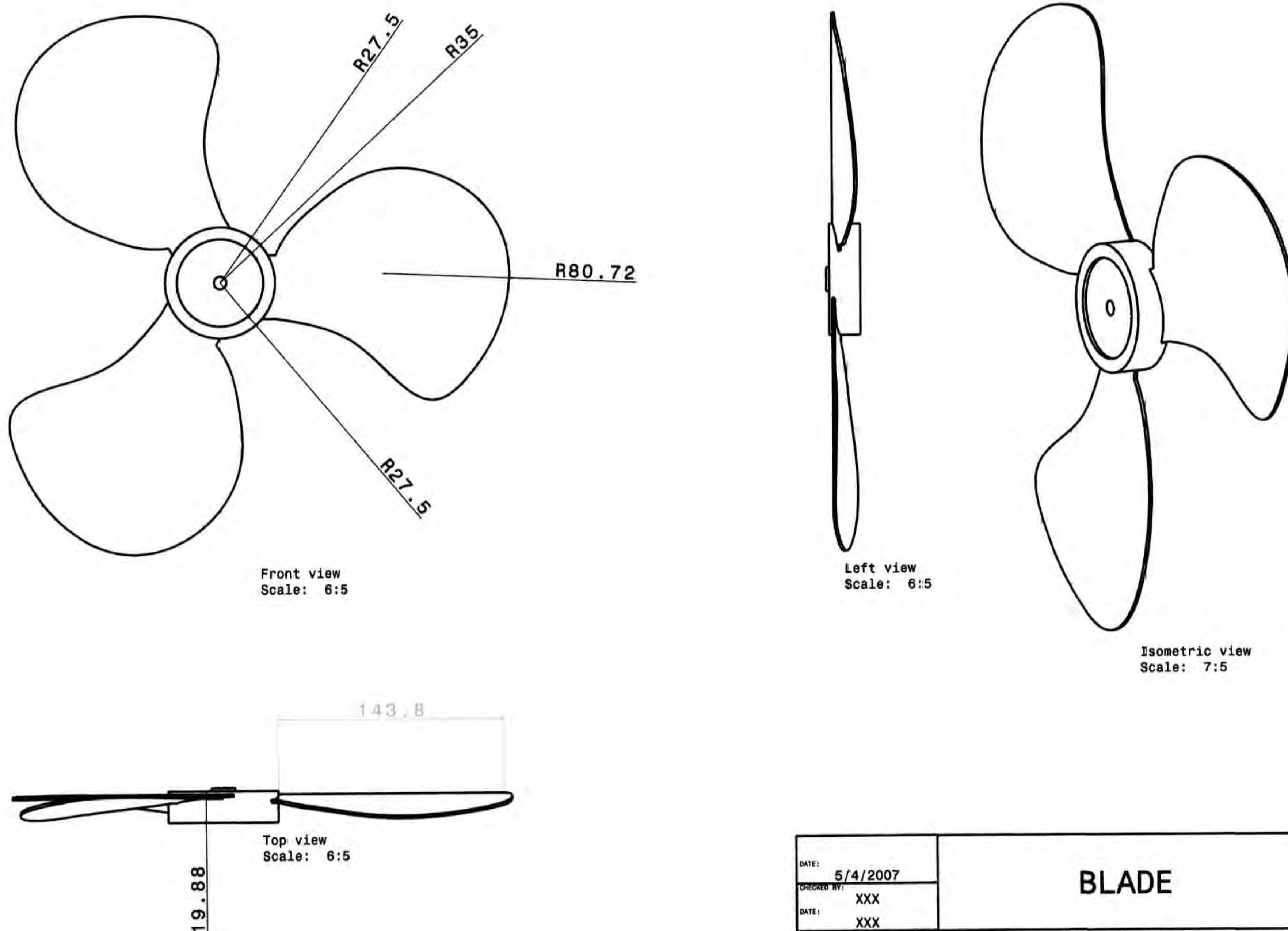
DATE: XXX		G	-
		F	-
SIZE A0	STAND FAN	E	-
		D	-



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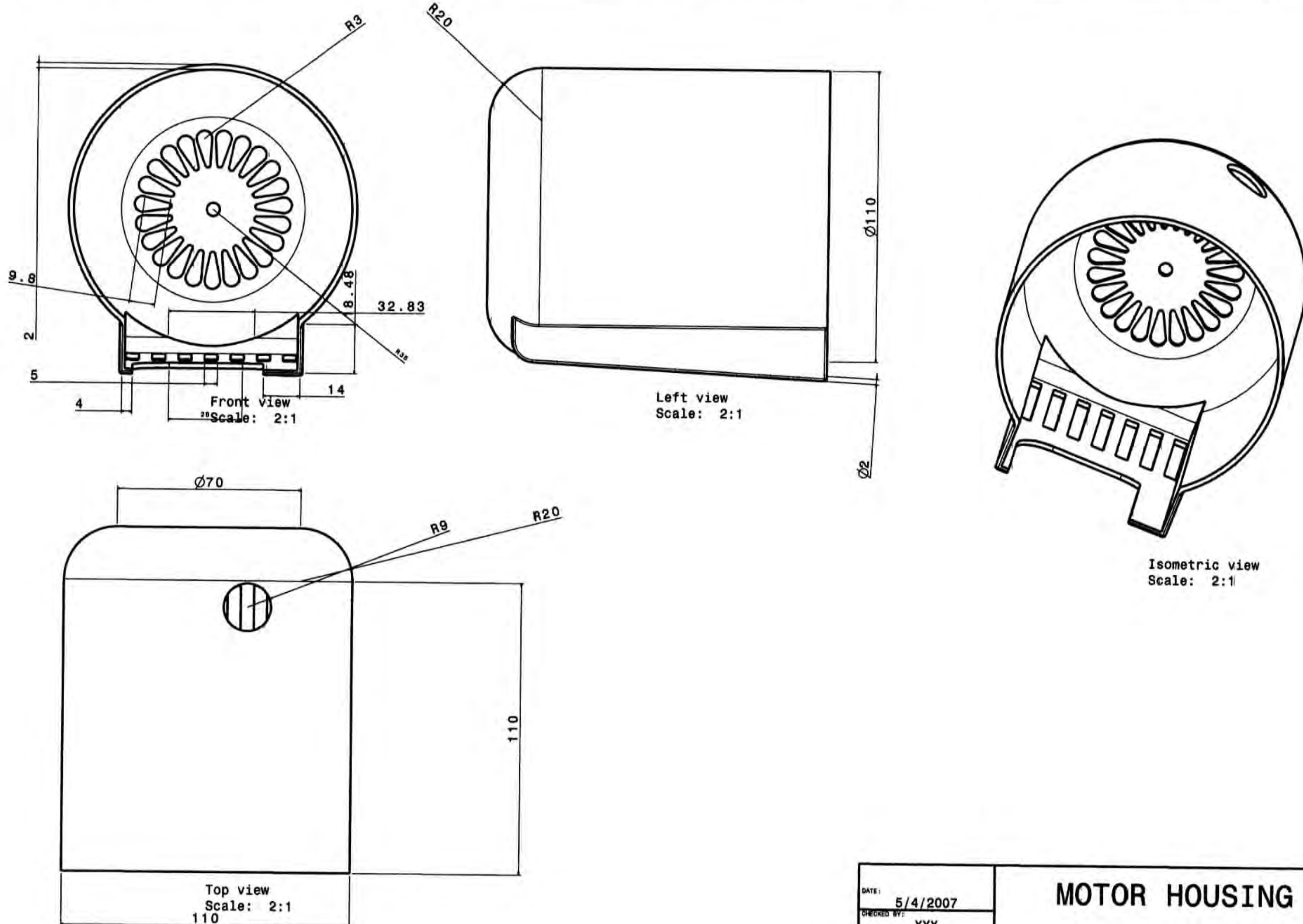
DATE: XXX
SIZE A0

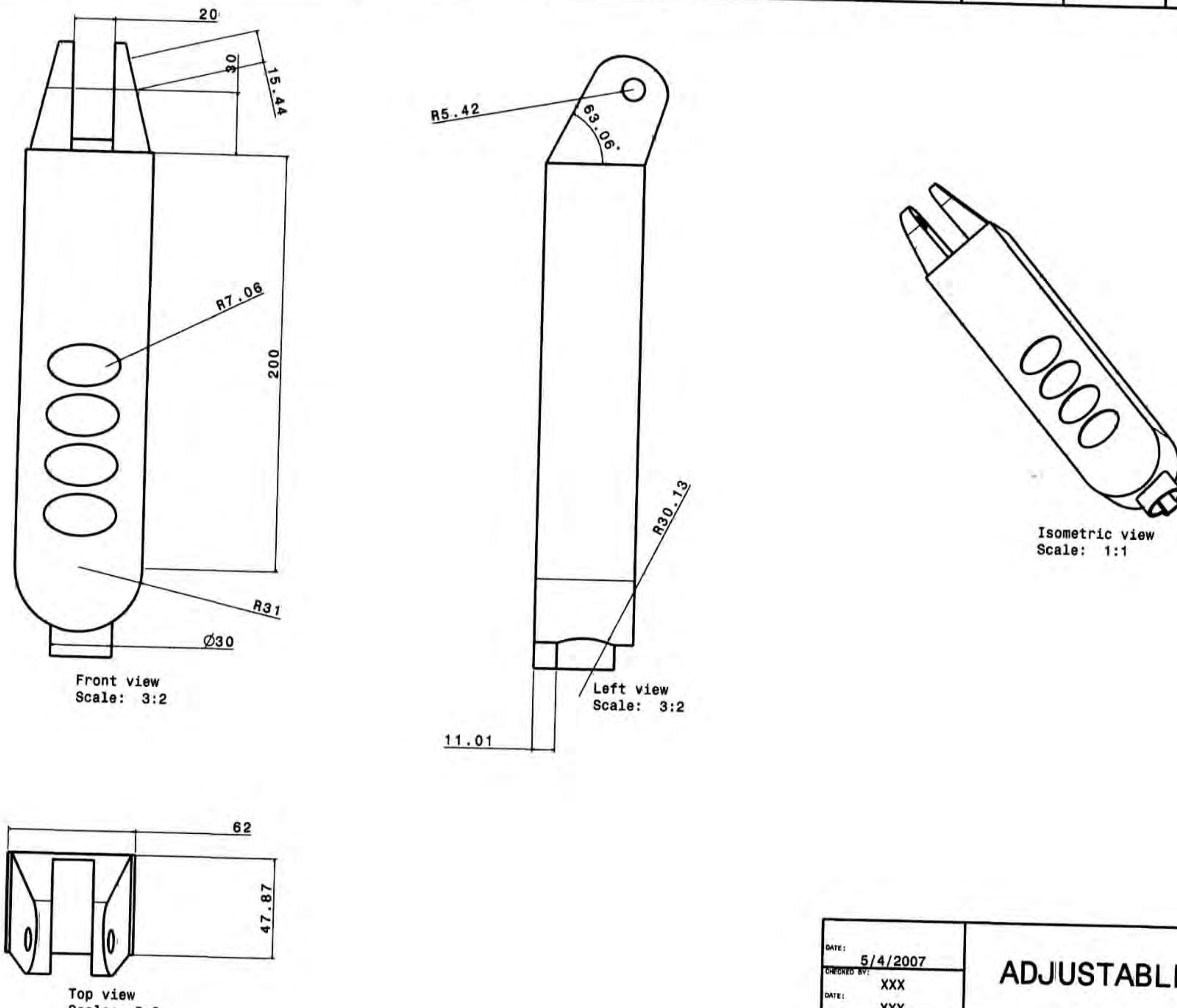
BLADE

STAND FAN



DATE: 5/4/2007	MOTOR HOUSING
CHECKED BY: XXX	
DATE: XXX	
SIZE A0	STAND FAN

I	–
H	–
G	–
F	–
E	–
D	



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DATE: XXX
SIZE

ADJUSTABLE PANEL

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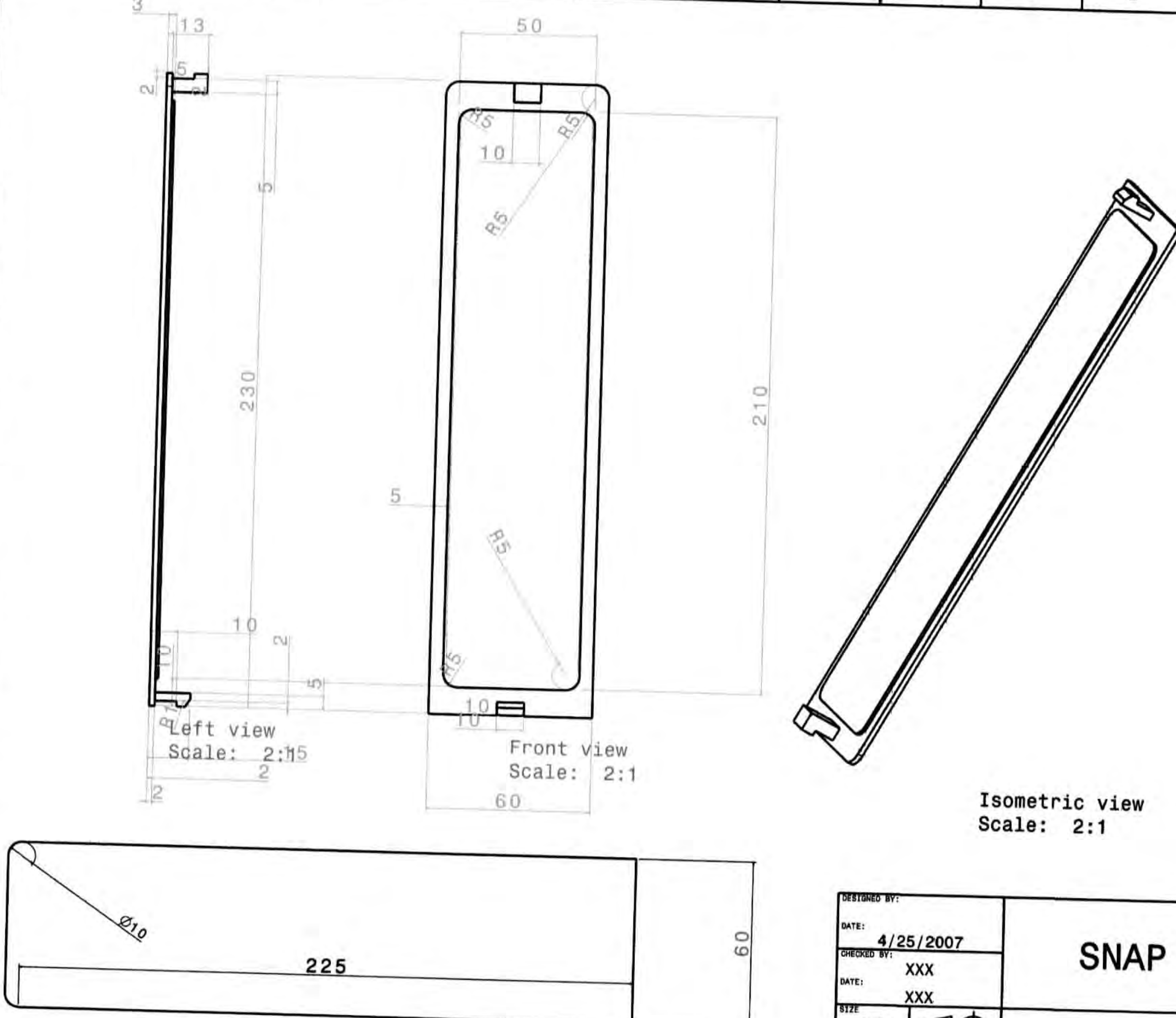
H	–
G	–
F	–
E	–



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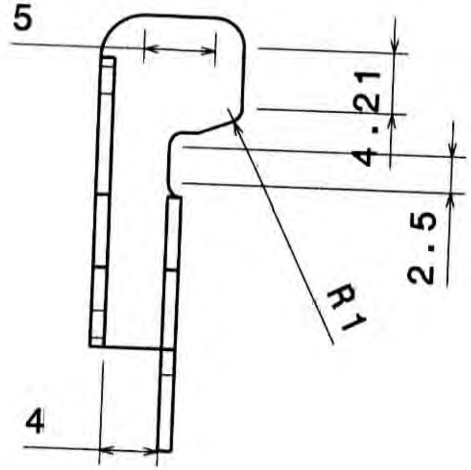
DATE: 4/25/2007	SNAP FIT COVER
CHECKED BY: XXX	
DATE: XXX	
SIZE	



Front view
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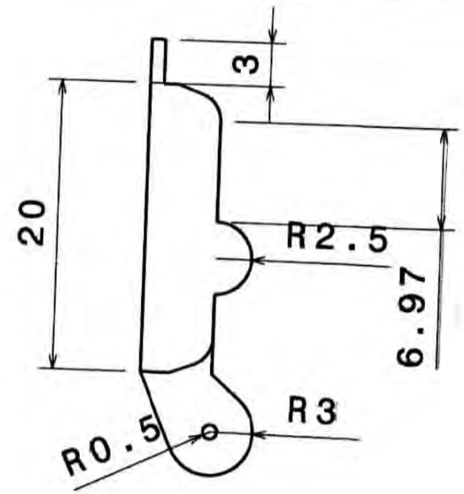

Left view
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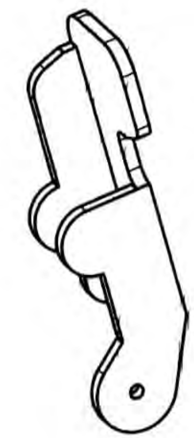

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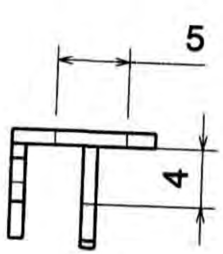

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Scale: 2:1

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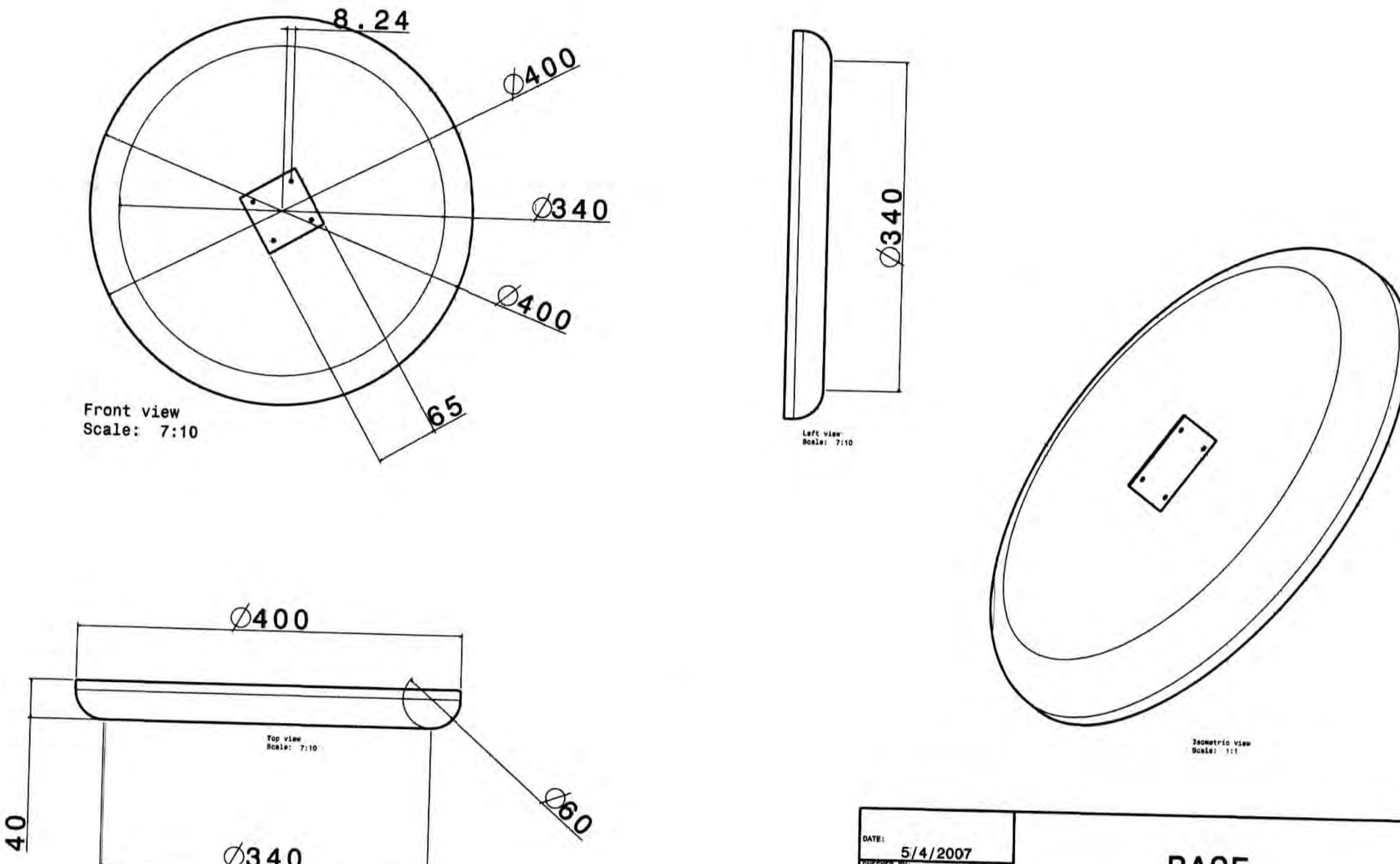
CHECKED BY XXX	DATE XXX	SIZE A4 · MOHD IZWAN ZAINI · REV



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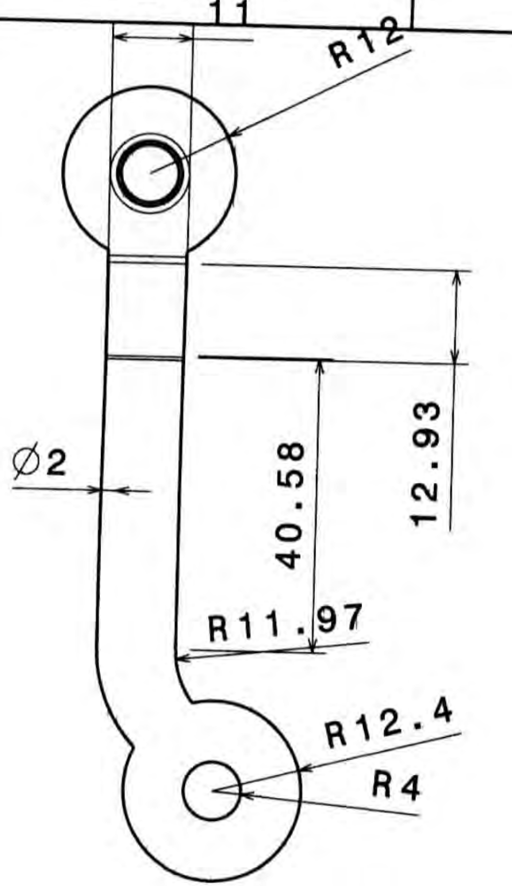
DATE: XXX		G	–
SIZE A0		F	–
		E	–



Front view
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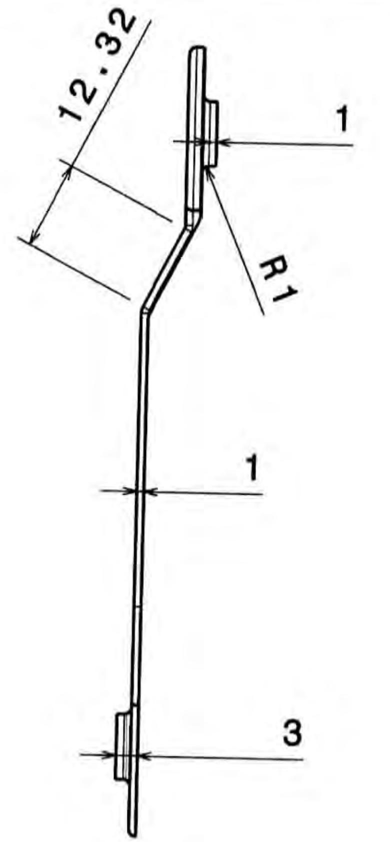

Left view
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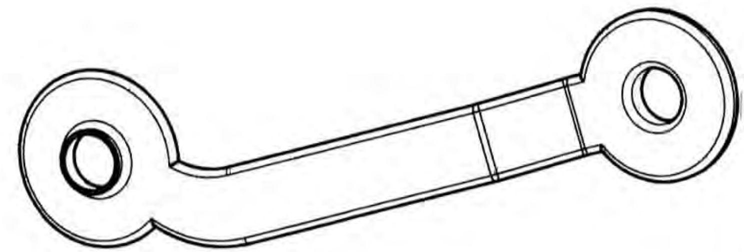

Isometric view
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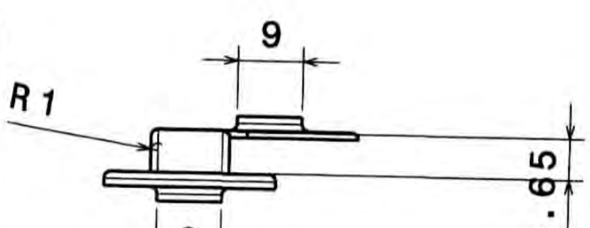

WIRE CLIP

STAND FAN

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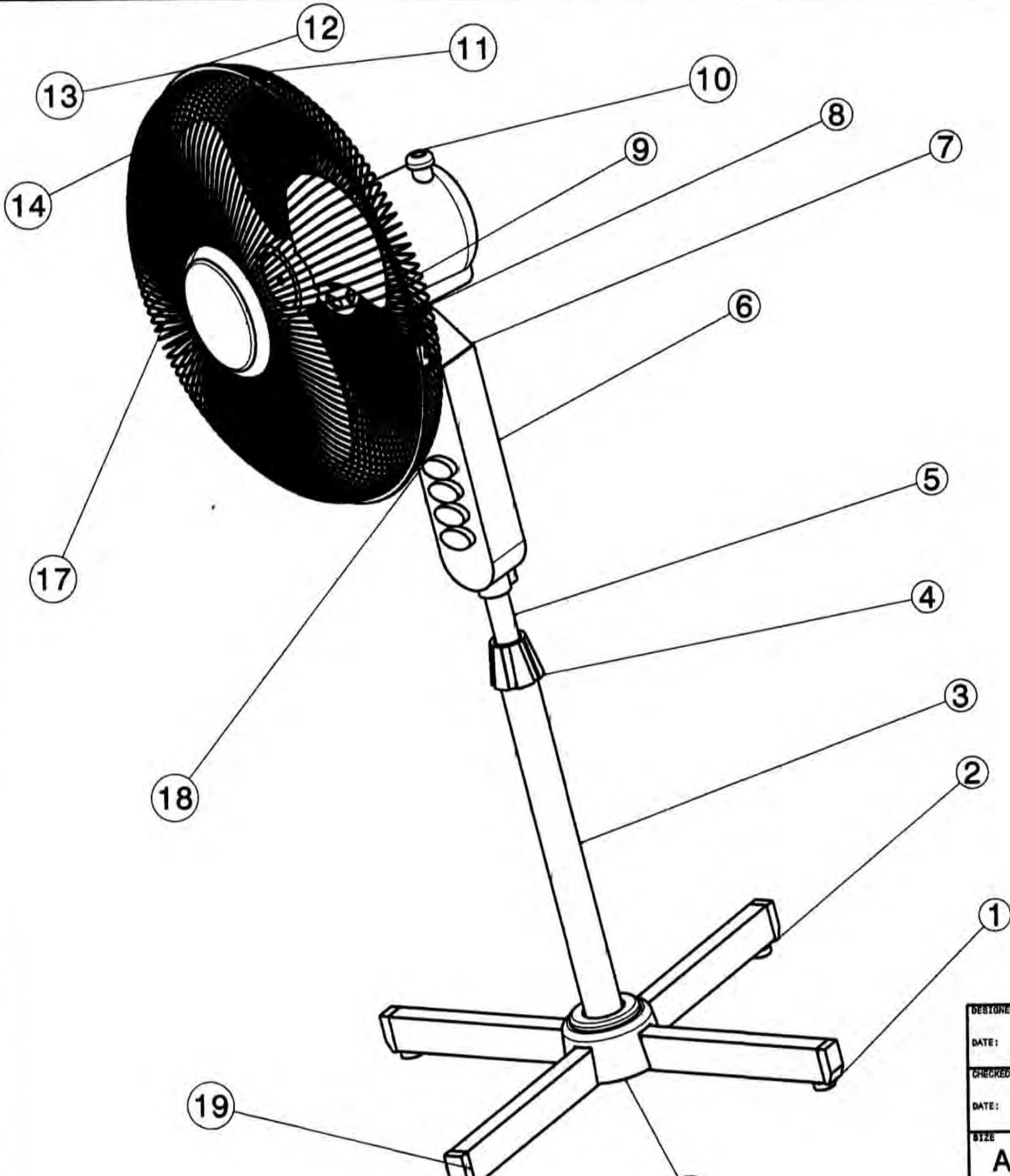
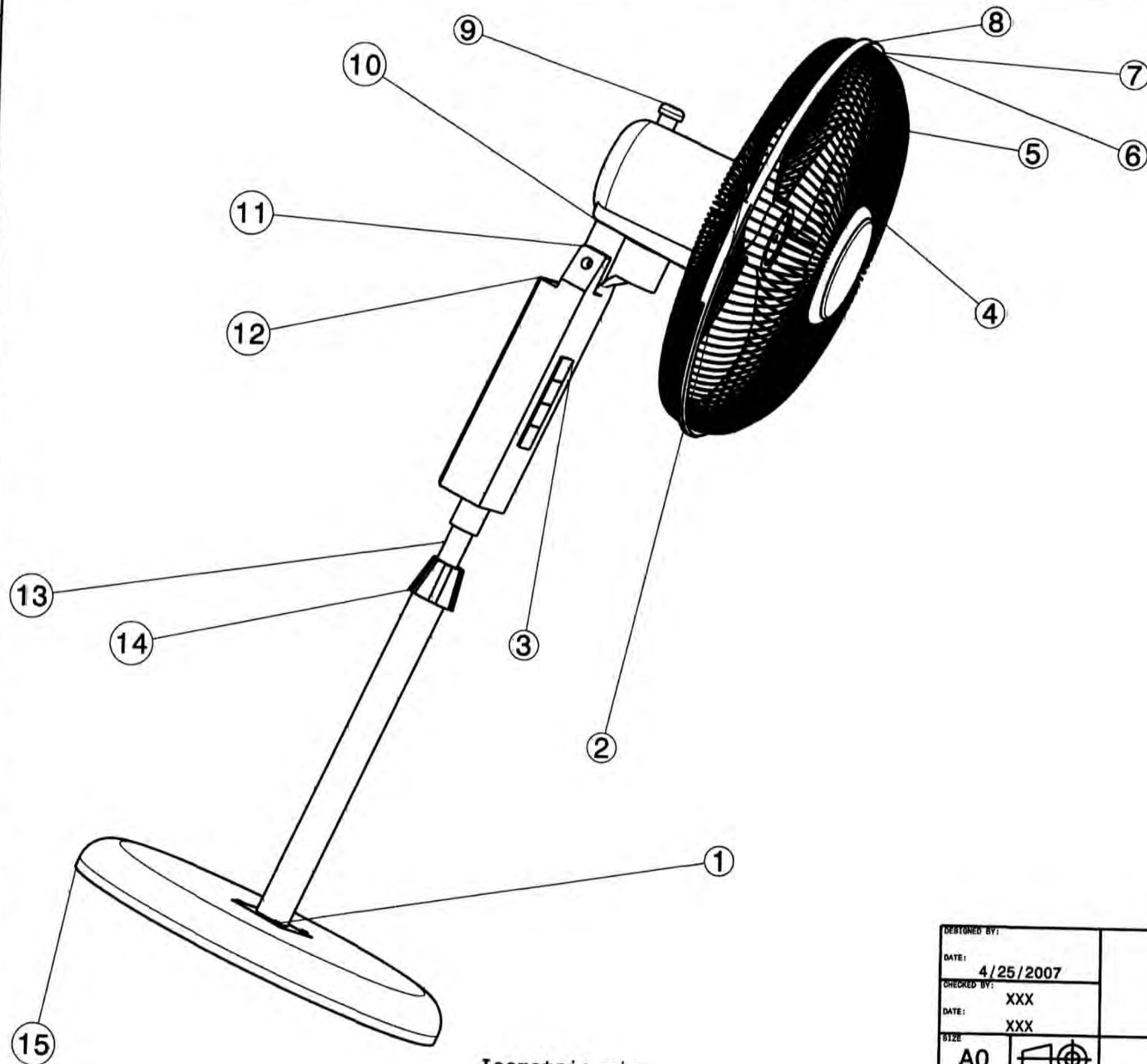
CHECKED BY XXX	DATE XXX	A4		X



Bill of Material: STAND FAN

Quantity	Part Name	No
4	BOTTOM BASE	1
4	BOTTOM HOLD	2
1	OUTSIDE PILLAR	3
1	PILLAR LOCK	4
1	INSIDE PILLAR	5
1	BACK COVER PANEL	6
4	SCREW	7
1	NUT	8
1	BACK MOTOR COVER	9
2	BUTTON ROTATE	1[illegible]
1	BACK GRILL	1[illegible]
4	CLIP	1[illegible]
1	SCREW	1[illegible]
1	FRONT GRILL	1[illegible]
1	FRONT CAP	1[illegible]
1	BLADE	1[illegible]
4	BUTTON	1[illegible]
4	BASE CAP	1[illegible]
3	STAND CAP	20

DESIGNED BY:	BILL OF MATERIAL	I	–
DATE: 4/25/2007		H	–
CHECKED BY: XXX			
DATE: XXX			
SIZE A0	STAND FAN		



Bill of Material: STAN FAN

Quantity	Part Number	No
4	SCREW	1
1	FRONT GRILL	2
1	BUTTON	3
1	COVER GRILL	4
1	BLADE	5
1	GRILL RING	6
1	Part11	7
1	BACK GRILL	8
1	BUTTON ROTATE	9
1	ADJUSTABLE	10
1	STAT	11
1	BACK CAVER PANEL	12
1	INSIDE PILLAR	13
1	PILLAR LOCK	14
1	BASE	15

Isometric vi...

DESIGNED BY: DATE: 4/25/2007 CHECKED BY: XXX DATE: XXX	STAND FAN	I – H – G – F – E –
SIZE A0	BILL OF MATERIAL	