

DESIGN AND ANALYSIS OF ELECTRICAL IRON USING BOOTHROYD
DEWHURST DFMA METHODOLOGY

MOHD HAZUAN BIN MOHD ZAWAWI

This report is submitted as partial
fulfillment of the requirement for the award of
Bachelor of Mechanical Engineering(Design and Innovation)

Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

APRIL 2009

“I/We hereby declared that I/we have read through
this report and found that it has comply the partial fulfillment for
awarding the degree of Bachelor of Mechanical Engineering (Design and Innovation)”

Signature :

Supervisor's name :

Date :

Signature :

Supervisor's name :

Date :

“I hereby declared that this report is a result of my own work except for the excerpts
that have been cited clearly in the references”

Signature :
Name : MOHD HAZUAN BIN MOHD ZAWAWI
Date :

For my beloved mother, Halizan Binti Abdullah and my father,
Mohd Zawawi Bin Hj Hassan.

ACKNOWLEDGEMENT

Praise be to Allah S.W.T for giving me the strength to complete my Bachelor Degree Project (PSM) and writing this report without any major obstacles.

First of all, I would like to express my utmost gratitude and respect to my beloved parents, Mr. Mohd Zawawi Bin Haji Hassan and Mrs. Halizan Binti Abdullah, who has been really supportive throughout my whole journey in completing my bachelor of degree study in UTeM. I would also like to express my highest gratitude to Mr. Shafizal Bin Mat for being a real guidance as a supervisor in completing my research on design and analysis of an electrical iron using Boothroyd Dewhurst DFMA methodology. His valuable advices, motivation and ideas has really helped me in finishing this dissertation.

A special appreciation to UTeM especially the Faculty of Mechanical Engineering for giving me the chance to participate in this project. This project has really helped me understand most of the things I've learned during my learning period in UTeM.

Finally, I would also like to acknowledge the assistance of my colleagues and other persons involved in the completion of this research and preparation of this report writing.

ABSTRACT

The objective of this project is to analyze an existing design of a selected electrical iron and to produce a new design and analyze it using the Boothroyd Dewhurst DFMA method. The new design will contain less parts, hence reducing the cost, assembly time and operation. In order to get to the objective, any information about electrical iron were gathered to get a better insight on how the iron works. Information about software such as CATIA and Boothroyd Dewhurst will also be gathered. These information may come from books, journals, the internet, newspapers and the library.

ABSTRAK

Objektif utama bagi projek ini adalah untuk menganalisa satu seterika elektrik yang berada di pasaran dan menghasilkan satu rekaan baru menggunakan kaedah Boothroyd Dewhurst DFMA. Rekaan baru ini akan mempunyai komponen-komponen yang lebih kurang, sekaligus mengurangkan kos, jumlah masa pemasangan dan operasi. Untuk mencapai objektif, setiap maklumat berkaitan dengan seterika elektrik dikumpul bagi memberi lebih pemahaman tentang prinsip kerja sesebuah seterika elektrik. Maklumat-maklumat berkaitan perisian seperti CATIA dan Boothroyd Dewhurst juga akan dikumpulkan. Sumber-sumber maklumat ini mungkin hadir dari buku-buku, jurnal-jurnal, internet, surat khabar dan juga perpustakaan.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iv
	ACKNOWLEDGEMENT	v
	ABSTRACT	vi
	ABSTRAK	vii
	TABLE OF CONTENTS	viii
	LIST OF TABLES	xi
	LIST OF FIGURES	xii
1	INTRODUCTION	
	1.1 Introduction	1
	1.2 Objective	1
	1.3 Scope	2
	1.4 Problem Statement	2

CHAPTER	TITLE	PAGE
2	LITERATURE REVIEW	
2.1	Introduction	3
2.2	Definition Of Ironing	3
2.3	Equipments	4
	2.3.1 Iron	4
	2.3.2 Ironing Board	4
	2.3.3 Commercial Equipment	5
2.4	History Of Iron	5
2.5	Raw Materials	9
2.6	The Manufacturing Process	9
	2.6.1 Sole Plate	9
	2.6.2 Thermostat	10
	2.6.3 Housing and Handle	10
	2.6.4 Assembly	11
2.7	Quality Control	11
2.8	The Future	12
2.9	Steam Iron	12
2.10	Boothroyd Dewhurst DFMA	14
2.11	CATIA - Design Excellence For Product Success	14
2.12	DFMA – Design For Manufacture And Assembly	16

CHAPTER	TITLE	PAGE
3	METHODOLOGY	
3.1	Introduction	19
3.2	Literature Review	21
3.3	CAD Drawing	21
3.3.1	Measurement of Existing Iron	22
3.3.2	Assembly Sequence	23
3.3.3	CAD Drawing	25
3.4	Analysis Of Existing Design	29
3.5	Conceptual Design	31
3.6	Analysis Of The Conceptual Design	32
3.7	Improvement On The Selected Concept	33
3.8	Final Design	34
4	RESULTS AND DISCUSSIONS	
4.1	Introduction	36
4.2	Results And Discussions	36
4.2.1	Results of Analysis On Existing Design	37
4.2.2	Results of Analysis On New Design	42
4.3	Design Comparison	46
5	CONCLUSION AND RECOMMENDATION	
5.1	Conclusion	47
5.2	Recommendation	47
	REFERENCES	48
	APPENDICES	49

LIST OF TABLES

NO	TITLE	PAGE
3.1	Alpha And Beta Rotational Symmetries For Electric Iron Parts	30
3.2	Alpha And Beta Rotational Symmetries For Redesigned Electric Iron Parts	33
4.1	Manual Handling Classification Coding	38
4.2	Manual Insertion Classification Coding	39
4.3	Completed Worksheet Analysis For The Existing Design Assembly	40
4.4	Manual Handling Classification Coding	43
4.5	Manual Insertion Classification Coding	44
4.2	Completed Worksheet Analysis For The New Design Assembly	45

LIST OF FIGURES

NO	TITLE	PAGE
2.1	Electric Iron	4
2.2	Gas Iron	7
2.3	Example Of a Steam Iron	13
2.4	Example Of Airplane Drawing using CATIA	15
3.1	Methodology Flowchart	20
3.2	CAD Drawing Process	21
3.3	Initial Sketching Of The Iron's Sole Plate	22
3.4	Assembly Sequence Of Electric Iron	24
3.5	The Existing Iron	23
3.6	Drawing Of Sole Plat	26
3.7	Drawing Of Bottom Housing	26
3.8	Drawing Of Top Housing	27
3.9	Drawing Of Heat Controller	27
3.10	Drawing Of Handle Cover	28
3.11	Drawing Of Wire Holder	28
3.12	Drawing Of Screw	29
3.13	Drawing Of Redesigned Upper Housing	31
3.14	Drawing Of Redesigned Bottom Housing	32
3.15	Added Slot To Reduce Product Cost	34
4.1	Exploded View Of Existing Design	37
4.2	Exploded View Of The Redesigned Iron	42

CHAPTER 1

INTRODUCTION

1.1 Introduction

Ironing or smoothing is the work of using a heated tool to remove wrinkles from fabric. The most popular way of ironing is by using an electrical iron. There are some features in a modern electrical irons such as thermostat, electrical cord, cord control and energy saving control, but sometimes, these features are not necessarily needed because it will contain more parts, thus increasing the cost and production time. The purpose of this project is to analyze an electrical iron using the Boothroyd Dewhurst DFMA methodology and redesign it by removing any unnecessary parts to reduce the cost and production time.

1.2 Objective

This project will focus on meeting these objectives:

- To design an electrical iron.
- To analyze the electrical iron using Boothroyd DeWhurst DFMA methodology.

1.3 Scope

This research project will focus primarily on the design of a new electrical iron mainly using Boothroyd Dewhurst DFMA method. This project will focus on the existing inner components of the electrical iron, and designing a new electrical iron with less possible components. Literature review about the related topics will be gathered. Other aspects such as the production method of the electrical iron and the marketing system will not be covered in this project.

1.4 Problem Statement

Nowadays, electrical irons largely sold around the world are expensive. This is due to the complexity of the iron itself. There are many unnecessary parts that can be removed by using the Boothroyd Dewhurst DFMA method to reduce cost, assembly time and operations.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, any information regarding electrical iron and DFMA method are gathered. This chapter will cover topics such as definition and history of ironing, types of iron and explanation about Design For Manufacturing and Assembly(DFMA). The information in this chapter are mainly gathered from journals from the internet.

2.2 Definition Of Ironing

Ironing or smoothing is the work of using a heated tool to remove wrinkles from fabric. Ironing works by loosening the bonds between the long-chain polymer molecules in the fibers of the material. While the molecules are hot, the fibers are straightened by the weight of the iron, and they hold their new shape as they cool. Some fabrics, such as cotton, require the addition of water to loosen the intermolecular bonds. Many modern fabrics (developed in or after the mid-twentieth century) are advertised as needing little or no ironing. Ironing may also be used as a germ/parasite killing hygienic operation.

(<http://en.wikipedia.org/wiki/Ironing>)

2.3 Equipments

2.3.1 Iron

The iron is the small appliance used to remove wrinkles from fabric. It is also known as a clothes iron, flat iron, or smoothing iron.



Figure 2.1 : Electric Iron

(Source : <http://www.chodansinh.net/multidata/200705080415548216.jpg>)

2.3.2 Ironing Board

On 16 February 1858 W. Vandenburg and J. Harvey patented an ironing table that made pressing sleeves and pant legs easier. A truly portable folding ironing board was first patented in Canada in 1875 by John B. Porter of Yarmouth, Nova Scotia. The invention also included a removable press board used for sleeves.

(<http://en.wikipedia.org/wiki/Ironing>)

2.3.3 Commercial Equipment

Commercial dry cleaning and full-service laundry providers use a large appliance called a steam press to do most of the work of ironing clothes. Alternately, a rotary iron may be used. Some commercial-grade irons have a boiler unit separate from the handheld iron and most ironing is done on an ironing board, a small, portable, foldable table with a heat resistant top. Permanent press clothing was developed to reduce the ironing necessary by combining wrinkle-resistant polyester with cotton. (<http://en.wikipedia.org/wiki/Ironing>)

2.4 History Of Iron

Though objects have been used for thousands of years to remove wrinkles and/or press clothing, for much of that time only the wealthy had their clothes so treated. Because the use of such implements was hard and laborious, only the rich could afford to employ people (usually slaves or servants) to do the work. In about 400 B.C., Greeks used a goffering iron to create pleats on linen robes. The goffering iron was a rolling pin-like round bar that was heated before use.

Empire-era Romans had several tools similar to the modern iron. One was a hand mangle. This flat metal paddle or mallet was used to hit clothes. The wrinkles were removed by the beating. Another implement was a prelum. This was made of wood and not unlike a wine press. Two flat heavy boards were put between a turnscrew, also made of wood. Linen was placed between the boards and the increasing pressure applied by the turnscrew created pressure to press the fabric.

The ancient Chinese also had several primitive types of irons, including the pan iron. The pan iron looked rather like a large ice cream scoop. This iron had an open compartment with a flat bottom and a handle. The compartment held hot coal or sand, which heated the bottom of the pan iron. It was moved across clothing to remove wrinkles.

By about the tenth century A.D., Vikings from Scandinavia had early irons made of glass. The Vikings used what was called a linen smoother to iron pleats. The mushroom-shaped smoother was held near steam to warm up, and was rubbed across fabric.

What contemporary consumers would recognize as an iron first appeared in Europe by the 1300s. The flatiron was comprised of a flat piece of iron with a metal handle attached. To heat the iron, it was held over or in a fire until it was hot. When a garment was pressed with the flatiron, it was picked up with a padded holder. A thin cloth was placed between the garment and the iron so that soot would not be transferred from implement to the finished garment. The flatiron was used until it was too cool to do its job. Many people owned several flatirons so they could heat one or more while one was being used.

In approximately the fifteenth century, an improvement over the flatiron was introduced. The hot box (also known as the box iron or slug iron) was made of a hollow metal box with a smooth bottom and a handle. Inside, hot coals, bricks, slugs (heated metal inserts) or some other heating element were placed. This eliminated the need for an extra cloth between clothing and iron because the iron did not get the clothes dirty. Both the flatiron and hot box were used for several hundred years.

Many innovations in iron technology came in the nineteenth century. When cast iron was invented in the early part of the nineteenth century, some of the problems with flatirons were solved. With the advent of cast iron stoves, flatirons could be heated on top of them, which was much cleaner than a fire. By the 1820s, cast iron was also used to make flatirons. These irons were called sad irons because they were heavy, weighing about 15 lb (5.6 kg), and hard to move.

Like flatirons, sad irons were heated on the stovetop, but they sometimes heated unevenly. The handle also heated up, which posed problems for users. American Mary Potts solved these predicaments in 1870. She made a cardboard base and filled it with plaster of Paris. This was placed around the iron's body and kept it cooler for more even heating.

After gas became available in American homes in the late 1800s, gas irons came into existence. The earliest were patented in 1874. Homes had individual gas lines into them, and the gas iron was hooked up to the gas line by a pipe. The iron contained a burner to which the gas flowed. When the burner was lit with a match, the iron heated up. The iron was very hot and gas sometimes leaked, but the gas irons were lighter than sad irons. Other fueled irons soon followed. These irons were heated with oil, gasoline, paraffin, and other fuels.



Figure 2.2 : Gas Iron

Source:

(<http://www.coleauctionsinc.com/2007%20Auctions/JAN.20.07/coleman%20gas%20iron.jpg>)

The electric iron was invented in the 1880s when electricity became widely available in homes. The first electric iron was patented by Henry W. Seeley in 1882. His iron was hooked up to an electrical source by detachable wires. The electricity stimulated the iron's internal coils. But Seeley's iron, like many early electric irons, did not have electric cords. The irons were heated on a stand. One big problem with Seeley's iron was that it heated very slowly on the stand, and cooled quickly while in use. This iron had to be reheated frequently.

By the turn of the century, iron technology had progressed considerably and irons became more common in American households. In 1903, irons with electric cords directly attached to the iron were being sold. Earl Richardson invented a sole plate (the bottom part of the iron that is made of metal and does the actual pressing) that improved how and where sole plates were heated for better ironing. His iron had more heat in the tip than in the center and was known as the Hotpoint.

In the 1920s, Joseph Myers improved the iron and cord by adding an automatic heat control made of pure silver. Thermostats soon became a standard feature. The first cordless irons were introduced in 1922, though they did not catch on. (The first successful cordless irons were sold in 1984).

In 1926, the steam iron was introduced by the Eldec Company. Steam made it easier to smooth dry stiff fabrics. Previously the user sprinkled water on dry clothing, or clothing had to be ironed when damp. The steam irons employ a water tank that allows heated water vapor to be created and applied through small holes on the sole plate. Steam irons did not become popular until the 1940s.

Edward Schreyer conquered the problem of rusting sole plates in 1938. He developed an aluminum alloy that would not rust or leak. Irons that could vary between steam or dry were introduced in the 1950s. The first iron with automatic shut off was introduced in 1984.

Contemporary irons have nonstick coating on the sole plate, an innovation that was introduced in 1995. Most featured bodies made of plastic and more holes on the sole plate to allow steam to come through. A whip holds the cord out of the way during use. In 1996, about 13-14 million irons with a variety of features were sold in the United States.

2.5 Raw Materials

Irons are made primarily of plastic and metal (aluminum and steel). The materials often come to the factory in the form of plastic resins, aluminum ingots, and steel sheets. The metal is used to make the sole plate, thermostat and other internal mechanisms. Plastics are used to make the exterior and handle, as well as the water tank. Certain components, like the spring for the thermostat, cord, plug, and related connections are usually outsourced by iron companies.

2.6 The Manufacturing Process

First, each sub-assembly of the iron is produced, most often on separate, automated production lines. Then the iron is assembled.

2.6.1 Sole Plate

The sole plate is cast of molten aluminum. Part of the mold creates the holes that are essential in a steam iron. Heated metal is inserted into a mold under pressure, cooled, and released. The cooled sole plate is treated in one of three ways.

It is polished, coated with a non-stick PTFE material, or covered with another metal. Such metals include stainless steel. To complete one or more of these processes, the sole plates are put on a large automated carousel, which rotates through each step. To polish the plate, an automated belt sander uses bands of abrasive to polish and buff the plate.

The finish required determines which grade of abrasive is used. An automated spray-painting machine applies non-stick coating. After application, the sole plate is baked in an automated industrial process. To coat with another metal, the external metal cover is created by an automated stamp press. The resulting cover is either pressed or riveted onto the sole plate, through a smaller machine press.

2.6.2 Thermostat

In an injection mold, a small metal post is cast. A spring is mounted onto the metal post. This spring is a bimetallic switch made of two different metals with divergent linear thermal coefficients bonded together. The spring actually controls the iron's temperature. Power contacts are attached to the end of the spring, which let the electricity through so the iron can be heated. This whole process is generally automated.

2.6.3 Housing and Handle

In an injection mold, heated plastic is inserted into a mold under pressure, cooled, and released.

2.6.4 Assembly

When all the parts are manufactured, the iron is assembled on an automated assembly line. The sole plate is the first part on the assembly line. The thermostat is either screwed onto the plate, or welded to the plate by a robot. It is secured on an automated line with screws or other industrial fasteners. The handle and body are attached over the sole plate, thermostat and water tank, and fixed by screws. Sometimes this process is automated, but it also can be done manually. The electrical cord is the last piece to be added. Sometimes this process is automated, but it also can be done manually. After an automated testing process, the irons are inspected by hand. Completed irons are packed into individual boxes with instructions and other documents by hand. (For some companies, this is an automated process.) The individual boxes are placed in shipping cartons or master packs for distribution to warehouses.

2.7 Quality Control

Before the manufacturing process begins, all the raw materials are sample checked for consistency. As each subassembly of the iron is manufactured, the pieces are checked for correct functionality.

During the assembly process, an iron is removed from the production line and taken apart by an independent department to look for errors. Any mistakes result in the whole batch of irons being checked and corrected if necessary. After the product is assembled, a worker also checks the iron for electrical functionality and water integrity.

2.8 The Future

The most obvious improvements on the iron probably will be to the sole plate. Better coatings will probably be invented that are more resistant to damage from zippers or other protrusions on garments and reduce drag over fabric. These improvements might be in the form of better alloys or better nonstick coatings. Internal mechanisms that better control heat and steam also will continue to evolve.

2.9 Steam Iron

A steam iron is a type of electrical iron that uses superheated water to eliminate wrinkles in clothes and fabrics which may not be suitable for traditional dry ironing. Usually, a distilled water is poured into a holding tank and the water is converted to a steam by using a special heating element. This hot mist comes out through a number of holes in the soleplate (bottom heating element) of the steam iron. As the steam loosens the individual fibers of the clothes, the steam iron's pressing action smooths out wrinkles.

A steam iron option is available in many traditional dry irons. Water is poured into a small reservoir and superheated until it becomes usable steam. User can select the steam setting with a mechanical switch on the handle of the iron. The steam itself should come out of small holes located near the tip of the pressing plate. For most conventional ironing needs, this combination of dry and steam iron settings should suffice. The steam generated by a traditional dry iron may not be overwhelming, but it will loosen wrinkled fibers.