

# Design and Development of Semi-Automatic Injera Making Machine for Family Households in Ethiopia

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**Abstract :-** Injera is sourdough risen flatbread with bubbly texture on the top and smooth underside. Traditionally injera is made from teff flour, it is national dish of Ethiopia and Eritria. In household family level, Injera is made by hand and as it requires high physical effort and consumes much time, baking injera is not interesting task. Previous attempts in automating injera making process more focus on manufacturing injera in a mass basis. However, a thesis made in Kombolcha institute of technology, designed automatic injera making machine for small scale application. This paper aims to design semi-automatic injera making machine to reducing the cost of fully automatic injera making machines. Planning, Identification of customer need, concept generation, and concept selection are used for concept development of semi-automatic injera making machine. The solid model of the product designed by using Solidworks 2016. And finally, the bill of material and break-even point analysis has been made. The cost of semi-automatic injera making machine reduced to 4500 birr effective than the market.

**Key Words:** Injera, semi-automatic, cost effective, customer need, product design and development

## 1. INTRODUCTION

Ethiopian cultural food injera is pancake like bread, it has bubbly texture on the top and smooth texture underside. It is originally made from fermented batter of teff flour which is mainly grown plant in Ethiopia. Injera baking involves preparing the batter, pouring the batter on hot flat plate called mitad, and finally removing it from the hot plate.

Mostly injera baking is performed by women and it is labor and time consuming work. In our country injera baking process is done by hand and some of the processes like pouring is physically challenging and it may lead to anatomical disorder.

Automatic injera making machines are developed and used for mass manufacturing in the US where most Ethiopian Diasporas lived. Since these machines are huge and expensive, cannot be adapted for family households.

This paper discuss about reducing human effort in injera baking process as well as reduce the cost and size of fully automatic injera making machines.

### 1.1 Objective

The objective of this paper is to design and develop semi-automatic injera making machine which is cost effective and compacted for family households in Ethiopia.

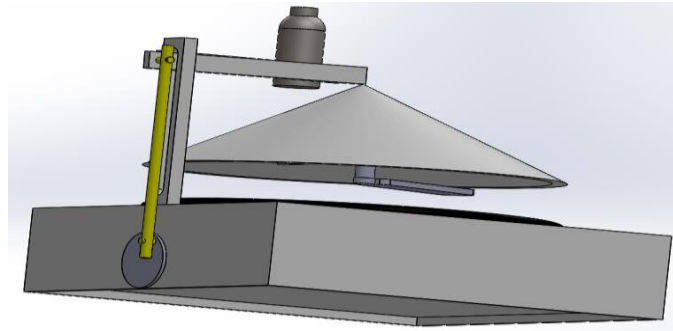
## 2. PROBLEM STATEMENT

Injera is staple food of Ethiopia and most of Ethiopian households eat injera at least twice a day. Nowadays most peoples are becoming more interested in automatic household utensils. Previous attempts in automating injera making process more focus on manufacturing injera in a mass basis. However, a thesis made in Kombolcha institute of technology, designed automatic injera making machine for small scale application. This paper tries to reduce the cost and size of fully automatic injera making machine by introducing a semi-automatic injera machine at optimal cost.

## 3. NEW FEATURES OF SEMI AUTOMATIC INJERA MAKING MACHINE

New feature of semi-automatic injera making machine consists batter delivery, polishing, and batter dispensing mechanism. The connecting rod pushes the cover downward direction, as a result the rotating plate inside the cover polishes the pan. When the cover further pushes the pan, the spring under the pan stores energy and when released, the spring creates vibration. So that the batter delivered over the pan will be dispensed. The bottle which is located over the cover uses gravity to deliver the batter through solenoid valve which is located inside the cover.

Unlike others this design uses indirect method to spread the batter over the pan rather than using direct contact method like rotating plate over the pan. So that this helps to produce quality injera with its bubble texture on top side. The previous injera making machine were huge and very expensive but this product reduce cost and size of the previous automatic machines. The solid model of semi-automatic injera machine is shown in figure 1.



**Fig-1:** Solid model of semi-automatic injera machine.

#### 4. MISSION STATEMENT

In order to provide guidance for the development team, the mission statement for semi-automatic injera making machine is formulated as follow:

- Product description: Semi-automatic injera making machine with batter delivery and dispensing mechanism.
- Benefit proposition: Reduce time and mechanical effort of workers.
- Primary market: family households.
- Secondary market: small restaurants.
- Assumptions & constraints: manufactured in Ethiopia.
- Stakeholders: user, shareholder, manufacturer, distributor and reseller.

#### 5. IDENTIFICATION OF CUSTOMER NEED

Identifying the customer need is the most important task in developing a new product. Identification of customer need for semi-automatic injera making machine follows the following steps:

1. gather raw data from the customer
2. Interpret raw data in terms of customer need
3. Organize the need into hierarchy
4. Establish the relative importance of the need
5. Reflect on the result and the process

##### 5.1. Gather raw data from the customer

In this stage a lots of customer needs were identified through the following ways:

###### 5.1.1. Interview

The designer discuss with 30 to 40 customers about the product in the customer environment in one to one basis.

###### 5.1.2. Focus group

In the focus group session, a group of 10 customers discuss about the product and revealed a lot of important information including the strength and weakness of the existing machine.

###### 5.1.3. Observation

Observing customers in their use environment while using the product. During observation the designer observes some customers using the product to bake foods other than injera like bread.

##### 5.2. Organizing the need into hierarchy

###### Primary needs:

Automation

Ergonomic design

Low energy usage

Easy to maintain

**Secondary needs**

Cost effective

Compacted

Flexible use

It has less weight

**Table-1:** Customer data template filled in with sample customer statements and interpreted needs.

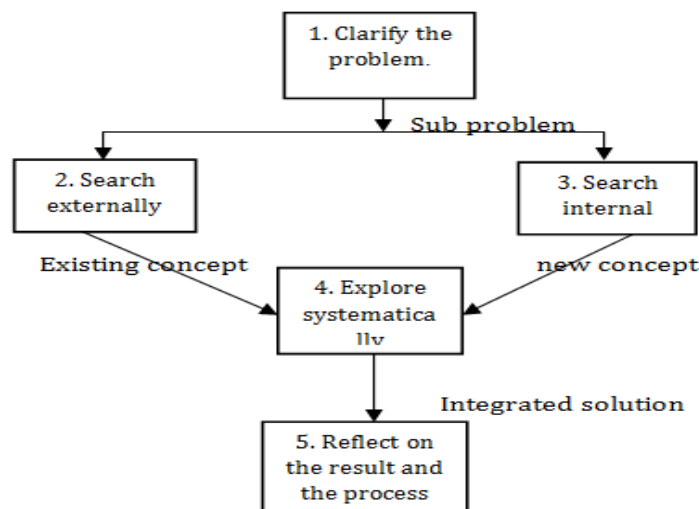
Question/prompt	Customer statement	Interpreted need
Typical uses	I used to bake different foods other than injera like bread	Flexible use
Likes	I like user friendly height of conventional mitad	Ergonomic design
	Cost effective	Cost effective
	It has small size	compacted
	it can be repaired locally	Easy to maintain
Dislikes	fatigue	automation
	I spent a lot in electric bill	Low energy usage
Suggestion improvements	Would be better if it weigh less	It has less weight

**6. QUALITY FUNCTION DEPLOYMENT**

Quality function deployment is use to translate the need statements gathered from the customer into design requirements or engineering specifications.

**7. CONCEPT GENERATION**

After the design requirements has been establish, the next step in product design and development is to generate concepts which satisfy customer requirements. Generally there are five steps:



**Fig-2:** Five step methods of concept generation

### 7.1. Concept Decomposition

In order to simplify the problem semi-automatic injera making machine decomposed into sub problems as shown below.

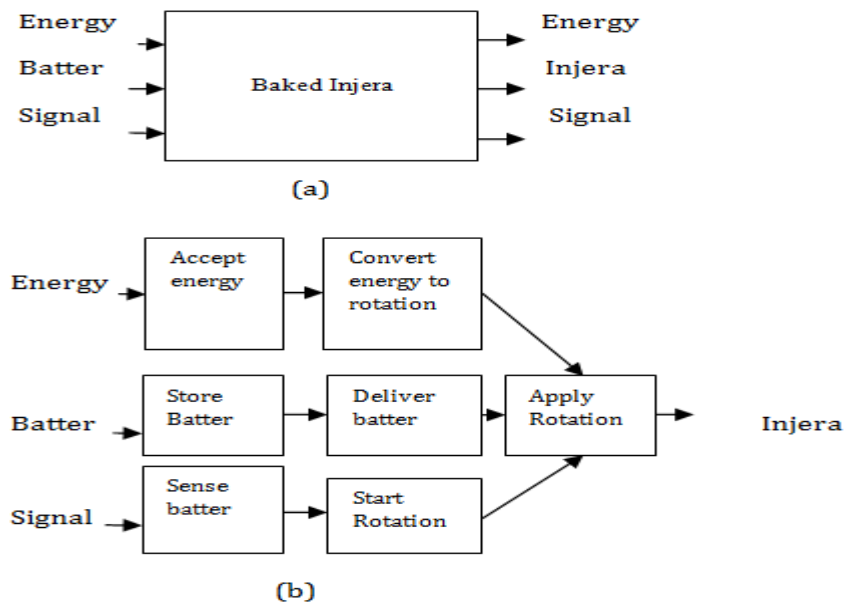


Fig-3: (a) black box, (b) functional decomposition of semi-automatic injera machine.

### 7.2. External search

External search is information gathering process to find the possible existing solution for the sub problems of the product. The required time and resources can be minimized by using expand and focus strategy. The existed Information for semi-automatic injera making machine is gathered through the following ways:

#### 7.2.1. Interview lead users

Household families are the main lead users for semi-automatic injera making machine. And they describe about the strength and weakness as well as the likely changes to be made in the existing products.

#### 7.2.2. Patent search

In the patent search, a lot of invention and technics related to the sub problems have been found. Publication number US 7,063,008 B2, discuss about using air based spreader to dispense the batter. Another invention Publication number US 2018/0035676 A1, uses rotating inline nozzles to dispense batter over the cooking pan [1].

#### 7.2.3. Related product benchmarking

For benchmarking purpose, automatic pancake, bread and other related or unrelated machines have been studied in some detail and many important concepts considered.

### 7.3. Internal search

Internal search involves using of the capacity of a person or the team to generate a lot of alternative solutions. The organized team use the following method to develop suitable solutions for semi-automatic injera making machine.

#### 7.3.1. Brainstorming

The team attend both individual and group session for generating concepts. First, all team members generate concepts individually for few days and then gathered to discuss and refine concepts generated during individual brainstorming session.

#### 7.3.2. Graphical and physical media

All generated concepts displayed on the wall of the room by using cardboard and projector to help the team to deeply understand the concepts.

**7.4. Concept classification tree**

Concept classification tree enables the team to divide possible solution fragments into independent categories [2]. Concept classification tree for semi-automatic injera making machine is shown in figure 3.

**8. CONCEPT SELECTION**

In the previous sections, customer needs are identified and a lot of concepts has been generated to satisfy those needs. The next step in product design and development is that to the select the promising concept among the generated concepts and this process is called concept selection process. The concept scoring for semi-automatic injera making machine is shown in figure 5.

**Table-2:** Performance rating

Relative performance	Rating
Much worth than reference	1
Worse than reference	2
Same as reference	3
Better than reference	4
Much better than reference	5

**9. ECONOMIC ANALYSIS**

Economic analysis is essential part of product development for a company launching a new product. Bill of material and break-even point analysis has been done for semi-automatic injera making machine.

**9.1. Bill of material**

The bill of material comprises assemblies, sub-assemblies, and parts of the product. The bill of material for semi-automatic injera making machine is shown below in table 4.

**9.2. Break-even point analysis**

Break-even point is the point at which the total cost (total fixed + total variable cost) equals total revenue (number of products to be sold\* unit price). Break-even point analysis determines the number of products the company need to sell to cover the cost of doing business.

The fixed cost needed for the start of the manufacturing of semi-automatic injera making machine is found to be 1 million birr. From bill of material the unit cost of the machine is 4055 birr. And revenue per machine is 4500 birr. Let, Y= number of products to be sold.

Thus, the break-even point can be calculated by

$$\text{Total cost} = \text{Total revenue}$$

$$1000000 + 4055*Y = Y*4500, Y=2248 \text{ units}$$

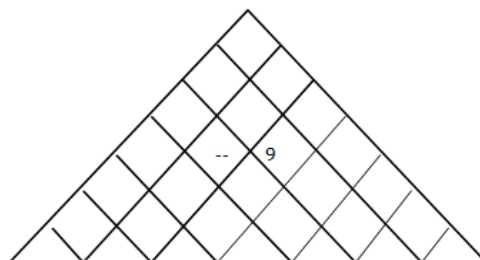
Therefore, it is showed that the break-even point of semi-automatic injera making machine is 2248 units. The graph of break-even point analysis is shown in figure 4.

**Table-3:** Bill of material of semi-automatic injera making machine

ITEM NO.	PART NUMBER	QTY.	Unit cost	Total
1	base	1	350	350
2	cover	1	150	150
3	AFBMA 20,1 - 48-20 - 18,SL,NC,18_68	2	150	300
4	shaft	1	100	100
5	connecting rod	1	130	130
6	bottle	1	80	80
7	Pan	1	400	400
8	spring	1	150	150
9	B18.67M - M3.5 x 0.6 x 16 Indented HFMS -- 16N	2	5	10
10	DIN EN 28734 - 5 x 12 - A - St	3	5	15
11	Polishing plate	1	120	120
12	motor1	1	1600	1600
13	motor2	1	250	250
14	solenoid valve	1	300	250
15	thermostat	1	250	250
16	resistor	1	150	150
Total				4055

**Table-4:** Concept scoring for semi-automatic injera making machine

Selection criteria	Weight (%)	concepts													
		A		B		C		D		E		F		G	
		Dispenser	Polisher	Remover	Positive displacement pump	Solenoid valve	Induction	Resister							
		R	WR	R	WR	R	WR	R	WR	R	WR	R	WR	R	WR
Easy to use	20	4	.8	4	.8	4	.8	4	.8	4	.8	4	.8	4	.8
Easy to move	15	3	.45	3	.45	2	.3	2	.3	4	.6	4	.6	4	.6
Low cost	25	3	.75	2	.5	1	.25	1	.25	3	.75	3	.75	4	1
Ergonomic design	2	4	.08	4	.08	4	.08	4	.08	4	.08	4	.08	4	.08
compactd	10	3	.3	4	.4	1	.1	3	.3	4	.4	3	.3	3	.3
automatic	20	5	1	4	.8	4	.8	4	.8	4	.8	4	.8	4	.8
Maintainability	8	4	.32	3	.24	2	.16	3	.24	4	.32	3	.24	4	.32
Total score		3.7		3.27		2.49		2.77		3.75		3.65		3.9	
Rank		3		5		7		6		2		4		1	
Continue		Yes		Yes		No		No		Yes		Yes		Yes	



	Priority	Size (Inch)	Price (Birr)	Energy consumption (Kw)	Time taken (min)	Weight (kg)	Flexibility (subjective)	Comfortable (subjective)	WASS mitad	Automatic mitad for small scale	Conventional mitad
Easy to use	7				1			9	1	4	1
Easy to move	5	1				9		1	4	2	3
automatic	8				9			3	0	4	0
Low cost	9		9						3	1	4
Low Energy usage	4			9					4	4	1
Ergonomic design	3	1						9	3	4	3
compactd	6	9							4	2	3
Flexibility	2						9	1	4	4	4
Maintainability	4				9				3	2	4
WASS mitad		16	3400	1.5	7	8	Yes	Yes			
Automatic mitad for small scale		16	7464	1.5	1.2	25	Yes	Yes			
Conventional mitad		22	1700	3.5	7	20	Yes	No			
<b>Target</b>		16	4000	1.5	4	8	Yes	Yes			

Fig-2: Quality function deployment

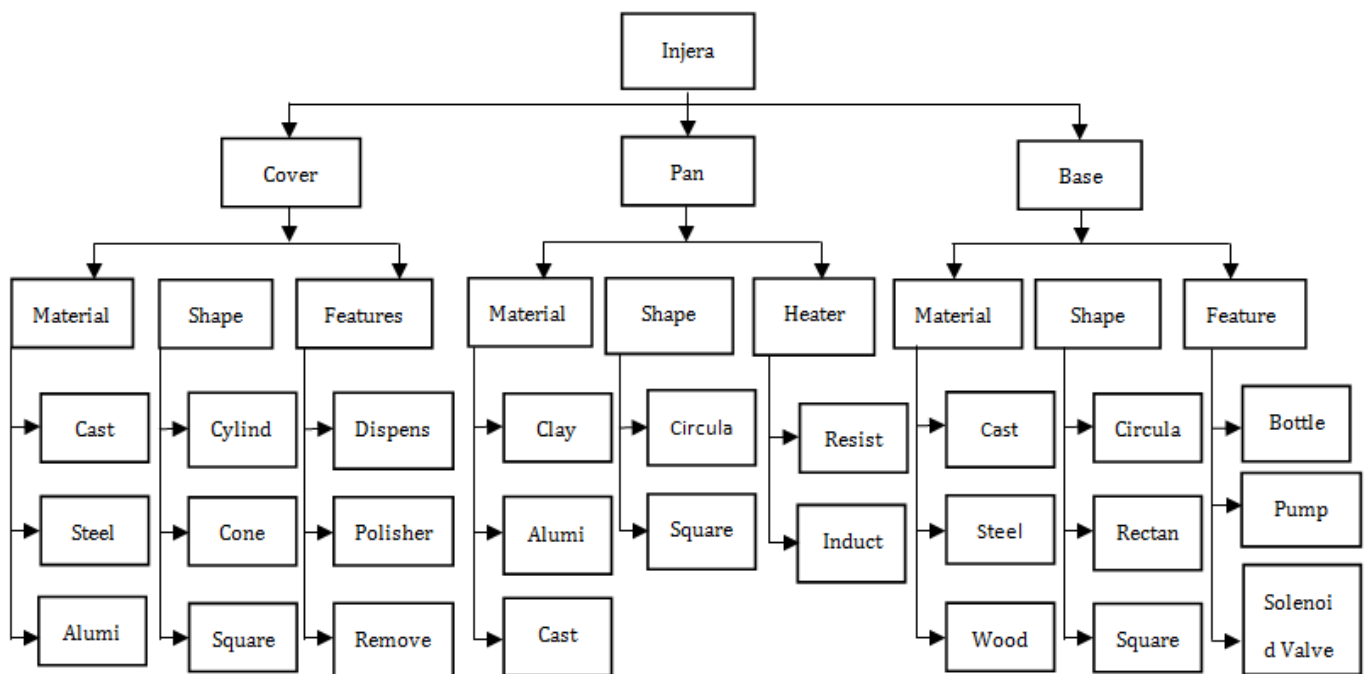


Fig-3: Concept calcification tree

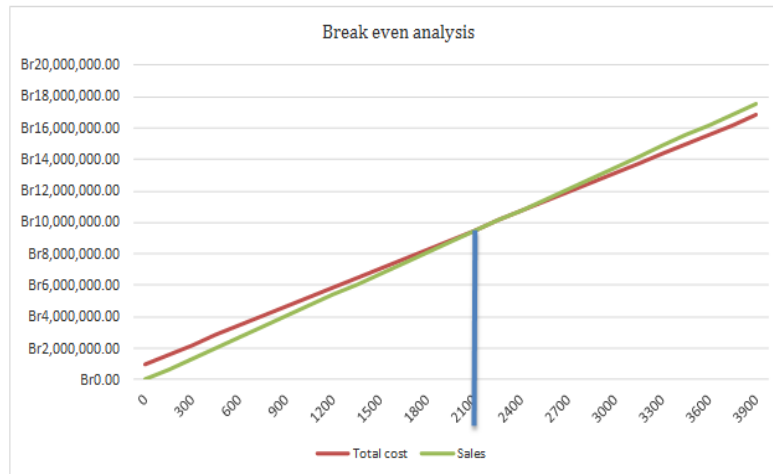


Fig-4: Break even analysis for semi-automatic injera making machine

Fig-4: Break even analysis for semi-automatic injera making machine

## 10. CONCLUSIONS

In this paper, the customer need for semi-automatic injera making machine is identified and interpreted. Concepts generated to satisfy the customer requirement and promising concepts selected through concept scoring method. The selected concept designed by using Solidworks 2016. Finally, the break-even analysis for semi-automatic injera making machine is proposed.

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