4th Year Group Development Project

Light-weight, Low-cost, Wood-fired Bread Oven

Introduction (1)

Bakery needed in Soroti

- Lack of bakery in Soroti
- Main supply from Kampala is expensive for some people in Soroti

Introduction (2)

- Suggested by Agape Education Trust
- Organised and will be run by: Job, Robert and Anne

Specifications (1)

- Must hold 30 1 lb loaves to bake 300 loaves per day
- Achieve a working temperature of 250°C to bake bread
- Use locally harvested wood as fuel
- Portability
- Simple design

Specifications (2)

- Reproduced from CAD and instructions
- Low cost
- Basic workshop facilities

Specifications (3)

Need for Portability

- The bakery will be in rented property
- Traditional ovens are permanent fixtures
- The landlord will raise rent
- If mobile then the bakery can move location if rent becomes excessive

Traditional Batch Ovens (1)

- Clay or brick for insulation
- Fire inside heats insulation
- Embers removed and replaced by bread
- cook with heat retained by insulation

Traditional Batch Ovens (2)

Problems

- Oven must be reheated after each batch
- Small capacity
- Permanent fixture

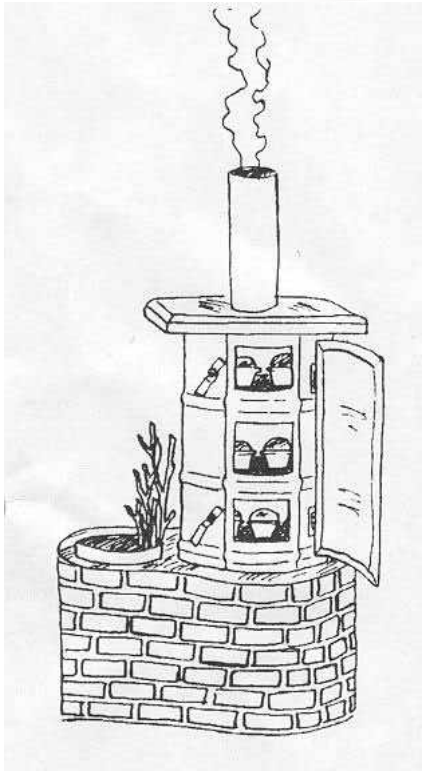
Alternative Designs (1)

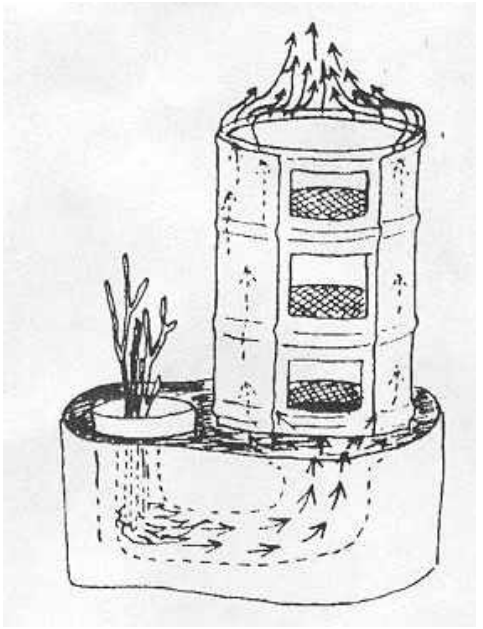
- Oil Drum Casing Oven
- Insulated Oil Drum Oven
- Steel Box Oven
- Double Skinned Steel Oven

Alternative Designs (2)

Oil Drum Casing Oven

- One oil drum inside another
- Heated from sides and underneath
- Low cost
- Small Capacity

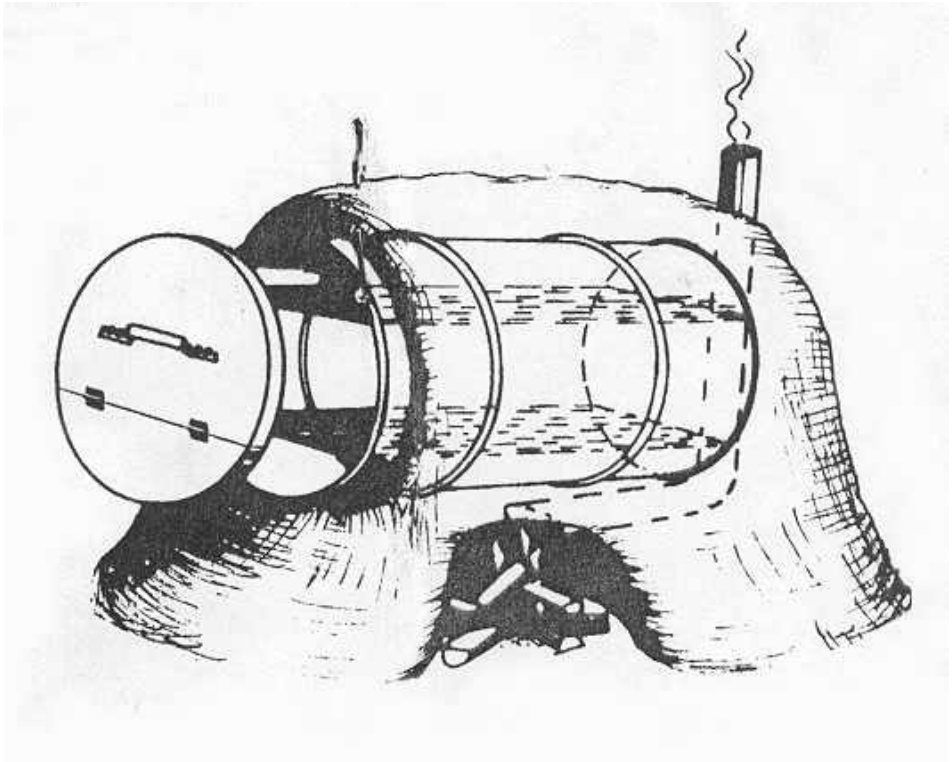




Alternative Designs (3)

Insulated Oil Drum Oven

- Oil Drum is insulated
- Fire underneath
- Cheap
- Easy
- Small capacity
- Permanent fixture



Alternative Designs (4)

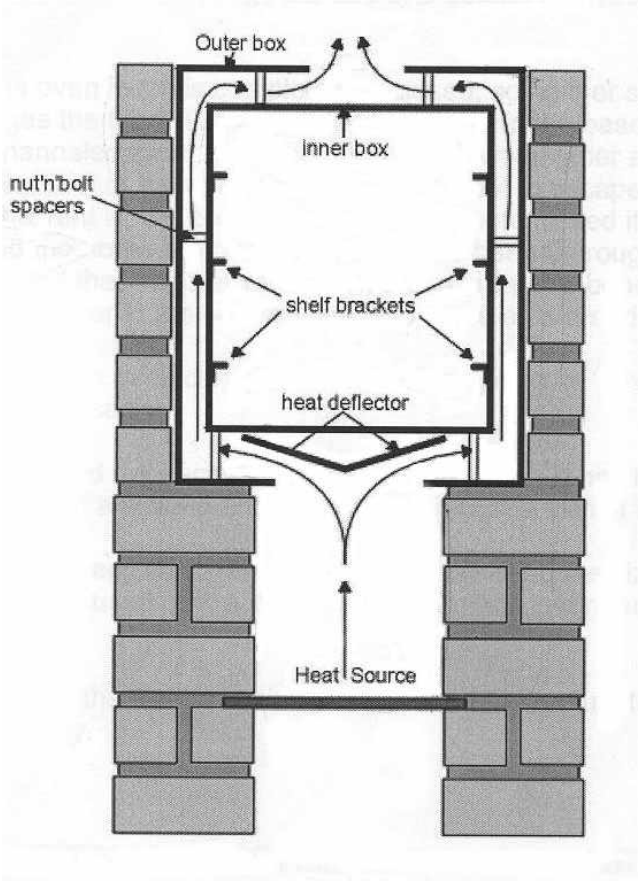
Cast Iron Oven

- Separate oven and firebox
- Cast iron used
- Heavy therefore not portable
- Expensive to manufacture

Altenative Designs (5)

Double Skin Oven

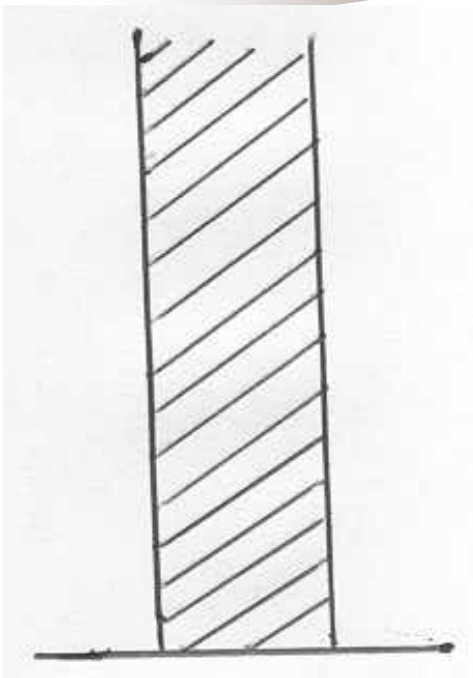
- Brick insulation
- Flue gases flow around sides and over top of oven
- large capacity



Initial Development (1)

Design Concept

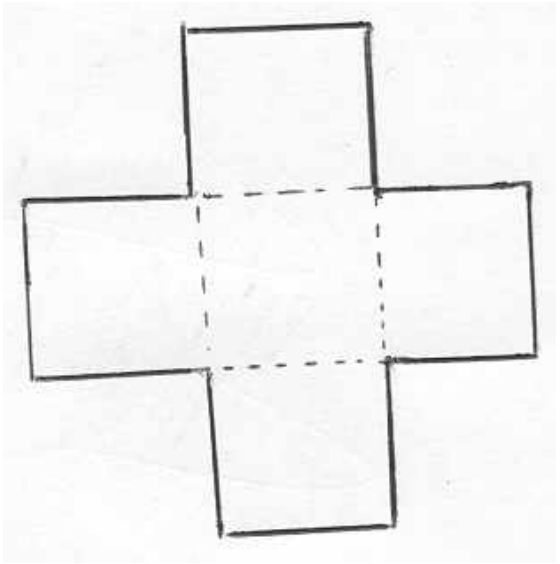
- Brick insulation
- Sand Insulation
  - Thermal Properties
  - Filling/Emptying
  - Availability



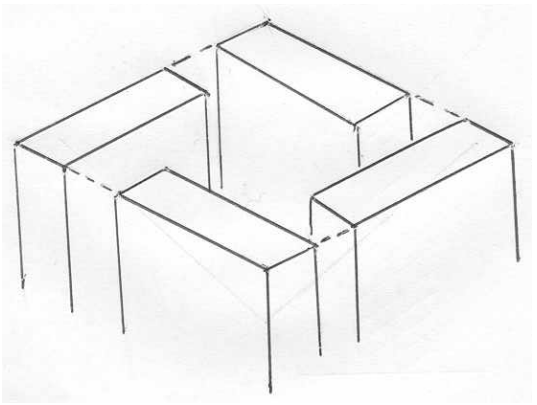
Initial Development (2)

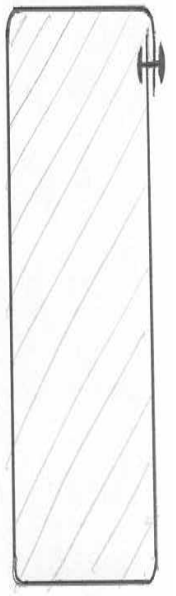
Basic Fabrication

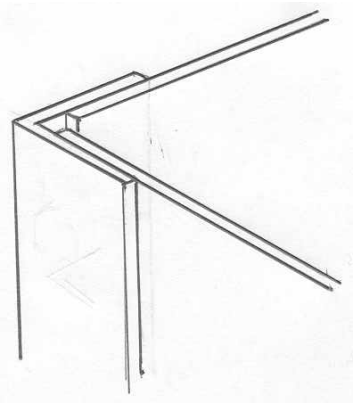
- ‘Net’ design



- Box sections
  - Folding & Riveting
  - Flat Packing
- L-sections & Sheet steel

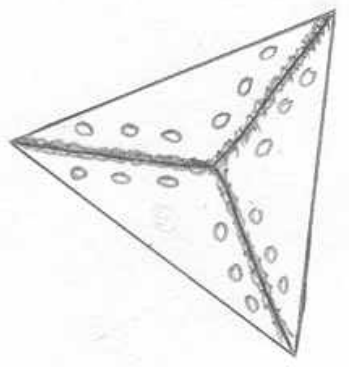






L-sections & Sheet steel

- Dexion
- Thermal Expansion
  - Oversize holes on sheet
  - Frequency of bolts
- Access for manufacture
  - Square head bolts
- Corners



Oven Heating

- Uniform heat requirement
- Fan oven
  - Driven by flue gases
- Duct Flue Gases
  - Through oven chamber
  - Across oven ceiling
    - Up sides
    - Up back

Materials

- Corrosion
  - UK testing
  - Damp sand
  - African climate
  - Long term use
- Stainless steel prototype
  - Except welded panels

Doors

- Primary and Secondary air
- Primary air
  - Burns wood
  - Under fire grate
- Secondary air
  - Burns gas
  - Above fire grate
- Control of oven temperature using sliding barriers

Location

- Importance of location
- Long bolts through both walls
- Cross braces
  - Multiple
  - Single
  - Welded nuts

Dimensions

- Oven Chamber
  - Dictated by baking requirements
- Insulation thickness
  - Manufacturing requirements
- Spreadsheet
  - Flue gas channel depth
  - Primary & Secondary air flow rates
  - Wood combustion rates
  - Chimney length

Calculations (1)

Objective:

- “Calculate critical dimensions that will enhance combustion and yield maximum theoretical efficiency.”

Calculations (2)

The Objective Was Achieved Through Calculating:

- Amount of Wood required /s for a steady state oven temperature of 250°C
- Primary and Secondary airflow required for complete combustion
- Required length of chimney
- Conduction losses in the structure

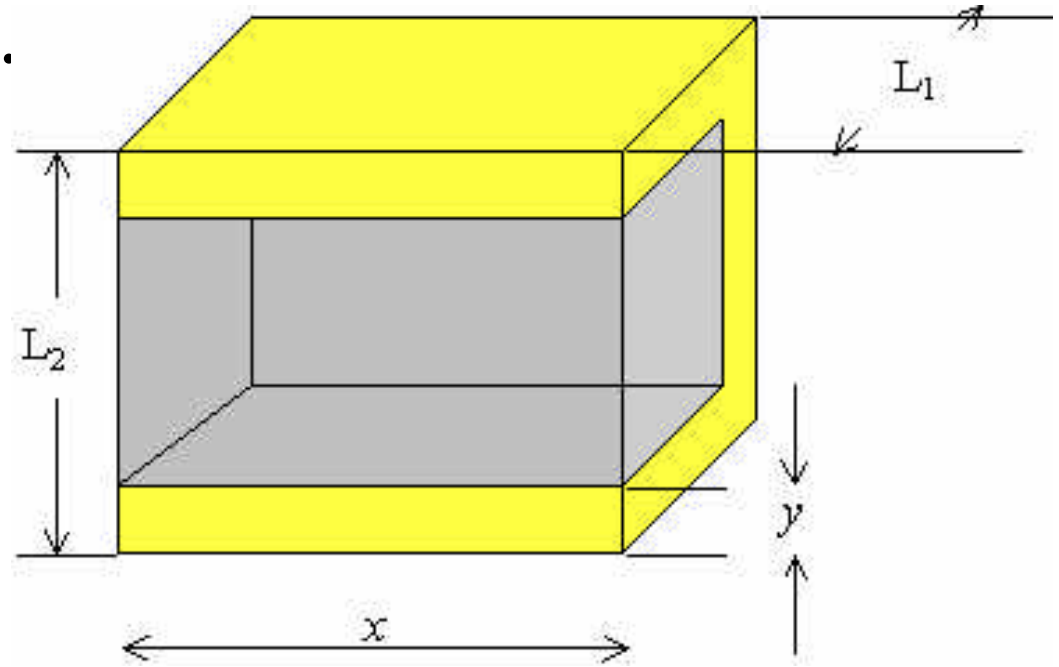
Calculations (3)

Assumptions

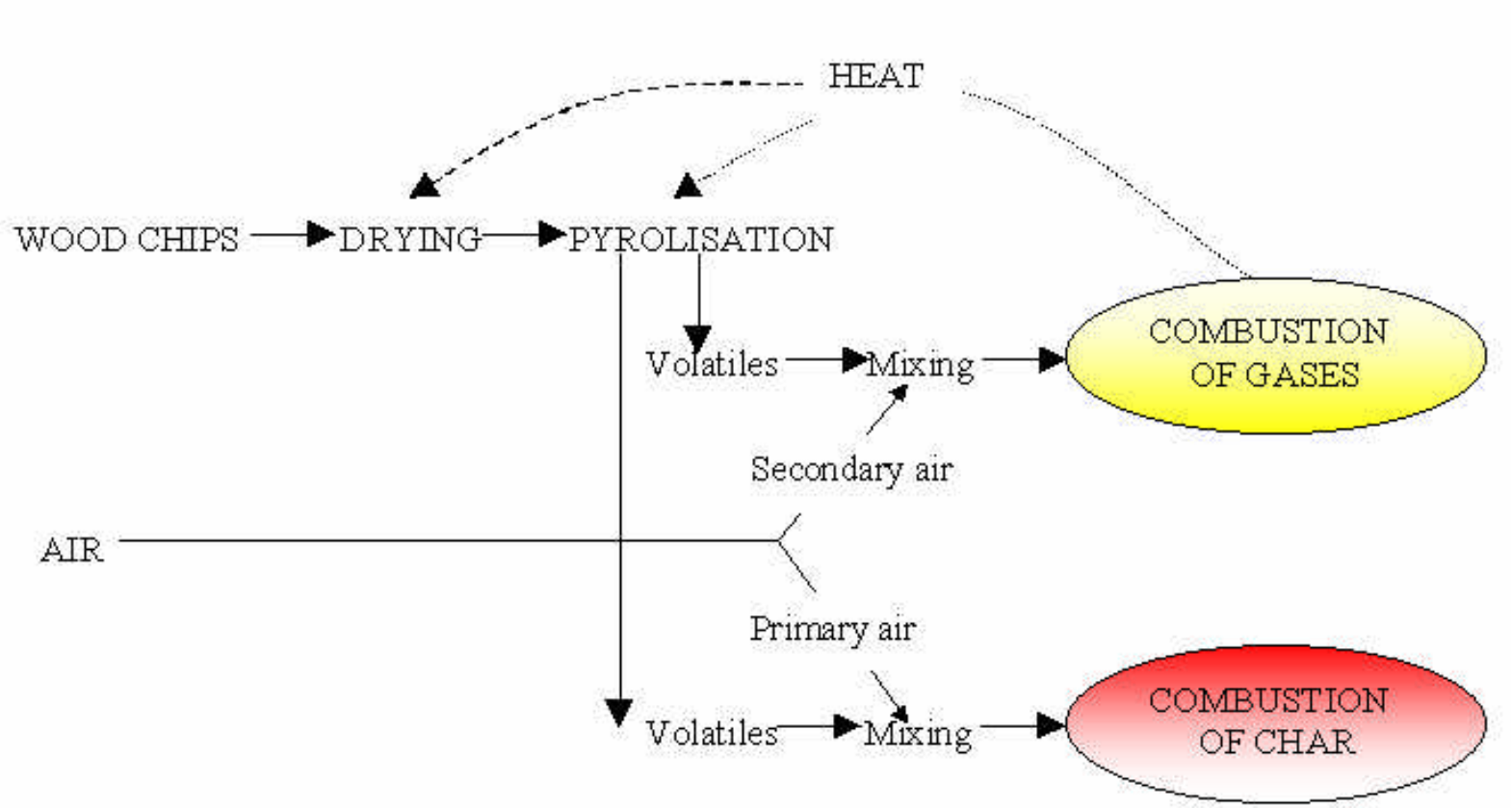
- Required Oven Temperature: 250°C
- Moisture in Wood: 30 %
- Excess air required for complete combustion: 100%
- G.C.V of Wood: 11000 KJ/Kg

Calculations (4)

- Flue gas channel dimensions; x, y.
- Height L_1
- Length L_2



Calculations (5)



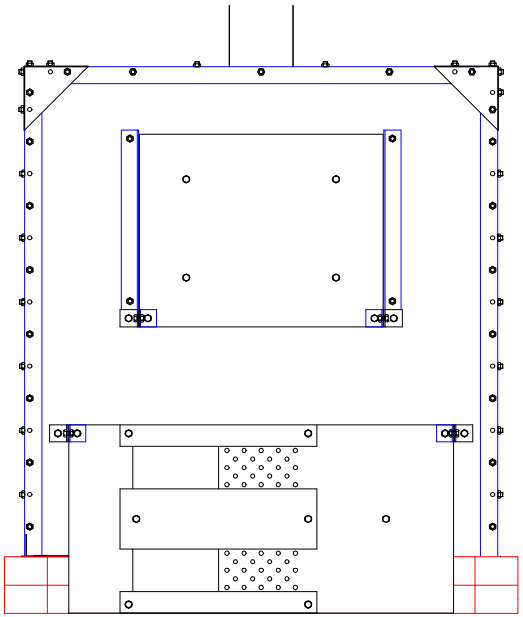
Calculations (6)

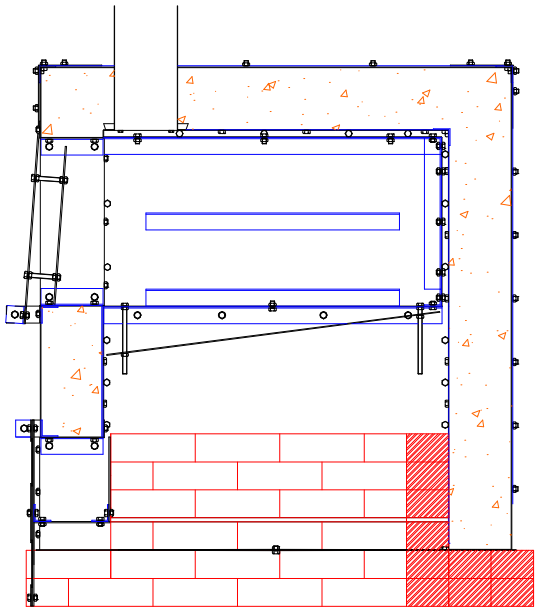
Dimensions /

Combustion analysis

Inner Oven Dimensions		
Length, L_1	800	mm
Height, L_2	400	mm
Width, x	800	mm
Air gap, y	15	mm
Oven Dimensions		
Stainless Steel Thickness	1.5	mm
Door Thickness, α	1.5	mm
Sand Thickness, β	150	mm
Roof Thickness, γ	150	mm
Length of chimney	400	mm
Combustion Analysis		
Mass of wood/s	0.0007	Kg/s
Primary air/s	0.0027	m^3/s
Secondary air/s	0.0027	m^3/s
Flue gas Temperature	400	oC
Conduction losses	3.84	KJ/s

Final Design





Testing (1)

Objective

- “Adjust the variables to maximise combustion efficiency and create a uniform temperature throughout the oven.”

Testing (2)

Test 1 – Investigate alterations to primary and secondary airflow

- Investigate by opening and closing primary and secondary air vents
- Are they effective in controlling the oven temperature

Testing (3)

Test 2 – Is the oven capable of baking 30 loaves at a time?

Monitor:

- Baking time,
- amount of wood used
- maximum and minimum temperature of the oven.

Testing (4)

Test 3 – Altering angle of deflector plate

- Adjust angle to induce/reduce eddies at the base of the oven .

Testing (5)

Test 4 – Altering the path of the flue gases

- Alter the size and shape of the air gap; y
- Monitor the effect it has on the oven's temperature.

Testing (6)

Test 5 – Altering distance of fire from deflector

- Raise fire by increasing the number of bricks supporting grating
- Monitor the effect on the oven's temperature

Testing (7)

Test 6 – Alter door dimensions

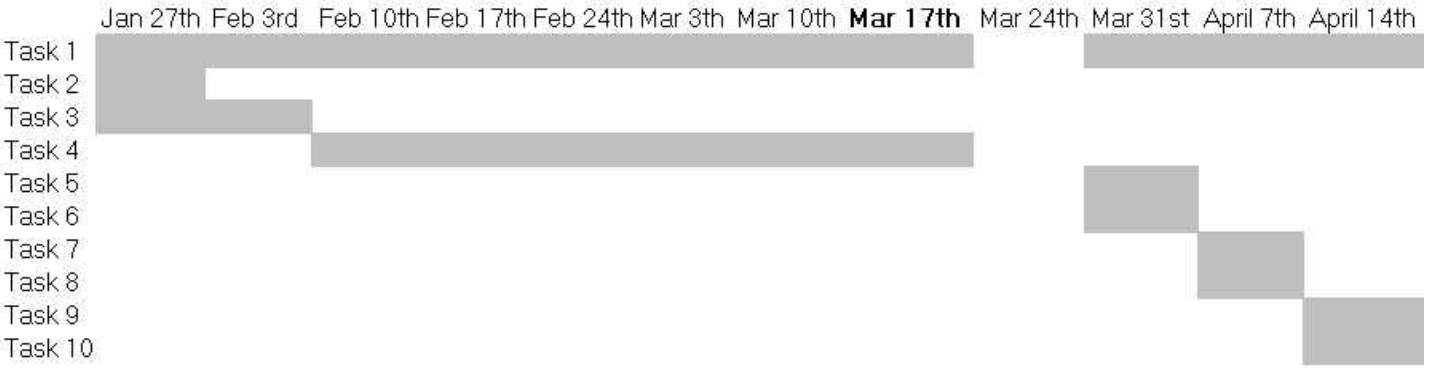
- Alter door's thickness
- Monitor the conduction losses.

Timetable (1)

H34GDP Group Development Project
Light Weight Low Cost Bread Oven
Dr Clifford

Project starting date : 3/10/02

Project finishing date: 9/5/03



Task 1 Report/ Buisness Plan
Task 2 Presentation
Task 3 Order materials/ collect
Task 4 Construction
Task 5 Test 1 :Investigate alterations to primary and secondary airflow
Task 6 Test 2: Is the oven capable of baking 30 loaves at a time?
Task 7 Test 3: Altering angle of deflector plate
Task 8 Test 4: Adjusting size of air gap
Task 9 Test 5: Altering distance of fire from deflector
Task 10 Test 6: Alter door dimensions

Timetable (2)

H34GDP Group Development Project
Design and Build a Wood Fired Portable Bread Oven
Dr Clifford

Project starting date : 3/10/02

Project finishing date: 9/5/03

April 23rd April 30th May 7th

Task 11

Task 11 Final Report