1.1 INTRODUCTION:

Even India is the major producer and exporter of turmeric in the world. The primary processing of turmeric is still being done with traditional method. The traditional method requires more boiling time around 90 minutes per batch. Traditional method consumes more fuel due to open pan used for boiling. Laborious work in this method is high for loading and unloading the Rhizomes. There is loss of quality of Rhizomes due to scorching, piercing, mud mixing and improper handling of hot Rhizomes. The above methods of turmeric processing are not economical.

1.2 TURMERIC PROCESSING:

The Turmeric can be processed in following steps:

[ Bala Shamungam P.V., (1991) ]

1. Turmeric Rhizomes.
2. Washing
3. Boiling / blanching
4. Drying
5. Colouring
6. Grinding / Powdering
7. Packing and Marketing

The Turmeric Rhizomes [ Mother, Primary and Secondary fingers ] dug out are kept soaked in water throughout night. The Rhizomes mother / Doctor ( The first round middle part ) is separated and usually it is used for seed. The Rhizome finger ( secondary long and thin like finger ) are washed and cleaned for further processing. The method of boiling / blanching / cooking is discussed in detail in this research work.
1.3 TRADITIONAL BOILING:

Turmeric being a cash crop, medicinally and industrially important, it is produced in 1,37,000 hectares of area in India. In Marathwada 8220 tonnes of turmeric is produced from 6644 hectares of area [www.indianspecies.com]. The primary processing of turmeric is still being done with traditional method, leading to many losses and difficulties. Farmers use open shallow metal (mild steel) pan for turmeric boiling. The pan is kept on the furnace and turmeric Rhizomes are heaped in, water is added upto 3/4th part of the heap height in pan and covered by gunny bags or plastered. It takes about 50-60 minutes to boil the water and 40-45 minutes to boil the turmeric. Figure 1.1 and Figure 1.2 shows method of traditional boiling. [K.J.Kamble and S.B.Soni, (June 2008)]. When white flume comes out, a small grass or wooden stick is easily pierced through the Rhizome, then it is presumed that turmeric is boiled. The boiled Rhizomes are then pulled out of the pan with the help of wooden comb with long handle and allowed to leach the water through it. The boiled Rhizomes are spread on a clean open ground for drying.

Because of shallow open pan there are more heat losses, increasing boiling time and there is loss of curcumin and oleoresin. The ammonia in the cowdung is reacted with turmeric to produce the final product, for hygienic reasons this method is being discouraged. Also there is loss of large amount of heat and also the properties of Rhizomes.

In another existing method of boiling/cooking as shown Figure 1.3, the Rhizomes are treated with 0.1% soda [Sodium Carbonate, sodium bicarbonate or ammonium carbonate] and water solutions and they are steam boiled in the same way for 30 to 45 minutes. When the white fume comes out, a small grass or wooden stick is easily pierced through the Rhizome, then it is presumed that the turmeric is boiled. The boiled Rhizomes are taken out from the bottom opening of the tank and allowed to leach the water through it. The boiled Rhizomes are spread on a clean open ground for sun drying. Because of shallow open pan heat losses are more due to increase in boiling time and more loss of curcumin and oleoresins, [Source M.A.U., Parbhani], also it is difficult to handle hot Rhizomes.
1.4 MAJOR DRAWBACKS OF TRADITIONAL METHOD:

- Ammonia from cowdung is reacts with turmeric, hence for hygienic reasons this method is discouraged.
- There is huge loss of heat due to open pan and traditional heating method.
- There is loss of quality and properties of Rhizomes due to mud mixing scorching and trampling, during loading and unloading of hot Rhizomes.
- There is high labor cost for cleaning, loading, unloading and drying the Rhizomes.
- There is uneven heating of Rhizomes and there is loss of volatile matter of Rhizomes due to heating and boiling by traditional method.
- There is increase in overall cost of Turmeric Processing.

1.5 SIGNIFICANCE OF TURMERIC AS A PRODUCT:

India ranks first in production of turmeric i.e. 701.16 Lac tones from 185.32 Lac hectare of area [Varsheney A.K., Garala, (2004)]. Maharashtra produces about 400 MT from 700 hectare area [Vikas S., (2003)]. Turmeric is the dried rhizome of the plant curcuma domestica val. syn. C. Longa L. The genus Curcuma originated in the Indo-Malayan region [Pursegove, (1981)]. Considerable species diversity of curcuma occurs in this region. In India about 40 species of the genus including C. Longa are indigenous to India indicating the Indian origin [Velayudham J., (1999)].

According to macropola (1280) the spread of turmeric to China took place in AD 700 [Ridley, 1912]. Burki-II (1966) believed that the crop spread to West Africa in the thirteenth and to East Africa in seventeenth centuries, respectively. Though turmeric is now grown in Japan, Malasiya, Thailand, Korea, Nepal, East and West Africa etc, India is the major producer and exporter of turmeric at present [Velayudham J., (1999)]. Indian Species [www.indianspices.com], recognized six taxonomic varieties within C. Longa based on numerical taxonomic analysis, namely,
I- Introduction

Figure 1.1 Traditional boiling at field Nizamabad

Ref: farm beast Nagtum

Figure 1.2 Traditional method of boiling at Naigaon

Ref: farm house Naigaon

Figure 1.2 Traditional method of boiling at Naigaon
The boiled Rhizomes are spread slowly in the yard for drying. It takes 10 to 15 days for sun drying. Mother Rhizomes take more time compared to Doctor Rhizome, so they are separately dried.[Bansal P.K. and Kaushik S.C., (1980)]. The complete dried Rhizome holds 6% moisture. The dried Rhizomes are rubbed against ground to take out hard layer over them and small roots are removed. By this process colouring of Rhizomes becomes bright and shining, machines are also used for polishing. The Rhizomes after polishing and colouring as shown in Figure 1.5, cut into small pieces and milled to get 60-80 mesh powder.

Traditional handling method of boiled Rhizomes causes trampling, mudmixing, scorching, leading to quality and quantity loss. Labor cost is very high for cleaning Rhizomes, washing, loading, unloading the pan and drying the Rhizomes.
I- Introduction

1. C.Longa Var. typica
2. C.Longa Var. atypica
3. C.Longa Var. camphora
4. C.Longa Var. Spirailifolia
5. C.Longa Var. Musafolia and
6. C.Longa var platitolia.

Most of the C.Longa found in India belong to C.Longa Var. typica or atypica [B.Sasikumar, “Turmeric”, (2001)].

Turmeric is an erect perennial herb grown above the ground as an annual crop. The plant is erect with leaves and inflorescence as shown in Figure 1.4. There may be 2-3 Pseudostems (tillers) per plant. The height of the plant varies from 90 to 100 cm, with leaves ranges from 7 to 12. The leaf sheath is usually green in colour, lamina may be lanceolate or elliptic in shape, thin with acuminate tip. The colour of lamina is usually green and pale green below, with a length of about 30 to 40 cm and width 8-12 cm. Inflorescence is a cylindrical, fleshy, central spike of 10-15 cm length, arising through the pseudostem. Flowers are subtended by bracts in the spike. The bracts are adequate for less than half of their length and are elliptic, lanceolate and acute. The upper bracts are white in colour while the lower bracts are green. One to four flowers are born in the axil of the bract, opening once at a time. About thirty flowers are produced in a spike. [Sasikumar, B.Ravichandran, P.N.Jonson, (1996)]. Seeds are produced in capsules and there will be from one to numerous sunken capsules in an inflorescence depending on the flowers fertilized. At the base of the pseudostem, below the ground, rhizomes are formed consisting of mother rhizomes, primary, secondary and even tertiary fingers, forming a compact clump. [www.ramdevfoodproducts.com]. Rhizomes grow symbodically and are of orange brown, pale yellow or redish yellow color. C.Longa is considered to be a triploid with a somatic chromosome number of 63 [2n = 3x = 3].

American Spice Trade Association (ASTA) cleanliness specification effective from May 1997 for turmeric allows only a maximum of three dead whole insects. 5 mg/lb Mammalian or other excreta 3% by weight mould, 2.5% by weight insects infested material and 0.5% by weight extraneous foreign matter in turmeric.
Figure 1.4 Turmeric plant with Rhizomes

Figure 1.5 Rhizomes after cleaning and polishing
The admissible level of defective Rhizomes allowed in US Turmeric is given below.

- Maximum moisture: 8-10% by wt.
- Maximum ash: 7% by wt.
- Maximum acid insoluble: 0.5% by wt.
- Maximum crude fiber: 6% by wt.
- Maximum volatile oil: 4% by wt.
- Maximum curcumin as color: 5% by wt.
- Volatile oil ml/100gm: < 3.5

Turmeric is valued mainly for its principle coloring pigment curcumin, which imparts the yellow color to turmeric having molecular formula \( \text{C}_{21}\text{H}_{2}\text{O}_{6} \). To various food items, the specified limit for curcumin to maximum level is 500 mg/kg. [B. Sasikumar, Indian Institute of Spices Research, Kerala, (1991)]. Table 1.1 shows specified limits for curcumin in various food items.

**Table 1.1 Specified limits for curcumin in various food items**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Curcumin in various Food Items [Source: Henry 1998].</th>
<th>Mg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Decorations and coatings, Surimi, sauces, Seasonings, Curry powder, tandoori, Salmon, substitutes.</td>
<td>500</td>
</tr>
<tr>
<td>2</td>
<td>Preserves of red fruits and confectionary, Fish roe and solid food supplements, mustard, dietary integrators.</td>
<td>300</td>
</tr>
<tr>
<td>3</td>
<td>Snacks, (Potato, cereal etc.), Aromatized and fruit wines, candied fruits and vegetables, preserves of red fruits, fine bakery wares, spirituous beverages, cider and perry.</td>
<td>200</td>
</tr>
<tr>
<td>4</td>
<td>Liquid Food supplements, Meat and Fish analogues based on vegetable proteins, dietary integers, non alcoholic flavoured drinks, flavoured processed cheese, fish paste, smoked fish.</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>Edible cheese rind and edible casings, daily food, nutritional supplement for use under medical supervisions.</td>
<td>50</td>
</tr>
</tbody>
</table>
1.6 THE IMPORTANT PROPERTIES AND USES OF TURMERIC:

The use of turmeric has been in India since very ancient days. Turmeric powder is used in mustard paste and curry powder, as colour and aroma are important. Turmeric oleoresin is used in the brine pickles and relish formulations, gelatines, in breading of frozen fish sticks, potato croquettes, butter, cheese and ice creams. In Asian countries turmeric powders with other species like chillies are used for making soup, vegetable and meat dishes.

Turmeric powder mixed with sesame, coconut or ground nut oil is used for pickling mango, lemon, garlic etc. In foods, the antioxidant property of turmeric was effective in preventing peroxide developments [Khanna, (1999)]. Turmeric is credited with medical properties as anti inflammatory, hypocholestremic, choleric, antimicrobial, antirheumatic, spasmyloytic, hypersensitive, antibacterial, antiviral, cytotoxic, antidiabetic and antiheptotoxic [www.indianspecies.com, Govindrajan, (1980)]. Turmeric also has meditional uses in digestive disorders, hyperacidity, blood purifier, used for cuts, burns, anti inflammatory effects. It is also used in cosmetics to glow the skin, traditional bathing in Indian marriage, for fair, soft and smooth skin.[www.ramdevfoodproductsptltd.com.]

1.7 AIM AND SCOPE OF THE WORK:

The main aim of the research work is to remove all drawbacks of the traditional method and to develop a new method for turmeric processing, specially boiling unit which improves the quality of Rhizomes and overall efficiency of the plant.

The main objectives of the work are:

1. To reduce the loss of heat in traditional method due to open pan, by designing a new blancher and providing proper insulation to it.
2. To reduce the loss of fuel, handling cost, time consumption, processing cost and overall cost.
3. To reduce the laborious work in traditional method of turmeric processing during loading, boiling, unloading of hot Rhizomes, drying etc.
4. To reduce the uneven heating of the Rhizomes by designing the blancher for uniform distribution of heat.

5. To improve the quality of Rhizomes by replacing mild steel pan with high quality stainless steel blancher for boiling.

6. To improve the quality of Rhizomes by steam heating, instead of traditional boiling, which also reduces the heat loss.

7. To improve the quality of Rhizomes by proper handling of hot Rhizomes to avoid mudmixing, trampling, scorching, piercing etc.

8. To design the blancher which is mobile to operate and it can be installed easily at various places to handle less quantity of turmeric with poor and small farmers in India.

Hence the study was undertaken for design, fabrication and testing of a new turmeric boiling unit called blancher, in the Department of Production Engineering at S.G.G.S.College of Engineering and Technology, Vishnupuri and Department of Mechanical Engineering, M.G.M’s College of Engineering, Nanded.

A model of Turmeric blancher is designed on Uni-Graphics software. The blancher model is made of stainless steel (SS 304L) material. [A.K.Steel304L stainless steel (2007)]. The thermal and structural analysis of the blancher is carried out on ANSYS Software.

The software test of the blancher was found satisfactory for uniform distribution of heat flux, thermal and structural stress are within the limits.

1.8 MATERIAL PROPERTY DETAILS:

The details of the structural material SS 304 L of which blancher is made are mentioned in Table 1.2. [Prosenjit Santra.2009 (1708-1712)]. The analysis is being attempted with existing material test reports. The tensile stress, yield stress, elongation values are considered for test. Figure 1.6 shows proposed mobile blancher.
1.9 **BOUNDARY AND LOADING CONDITIONS:**

Based on the process requirements the turmeric processing blancher model made of stainless steel is designed to handle 50 kg of turmeric in single batch. The finite element model is generated with the quadrilateral, 2D shell and 3D brick elements to create the mesh. The self-weight is considered 1G [9.81 m/s² and 760 Torr], number of line are 10082, number of surface areas are 2851, number of 2D elements are 72, 391, number of 3D elements are 18289 and total number of elements are 90680. The thermal analysis is carried out within temperature limits 120°C to 210°C and pressure limits 3 bar to 9 bar. The thermal and structural analysis of the blancher model is carried out using ANSYS software.

<table>
<thead>
<tr>
<th>Sr.</th>
<th>Material specifications</th>
<th>Typical values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Young's Modulus (N/mm²)</td>
<td>196200</td>
</tr>
<tr>
<td>2</td>
<td>Poissions ratio</td>
<td>0.29</td>
</tr>
<tr>
<td>3</td>
<td>Density (kg/mm³)</td>
<td>8.00E-06</td>
</tr>
<tr>
<td>4</td>
<td>Coefficient of thermal expansion (mm/mm/°C)</td>
<td>17×10E-06</td>
</tr>
<tr>
<td>5</td>
<td>Thermal conductivity (W/mmK)</td>
<td>0.0163 and 0.0214 at 25°C and 500°C</td>
</tr>
<tr>
<td>6</td>
<td>Specific heat (J/kgK)</td>
<td>500 and 563 at 25°C and 400°C</td>
</tr>
<tr>
<td>7</td>
<td>Emissivity</td>
<td>0.11 (polished surface)</td>
</tr>
<tr>
<td>8</td>
<td>Tensile strength (MPa)</td>
<td>554 (from material test certificate)</td>
</tr>
<tr>
<td>9</td>
<td>Yield strength (MPa)</td>
<td>281 (from material test certificate)</td>
</tr>
<tr>
<td>10</td>
<td>Elongation (%)</td>
<td>44 (from material test certificate)</td>
</tr>
</tbody>
</table>

*Table 1.2 Material properties of SS 304L*
Fig. 1.6 Proposed mobile blancher with components
Uniform temperature of the Turmeric Processing Plant is studied at 120°C, 150°C, 180°C and 210°C. It was found that the temperature of the Turmeric Processing Plant [T.P.P.] is within the limits, which indicates that there is uniform temperature and heat distribution throughout the assembly.

The results of deflection and stress analysis shows that the deflection is less at pressure 3 bar and it increases with increase in pressure up to 9 bar. The deflection and stress values are increasing gradually with increase in pressure and their results are within the limits. The actual value of steam pressure is not more than 2 bar, hence the design is safe.

1.10 FABRICATION AND TESTING:

An experimental work is carried out by fabricating a prototype of the blancher. A 50 kg capacity blancher is fabricated with certain modifications according to availability of material with standard dimensions. The experimental work is carried out at the farmhouse of one of the leading farmer of Nanded district Mr. Shivaji Supare, Takalgaon Tq. Naigaon, District Nanded.

1.11 ORGANIZATION OF THE THESIS:

The method of Boiling the turmeric in Turmeric processing plant is the complicated process in the real life of farmers. The traditional method is very complicated, lengthy, costly and laborious. It has not been taken by any researchers to reduce the losses and efforts of Turmeric processing plant. The proposed research work presents the new design and fabrication of the turmeric blancher. It reduces the heat loss, labour requirements and processing time.

Chapter 1. Presents the introduction of Turmeric processing, traditional and existing methods of processing. The details of traditional and existing method, its design, working, advantages and disadvantages are explained with brief review of the proposed blancher model.
Chapter 2. deals with literature review. It is carried out with an introduction to identify the real problems in the design of Turmeric Processing Plant. The real problems were studied by visiting to existing traditional turmeric processing plant at various places, Parbhani, Nizamabad and Naigaon. The problems were also identified and studied by discussion with experts and farmers in the exhibition held at Agricultural University Parbhani.

Chapter 3. Presents the objectives and Research Methodology of the research work.

Chapter 4 includes the details of the manual, software design of the blancher and mathematical model. The model of the blancher is created on UNIGRAPHICS Software. The details of the various parts and blancher assembly is presented in this chapter.

Chapter 5. Presents the Thermostructural Analysis of the blancher is carried out using ANSYS Software. The effect of temperature, Pressure, deflection, stresses were analysed, verified and presented in this chapter.

Chapter 6. Presents the fabrication and testing of blancher assembly. The experimental setup of the plant, its operation is carried out at Takalgaon, one of the leading farmer of Nanded District. The details of the test reports, operation is explained in this chapter.

Chapter 7. Includes the result based on Design and experimental work are plotted and compared with traditional and existing method in this chapter.

Chapter 8. Includes the limitations and future research scope of the work. The Publications and References were also included in this chapter.