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Pressure cooker lid – Literature review

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ABSTRACT

A kitchen without pressure cooker is like a human being without sole. Because nowadays it is not only the fashion but also it works with hand in hand with the working woman. This is because of saving in time & energy. It means that the pressure cooker has become an inevitable item in the kitchen. Easier handling will increase the life of the pressure cookers. From the ancient time, there were always innovations about cooking. The researchers always give advice over wastage of energy during cooking. Saving energy is always need of the nation and an approach for saving energy leads to the change in shape of a pressure cooker. These changes were in size of a pressure vessel, the shape of the lid or may be the provision of the coating to cooker. During the changes, alternative sources such as electrical and solar were also played an important role in energy saving. The shape of inner lid of pressure cooker used is elliptical in shape. This elliptical shape is for locking & easy to handle. The different alternatives for the shape of inner lid of pressure cooker were arising. But due to different restrictions, designers concentrated on changes in lid shape from circular to an ellipse. Also, the demerits of elliptical inner lid shapes are overcome by the hybrid shape of circular and elliptical i.e. circular shape having straight edges at the edges, as one of the alternatives. The modification suggested here is also serving the all purposes elliptical pressure cooker. The advantages obtained here are also giving better results for locking, increase in heat transfer area, reducing locking angle position in a measurable way and saving in waiting for time for food than the elliptical inner lid.

Keywords: Pressure cooker (PC), Elliptical shape, Solar energy, Modified lid

1. ORGANIZATION OF LITERATURE SURVEY

The researchers after carrying out their work publish the same. This publication forms the base about the work carried out in the selected area. It provides guidelines for further work to young researchers. The literature review also helps in knowing current trends in a particular area of research and useful for planning the future work. With these objectives in mind, the available literature on pressure cooker (PC) and their related

parameters such as temperature and pressure effects, simple and thermal stresses developed, accidental awareness about lids, the cooling time of food and ease of handling of PC is reviewed here.

The research carried out by various researchers on working on the pressure cooker with different working parameters is discussed in this paper.

Heat and mass transfer analysis, determination of cooking time, experimentations and their comparisons etc. carried out by various researchers are discussed in section 1.2.

Based on literature reviews, observations made and objectives of present work are discussed in section 1.3.

1.1 Pressure Cooker

1.1.1 Cooking Background:

Before going to the detailed study of PC, it is very essential to consider the traditional cooking processes. Traditional cooking was on stone, heated up to cooking temperature. As the time gone, the stone was replaced by Chulas burned with wood. At that time, food was cooked on plate i.e. pan. By the day by day research, this traditional cooking was replaced by cooking food in a pot which slowly became pressure vessel of the pressure cooker (PC). Some researcher invented kerosene stove, scanners, gas cooker and solar cooker. But pressure cooking popularity had been increased because of its fast cooking, ease of handling and a higher standard of living of the family.

1.1.2 Working of PC:

Pressure cooking is a method of cooking in a sealed vessel that does not permit air or liquid to escape below a preset pressure value. After reaching 100°C temperatures i.e. the boiling point of water, the pressure is built up inside the cooker.

The food to be cooked is placed in the pressure cooker with a small amount of water. The vessel is then sealed & placed on the heat source. E.g. a stove. As internal temperature rises, the pressure reaches the design gauge pressure. Most pressure cookers have a working pressure as 15 psi (107 KPa) over the existing atmospheric pressure i.e. the standard set by the United States Department of Agriculture in 1917. Pressure cooking is often used to stimulate the effects of long braising

or simmering in a shorter period of time. Some pressure cookers have a lower maximum pressure or can be adjusted to different maximum pressures and cooking time will be varying accordingly.

For airtight seal of the lid with the vessel, gasket and lid lock with flanges are used. This works by placing the lid on the pot and twisting it for the lock. Contemporary designs of this style of cooker also have a pressure-activated interlock mechanism that prevents the lid from being removed while the cooker is pressurized. This provides the pressurized steam inside which keep lid tightly in place, preventing accidental removal during cooking. Other cookers used were home canning, oval, oversized lids. Since pressure cooking depends on the generation of steam, the process cannot be used easily for cooking that produces little steam, such as in pan frying or deep frying cooking.

1.1.3 PC as Fuel Saver:

Around 200 BC India took major steps about the alteration of traditional cooking. Roman Garrisons from Britain led to the determination of cooking technique. In the 19th century, Sir Benjamin Thompson [2] proposed developments in insufficient developments in cooking. His energy-saving idea was successfully incorporated in Thompson’s -Aga cooker and marketed the first cooker in 1929. In this paper, Douglas Robert *et. al.* implemented this idea to electric cooker also. After sometimes, the trend developed that pressure cooker became energy saver utensil and finally gateway to enter in the kitchen had been developed to the PC. Developments in cooker design had been concerned mainly with reducing cooking time, making appliances easier to use and improving their appearance. Leach doubled cooker efficiencies by 2010. This paper was also assisted by McConnell design of oven and electric cooker. It made compressive studies overcooking in oven and cooker. From 1960 onwards, awareness of using cooker increased. In 1975, Vale & Vale created awareness by using cooker himself. Brundrett & Poultney published a note on advantages of PC over ovens. They found that maintaining a lid in place of saucepan while simmering decreased the necessary power dissipation by about 80% as shown in figure 1.1 and inner lid PC as in figure 1.2. Dakerskog gave design about whirling action of steam within cooker [2]. To obtain satisfactory results, Nilsjohan Ltd. suggested that Aluminum is the best material from minimum expenditure of energy.

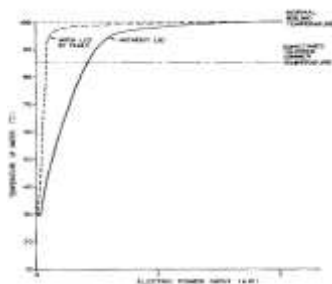


Fig. 1.1: Temperature variations with saucepan & lid

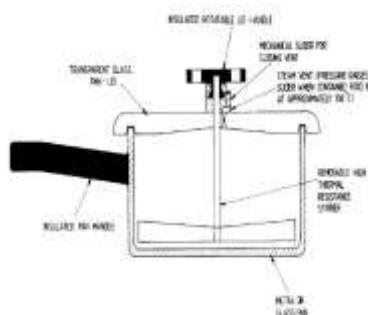


Fig. 1.2: PC with evaporation rate reduction

Adela M. A. Khalifa *et. al.* investigated new oven cooker and simulation studies were conducted for thermal behavior of concentration type of solar cooker by various tests and cooking experiments, new cooker hold promise. Here temperature more than 100° c was attained. Comparing oven with cooker, cooker gave more efficiency, ease of operation, availability of material and simplicity. Telkes Oven [5] was the development of new PC. In his presentation, he formulated cooking time for food in the cooker as

$$q_f = q_{top} + m_f C_f dT_f/dt$$

with

$$q_f = h_f A_f (T_r - T_f),$$

$$q_{top} = A_{top} (T_f - T_a) / R_{top},$$

and,

$$R_{top} = 1/h_a + 1/h_{gap} + x_i/k_i,$$

where

- T_f = the fluid or food temperature in the pot, °C
- T_r = the temperature of the receiving surface for the pot, °C
- T_a = the ambient air temperature, °C
- h_f = the heat transfer coefficient between the fluid (or food) and the inner surface of the pot, W/m² °C
- h_{gap} = the heat transfer coefficient in the air gap between the surface of the fluid in the pot and the lower surface of the oven cover, W/m² °C
- R_{top} = the total thermal resistance between the fluid surface and the ambient, m² °C/W
- k_i = thermal conductivity of the material of the top cover, W/m °C
- x_i = thickness of the top cover, m
- m_f = mass of fluid (or food) in the pot, kg
- C_f = specific heat of fluid or food, kJ/kg °C
- A_f = the inner surface area of the pot wetted by the fluid, m²
- A_{top} = surface area of the top cover, m²
- t = time, S.

By testing and analysis with a computer model, the researcher concluded that cooking times were shorter for cooker and new pressure cooker attained 100°C temperatures.

Jamin Ling *et. al.* [4] studied the coating of the pressure cooker, its reliability assessment of high lead material [TAB]. They developed ceramic lid after having 200 temperature cycles and 75 thermal shocks between temperatures between - 65°C to 150°C.

Rakesh Kumar Sandhir *et. al.* wrote to the editor of Burns, Great Britain [5] about accidental PC blow-out. They explained all working of PC considering maximum temperature i. e. up to 121° C and its effects on working woman/man. He wrote about safety precautionary measures in the accidental case due to choke-up of vent pipe & fusible plug. Mathur forced to follow manufacturing standards. This was the mild stone for the design of pressure cooker lid.

1.1.4 Aspects of PC:

Some researchers also dealt with the analysis of different parameters for solar. This analysis was very much useful for experimentation of pressure cooker because steaming, whirling and heat transfer takes place in a similar manner in all types of PC. So this gave same mathematical formulation and experimentation procedure except for the design of solar cooker.

S. Lakshmi *et. al.* did energy assessment under normal and controlled methods of cooking. Alfred Vischler introduced the first cooker designed for a home in 1938 [16]. He compared the performance of microwave oven also with our earlier studies on electric rice-cooker (ERC) and PC. Among the cooking appliances assessed, ERC was the most energy-efficient while microwave cooking offered the least cooking time (15–22 min). Microwave cooking was on par with pressure cooking in terms of energy consumption, besides, it offered shorter cooking time. This paper helped for determination of cooking time in PC. The same was analyzed for the performance and analysis of top burner by U. Makbool *et. al.* and focused on reported performances of the burners appears to be due to ad-hoc knowledge gained through trial and error of local manufacturers rather than scientific principles [17] and their final output was the PIV cooker top burner.

E.I. PARAU *et. al.* discussed pressure distribution on surfaces of PC. Tulin and Miloh used perturbation cross flow theory for pressure determination [18]. Characterization and design methods of solar cookers were given by Klemens Schwarzer *et. al.* They focused on characteristics [19] for safety operation to avoid burning and other risks with ease of handling. Different aspects of handling ways of PC were helpful in the design of PC.

Atul Sharma *et. al.* explained latent heat storage systems for solar cookers [20]. They investigated phase change materials for better performance as they are white in nature and having a melting point of 64.6°C.

Design and development were carried out by Deepak Maulikar *et. al.* for consideration of radiation phenomenon of solar PC. They described the design and development of MQUAD packing system [6]. The aluminum alloy had chosen for best heat dissipation, mechanical integrity, and lightweight construction. They compared the results with same results of copper and its alloy, aluminum and its alloy and molybdenum. Out of these, aluminum alloy 3003 is the best from thermal conductivity, light weight, low cost, good formability and strength point of view. MQUAD packing system is a high-performance reliable technology. Deepak Maulikar *et. al.* [7] had investigated that aluminum alloy was the best material for the lid of the PC.

D. A. Janes *et. al.* explained a metastable state in extrusion cooker. In their work, Robert and Guy in 1987 developed the die pressure cooker [9]. This paper was special for extrusion cooking. In this, pressure changes due to a reduction in the size of the die were explained. They used screw system for pumping to enhance pumping capacity of steam.

A.K BENAK and TURKMEN did modeling of hot box solar cooker at Istanbul Technical University [I.T.U.-2]. In thermal analysis, they used fourth-order Runge –Kutta method for the solution of differential equations used [10]. The results obtained had been compared with the experimental results by another pressure cooker. The probe of solarimeter for measuring a total intensity of radiations was mounted in the middle position of a pressure cooker as shown in figure 1.3. Fe-const. of 0.5 mm for measuring the temperatures during experimentation was used. This gave an idea of using whistle location and measuring of temperatures of modified PC in our thesis.

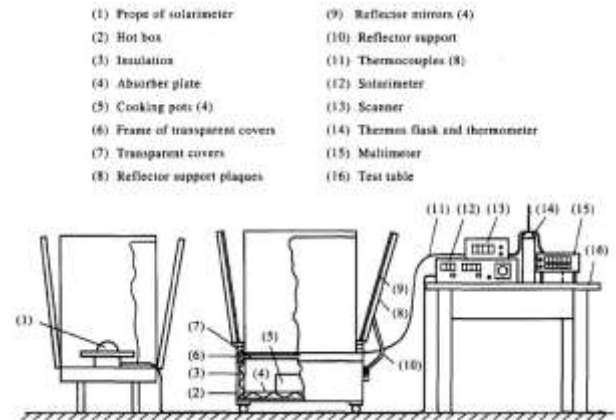


Fig. 1.3: Test Equipment

P. KARIKURI NYAHORO *et. al.* did simulated performance of thermal storage of same cooker [11]. Due to simulation, all the invisible difficulties arise in mind removed and obstacles on the way of PC were cleared. According to them, the dimension range of cooker system satisfied the conditions proposed by Churchill and Chu to calculate natural convection heat transfer as given in Nusselt No.

In the paper “Exergy Analysis of Solar Cylindrical -Parabolic Cooker” by Richard Petela [14] focused on input parameters i.e. geometrical, emissivity, heat transfer coefficient and temperature of water and air. From these design, parameters were cleared.

1.2. Literature Review on Heat and Mass transfer:

E.R.G.ECKERT *et. al.* made literature review on heat transfer in PC. They reviewed papers of various international conferences and finally concluded that heat transfer in PC depends on boundary layer, fluid types and compressibility [8]. The International Center for Heat and Mass Transfer was especially active in organizing meetings and Symposia. The Spacio-Temporal Structure and Chaos in Heat and Mass Transfer Processes were discussed in a symposium on 21-24 May in Athens, Greece. The 2nd International Conference on Advanced Computational Methods in Heat Transfer -was organized by the Wessex Institute of Technology at Milan, Italy on 7-10 July. Papers were published by Computational Mechanics Publications. The 28th National Heat Transfer Conference and Exhibition on 9-12 August in San Diego, California, discussed over the whole field of heat transfer and its applications in general and poster sessions, panel discussions, symposia, and open forum topics ranging. In 1992, Donald Q. Kern [59] Lecture was held by Hans K. Fauske on “Prevention and Mitigation of Hazardous Chemical Releases”. Likewise, the papers and proceeding of various international conferences and reputed journals like ASME had been reviewed. The papers were related to the conduction, boundary layer, heat transfer and experimental methods and devices. Some papers are very much useful for knowing the heat and mass transfer phenomenon in PC which suggest experimental methods and devices for heat transfer by radiation.

1.2.1 Design Philosophy:

O.V. Ekechukwu *et. al.*, in 2002, designed philosophy about measured performance of PC. During experimentation, they kept provision for 4 cooking vessel each having a capacity of holding water up to 1 kg and results were obtained at 138°C for one hour boiling. They introduced the features to enhance the performance and design of traditional cooker [12]. They focused on the parameters such as type, qthe uantity of food that is affecting cooking time in PC. Finally results obtained

between heating of water with respect to time as shown in figure 1.4. In this graph, they started to heat the water between temperature range starting 0° C to 110° C and step by step cooking time is calculated. This helps us for phethe nomenon of cooking time calculation.

S.D. Pohekar *et. al.* made a survey for policy formation for cooking energy substitution by PROMETHEE [13]. They ranked for different cooking alternatives on the basis of better performance type and time.

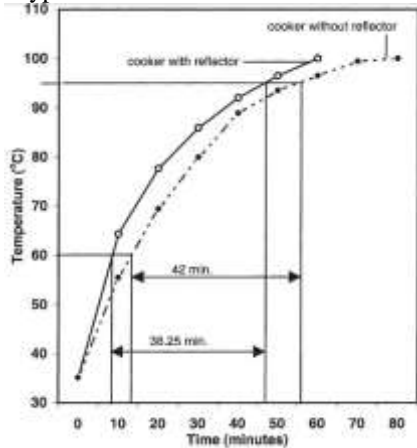


Fig. 1.4: Variation of water temperature with time

A. Z. Hafez *et. al.* [41] presented a review of the design parameters, mathematical techniques, and simulations used in the design of parabolic trough solar systems, along with a review of their applications. The mathematical models allowed the calculation of effects of different parameters of the solar parabolic through the system. Finally, the new parabolic solar collector had been designed.

A model of heat and mass transfer inside PC by Richard Rocca- Polimeni *et. al.* [21] focused on phenomenon such as conduction in solid, liquid and gas free convection undercooked and emitted steam using three periods i. e. above, regular and below pressures. He used foodstuff model PTFE cube for experimentations. Y.S. Wang *et. al.* predicted the acoustical properties of the pressure cooker and FVM-LES acoustic analogy method. The FVM-LES-AAM prediction technique showed promise as a feasible and computationally affordable approach for not only noise analysis of induction cookers but also for other aeroacoustics problems in engineering [22]. Accordingly, the acoustical properties of PCs, which influence people’s health, are very important. It is known that the noise of PC is not easy to predict and reduce due to the complex coupling characteristics of the thermodynamics, hydromechanics, and aeroacoustics of the flowing gas within it. Under the above parameters, acoustical design of PC was done.

In the conceptual design of PC, Paolo Cicconi *et. al.* [34] investigated support approach for a cooker hood. This paper also explains conceptual support for noise level. A validation activity had been described. CFD simulation and FEM solver were used along with analytical solver. This paper helped with FEM analysis. Using this approach, they formalized an architecture platform tool as shown in figure 1.5. The same was supported by energetic analysis for the parabolic shape of the vessel in the paper by Evengelos Bellows *et. al.*[35]. For which they developed a complete thermal model in EES (Engineering Equation Solver).

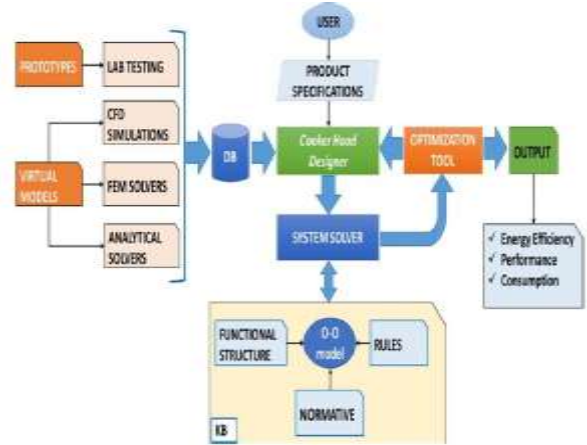


Fig. 1.5: Architecture Platform Tool

Also in 2010, Ishan Purohit presented and supported the results of using various test procedures for characterizing family size parabolic concentrator solar cooker, based on detailed experimental investigations [23].

Dr. H. P. Garg *et. al.* reported the design details and performance studies carried out on five different types of solar cookers that were fabricated and tested at the Central Arid Zone Research Institute, Jodhpur [45]. The study was undertaken to determine the cookers' potential usefulness. Two of them were of reflector type; two were of hot box type, and one as the flat-plate collector. Of these five cookers, the hot box type solar cooker (solar oven) showed the greatest promise due particularly to its efficiency, ease of operation, ease of construction with local techniques, material, and simplicity. Paraboloid solar cooker was extensively studied at the Central Arid Zone Research Institute, Jodhpur, India and by the Scientists of the National Physical Laboratory, New Delhi, India. The analysis showed that step reflector type solar cooker was limited to a small size because of their low resistance to strong winds. For fabrication, they require highly skilled technicians and a big workshop. Their performance, however, could be sufficiently improved by using a number of small size plain mirrors or reflecting metal strips arranged in such a way as to allow concentration of solar radiation in a small area. Based on this principle, a new step reflector for use as a cooker had been designed and tested by the authors of these five solar cookers. Out of these, solar oven showed the greatest promise particularly to its efficiency, ease of operation, and ease of construction with local technique, material, and simplicity.

Seyedreza Shafiei *et. al.* [38] investigated tsunami bore an impact on a cylindrical structure. The vertical and angular distributions of the applied pressure were measured using a vertical array of pressure sensors. The total stream-wise force was computed as a summation of the hydrostatic and hydrodynamic forces. A hydrodynamic coefficient of 0.65 was found to be appropriate for this study. The height of the Centre of the effort of the force on the cylinder surface was estimated by dividing the measured moment by the measured force and was found to be proportional to the actual water height at the front face of the cylinder. In experimentation, they considered steam wave impact like a tsunami by considering temperature location points as shown in figure 1.6. Bingyue Song *et. al.* [39] supported their study airwave impact on the wall by applying boundary conditions. Effects of the air pressure on the impact process with air entrapment were also studied where an analytical deduction based on the conservation law of conservation was used to explain the findings.

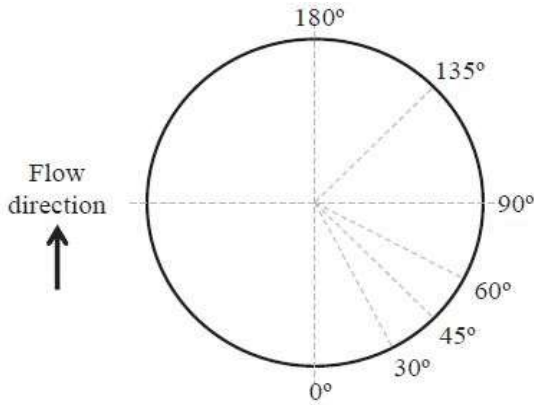


Fig. 1.6: Pressure points

1.2.2 Algorithms:

P. D. Darade *et. al.* have proposed the idea of vibration control with fuzzy logic control with Particle Swarm Optimization (PSO) algorithm [36]. The accuracy of the PSO was done by comparing the result with normalized value and with the Genetic Algorithm and had proved that proposed method produces the optimal result. Vibration in industrial equipment could be continuously monitored for unusual types of operating conditions and the resultant potential failures. In PC, the lid is also under stress and so testing must be done for vibrations by making use of same techniques. They suggested that the Fuzzy controller may be used as feedback control system for producing the control force to the system for stable operation. Here, the fuzzy logic controller operated the actuator which is connected with the system for controlling purpose. The fuzzy controller has the following steps for processing the feedback signal. The steps are Fuzzification, Inference, and Defuzzification. Figure 1.7 shows the fuzzy logic operation and Algorithm for the Fuzzy logic algorithm.

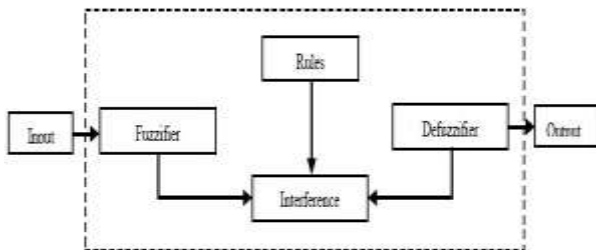


Fig. 1.7 Fuzzy Logic System

The logic operations are

- Define the linguistic variables and terms (initialization)
- Construct the membership functions (initialization)
- Construct the rule base (initialization)
- Convert crisp input data to fuzzy values using the membership functions (fuzzification)
- Evaluate the rules in the rule base (inference)
- Combine the results of each rule (inference)
- Convert the output data to non-fuzzy values (defuzzification)

1.3 Lid Literature Review

1.3.1 Renovation of PC:

The collection of heat and temperature decay in PC was studied by Abbu-Hussen in 1961. He focused on the design of dome shape for the collector and finally remarked about gain, loss and thermal insulation sustainability [1]. He developed a mold for high temperature.

SEB Sa France, in his patent [Patent number: WO/2011/083284, Publication date: 14 July 2011], designed

vertically depressible joint for PC. It had been developed to ensure that satisfactory sealing action was achieved against both lid and vessel, but it had sufficient flexibility to ensure the locking latches [24]. He also, in another patent [Patent numbers: WO/2011/077036 and WO/2011/077037, Publication date: 30 June 2011], developed a seal for the lid of a pressure cooker. Its design included a flange arrangement and a series of vents spaced around its circumference. The purpose of this structure was to provide an automatic vent. In addition, a way of ensuring that the seal should center relative to the vessel and the lid. This patent helped for design for flange arrangements and series of vents spaced around its circumference [25].

Diet is a subject of perennial interest and to the doctors and patients it oftentimes a means for rectification of many lapses for health. But after the proper selection of food, it is essential to see that it is suitably prepared and served in carrying out the hygienic management of tuberculosis, special attention for cooking is to be given. A scientific cooker of much practical value had been introduced under name of "PENTECON" [46] high-pressure Casserole Cooker i.e. the British agents for Messers, Philips and Proctor Ltd. Its general form is as shown in figure 1.8. It consists of enameled steel receptacle which was available in a variety of sizes and the lid which was firmly fixed so that when contained water is converted into steam it was kept under pressure. Whistles provide a signal for turning off gas or remove Pentecon from the fire. When cooking was completed, there was a safety valve to avoid suffering from too great internal steam pressure. All kinds of food could be economically and hygienically cooked in Pentecon within no time and no risk of burning or overcooking.



Fig. 1.8: PENTECON Cooker

Alfred Vischer *et. al.* [Patent No 2,904,212] studied Pressurized Vessel [47]. They have two types of pressure cooker i. e. inner lid and outer lid pressure cooker. For the inner lid PC, elliptical shape satisfied maximum technical expectation. By the invention of elliptical shape, they got patent from United States Patent Office on July 31, 1956. The warped shape of the lid is for whirling action of steam. This change in the shape of the cover is also affected by upward force to the cover, which when applied snaps the cover into its unwarped operative shape and into sealing a relationship with the seat on the rim of the vessel. This shape was widely accepted, but some had voiced objects to them on the ground that too much force is required to change the shape from warped to unwarped operative shape. This is not the difficulty of women. Even though this was minimized by making covers

from thin material. This was also objectionable because of resultant decrease in pressure which can be safely maintained inside the vessel. Contrariwise, if the cover is made of heavier material to withstand higher pressures, then cover become less flexible and harder to change from warped to unwarped operative shape. Finally, the suitable pressure sustainable lid was developed by them.

Von der Becke *et. al.* [Patent No 4,627,417] studied Steam Pressure Cooker [48]. This invention relates to a steam PC essentially consists of the circular lid. By the invention of elliptical shape, they got patent from United States Patent Office on Dec 9, 1986. Because of the circular lid shape, special locking attachment is to be made at the top of PC. A special logic and attention were to be needed while locking and unlocking of the lid of PC. This also caused the difficulty for women in the kitchen.

Monica Galleano *et. al.* had published a paper on understanding the Clausius - Clapeyron equation by employing an Easily Adaptable Pressure Cooker [49]. They gave the working of PC from locking to unlocking of the lid, how temperature and pressure changes took place, at what temperature boiling of water, steam formation, saturated and superheated steam took place and finally gave an extreme limit for temperature and pressure. Accordingly, steam formation between temperature 100°C to 130°C and pressure between 150 KPa to 170 KPa is best suited for cooking of food. The overpressure, they defined as 202KPa at which fusible plug melts. The verification of Clausius-Clapeyron equation was done for varying pressure and temperature in PC and when the lid is to be removed from the pressure vessel.

Denis Flick *et. al.* applied three dimensional CFD [50] approach inside PC. They observed experimentally the trends about steam flow inside PC. By simulation, they gave operating conditions and design during condensation. Richard Rocca-Poliment *et. al.* [51] supported the Denis article by publishing a paper on a model of heat and mass transfer inside a pressure cooker.

Moh Kenechukwu David [52] made literature research review on design and development of a Portable Kerosene Pressure Cooker. He studied gas cooker, alcohol stove kerosene stove, and their properties. Finally, he recommended that production of this cooker reduces costing affordable to Country Nigerian.

Tasgaonkar Chanashyam Shankar *et. al.* [53] filed a patent on the improved pressure cooker. They invented modified PC with a change in the main body, valve, flame patent and lose by convection and radiations from PC. Their invention told about thermal efficiency of the cooker, less consumption of fuel and reduction in cooking time. But this paper didn't focus on lid shapes of PC.

Loren Agrey published a paper on "The Pressure Cooker in Education" in the University of Alberta [54]. He remarked that PC is important utensil in every body's kitchen. He made a standardized assessment and marked the importance of PC in education. During the assessment, he noted very interesting points of cooking by PC.

In speedy human life, everybody has a minimum time for activities even cooking and eating also. This could be served by pressure cooker. So design the PC which could be operated even by an old woman to child, more than 10 years. But before operating, they must know the working and

precautionary measures to avoid accidents like burning or explosion.

An early pressure cooker, called a steam digester, was invented by Denis Papin, a French physicist in 1679. So Denis Papin is called as the father of pressure cooker. The idea of steam digester came into his mind when he was in his office without fans. Only the steaming action was going on and he felt like a cooking food. With the same conditions, the first pressure cooker i. e. steam digester birthed on the earth.

TORONTO also experienced the same conditions as like Denis Papin. He planned to make the dinner and invented another type of pressure cooker in the form of Canners. Large pressure cookers were often called pressure canners in the United States, due to their capacity to hold jars used in canning. The United States developed a version of a pressure cooker used for laboratories & hospitals to sterilize materials is known as an autoclave i.e. again pressure cooker.

Chavich, who lives in Calgary, said that pressure cooker takes one-third time to prepare a dish compared to other cooking methods. Finally, he thought over the design of PC. He started cooking food inside the pot having a flat lid on the top to trap the steam. Slowly he knew that steam was escaping from the gap. So he gave some shape to the lid. It showed not only good results about trapping but also steam circulating within the pot. But the same difficulty about escaping steam from gap was there. Due to a dome shape, the steam was trying to accumulate at the center point of the top plate and hence maximum pressure was at that point. This pressure was lifting the top plate and spilling food outside. Because of this burning of food was going on.

Chavich and TORONTO came together and developed locking system for the lid with pot. But yet, the problem of escaping of steam from gap was there. They suggested sealing ring i. e. now pressure cooker rings a remedy. But the difficulties had not finished. As the pressure inside pot was built up, the pot along with lid would throw away. This would cause a major accident. After long study, Chavich drilled a hole at the center of the top of the lid, but next problem was escaping of steam from the hole and no pressure was developed inside and so no cooking. Then he welded the tube to the hole of the lid to obtain streamline flow of steam and experimented about the increase of pressure by putting small weights at the opening of the hole. Certain pressure had been developed inside and at least 50% of cooking took place. After observations, he heard certain noise coming while escaping steam gap between weights and tip of the hole which whistled loudly. Here was the birth of whistle. He designed whistle according to development of pressure beneath the lid. There was also not the end of difficulties. Because of pieces of food and vegetable leaf, the hole blocked and again cooker jumped and even blasted due to excess pressure inside the cooker. This was very serious matter and slowly tackled by providing fusible plug in lid adjacent to vent pipe. Day by day popularity of this pressure cooker increased, as the cooked food from cooker was tested and hygienic. Yet the problems had not stopped because working women were required a special training for locking and unlocking. So the next innovation over these was inner lid pressure cooker.

1.3.2 Inner Lid Revolution:

Chavich and Toronto had started to invent the easiest way of locking and try to avoid complicated locking system. The first

step to that was to insert inner lid in pressure vessel pot easily. From leak-proof point of view, locking of the lid to pot and ease of operation, both had changed lid shape from circular to rectangular followed by a square, triangle, pentagon, hexagon and elliptical as shown in figure 1.9.



Fig. 1.9: Inner Lid Revolution

Charles Darwin supported the design of pressure cooker by his investigations not only for low-level altitude location but also for hilly regions.

In a literature review, the journey of innovation in inner lid started from circular to the elliptical inner lid. The discussion was made over the various shape and found certain merits and demerits. By overcoming the demerits, generation of new inner shape would be created. The details about these are discussed subsequently.

For the circular lid, maximum stress concentrations were at the periphery and hence special locking attachment was required. To overcome the difficulties of the circular lid, the alternative rectangular lid was introduced. But again lid had not only maximum stress concentration at corner, but also caused an accident by sharp corners. That lid also had difficulty in production of dome shape for whirling of steam within PC and special locking attachment was to be provided. Hence this lid was not up to the mark of the customer. Next alternative was the triangular lid; it had same disadvantages as like rectangular lid plus less heat transfer area. So it was not right solutions. Pentagonal and hexagonal lids had not only maximum stress concentration at sharp corners but also manufacturing difficulties of the dome and needed special locking arrangement. These lids were aesthetically good but sharp corners cause accident and leakage problem of steam if corners blended. So they didn't stand as an alternative against previous lids.

Hawkins invented elliptical new shape by overcoming remedies maintained by Chavich. He started his own company production by name "Hawkins' Pressure Cooker". After very long research survey, Hawkins gave elliptical shape to the inner lid to pressure cooker.

Now in the market, various inner lid pressure cookers are available. The different brands are Hawkins, Prestige and other local brands. But all are having an elliptical inner lid but variations only in the bottom pressure vessel. The working procedures for each of them are same. Hence the change in the lid will not disturb another pattern of inner lid PC.

The comparative details among the various inner lid shapes by considering merits and demerits have been elaborated in table no.1.1. The chart enhances to exhaustive literature survey to clarify all the queries in mind.

By throw literature survey, it was cleared that all modern pressure cookers are coming from places in France, Switzerland, Spain, and Italy. But nowadays Indian Pressure Cooker is the best alternative due to "Make In India" concept. It is clear that maximum innovation is made over inner lid shapes to enhance heat transfer, less cooking time and ease of handling for everyone.

Description	INNER LID SHAPE OF PRESSURE COOKER						
Inserting	Easy	Difficult	Difficult	Difficult	Difficult	Difficult	Easy
Locking	External	External But Difficult	External But Difficult	External But Difficult	External But Difficult	External But Difficult	External
Turn of Angle For locking	0°	30°-60°	60°	60°	60°-75°	60°-75°	90°
Pressure Ring Design	Easy	Difficult	Difficult	Difficult	Difficult	Difficult	Difficult
Availability of Material	Available	Available	Available	Available	Available	Available	Available
Manufacturing	Easy	Easy	Easy	Easy	Difficult	Difficult	Difficult
Construction of Dome Design	Easy	Difficult	Difficult	Difficult	Difficult	Difficult	Easy
Stress Concentration	Max. At Periphery	Max. At Corners	Max. At Corners	Max. At Corners	Max. At Corners	Max. At Corners	Max. At Periphery
Safety	Good	Bad	Bad	Bad	Bad	Bad	Good
Heat Transfer area	More	Less	Very Less	Very Less	Less	Less	Medium
Cooking Time	Less	More	More	More	More	More	Less
Aesthetic Look	Pleasant	Horrible	Good	Horrible	Horrible	Pleasant	Pleasant
Ease of Handling to Woman / Man	Easy	Uneasy	Easy	Uneasy	Uneasy	Uneasy	Easy
Efficiency	Good	Less	Less	Less	Less	Less	Good

Table 1.1: Comparisons between inner lids

2. CONCLUSION

After the exhaustive survey of pressure cooker focusing particularly on shapes of the inner lid, various merits and demerits of different shapes were arising. Some researchers focused on different parameters such as heat and mass transfer, cooking time and ease of handling of PC. Some researcher invented new PC as alternative energy saving source through a social survey. By literature review, we knew that different parameters used for solar, electrical cookers could be utilized for the design of PC. From all researchers, it is very clear that out of different shapes, the elliptical inner lid of pressure cooker gives best results in heat and mass transfer area, cooking time and ease of handling.

Since 1992 onwards, the elliptical inner lid is the favorite to industries and customers. Though the elliptical shape is better, it has also certain disadvantages such as locking and unlocking in particular directions, faster cooling of food, spilling out food during in and out of pots and burning to work woman /man. This lacuna of the elliptical inner lid of pressure cooker will be the new area for young researchers in future.

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