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Smokeless Chulha- Smart Wood Burning Cook Stove: A Review

Aniruddha R. Gomase[1], Harshavardhan R. Jawanjal[2]

[1]Student, Department of Mechanical Engineering, Siddhivinayak Technical Campus Shegaon, Maharashtra, India.
[2]Assistant Professor, Mechanical Engineering, Siddhivinayak Technical Campus Shegaon, Maharashtra, India.

Abstract – *In rural India many women spending several hours a day cooking over an indoor open stove is a normal practice. A design initiative can use its design expertise to help these women continue with their traditional culture, while empowering them to select a way of cooking that does not endanger their lives. It describes the brief and the open-innovation process used in creating the 'Chulha' (Stove) – a low-smoke stove that prevents sickness and death from indoor air pollution due to cooking activities with biomass fuels in rural low-income communities. Evaluation included a certification of stove's thermal performance, fuel consumption and carbon monoxide emissions. Stoves under testing used bio-organic waste. The firewood used as fuel was free from any potential pollutants. The design brief challenged team has to come up with a low-smoke solution for healthy and safe cooking able to fit the local socio-cultural and infrastructural conditions of rural and semi-urban areas.*

Key Words: (Stove1, Low smoke2, Fuel3, Firewood4)

1.INTRODUCTION

Smokeless Chulhas are commonly used in houses, canteens, hotels etc. for cooking purpose. These are gaining more popularity in rural and semi-urban areas where firewood is generally used as the fuel. Coconut husks, leaves, firewood, coconut shell, etc., which are easily available in rural and semi-urban areas can be economically used in houses, hotels etc., for cooking purposes. The main advantage of installing smokeless chulha is that it does not emit smoke in the kitchen and make the area smokeless unlike the conventional type country oven. The construction of the oven is such that the entire smoke generated while burning the fuel is taken through a pipe and discharged into the atmosphere at a higher level. Thus an air draft is created and it helps smooth burning of the fuel. The ovens are so designed that flames are not directed outside and thus more heat is absorbed by the vessel giving more fuel economy. Smokeless chulhas can be constructed in different models and sizes. The standard family unit is with 3 ovens, size 9", 8" and 7" diameters. A cast iron reducer plate is also supplied to accommodate smaller vessels. In this oven firing is made only in two ovens at a time. The third oven gets heat from the flame of these two ovens and it is normally used for warming water, food etc., only. Firing can be done and one oven also depending on the use. In such cases the passage to the unused oven should be closed by using the shutter supplied with the unit. The ovens which are not in use should be covered with the lid/cover. [13]

1.1 General Concept

Clean Energy use and human development are closely linked. Access to and affordability of clean energy results in better quality of life. More specifically, biomass use for cooking leads to health hazard from inhaling smoke and drudgery from fetching the fuel. State Government and at Central level have formulated numerous programs for ensuring use of clean fuel for cooking. Unfortunately, in spite of technological progress, the use of smokeless chulha has not been up to expectation because of organizational and social factors. [2]

1.2 Cooking energy technology options:

Technology used for Cooking
1. Traditional stone stove
2. Kerosene Stove
3. Sampad Gasifier Stove
4. Smokeless Chulha
5. Gas Cooking Stove

Fig -1: Various types of cooking technology

1.3 Problems with traditional chulha:

1.3.1. Smoke:

- Every year 5,00,000 women and children die in India due to long term exposure to smoke in ruler kitchens.
- Eye problems.
- Lung problems.

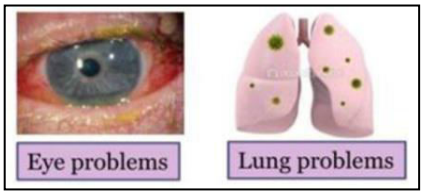


Fig -2: Smoke effect on Eye and Lung

1.3.2. Time and Money:

- Women and children have to spend time collecting wood.
- Women could be earning money and children could be at school.
- The cost of wood is going up in urban areas.
- This means less money to spend on food, education, and medical care. An improved cooking stove can help boost a family income.

1.3.3. Deforestation:

- Quality of the land will decrease.
- Flooding may increase.
- Reduced quality of air.
- Runoff in increased so ground water recharge is minimized.
- The main goal of most improved cooking stoves is to reduced amount of wood the stoves consume. [16]

1.4. Specification of Smokeless chulha:

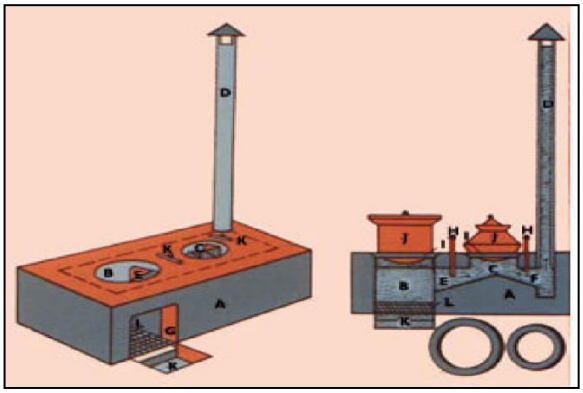


Fig -3: Specification of Smokeless Chulha

Table-1: Diagram details

Notation	Specification
A	It traps smoke and heat inside.
B	Pot number one 80% of heat cooking.
C	Pot number two 20% of heat keeping food warm.
D	Vents smoke out of room with a chimney.
E	Vent lid to stop rain and animals entering.

1.4.1 Specification for construction of Smokeless chulha:

Foundational clay slab measuring 75cm x 40cm x 22cm. First oven (hole for cooking) measuring 20 cm in diameter and 20cm in depth. Second oven measuring 17.5cm in diameter and 10cm in depth. Smoke outlet pipe 7.5cm in diameter and 2 meters in length. Flame passage tunnel 13cm x 6cm (height) connecting first oven to second oven. Smoke passage tunnel from second oven to pipe 7.5cm x 5cm. Hole for placement of firewood to be burned 18 cm x 18 cm. Damper for controlling flames between ovens. Steel rings for placing different sized pots and pans on ovens. Ash pit 22cm x 15cm x 7.5cm - Steel grating for ventilation. [14]

2. LITERATURE REVIEW

Rekha Singh Sci (2018) In this paper study of some ruler areas in Bhadohi district, the farm women are using traditional chulha for cooking food. The tradition chulha produces high carbon emission which causes indoor air pollution and health problem in farm women of 45 plus age. The study was conducted through OFT (Office of Fair Trading) by Krishi Vigyan Kendra, Bhadohi during 2016-2017. After the training program the gain in knowledge was increased by 66.67% to 83.33). In post evaluation study it was observed that 100% of the beneficiaries accepted that the smokeless chulha was very fuel efficient. [1]

Mahesh V. Rawlani January (2017) in the remote areas traditional chulhas are used for cooking purpose which uses wood as a fuel. Use of this kind traditional Chulhas causes indoor pollution, ineffective utilization of fuel also takes more time for cooking. But our low smoke Multipurpose Chulha overcome all these problems also increase heat utilization for the same mass of the fuel as compare to traditional chulha. In short we are trying to accelerate, Eco friendly cooking, and Healthy cooking. Rural entrepreneurship, multipurpose, fuel effective and efficient cooking. [2]

Shiv Sankar Das, Haribandhu Panda July 2017 Demand for clean energy is directly proportional to the economic development (UNDP, 2001). In increasing awareness of the harmful effect of fossil fuels on environment and consequently quality of life of people, both Government and households are looking ensuring availability of reliable clean energy. Few studies conducted in India concerning the cook stoves situation have highlighted the detrimental impact it has had on households, particularly women who are exposed to high level of smoke. [3]

Meena Khandelwal (2016) In this paper An estimated 2.7 billion people cook meals on biomass-fueled brick, stone, and clay stoves. Scarcity of wood and negative impacts on health and environment have motivated efforts to design and distribute “improved” cook-stoves in developing countries in India. By using smokeless chulha the drudgery was reduced conventional method. If farm women are healthy then their children will progress and other family members will leave a positive life. [4]

Manoj Kumar Sharma, R.N. Shrivastava, Nikita Sharma (2015) The National Program on Improved Cook stoves (NPIC) was implemented through involvement of various State Nodal Departments/ Agencies in almost all the States and Union Territories. The technical training support program was provided by 22 Technical Back-up Support Units (TBSUs), set up under the NPIC at different universities, IITs and other institutions of the country. More than 60 fixed and portable models of improved

Chulha, with and without chimney, single-pot and multi-pot, suitable for different fuels, cooking habits and local requirements and using different materials of construction were developed and taken up for installation under NPIC.[5]

Dr. Indira Bishnoi April,(2013) The study also shows that Solar Lanterns and Smokeless Chulhas are beneficial for rural households. The whole family could make use of the time from 6.00pm to 10.00pm and early morning 4.00am to 5.30am. The children who could not study earlier during the night were very happy with this. While the children studied, their parents did their household or other work. It saved money that had been used on between 4 and 8 liters of kerosene per family per month. The consumption of wood decreased 30% roughly and time spent on cooking was also saved by 30 to 35%. [6]

Sayanika Borah January, (2012) In this paper the study was undertaken with an objective to identify the problems of respondents in practicing the technologies dissemination through Home Science extension programmes. The respondents of the present study were rural women from adopted villages of Department of Extension Education, Faculty of Home Science, Assam Agricultural University, Jorhat selected purposively. The data were collected through a structured interview schedule prepared by the researcher. [7]

Vijaykumar Palled April (2012) in this paper An ORP demonstration was carried out in selected villages of Raichur district to evaluate and demonstrate the technical soundness of improved cook stoves of Udairaj model for adoption by the rural women. The performance of the improved cook stoves was evaluated in terms of thermal efficiency and power output rating. The results indicated that, the thermal efficiency of double pot improved cook stove of Udairaj model varied from 24 – 26 per cent as compared to that of 10 - 12 per cent for traditional chulha, while the power output rating of these chulhas was 1.42 and 0.98 kW, respectively. [8]

Gireesh Shrimali 14 July (2011) Burning of biomass in traditional stoves is associated with a host of ills among the estimated 2.5 billion people around the world that do not have access to modern fuels (IEA, 2009). Indoor air pollution (IAP) from traditional biomass burning contributes to serious health problems, particularly cancer and respiratory infections that cause an estimated 1.6 million premature deaths annually (Naeher etal.,2007; Smith, 2006; WHO, 2006).With use of smokeless cook stove its protect human health. [9]

R.D. Hanbar and Priyadarshini Karve. June, (2002) The National Program on Improved Chulha (NPIC) in India was a unique program aimed at popularising the use of improved cooking devices in rural areas. India's heavy dependence on wood and biomass as domestic fuel is expected to continue even in the present century. However, from April 2002, the Ministry of Non-conventional Energy Sources has discontinued its funding support to NPIC. The present paper attempts to make a critical appraisal of the program. NPIC concentrated mainly on development of a variety of efficient stove models, and their promotion and popularization. [10]

Roy et al. (1992) have reported that, out of the 150 initial adopters of smokeless chulha, only 30 per cent continued its full or partial use. Fifty four per cent had rejected the technology within one year from the date of installation. [11]

Gusain (1990) maintains that smokeless chulha can easily be made to burn biomass fuels with efficiencies in the range of 20 to 30 per cent in the laboratory and 15 to 25 per cent in the field. Iyer's study (1985) shows the heat efficiency of a traditional chulha as 10 per cent as against 100 per cent for a smokeless chulha. ASTRA chulha, which is a three pot mud stove, has a Percentage Heat Utilization of 40- in laboratory conditions. But in the field, this stove showed the average fuel saving as only 19 percent and in certain regions, a negative saving. [11]

Prasad (1985) has defined performance of a chuiha as a collective term for the power output of the fire, the range of power output, efficiency, the ease of starting, reduction in tar formation, ease of maintenance and life expectancy. Performance testing of biomass stoves is done to determine their thermal efficiency and emission levels. [11]

3. WORKING

The smokeless chulha still burns wood like the traditional chulha. However, the closed design of the smokeless chulha uses the heat from the burning wood more efficiently and diverts the carcinogenic fumes out through an overhead cement pipe - away from the individual cooking. It is still requires burning wood and therefore it is not the ideal choice. There is still some indoor air pollution, it does not stem the degradation of forest lands and it is more expensive on a day-to-day basis the cost of LPG.

However, the initial investment required to build the smokeless chulha is roughly Rs. 850, something much more accessible to most poor families than Rs. 5,000 to purchase the necessary equipment for the gas stove. The smokeless chulha is a technology that has been in use and available for many years and is being used throughout various parts of Asia and Africa. This type of chulha, shown in Fig- 4, is designed with closed walls on all four sides and two top open holes for cooking. A cement pipe affixed to a corner edge is a key feature that diverts the smoke up and away from the individuals cooking.

3.1 Principle of Working:

Figure shows the constructional details of Smokeless Chulha,

Firewood placed at a first pot hole size is 18cm x 18cm. Whenever it is required some external source to burn firewood and start burning process of firewood. Hence heat distributed under first pot into better contact of pot with

the heat. It is help to reduce time of boiling or other heating purpose, it also called as 'Bypass Duct'.

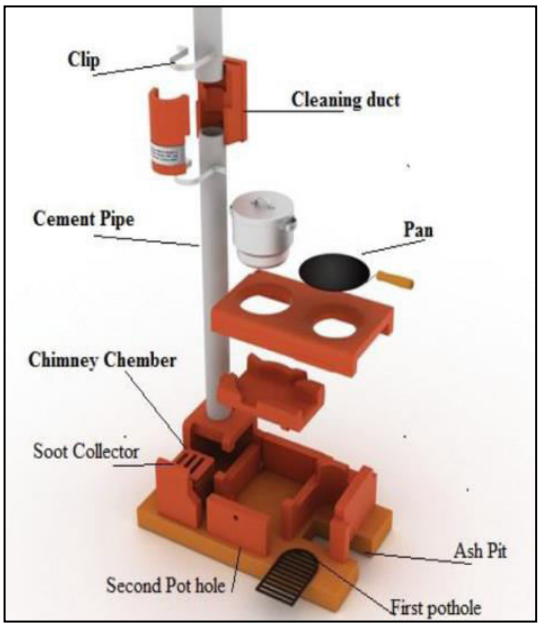


Fig -4: Schematic view of Smokeless Chulha

Another second pot hole is bellow the portion of 'Main tunnel' and 'Bypass tunnel' Also second pot hole depend upon first pot hole but difference is that it is store some amount of heat in it due to curve shape and transfer to required purpose. The purpose of main tunnel and bypass tunnel to reduce percentage of smoke and generate maximum heat at low firewood. Then exhaust air is transfer to the soot collector and chimney chamber. In soot collector up to six plate are placed, plate are vary with size and shape of chulha. Material use for soot collector is clay; on the collector plate alternating vent are placed. When exhaust air is passes through alternating vent it reduced smoke in air with the help of shape of soot collator.

Finally exhaust air is collected in Chimney chamber at the top of chamber cement pipe are fixed; that can be collected all smoke produced in chulha. Then smoke is transfer to atmosphere. [15]

3.2 Major Components:

Following are the main working components of smokeless chulha,

3.2.1 Bypass Duct For Efficient Draft:

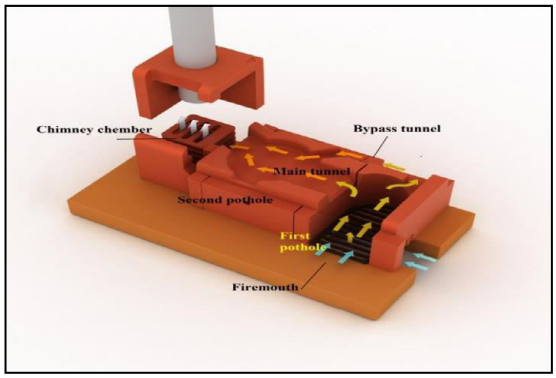


Fig -4: Bypass duct for efficient draft

It ensures even heat distribution and right turbulence under the first pot resulting into better contact of pot with the heat and hence faster and even boiling. It shows that this helps bring down the boiling time by 3minutes > Standard stove boils between about 22 minutes, our previous design (without bypass) 13-14 minutes. This arrangement helps bring the time to boil to 10-11 minutes. [15]

3.2.2 Chimney connector for easy cleaning and installation:

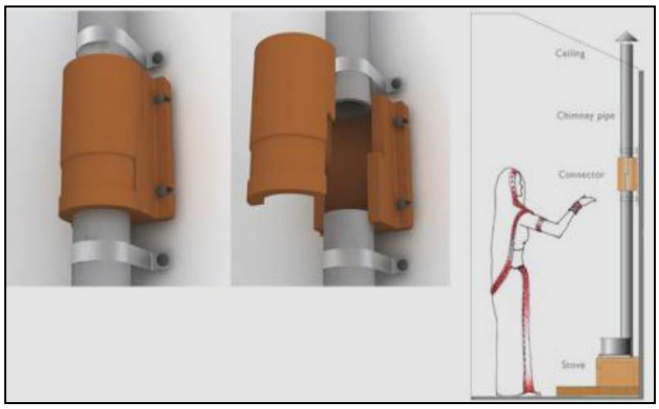


Fig -5: Chimney connector for easy cleaning and installation

Conventional chimney needed to be cleaned from out-side (from roof top). Earlier chimney design was splitting chimney in 3 parts. This created an issue of soot falling on the wall and surrounding from the fixed piece during cleaning. This solution moves the joint up so that the top part of the pipe – connected to the roof - is smaller and the fixed pipe – connected to the chimney - is longer. The connection in-between holds the pipes and when from cover is opened can help cleaning the fixed part- ensuring all the soot falls in the chulha. [15]

3.2.3 Soot collector:

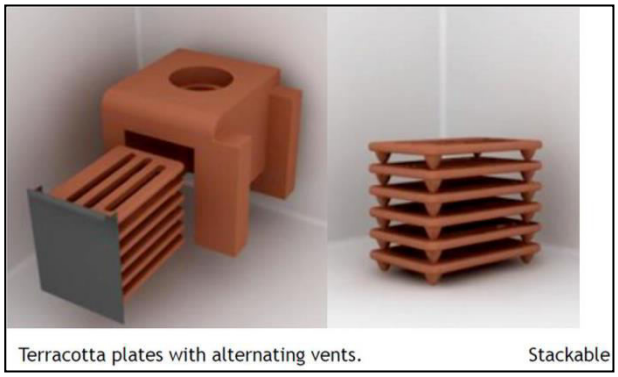


Fig -6: Scoot collector

Soot particles when cooled condense and stick to any surface. This is why one gets a lot of soot on the chimney pipe and the pipe tends to get clogged. Cleaning chimney pipe is a task as one needs to climb on the roof to clean the pipe or dismantle it partly or fully. Soot can be collected by passing the gases through a zig-zag path in the chimney chamber at the stove level. This path built as a separate assembly can be removed and scrubbed to clean the soot. As soot is collected at the earlier point the frequency of cleaning chimney is reduced.

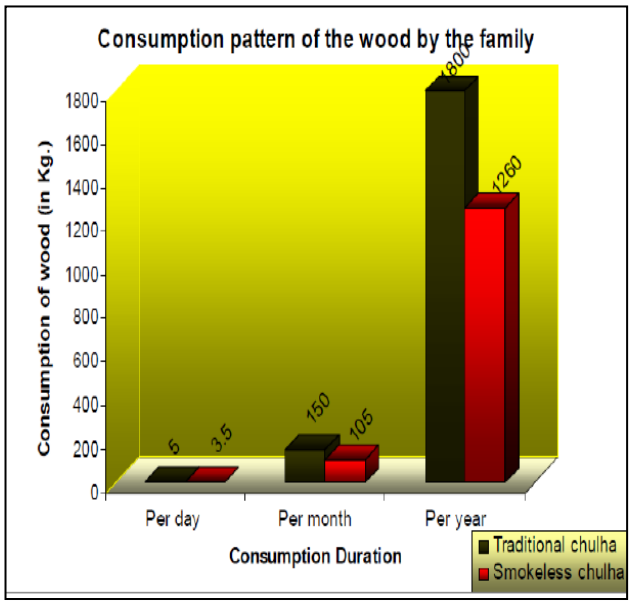
3.3. Impact of Smokeless Chulha on Respondents

3.3.1 Consumption pattern of wood by families:

Table -2: Consumption of wood by family:

Sr.No.	Categories	Traditional chulha	Smokeless chulha
1	Per day	5	3.5
2	Per month	150	150
3	Per year	1800	1260
	Total	**1955 Kg**	**1368.5 Kg**

The above table 2 reveals that after using smokeless chulha there is a slight change in the consumption of wood by each family per day, per month and per year. (In Kg) [6]



Graph. 1 Comparative consumption pattern of wood (per year) in Traditional Chulhas and Smokeless Chulhas

3.3.2 Utility and Advantages of Smokeless Chulhas

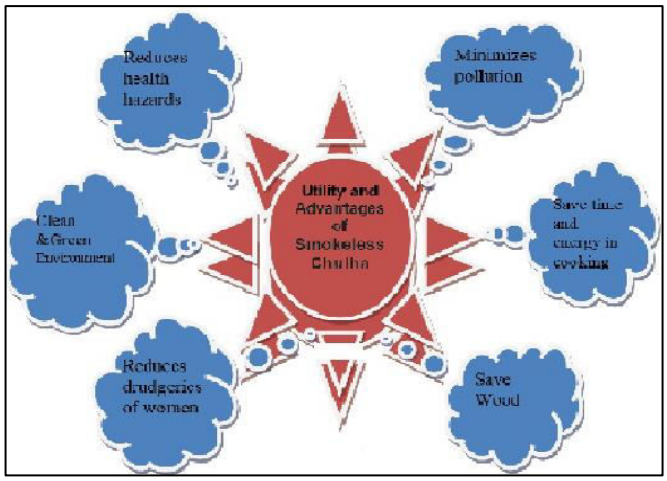


Fig -7: Utility and Advantages of smokeless chulha.

3.3.3 Impact of Smokeless Chulhas on Respondents:

It increases the efficiency and productive hours of respondents; it reduces their drudgery and health hazards. It also provides a clean and green environment free from smoke and saves wood as well as kerosene. [6]

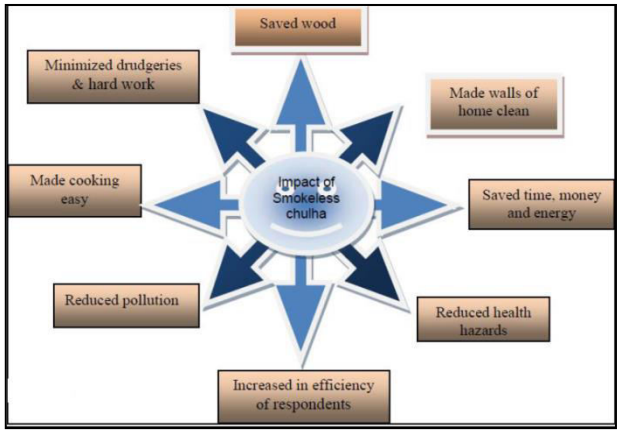


Fig -8: Impact of smokeless chulhas on respondent

3.3.4 Estimation:

Table -3: Estimation of smokeless chulha [14]

Material	**Quantity**	**Approx. Cost Per Unit (Rs.)**	**Approx Total Cost (Rs.)**	**Purchased From**
Iron Grill	1	100	100	Selected material store
Bricks	25	4 per brick	100	Local Store
Cement	15	10 per Kg	150	Local Store
Sand	8 pans	10 per pan	80	Local Store
Small pebbles	2 pans	10 per pan	20	Local Store
Cement pipe and cap	1	200	200	Selected material store
Labor Charges	---	200 per chulha	200	---
Total Cost			**Rs.850/- to 1000/-**	

4. ADVANTAGE

1. Improved Thermal Efficiency
2. Reduction in Cooking Time (cooking with two stoves.)
3. More trees saved means improved environment and reduced pollution.

4. Improved chulha uses less firewood which means less carbon dioxide emission.
5. Diversion of smoke away from cooking area. Multiple health benefits including.
6. Prevention of injuries to eye, lungs, minimal inhalation of carcinogenic fumes.

5. LIMITION

1. Required fully dry firewood.
2. Firewood cut as per Size and shape.
3. When chulha at working condition; produced heat that can be working area is heated.

6. APPLICATION

1. House hold application like as cooking purpose, boiling of water.
2. Commercial purpose like as hotels, canteens.

7. CONCLUSION

In this manner, we have studied the concept of smokeless chulha and also the various terms related to it. During the study we briefly discussed about the various types of technology used for cooking. On forth, we observed the various parameters affecting the performance predominantly. In the end we gathered and proposed various ways which had proved to be beneficial in improving working performance of modern smokeless chulha.

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