RESEARCH PAPER

Design, Development and Performance Evaluation of ICAR-CIRCOT Briquette Based Crematorium

S. K. SHUKLA[1*], V. G. ARUDE[2], P. G. PATIL[3], A. S. M. RAJA[1],
A. K. BHARIMALLA[2] and D.U. PATIL[4]

[1]Principal Scientist, [2]Senior Scientist, [3]Director, [4]Chief Technical Officer
ICAR-Central Institute for Research on Cotton Technology, Mumbai - 400 019, INDIA.

Abstract

In this work, a briquette-based crematorium, as an alternative to the firewood cremation process has been designed, developed and extensively evaluated at a crematorium site. The two types of crematoriums having a rectangular and a trapezoidal shaped cage were designed and developed and compared with the traditional firewood cremation process. An electrically operated centrifugal fan was used to supply the forced air draft at the bottom and two long sides of the crematorium. The trapezoidal shaped crematorium was found to be optimum shape requiring 200 kg briquettes and 3-4 h duration for complete cremation of a dead body. The developed innovative crematorium has been found to be very efficient in cremation and is environment friendly. All social customs like mukhagni, kapakriya, etc. can be performed easily in the developed crematorium. The use of forced air draft system not only brings down emissions and smoke formations to very low level but also reduces the requirement of camphor, kerosene/diesel and ghee needed for fire initiation to almost zero. Due to supply of adequate air for combustion, the temperature was found to go as high as about 1000^{0}C within 30 min of igniting fire. Thus, briquettes burnt efficiently and effectively during entire cremation process resulting into smokeless, foul smell free cremation. The promotion of briquettes for cremation would result in value addition to biomasses, specially cotton stalks readily available in India leading to increase in farm income and employment generation in rural areas.

Keywords : Cotton Stalk Briquette, Design, Crematorium, Forced Draft Aeration, Energy Saving, Environment Friendly, Biomass Use

[Paper Received on 22/10/2018 and Accepted on 19/11/2018]

---

*For Correspondence : E-mail : skshulka2000@gmail.com

Introduction

Wood based cremation is an ancient rite and practice in Hinduism since evolution of human civilization on the motherland earth (Kashyap and Kesari 2014; Arnold, 2017). Traditional cremation requires about 350 kg firewood and substantial amount of ghee as 1 kg, 5 litres kerosene and 2 kg camphor per body. The firewood equivalent to 25-30 lakh fully grown trees is burnt annually in India for about 75 lakh cremations contributing to deforestation and global warming (Dube and Rawat, 2013). Mostly, the traditional cremations are performed in open spaces, hence, the oxygen supply needed for firewood combustion is naturally drawn from the environment. Many a time, mostly due to low wind velocity, the availability of oxygen supply is insufficient for fuel combustion resulting into slow cremation process and incomplete burning, which results in black thick smoke formation and discharge of a large amount of hazardous air pollutants like CO, CO_2, NOx, Volatile Organic Compounds (VOA), etc. during cremation process (Dube and Rawat, 2005). In addition, the uses of kerosene for fire initiation also leads to emission of a large quantity of air pollutants and smoke formation. Mostly during rainy seasons, due to scarcity of dry firewood, wet firewood is utilised during cremations leading to improper combustion and loss of significant amount of heat energy in steam formation. Hence, the time and fuel requirements in traditional firewood cremation using wet firewood is increased significantly. Also, the wet firewood burning increases air pollution as its burning produces much more smoke, releases more pollutants and release of small dust particles into the air as compared to dry wood burning.

Crematoriums using electrical, diesel, gas, etc. energy as fuel have also been attempted as alternatives to wood-based cremations at several places in India. The closed chamber designs of these crematoriums do not allow performing traditional rituals like mukhangi and kapalkriya as mentioned in religious scriptures. Since, the last rites of a loved one is understandably a very sentimental issue, these non-traditional cremations are not much accepted by the society at large resulting in continuous uses of firewood for cremation of dead bodies even in the 21st century in India. Now a days, with greater emphasis on renewable energy, biomass briquettes have been extensively used as alternative to coal for firing of boilers and generation of heats in many industries (Dube and Rawat, 2013). Briquettes are homogeneous, uniformly sized solid pieces of high bulk density produced by densification of agro-residues. The softening of lignin due to generation of heat and its subsequent cooling during briquetting process causes natural binding of particles of cotton biomass into briquettes. The biomass briquette contains very little amount of moisture i.e. <8%, hence, it burns very efficiently and almost completely, resulting in fewer pollutants to escape into environment. Though, most of agro-residues can be converted into briquettes, which can be effectively used as fuel, the cotton stalk briquettes are preferred in many industries as boiler fuel due to its high bulk density, calorific values and less ash content. It is estimated that about 25 million tonnes of cotton stalk is generated every year in India. Most of the stalk produced is treated as waste though a part of it is used as fuel by rural masses. Hence, the promotion of cotton stalk briquettes as alternative to firewood has potential to increase farm income and promote rural industrialisation.

Many local bodies attempted to use biomass briquettes as fuel for cremation of dead bodies in the traditional open crematoriums. However, it leads to large amount of smoke formation, discharge of pollutants, incomplete burning of dead bodies, increase in cremation duration, etc. It is primarily due to reason that the haphazardly oriented densely packed fine particles of briquettes do not allow air to percolate inside of briquettes unlike firewood combustion due to structured orientation of particles in firewood. When the methods and techniques, which are being successfully employed in industries for briquette firing in boilers studied, it was found that were provisions made to supply forced air draft in furnaces to cope up the additional air supply needed for proper and complete burning of briquettes. Hence, it was realized that a forced draft system would be needed for briquettes to be successfully used as accepted solid fuels alternative to firewood for cremation of dead bodies.

The present study deals with design, development and performance evaluation of a crematorium having provision of supply of forced draft of air for efficient, smoke less and rapid burning of dead bodies using densified renewable biomass briquettes as fuel. In this study, two designs of crematoriums were developed and evaluated at large scale at a cremation centre.

Materials and Methods

The designed and developed ICAR-CIRCOT crematorium consists of a metallic cage, a forced air draft system to supply air during cremation process, perforated air pipes for distribution of forced air to the bottom and two sides of the combustion chamber, moveable stands for loading of briquettes, etc. as shown in **Fig. 1.** In this work, a rectangular and trapezoidal shape cages were designed and developed to optimise the cage shape. The length, width and depth of the rectangular cage was 2250x975x1200 mm, respectively while the trapezoidal cage had 700x450 mm bases. The length and height of the trapezoidal shape cage were 2000 and 1370 mm, respectively. In the trapezoidal shape the quantity of briquettes coming into contact of the body is rationalized according to heat requirement for burning of different body parts (the lower body parts require lesser heat for burning as compared to upper body part). This design was chosen also to reduce the quantity of briquettes burning outside the body parts.

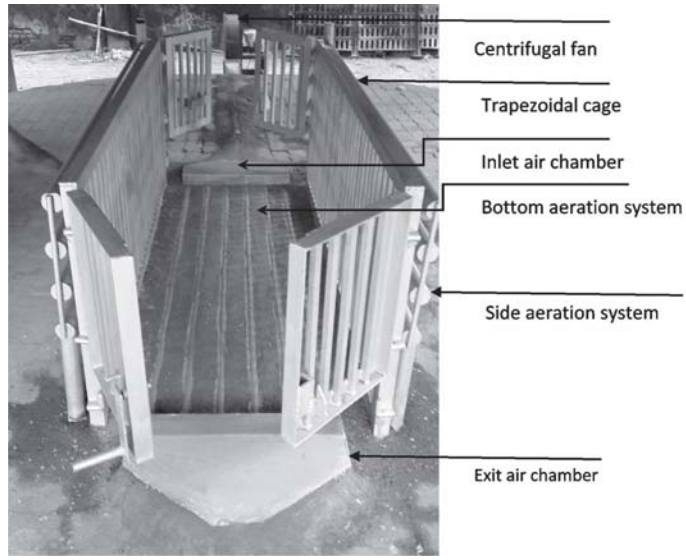

Fig.1. ICAR-CIRCOT briquette-based crematorium

An electrically operated centrifugal fan of 150 mm WGP and 1000 CFM was used to supply air to the forced air draft system provided in the present invention. Single phase 1.5 kW electric motor was required to operate the fan. The air supplied by the fan was distributed to the bottom aeration system through an inlet air chamber and the exit air chamber was used to release the pressure on fan through the specially designed exit valve. As depicted in **Fig. 1,** there were also two side aeration systems, which were connected to the inlet air chamber, these systems supply air to both sides of the designed crematorium. The amount of air passing through the side aeration systems could also be controlled by the exit valve. The bottom and side aeration systems consist of specially arranged pipes with minute apertures on the body of pipes for supply of air during cremation. A metallic moveable platform was designed and developed for placing the briquettes and body for cremation. The front and back doors provide access to the crematorium for placing of briquettes and removal of ashes and body remains. In addition, the rituals can also be performed through these doors. The line diagrams for supply of forced air draft to the developed crematorium is given in **Fig. 2.**

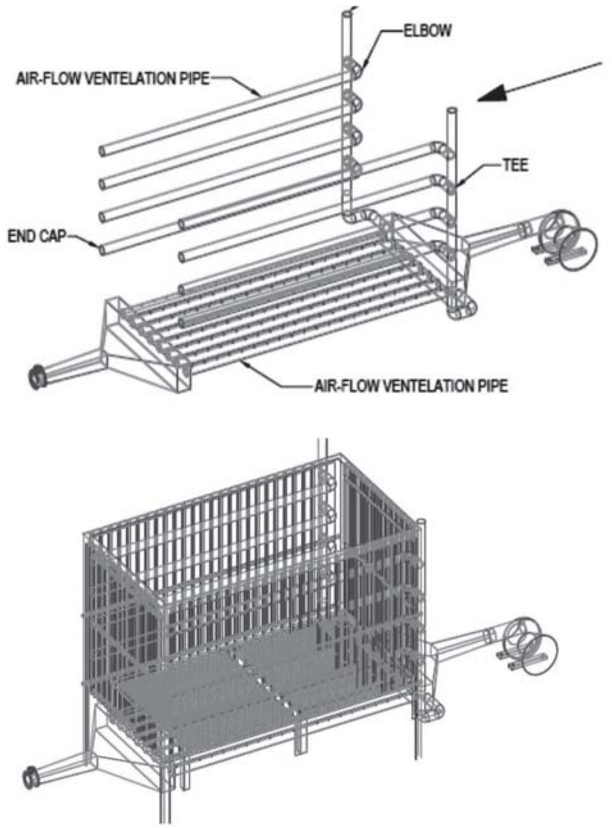

Fig. 2: Line diagram for supply of forced draft air in the crematorium

Fig. 3: ICAR CIRCOT rectangular shape (top) and trapezoidal shape (bottom) crematoriums in operation at Ambazari Ghat, NMC, Nagpur

The developed set up was installed at Ambazari Crematorium, Nagpur Municipal Corporation (NMC), Nagpur **(Fig. 3).** The cotton stalk briquettes having about 1200 kg/m^3 density, 5-6% ash content and 4000 kcal/kg were used as solid fuel. First, two layers of briquettes weighing about 140 kg was laid over the moveable platform. Thereafter, the dead body is to be placed over the laid briquettes. Further, 70 kg briquettes were laid over the body in one layer. Finally, 1 kg ghee was sprinkled over the pyre as traditional practice and the fire was ignited using 0.5 kg camphor. The air supply system was started 5-8 min after the pyre was lit.

The temperature generated and time required at different stages of burning was recorded. In addition, the problems experienced during the trials were also observed. The fan was operated/switched off as per cremation requirement. Crematoriums with both type of cages and traditional firewood cremation process were evaluated at this crematorium centre. The performances of rectangular and trapezoidal cages were compared with a traditional firewood cremation process. A number of cremations were performed to optimize the refined Crematorium. During trials, the quantity of briquettes laid at the bottom and side of body, time of operation of exhaust fan, amount of ghee and camphor, etc. were varied to optimize the crematorium and the cremation process.

Results and Discussion

Extensive trials were conducted to assess the comparative performances of the developed crematoriums and a traditional firewood-based cremation process. **Table 1** presents the comparative performances of the developed rectangular and trapezoidal shaped crematoriums with traditional firewood cremation process for two cases, in first case the air supply fan was after 30 min of operation and in the second case the fan was stopped 2 h after operation. It can be seen from this table that the trapezoidal shaped crematorium required least quantity of briquettes and least duration for cremation among all trials. It is mainly due to reason that in the rectangular shaped crematorium, the briquettes were laid uniformly in the entire rectangular cage, hence, it provided equal amount of heat energy to the entire body parts starting from head to leg. It was observed during trials that the hard and thick body parts like head, chest, stomach, etc. required higher quantity of briquettes as compared to the lower body parts. The briquettes were kept on burning towards the lower body parts even after the cremation was completed in this area whereas there were shortages of briquettes towards the upper body parts. This problem was addressed in trapezoidal shaped crematorium wherein the briquettes were laid/distributed as per the heat requirements of the body i.e. higher quantity of briquettes towards upper body parts and lesser quantity of briquettes towards lower body parts.

It can be also seen from **Table 1** that quantity of briquette requirement was lower when the fan was stopped after 30 min of fire ignition for both rectangular and trapezoidal shaped crematoriums. It is mainly due to reason that the soft body parts burnt easily within 2 h of cremation process but hard body parts specially stomach are which contains a large amount of fluids exhumes slowly and required about 4 h duration in complete cremation. If the fan was operational for more than 30 min, the supply of air causes briquettes to burn faster than required for cremation of hard body parts, which burn slowly, hence, needs a slower heat energy supply. The maximum temperature obtained in case of the ICAR-CIRCOT crematoriums was 950^0C in less than 30 min while 850^0C maximum temperature was obtained in 1 h duration in the traditional firewood cremation process mainly due to shortage of oxygen supply needed for combustion process. It can be seen from the **Table 1** that the trapezoidal shaped crematorium with 30 min air supply requires about 200 kg briquettes and 3-4 h duration for a cremation and it saves about 59% expenditure on cremation and 20 lakh tonnes emissions due to complete avoidance of the requirement of kerosene/diesel for fire initiation.

Table 2 represents the environmental and economic benefits accrued due to promotion of cotton stalk briquettes for cremation process. There is a large quantity of cotton stalks available in India, it is mostly burnt in field s causing environmental pollution and soil degradation. There are about 70 lakh bodies cremated each year in India using firewood. If the cotton stalk briquettes are used as solid fuel for cremation process it would lead to saving of substantial amount of fossil fuels needed for fire initiation purpose in traditional crematorium, saving of trees and significant increase in farm income and generation of employments, specially in rural areas as mentioned in **Table 2.**

Conclusions

This work deals with the design, development and performance evaluation of a briquette-based crematorium to provide as an alternative to the traditional firewood cremation. In this work, a rectangular and a trapezoidal shaped cage crematorium were designed and developed and compared with the traditional firewood cremation process. In the developed crematorium, arrangement was provided to supply the forced air draft at the bottom and two long sides of the crematorium using a centrifugal fan for proper combustion of briquettes. The salient findings of this work are mentioned as below :

- It is possible to perform all traditional rituals, hence, the adoptability of is extremely good and bright.
- It requires 200 kg briquettes and 3-4 h duration for complete cremation of a dead body as against 350 kg of fire wood and 5-6 h duration in traditional cremations.
- Traditional fire wood cremation requires 1 kg camphor, 2 kg ghee and 5 lit of kerosene. However, ICAR-CIRCOT crematorium requires only half kg camphor and 1 kg ghee and does not require kerosene.

Table 1 : Comparative Performance Evaluation of the Developed Crematoriums and Traditional Firewood Cremation Process

Item/particulars	Traditional Firewood Cremation	ICAR-CIRCOT Green Cremation			
		Rectangular shape cage		Trapezoidal shape cage	
		Fan Operation: 2h	Fan Operation: 30 min	Fan Operation: 2h	Fan Operation: 30 min
Cremation Fuel	350 kg Firewood	350 kg Briquettes	250 kg Briquettes	270 kg Briquettes	200 kg Briquettes
Fuel Rate/kg	Rs. 9	Rs. 6	Rs. 6	Rs. 6	Rs. 6
Kerosene/Diesel	5 litres	Nil	Nil	Nil	Nil
Camphor	1 kg	0.5 kg	0.5 kg	0.5 kg	0.5 kg
Ghee/vegetable oil	2 kg	1 kg	1 kg	1 kg	1 kg
Maximum temperature	850^0C in 1 h	950^0C in 30 min	950^0C in 30 min	950^0C in 30 min	950^0C in 30 min
Cremation duration	5-6 h	4-5 h	4-5h	3-4 h	3-4 h
Expenditure	Rs. 5500	Rs. 3150	Rs. 2550	Rs. 2670	Rs. 2250
Cost saving	-	42.7%	53.6%	51.5%	59.1%

Table 2 : Environmental and Economic Benefits due to Promotion of Cotton Stalk Briquettes for Cremation Process

Item/particulars	ICAR-CIRCOT Trapezoidal Shape Green Cremation
Annual saving in kerosene/diesel	350 lakh litres (cremation of 70 lakh bodies)
Annual saving of trees	25-30 lakhs (cremation of 70 lakh bodies)
Briquette Requirements	15 lakh tonnes
Annual saving in pollutants	20 lakh tonnes annually
Annual employment generation	50,000 annually in briquette-based industries
Annual increase in farm income	Rs. 15,000 lakh @ Rs. 1000 per tonne
Annual income of entrepreneurs	Rs. 8,400 lakh @ Rs 600 per tonne

- The cost of cremation with ICAR- CIRCOT Crematorium comes to Rs. 2250 as against Rs. 5500 for traditional cremation. Around 59% of cost saving per cremation can be attained making it economical and eco-friendly. About Rs 2400 crores can be saved on 70 lakh cremations taking place annually in India
- The use of biomass briquettes for cremation would save firewood equivalent to 25-30 lakh fully grown up trees annum.
- The kerosene free fire imitation for cremation in ICAR-CIRCOT crematorium would reduce about 20 lakh tonnes emissions of COx, NOx and volatile matters into atmosphere as compared to traditional fire wood cremation process.
- The use of biomass briquettes for cremations may create opportunities for promotion of rural based industries and employment generation for rural youths. The demand for about 15 lakh tonnes of briquettes for cremation will create 50,000 additional employment opportunities in India.
- The utilization of cotton stalks and other agro-residues based briquettes is a step towards doubling the farmers' income. Cotton farmers can get Rs 1000 per tonne by selling of cotton stalks produced in their field. An additional income of Rs 150 crores can be generated annually for the Indian farmers.

References

Arnold, D. (2017) - Burning Issues: Cremation and Incineration in Modern India - *NTM Journal of the History of Science, Technology, Medicine,* **24(4)**: 393-419.

Dube, L.C. and Rawat, V.R.S. (2005) - Contribution of wood-based crematoria in Carbon dioxide emission and their clean alternatives *Paper presented in National Conference on Frontiers of Environmental Science and Engineering in India,* Organized by Bharathiyar University and National Environmental Engineering and Research Institute, Coimbatore, Tamil Nadu, 15-17 September 2005.

Dube, L.C. and Rawat, V.R.S. (2013) - Clean Cremation - LAP LAMBERT Academic Publishing, Germany.

Kashyap, A.C. and Kesari, J.P. (2014) - Feasibility study of a Solar Crematorium in India - *International Journal of Research and Scientific Innovations,* **1(4)**: 1-9.

Cotton Facts: Cotton Exchanges (ICAC, 2003)

- In the history of the world cotton trade there have been many exchanges trading futures contracts. Trading volumes on most cotton futures exchanges declined drastically after World War II, and many exchanges ceased operations during the 1960s as a result of government policies in many of the cotton- producing countries. Currently there are only two exchanges trading cotton futures and options: The New York Board of Trade (New York Cotton Exchange)in New York, and the Bolsa de Mercadorias and Futuros (BM&F)in Sao Paulo, Brazil.
- The Alexandria Cotton Futures Exchangewas established in 1861 and was the first exchange formally established for cotton futures trading. The futures contract in Alexandria was 250 kentares (about 2,500 pounds). However, the Alexandria exchange suspended futures trading after 100 years because the Government of Egypt centralized cotton trading and had a negative view of speculation. Alexandria remains a major trading center for Egyptian cotton, and most Egyptian cotton trading companies and the Alexandria Cotton Exporters Association are based there.