APPLICATION AND UTILIZATION OF THERMOELECTRIC GENERATOR FOR A BIOMASS COOKSTOVE

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by

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Dedicated to my Daughter

Adrita

CERTIFICATE

This is to certify that thesis titled "**APPLICATION AND UTILIZATION OF THERMOELECTRIC GENERATOR FOR A BIOMASS COOKSTOVE**" being submitted by **MS. RISHA MAL** to the Indian Institute of Technology Delhi for the award of degree **DOCTOR OF PHILOSOPHY** in Engineering/Technology is a record of original bonafide research work carried out by her under our guidance and supervision. In our opinion, the thesis has reached the standard of fulfilling the requirements of all the regulations related to the degree. The research report and results presented in this thesis have not been submitted, in part or in full, to any other university or institution for the award of any degree or diploma.

This is also certified that she has pursued the prescribed course of research.

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RISHA MAL

ABSTRACT

About 70% population of a developing country like India resides in rural areas and from those about 78% of them use biomass for cooking. The traditional biomass cookstoves are being used in such developing countries for the cooking needs. The burning of biomass increases health hazards due to emissions of harmful pollutants which also contribute to climate change.

Compared to a traditional biomass cookstove, a forced draft biomass cookstove can reduce polluting emissions to a considerable level. To achieve cleaner combustion the forced draft stoves are provided with a small fan. The household need to be connected with grid electricity to run the electric fan or with a battery. Many of the rural households do not have access to electricity. The requirement of this small quantity of electricity in such off-grid areas can be fulfilled by deploying an innovative, novel and sustainable technology in conjunction with a biomass cookstove, a Thermo Electric Generator (TEG). A TEG Stove can be used for cooking as well as some electricity generation from waste heat of the stove.

The thermoelectric generators modules are mainly made of semiconductor materials like Bismuth Telluride (Bi_2Te_3). Various types of thermoelectric generators are commercially available in the market.

A TEG stove could, thus, make a cleaner combustion as well as light an LED lamp (or charge a mobile phone battery) simultaneously. To achieve the adequate electricity

generation from TEG, different electrical topologies have been discussed and an appropriate one selected.

The laboratory testing of a TEG stove developed was turned to give a much better performance as compared to traditional cookstoves. The prototype developed is rather costly, INR 9000. The TEG cookstove manufacturing could be commercialized for off-grid rural areas. Scaling up the manufacturing in India may also lead to cost reduction of TEG stoves. Extensive field testing on these cookstoves for its performance has to be established.

सार

भारत जैसे विकासशील देश की लगभग 70% आबादी ग्रामीण क्षेत्रों में रहती है और उनमें से 78% खाना पकाने के लिए बायोमास का उपयोग करती हैं। खाना पकाने की जरूरतों के लिए ऐसे विकासशील देशों में पारंपरिक बायोमास cookstoves का उपयोग किया जा रहा है। बायोमास जलने से हानिकारक प्रदूषण के उत्सर्जन के कारण स्वास्थ्य के खतरे बढ़ जाते हैं जो जलवायु परिवर्तन में भी योगदान देते हैं।

पारंपरिक बायोमास कुकस्टोव की तुलना में, एक मजबूर मसौदा बायोमास कुकस्टोव प्रदूषण उत्सर्जन को काफी स्तर तक कम कर सकता है। क्लीनर दहन प्राप्त करने के लिए मजबूर मसौदे स्टोव को एक छोटे प्रशंसक के साथ प्रदान किया जाता है। बिजली के प्रशंसक या बैटरी के साथ घर को ग्रिड बिजली से जोड़ा जाना चाहिए। ग्रामीण परिवारों में से कई को बिजली तक पहुंच नहीं है। ऐसे ऑफ-ग्रिड क्षेत्रों में बिजली की इस छोटी मात्रा की आवश्यकता को बायोमास इलेक्ट्रिक जेनरेटर (टीईजी) के बायोमास कुकस्टोव के संयोजन के साथ एक अभिनव, उपन्यास और टिकाऊ तकनीक को तैनात करके पूरा किया जा सकता है। एक टीईजी स्टोव का इस्तेमाल स्टोव के अपशिष्ट गर्मी से खाना पकाने के साथ ही कुछ बिजली उत्पादन के लिए किया जा सकता है।

थर्माइलेक्ट्रिक जनरेटर मॉड्यूल मुख्य रूप से अर्धचालक पदार्थों जैसे बिस्मुथ टेलुराइड से बने होते हैं। विभिन्न प्रकार के थर्मोइलेक्ट्रिक जनरेटर वाणिज्यिक रूप से बाजार में उपलब्ध हैं।

इस प्रकार, एक टीईजी स्टोव एक क्लीनर दहन के साथ-साथ एलईडी लैंप (या मोबाइल फोन बैटरी चार्ज) को एक साथ ला सकता है। पर्याप्त बिजली प्राप्त करने के लिए टीईजी से पीढ़ी, विभिन्न विद्युत टोपोलॉजी पर चर्चा की गई है और एक उपयुक्त चुना गया है।

पारंपरिक कूकस्टोव की तुलना में विकसित एक टीईजी स्टोव का प्रयोगशाला परीक्षण एक बेहतर प्रदर्शन देने के लिए बदल दिया गया था। विकसित प्रोटोटाइप महंगा है, INR 9000. टीईजी कुकस्टोव विनिर्माण ऑफ-ग्रिड ग्रामीण क्षेत्रों के लिए व्यावसायीकरण किया जा सकता है। भारत में विनिर्माण को बढ़ाकर टीईजी स्टोव की लागत में कमी आ सकती है। अपने प्रदर्शन के लिए इन cookstoves पर व्यापक क्षेत्र परीक्षण स्थापित किया जाना है।

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NOMENCLATURE

α	Seebeck coefficient	V/°C
Z	figure of merit	dimensionless
T_H	hot side temperature	°C
T_C	cold side temperature	°C
Σ	electrical conductivity	$\Omega^{-1}cm^{-1}$
k	thermal conductivity	W/cm°C
ρ	electrical resistivity	Ωcm
L	length of one thermo-electric leg	cm
A	cross-sectional area of one thermo-electric leg	cm
Q_H	Heat flow from hot side	W
Q_C	Heat flow from cold side	W
R_L	load resistance	Ω
I	current	A
P	power	W
η_c	conversion efficiency	%
V_{oc}	open circuit voltage	V
P_{max}	maximum power	W
I_{max}	maximum current	A
R_{int}	internal resistance	Ω
ΔT	Temperature difference	°C
w	mass of water in vessel	kg
W	mass of vessel with lid	kg

F	rate of consumption of fuel wood	kg/h
H_{fuel}	calorific value of wood (or solid fuel)	kJ/kg