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G.A.R.6  
 [See Rule 22(1)]  
 RECEIPT



Docket No 133332

Date/Time 2021/12/17 21:21:29

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**CBR Detail:**

Sr. No.	Ref. No./Application No.	App. Number	Amount Paid	C.B.R. No.	Form Name	Remarks
1	E-106/2388/2021/DEL	202111059104	0	----	FORM28	
2	202111059104	TEMP/E-1/67154/2021-DEL	1600	45162	FORM 1	Hybrid Torrefaction-Energy Multi-generation system and Method of Operation thereof

TransactionID	Payment Mode	Challan Identification Number	Amount Paid	Head of A/C No
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Total Amount : ₹ 1600

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**FORM 1**  
**THE PATENTS ACT, 1970**  
**(39 of 1970)**  
**&**  
**THE PATENTS RULES, 2003**  
**APPLICATION FOR GRANT OF PATENT**  
**[See sections 7,54 & 135 and rule 20(1)]**

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**Application No.:** .....  
**Filing Date:** .....  
**Amount of Fee Paid:** .....  
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**1. APPLICANT(S):**

Sr.No.	Name	Nationality	Address	Country	State
1	THE LNM INSTITUTE OF INFORMATION TECHNOLOGY	India	Rupa ki Nangal, Post-Sumel, Via-Jamdoli Jaipur-302031, (Rajasthan) INDIA	India	Rajasthan

**2. INVENTOR(S):**

Sr.No.	Name	Nationality	Address	Country	State
1	Dr. Kamal Kishore Khatri	India	Associate Professor, Dept. of Mechanical-Mechatronics Engineering, The LNM Institute of Information Technology, Rupa-ki-Nangal, Jaipur.	India	Rajasthan

**3. TITLE OF THE INVENTION: Hybrid Torrefaction-Energy Multi-generation system and Method of Operation thereof**

**4. ADDRESS FOR CORRESPONDENCE OF APPLICANT /** Telephone No.: 9910222350  
**AUTHORISED PATENT AGENT IN INDIA:** Fax No.:  
 Ideas2IPR B-115 Chander Nagar, Janak Puri, New Delhi-110058. Mobile No: 9891016781  
 E-mail: mail@ideas2ipr.com

**5. PRIORITY PARTICULARS OF THE APPLICATION(S) FILED IN CONVENTION COUNTRY:**

Sr.No.	Country	Application Number	Filing Date	Name of the Applicant	Title of the Invention
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**6. PARTICULARS FOR FILING PATENT COOPERATION TREATY (PCT) NATIONAL PHASE APPLICATION:**

International Application Number	International Filing Date as Allotted by the Receiving Office
PCT//	

**7. PARTICULARS FOR FILING DIVISIONAL APPLICATION**

Original (first) Application Number	Date of Filing of Original (first) Application

**8. PARTICULARS FOR FILING PATENT OF ADDITION:**

Main Application / Patent Number:	Date of Filing of Main Application

**9. DECLARATIONS:****(i) Declaration by the inventor(s)**

I/We ,Dr. Kamal Kishore Khatri, is/are the true & first inventor(s) for this invention and declare that the applicant(s) herein is/are my/our assignee or legal representative.

(a) Date: -----

(b) Signature(s) of the inventor(s): .....

(c) Name(s): Dr. Kamal Kishore Khatri

**(ii) Declaration by the applicant(s) in the convention country**

I/We, the applicant(s) in the convention country declare that the applicant(s) herein is/are my/our assignee or legal representative.

(a) Date: -----

(b) Signature(s) : .....

(c) Name(s) of the singnatory: THE LNM INSTITUTE OF INFORMATION TECHNOLOGY

**(iii) Declaration by the applicant(s)**

- **The Provisional specification relating to the invention is filed with this application.**
- **I am/We are, in the possession of the above mentioned invention.**
- **There is no lawful ground of objection to the grant of the Patent to me/us.**
- **I am/We are, the assignee or legal representative to true first inventors.**

**10. FOLLOWING ARE THE ATTACHMENTS WITH THE APPLICATION:**

I/We hereby declare that to the best of my/our knowledge, information and belief the fact and matters stated hering are correct and I/We request that a patent may be granted to me/us for the said invention.

Dated this(Final Payment Date): -----

Signature: .....

Name: MALHOTRA RAJAT

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The Patent office at NEW DELHI

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FORM 2  
THE PATENTS ACT 1970  
(39 of 1970)  
&  
THE PATENTS RULES, 2003  
PROVISIONAL SPECIFICATION  
(See section 10 and rule 13)

1. TITLE OF THE INVENTION  
**Hybrid Torrefaction-Energy Multi-generation system and Method of Operation thereof**

2. APPLICANT

(i) NAME : THE LNM INSTITUTE OF INFORMATION TECHNOLOGY

(ii) NATIONALITY : IN

(iii) ADDRESS : Rupa ki Nangal, Post-Sumel, Via-Jamdoli Jaipur-302031, (Rajasthan)

INDIA

2. PREAMBLE TO THE DESCRIPTION

PROVISIONAL

The following specification particularly describes the invention and the manner in which it is to be performed.

## **Background**

Numerous types of Torrefaction plants have been provided in the prior art. While these plants may be suitable for the particular purpose to which they address, they would not be as suitable for the purposes of the present invention as heretofore described. The present invention have the provision of energy generation with multi-utility effects in addition to the torrefaction process without depending upon external sources of the energy thus providing a self sustainable solution. The waste heat available from the engine itself is used to provide the heat for Pre heating & Torrefaction reactor. Few innovative components would make the overall process highly efficient and economic, making it highly useful for remote and rural areas.

## 10 **Detailed Description of Invention**

The present invention is about a hybrid energy technology for torrefaction of Biomass and energy generation from an IC Engine which can improve upon the prior art technologies in the field of green charcoal production. In India huge amount of biomass available which can be used for heating applications. The Torrefaction plant is a considerable energy densification process. The proposed technology is about a hybrid torrefaction-energy system which is an improved torrefaction/green charcoal process that would be producing energy in the form of electricity, heating and cooling in addition to the charcoal production by utilizing the waste heat from the IC Engine. This modified system would have combined heating, cooling and power (CCHP) or Multi-generation facility based on the Torr gas obtained as by-product from the Torrefaction process. The proposed system is a plant consisting mainly of a hopper, screener, crusher, drier, pre-heater, torrefaction reactor, torr gas system and heat exchanger for charcoal cooling, pelleting machine, IC Engine etc. .

We collect biomass at a Hopper and remove suspended particles & dust at screening process. To convert biomass in standard powder size, it is crushed in a crushing machine. To remove moisture present in the biomass, it is allowed to pass through a solar dryer where temperature of biomass increases to around 100 °C. In a preheating process, temperature of biomass is further increased to around 150-200 °C by using flue gasses coming from Torrefaction reactor.

In Torrefaction reactor Temperature between 200 – 300 °C is maintained by flue gasses coming out from IC engine. At this stage we have two products namely Torr gas & charcoal. Charcoal is allowed to pass through a heat exchanger where temperature of charcoal is maintained at around 50 °C. To reduce and prevent self-ignition effect of charcoal, an inert atmosphere is maintained at Torrefaction reactor and Heat exchanger.

Torr gas is re-circulated to the preheater to increase temperature of biomass and then IC engine after purification process. The waste heat from the engine generator system is recovered to produce the Multi-generation effect producing simultaneous power and heating with multiple utility effects. The power and heating can be used for processes within the plants or can be supplied for external use. Even Refrigeration/ cooling can be achieved through thermally activated technology e.g. Vapor

absorption chillers from the waste heat available for fulfilling some specific requirement like cooling in the condenser of the torr gas. There is provision of back up energy of Electricity through LPG or Solar system in case of non-working of Torrefaction plant giving more flexibility and backup. The schematic set up is shown in the Figure 1.

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An object of the present invention is to provide a system for existing or new waste Biomass treatment facilities. The improved energy technology for waste Biomass treatment will overcome the shortcomings of prior art devices.

- A further object of the present invention is to provide a Hybrid energy system for Torrefaction with multigeneration system which can produce the charcoal & power.

- A further object of the present invention is to provide a Hybrid energy system for Torrefaction which is more efficient than the prior art plants by utilizing the waste heat recovery unit.

- An even further object of the present invention is to provide a Hybrid energy system for Torrefaction able to provide electrical power & charcoal as fuel input in co-firing of Electric power plants

- Another object of the present invention is to provide a Hybrid energy system for Torrefaction that is simple and easy to use. .

- A still further object of the present invention is to provide a Hybrid energy system for Torrefaction that is economical in cost to manufacture.

The proposed technology is a hybrid of several innovative components providing the best/optimum energy technology for Torrefaction. We can say that a new process with hybrid Torrefaction is proposed which has better performance with high efficiency with multigeneration system.

### **Features**

It has best mixed hybrid of energy supply using the all available waste energy sources e.g. Biomass, Agricultural waste etc. (2) It has innovative components e.g. IC Engine utilizing the locally available alternate fuels. It has flexibility to use the available waste heat from the engine generator system to fulfil the specific requirement of the plant and the community. (3) It has best hybrid system with smart controllers to maintain uniform temperature & Inert atmosphere at Torrefaction reactor, Preheater, heat exchanger. (4) It has low cost power solution for efficient operation of the Torrefaction system. (5) It has the best hybrid with flexibility of Torrefaction technology providing the better quality of the treated Charcoal.

In an implementation, a torrefaction reactor is provided in which the preheated biomass is supplied to the cyclone type reactor tangentially by the help of exhaust flue gases by the help of a blower thus directly heated (at around 250-300 C). Another stream of exhaust flue gases from engine is injected at

the bottom part of the cylindrical part of the cyclone in reverse direction to increase the retention time of the biomass being torrefied in the reactor.

In an implementation, the process of aftertreatment of the exhaust flue gases coming out from the Engine through a thermal converter where it is heated by series of glow plugs in presence of extra oxygen (thru compressed air). Thus the temperature and available heat is increased further so that sufficient heat is available in the main reactor. There can be a smart controller which may automatically start this converter if the temperature/heat of the flue gases does not reach a prescribed limit.

#### 10 Advantages

1) More overall efficiency of Torrefaction Plant (2) Increased Product quality of biomass similar to coal properties through smart control strategy (3) Less costly i.e. more economic on initial investment as well as operational (4) We can use in remote areas (5) Reduce environment pollution as parali etc.(5) Low payback period with high rate of return

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**Torrefaction Process:** The torrefaction process is a considerable energy densification process, during which chemical energy transfers from the feedstock to the torrefied product, while fuel properties are improved.

Figure 2 represents the general conceptual process flow diagram of the torrefaction process. The raw biomass is handled through Material Hopper, conveyor etc. and supplied to the screener and chipping machine for controlling size and then it is dried in the drier. It is preheated and then supplied to the main reactor after which the product is cooled in a controlled environment before sending for pelleting and finally to the storage. The depicted process layout is based on the direct heating of biomass during torrefaction by means of hot flue gas obtained from the IC engine. The hot gas consists of the torrefaction gas itself and is re-pressurized to compensate for the pressure drop in the recycle loop. It heats the recycled gas to deliver the required heat demand in the torrefaction reactor. The necessary heat for torrefaction and pre-drying is produced by the combustion of the liberated torrefaction gas in the IC engine. A utility fuel can be used when the energy content of the torrefaction gas is insufficient to thermally balance the torrefaction process and to provide stability and control of the combustion process.

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Figure 3 illustrates a Torr Gas purifier. It works on the principle of pressure absorption technique. The Torr gas is supplied from bottom and received from the top in the main vertical pipe and water is sprayed from the top hence there is mixing of gas with the water thus the water absorbs the CO<sub>2</sub> and other unwanted gases.

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## ABSTRACT

### Hybrid Torrefaction-Energy Multi-generation system and Method of Operation thereof

The present invention is about a hybrid energy technology for torrefaction of Biomass and energy generation from an IC Engine which can improve upon the prior art technologies in the field of green charcoal production. In India huge amount of biomass available which can be used for heating applications. The Torrefaction plant is a considerable energy densification process. The proposed technology is about a hybrid torrefaction-energy system which is an improved torrefaction/green charcoal process that would be producing energy in the form of electricity, heating and cooling in addition to the charcoal production by utilizing the waste heat from the IC Engine. This modified system would have combined heating, cooling and power (CCHP) or Multi-generation facility based on the Torr gas obtained as by-product from the Torrefaction process. The proposed system is a plant consisting mainly of a hopper, screener, crusher, drier, pre-heater, torrefaction reactor, torr gas system and heat exchanger for charcoal cooling, pelleting machine, IC Engine etc.

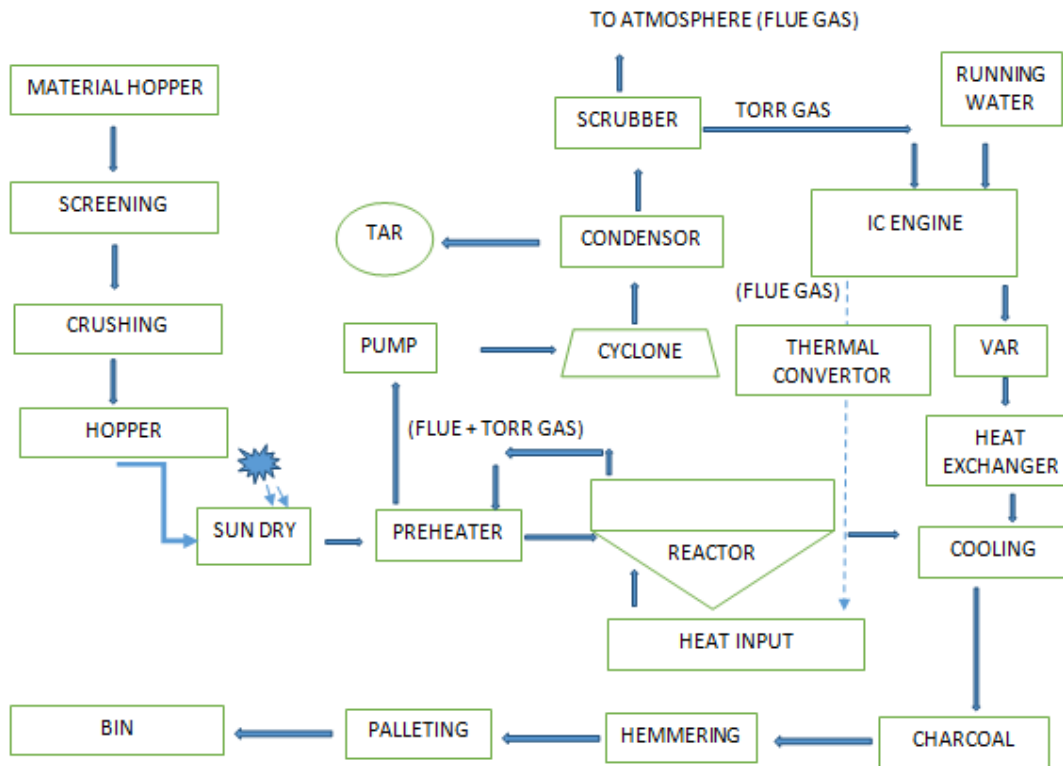


Fig.1 Schematic diagram of the system

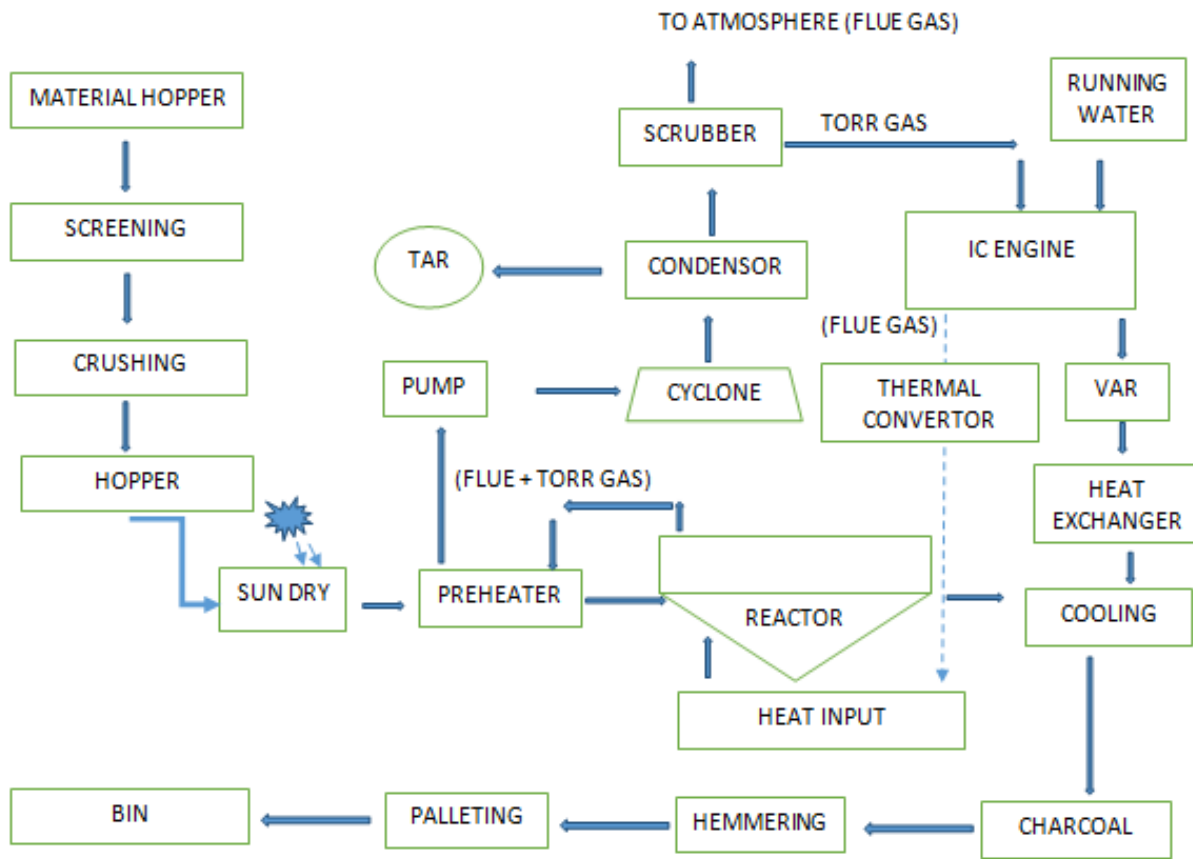


Fig.1 Schematic diagram of the system

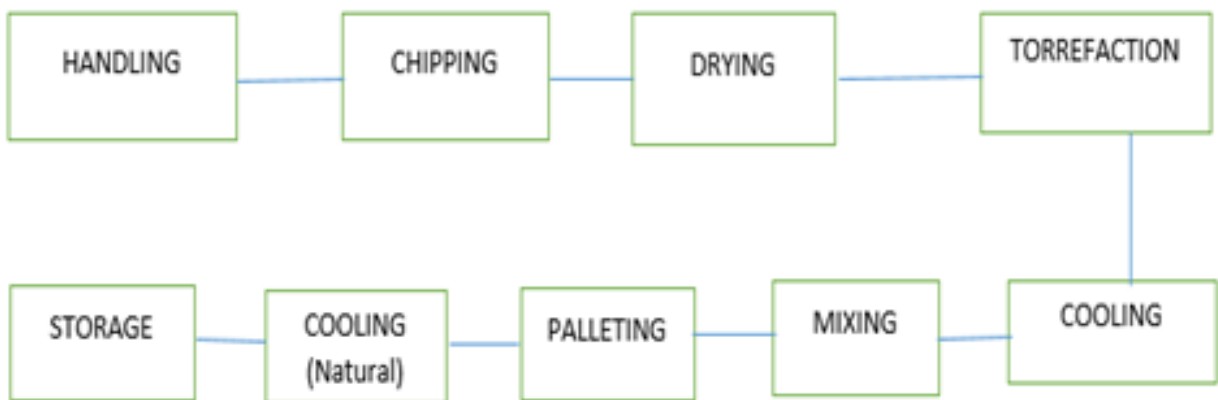


Fig. 2 General Process flow chart

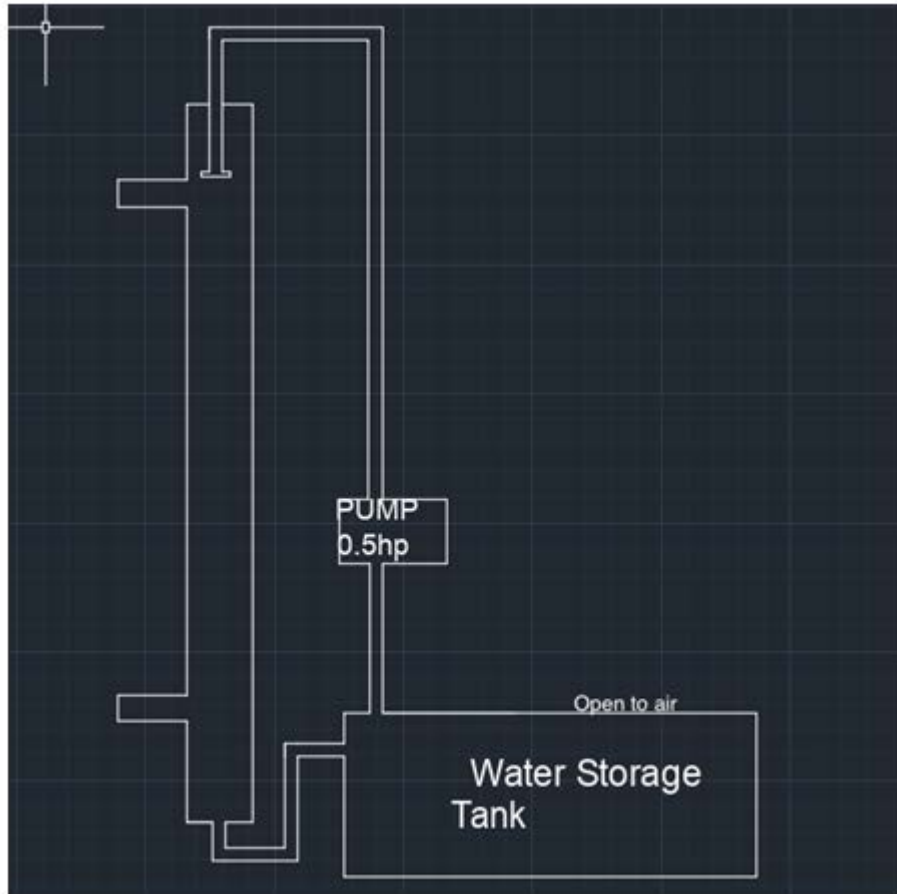


Figure-3 A Torr Gas purifier

*Rajat*

RAJAT MALHOTRA  
Agent for the Applicant [IN/PA-1775]  
Ideas2IPR

FORM 3  
THE PATENTS ACT, 1970  
(39 of 1970)  
&  
THE PATENTS (AMENDMENT) RULES, 2006  
Statement and Undertaking under Section 8  
[See Section 8; rule 12]

We, THE LNM INSTITUTE OF INFORMATION TECHNOLOGY having address at Rupa ki Nangal, Post-Sumel, Via-Jamdoli Jaipur-302031, (Rajasthan) INDIA; hereby declare

- (i) That we have not made any application for the same /substantially same invention outside India.
- (ii) That we undertake that upto the date of grant of the patent by the Controller, we would keep him informed in writing the details regarding corresponding applications for patents filed outside India within six months from the date of filing of such application.

Dated this 17<sup>th</sup> day of December, 2021



RAJAT MALHOTRA  
Agent for the Applicant [IN/PA-1775]  
Ideas2IPR

To  
The Controller of Patents  
The Patent Office  
At New Delhi

FORM 5  
THE PATENTS ACT, 1970  
(39 OF 1970)  
&  
THE PATENTS (AMENDMENT) RULES, 2006  
DECLARATION AS TO INVENTORSHIP  
[See section 10(6) and rule 13(6)]

1. NAME OF APPLICANT

THE LNM INSTITUTE OF INFORMATION TECHNOLOGY

hereby declare that the true and first inventor of the invention disclosed in the provisional specification filed in pursuance of our application numbered \_\_\_\_\_ dated December 17, 2021 is:

2. INVENTOR:

- (i) NAME : Dr. Kamal Kishore Khatri  
(ii) NATIONALITY : IN  
(iii) ADDRESS : Associate Professor, Dept. of Mechanical- Mechatronics Engineering, The LNM Institute of Information Technology, Rupa-ki-Nangal, Jaipur.

Dated this the 17<sup>th</sup> day of December, 2021



RAJAT MALHOTRA  
Agent for the Applicant [IN/PA -1775]  
Ideas2IPR

To,  
The Controller of Patents  
The Patent Office,  
At New Delhi

**FORM 28**  
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(39 of 1970)  
&  
THE PATENTS (AMENDMENT) RULES, 2006  
TO BE SUBMITTED BY A SMALL ENTITY /STARTUP/EDUCATIONAL  
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[See rules 2 (fa), 2(fb), 2(ca) and 7]

We, THE LNM INSTITUTE OF INFORMATION TECHNOLOGY having address at Rupa ki Nangal, Post-Sumel, Via-Jamdoli Jaipur-302031, (Rajasthan) INDIA, applicant in respect of the patent application no. \_\_\_\_\_ hereby declare that we are an educational institution in accordance with rule 2(ca) and submit the following document(s) as proof:

A. Document from UGC Website

The information provided herein is correct to the best of my/our knowledge and belief.

Dated this 17<sup>th</sup> day of December, 2021



RAJAT MALHOTRA  
Agent for the Applicant [IN/PA-1775]  
Ideas2IPR

To  
The Controller of Patents  
The Patent Office  
At New Delhi

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<p align="center"><b>FORM 1</b>  THE PATENTS ACT 1970 (39 of 1970) and  THE PATENTS RULES, 2003  <b>APPLICATION FOR GRANT OF  PATENT</b>  (See section 7, 54 and 135 and sub-rule (1) of  rule 20)</p>		<p align="center">(FOR OFFICE USE ONLY)</p>			
		<b>Application No.</b>			
		<b>Filing date:</b>			
		<b>Amount of Fee paid:</b>			
		<b>CBR No:</b>			
		<b>Signature:</b>			
<b>1. APPLICANT'S REFERENCE / IDENTIFICATION NO. (AS ALLOTTED BY OFFICE)</b>					
<b>2. TYPE OF APPLICATION [Please tick (✓) at the appropriate category]</b>					
Ordinary (✓)		Convention ( )		PCT-NP ( )	
Divisional ( )	Patent of Addition ( )	Divisional ( )	Patent of Addition ( )	Divisional ( )	Patent of Addition ( )
<b>3A. APPLICANT</b>					
<b>Name in Full</b>		<b>Nationality</b>	<b>Country of Residence</b>	<b>Address of the Applicant</b>	
THE LNM INSTITUTE OF INFORMATION TECHNOLOGY		India	India	<b>House No.</b>	Rupa ki Nangal, Post-Sumel, Via-Jamdoli Jaipur-302031, (Rajasthan) INDIA
				<b>Street</b>	
				<b>City</b>	
				<b>State</b>	
				<b>Country</b>	India
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<b>3B. CATEGORY OF APPLICANT [Please tick (✓) at the appropriate category]</b>					
Natural Person ( )			Other than Natural Person		
			Small Entity ( )	Startup ( )	Others ( )
				Educational Institution (✓)	

<b>4. INVENTOR(S) [ Please tick (√) at the appropriate category]</b>				
Are all the inventor(s) same as the applicant(s) named above?		Yes ()	No (√)	
If "No", furnish the details of the inventor(s)				
Name in Full	Nationality	Country of Residence	Address of the Inventor	
Dr. Kamal Kishore Khatri	India	India	House No.	Associate Professor, Dept. of Mechanical-Mechatronics Engineering, The LNM Institute of Information Technology, Rupa-ki-Nangal, Jaipur.
			Street	
			City	
			State	
			Country	India
Pin code				
<b>5. TITLE OF THE INVENTION</b>				
Hybrid Torrefaction-Energy Multi-generation system and Method of Operation thereof				
<b>6. AUTHORISED REGISTERED PATENT AGENT(S)</b>		IN/PA No.	1775	
		Name	Rajat Malhotra	
		Mobile No.	9891016781	
<b>7. ADDRESS FOR SERVICE OF APPLICANT IN INDIA</b>		Name	Ideas2IPR	
		Postal Address	B-115 Chander Nagar, Janak Puri, New Delhi-110058.	
		Telephone No.	9910222350	
		Mobile No.	9891016781	
		Fax No.	01125620164	
		E-mail ID	mail@ideas2ipr.com	
<b>8. IN CASE OF APPLICATION CLAIMING PRIORITY OF APPLICATION FILED IN CONVENTION COUNTRY, PARTICULARS OF CONVENTION APPLICATION</b>				



**(ii) Declaration by the applicant(s) in the convention country**

I/We, the applicant(s) in the convention country declare that the applicant(s) herein is/are my/our assignee or legal representative. : **NA**

**(iii) Declaration by the applicant**

We the applicant hereby declare(s) that: -

We are in possession of the above-mentioned invention.

The Provisional specification relating to the invention is filed with this application.

The invention as disclosed in the specification uses the biological material from India and the necessary permission from the competent authority shall be submitted by me/us before the grant of patent to me/us.

There is no lawful ground of objection(s) to the grant of the Patent to us.

We are the assignee or legal representative of true & first inventors.

The application or each of the applications, particulars of which are given in Paragraph-8, was the first application in convention country/countries in respect of our invention(s).

We claim the priority from the above mentioned application(s) filed in convention country/countries and state that no application for protection in respect of the invention had been made in a convention country before that date by me/us or by any person from which We derive the title.

Our application in India is based on international application under Patent Cooperation Treaty (PCT) as mentioned in Paragraph-9.

The application is divided out of my /our application particulars of which is given in Paragraph-10 and pray that this application may be treated as deemed to have been filed on DD/MM/YYYY under section 16 of the Act.

The said invention is an improvement in or modification of the invention particulars of which are given in Paragraph-11.

**13. FOLLOWING ARE THE ATTACHMENTS WITH THE APPLICATION**

a. Form 2

<b>Item</b>	<b>Details</b>	<b>Fee</b>	<b>Remarks</b>
Provisional Specification	No. of pages: 04	INR 1,600	Paid online
No. of Claim(s)	No. of claims: 00 No. of pages: 00	-	
Abstract	No. of pages: 01		
No. of Drawing(s)	No. of drawings: 03 No. of pages: 02		

- b. Provisional specification;
- c. Drawings;
- d. Statement and Undertaking on Form 3;
- e. Declaration of Inventorship on Form 5;
- f. Total fee : INR 1,600 paid online

We hereby declare that to the best of our knowledge, information and belief the fact and matters stated herein are correct and we request that a patent may be granted to us for the said invention.

Dated this 17 December 2021



Rajat Malhotra

Agent for the Applicant [IN/PA-1775]

**Ideas2IPR**

To,  
The Controller of Patents  
The Patent Office, at New Delhi