

**DEVELOPMENT OF BIOGAS ENRICHMENT AND  
COMPRESSION SYSTEM FOR RURAL ENERGY  
APPLICATIONS**

by

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**Centre for Rural Development & Technology**

**Submitted  
in fulfillment of the requirements  
of the degree of**

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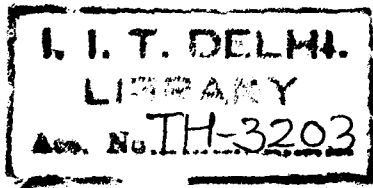


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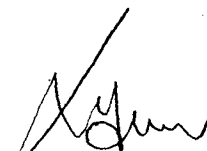
## CERTIFICATE

This is to certify that the thesis entitled, "**Development of Biogas Enrichment and Compression System for Rural Energy Applications**", being submitted by Er. S. S. Kapdi, to the Indian Institute of Technology, Delhi for the award of the degree of Doctor of Philosophy is a record of bonafide research work carried out by him. He has worked under our supervision and guidance and has fulfilled the requirements for the submission of his thesis, which to our knowledge has reached the requisite standard.

The results contained in this thesis have not been submitted in part or full to any other university or institute for award of any degree or diploma.



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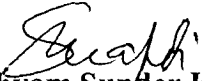
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## ABSTRACT

Ever increasing demand for conventional fuels such as diesel and petrol, their increasing prices and adverse effect on environment have led to exploitation of new, renewable and alternate sources of energy. Use of gaseous fuels like natural gas and biogas is a welcome step in this direction. Natural gas, in the form of CNG, is well established in this field, but it is not renewable and available universally. While biogas is similar to natural gas after enrichment, is renewable in nature and produced from biodegradable waste, which is available everywhere. This makes biogas a superior choice over natural gas. However, considerable efforts are required to make biogas as attractive fuel as CNG / LPG.

This thesis aims at developing a suitable low cost, simple and easy to operate system for enrichment and compression of biogas, produced from cattle dung, a waste available in plenty in rural areas. Rural areas are considered for the study as they are the worst affected by increasing prices and scarcity of diesel / petrol.

After reviewing different methods of enrichment, water scrubbing method was found to be the most suitable for rural application, being simple and of low investment. Accordingly a packed bed scrubber was designed, fabricated and installed along with other accessories for enrichment of biogas. During performance study, it was found that when compressed biogas (1.0 MPa pressure) was sent into the developed scrubber at 1.5 m<sup>3</sup>/h flow rate as against 1.8 m<sup>3</sup>/h flow rate of pressurized water (1.2 MPa pressure), it could remove up to 99 % of carbon dioxide present in raw biogas. Hydrogen sulfide, present in traces, was also removed during the scrubbing.

Enriched biogas was compressed using a three stage compressor after removing moisture and stored in high pressure steel cylinders. These cylinders were tested for vehicle application in Maruti - 800 car. After minor adjustment in air intake system and engine tuning, they gave excellent performance. Enriched biogas was also tested for stationary engine applications and found to be better than raw biogas in terms of engine performance.

A feasibility study was also conducted for its probable application in rural areas. It was found that cattle dung is available in plenty and a number of biogas enrichment and compression systems can be installed there. A 140 m<sup>3</sup>/day capacity biogas plant is suggested for this purpose. The economic analysis of the complete set-up i.e. from production to bottling was carried out using different economic indicators namely, net present value (NPV), internal rate of return (IRR), benefit cost ratio (B/C ratio) and pay back period by considering the different life periods of the system. The results of economic analysis indicate that biogas enrichment and compression is a profitable venture for all proposed life periods for end applications like diesel replacement. The internal rate of return is between 17 – 21 per cent.

It is hoped that the present study would encourage people to install biogas enrichment and compression system for large capacity biogas plants and use enriched and compressed biogas filled cylinders for energy applications particularly in rural areas.

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