



The Royal Academy
of Engineering

Research Exchanges with China and India Case Study

Development of computational models for biomass fast pyrolysis

Major Award



UK Researcher:

Dr Sai Gu

Senior Lecturer
University of Southampton



Indian Researcher:

Dr Jasvinder Singh

Research Scientist
Indian Institute of Petroleum (IIP)
India



Reasons for the exchange

The need to produce clean energy has increased interest in research in biofuels, which produce ethanol from the decomposition of organic material. The first generation of biofuels rely on the use of food crops e.g. sugar cane, corn and wheat. There is growing concern about food security due to the increase in food prices and food shortages this has caused. The second generation of biofuels use non-food crops and non-food parts of food crops including lignocellulosic feedstock. Biomass fast pyrolysis is a novel thermochemical process to convert biomass to liquid, which can be further upgraded to second generation biofuels. At the University of Southampton Dr Sai Gu is leading the development of computational models for biomass fast pyrolysis. Fast pyrolysis is a thermal process that rapidly heats the biomass to a carefully controlled temperature, then rapidly cools the volatile products formed. The models can provide insight into the complicated thermal processing, process design and optimization for scale-up. As a result, Dr Gu is managing a number of international bioenergy networks funded by EPSRC and the EU. India has rich underused biomass resources and the development of second generation biofuels is strategically important. The Indian Institute of Petroleum (IIP) has been supported by the Council for Scientific and Industrial Research (CSIR) to develop biomass to liquid technologies and in particular fast pyrolysis thermal processing. The Indian Institute of Petroleum has made progress in developing lab-scale pyrolysis rigs,

however, more technical support is needed to build large scale demonstration plants according to industrial needs. The Indian Institute has been actively seeking international collaboration to move this technology forward in particular for process modelling.

Match of institutions and researchers

The Carbon Trust has highlighted that the main challenges for pyrolysis are process scale-up and bio-oil upgrading. The two

Statement from the Host

"This exchange provided us with an excellent opportunity to work with the very best Indian research institutes and researchers in India. I am very pleased to have Dr Singh in my research group. He has done an exceptional job here and built good links with our researchers. We are definitely on the right track to establish strong long-term partnerships between the Indian Institute of Petroleum and the University of Southampton. Last year the director of the Indian Institute visited us and met the senior management in our school and the University. We are planning to organize joint bio-energy workshops in India and the UK. In the future, both institutes can work as a hub to facilitate UK-India collaboration for a wide range of activities."

Dr Sai Gu
Senior Lecturer, The University of Southampton

partners form an ideal match to address these two challenges. The University of Southampton is one of the top research-led universities in the UK. The Energy Technology Research Group is the focal point for energy research within the university and organises activities around eight Research Laboratories, covering a wide spectrum of mainstream and renewable energy technologies. In charge of research in biomass thermal conversion, Dr Gu has built up a research team expanding from computational modelling to kinetic study and integrative biorefinery. His research team is working with Aston University to provide essential modelling work for the EPSRC SUPERGEN Bioenergy and Carbon Trust "Pyrolysis Challenge". Dr Gu has played a pivotal role in establishing international collaborations in developing renewable and sustainable technologies.



Dr Gu and Dr Singh outside the Southampton e-Science Centre School of Engineering Sciences

The Indian Institute of Petroleum is one of the country's largest research institutes and almost every refinery in India has technology licensed by the institute. Its unparalleled strength in refining technologies, including catalytic cracking for oil-refining and chemical extraction, can make major contributions to bio-oil upgrading. The partnership developed from this visit will enable more constructive collaborations to follow. Dr Jasvinder Singh has both chemical engineering and modelling expertise. His visit is fully supported by the Indian Institute of Petroleum and the Council for Scientific and Industrial Research. The knowledge gained from his visit will enable him to significantly expand the computational fluid dynamic modelling capacity at the Indian Institute of Petroleum.

Objectives of visit

- To acquire computational modelling skills in Southampton and apply them to scale-up processes in India.
- To gain first hand knowledge of technology development in the UK and Europe on biomass fast pyrolysis by being involved in EPSRC and EU projects managed by Southampton University.
- To carry out a critical review of biofuel development in India and how fast pyrolysis technology may contribute to the future development.
- To establish partnerships between the UK and Indian institutes through a broad range of exchanges and collaboration.



Left to right: Dr Gu, Dr Singh and Dr Ben Hagen (Director of Ghana Institute for Industrial Research)

Statement from the Indian Researcher

"It was a great experience for me to work in the energy engineering research group at the University of Southampton. An open research environment provided ample opportunities for a productive outcome. I did not have advanced modelling experience in computational fluid dynamics when I arrived from India. At Southampton University, I had an opportunity to work with the people who were engaged in advanced modelling using CFD. Fortunately, I had been working in India on the same software which I needed to use here. Therefore it was a fruitful experience for me to learn advanced modelling skills by working with experienced researchers. It also helped me to work in a different research environment and in a new country. I found a very cordial environment here as well as a very friendly and helpful research group which made my time in the UK a very pleasant experience."

Dr Jasvinder Singh
The Indian Institute of Petroleum (IIP)



Dr Singh working with Southampton researchers

Visit outcomes

- Dr Singh has compiled two extensive reviews of biomass conversion technologies in India and the UK which have been submitted for publication.
- Dr Singh together with UK researchers has developed a new computational model of liquid collection process during fast pyrolysis. A joint paper has been prepared for publication.
- Dr Singh has participated in numerous networking activities hosted in Southampton including workshops, seminars and training courses with researchers from Ghana, South Africa, China and Europe.
- The senior delegation led by the Director of the Indian Institute of Petroleum visited Southampton to discuss strategic partnerships between two institutes.

Future links and collaboration

- Joint workshops are planned in both India and the UK to include a wide audience of academic and industrial researchers.
- A regular exchange of researchers between the two institutes is planned: another Indian researcher is coming to Southampton in 2010; the Indian Institute of Petroleum is planning to send its researchers to the MSc Sustainable Energy Technologies course in Southampton; a postgraduate student from Southampton will be seconded to the Indian Institute of Petroleum in 2010.
- Both partners will jointly bid for large research grants including FP7 and UK Research Council calls.

For further information please contact

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Further information regarding the scheme
is available from The Academy's website:

<http://www.raeng.org.uk/research/researcher/reci/scheme.htm>