The University of Queensland - IIT Delhi Academy of Research Joint PhD Project

PROJECT TITLE	**UNDERSTANDING THE MECHANISM OF PARTICLE FRAGMENTATION, ATTRITION, AND AGGLOMERATION DURING COAL AND/OR BIOMASS GASIFICATION**
PROJECT CODE	**UQIDAR 00164**
PROJECT DESCRIPTION	Gasification of coal is now widely recognized as the core of clean coal technologies, particularly in the context of coal-to-liquids (CtL) processes. There is significant interest on the Indian side, as part of a major government-backed initiative, to develop technology for conversion of high-ash (upto 45%) Indian coal to methanol (coal to methanol: CtM). With CO2 management being a strong driver for future gasification technologies, there is also interest in gasification of biomass, as well as blends of coal and biomass, in order to develop low-carbon (or ideally carbon-neutral) conversion of solid fuels to liquid fuels. For CtM technologies of the future, there is need to develop gasifiers that work with a suitable mixture of steam and oxygen (99%+ purity), so that downstream separation of waste gases (including N2) is less demanding. However, direct oxy-conversion puts several operational challenges on the gasifier, which motivates the present project. Three complex particle scale phenomena occur during gasifier operation: (a) fragmentation due to rapid product gas flow cracking up the ash layer, and because of percolation phenomena in the vicinity of the particle surface, which occur when the local porosity is sufficiently high; (b) attrition due to collisions between particles; (c) agglomeration, possibly due to the inorganic (ash) component of the coal particles approaching their liquidus temperature, leading to fusion of colliding particles. Both processes (a) and (b) lead to production of fines, while process (c) leads to production of large agglomerates. Any of these lead to poor gasifier operation; (c) actually leads to catastrophic shutdown of the gasifier. The aim of the proposed project is to examine these phenomena through modeling the transport (multicomponent mass transfer and heat transfer) effects at the particle scale, while incorporating the structure evolution and particle fragmentation as the gasification proceeds. This part of the project will be executed both at IITD and UQ. At a later stage, the goal would be to embed these models into a reactor-scale (gasifier-scale) CFD code, and examine for the first time how such phenomena affect the global gasifier behaviour.
PROJECT OUTCOMES	This project, when completed, would provide a comprehensive understanding of the complex phenomena occurring in a gasifier. Specifically, the two expected outcomes would be: (a) Suite of models at the particle scale â€“ incorporating fragmentation, attrition, and agglomeration; (b) CFD model of gasifier flow with the particle scale models embedded as the appropriate rate phenomena. There is no published work thus far which approaches the above challenges in a coherent manner. The UQ supervisor has worked on problems related to part (a) in the past, while the IITD supervisor has work on problems related to part (b). However, these has never been brought together in a coherent manner, which is the main aim of this project. On completion, this work should provide specific engineering guidelines to design better gasifiers in the future, for coal and coal-biomass combinations. Insights into better operational protocols are also expected. Given the importance of clean coal technology to both the Indian and Australian economies, this project has national significance for both countries.
ADVISORY TEAM	**Professor Suresh Bhatia** https://researchers.uq.edu.au/researcher/161 s.bhatia@uq.edu.au School of Chemical Engineering The University of Queensland

	Professor Shantanu Roy http://chemical.iitd.ac.in/faculty/shantanu-roy/ roys@chemical.iitd.ac.in Department of Chemical Engineering Indian Institute of Technology Delhi
TYPE OF STUDENT	Applications are open to i students who meet eligibility criteria.
DISCIPLINE BACKGROUND OF STUDENT	Ideally, this project requires students with a background in chemical engineering, cfd, mechanical engineering, physics
IDEAL CANDIDATE	Essential capabilities: • Ability to translate transport phenomena problems to set of PDEs and numerical solution thereof. Laboratory scale experimental skills preferred. Desirable capabilities: • Knowledge of CFD software like Ansys-Fluent, OpenFoam, etc. and multi-physics software like Comsol is preferred. Expected qualifications (courses, degrees, etc): • Bachelors or Masters degree in Chemical or Mechanical Engineering with excellent academic record.
APPLICATION PROCESS	Apply online by the due date: https://www.uqidar.org/students/how-to-apply/