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TRIG™: An advanced gasification technology to utilize low rank coals for power

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HIGHLIGHTS

- Low rank coal use becomes urgent or accessible.
- Costs to reduce emissions for power generation are increasing.
- LRC TRIG™ IGCC is advanced and cost effective clean coal technology.
- LRC TRIG™ IGCC has a higher performance than conventional USC.
- TRIG™ IGCC provides a viable solution for low rank coal.

GRAPHICAL ABSTRACT

On Overview of the Southern's Kemper IGCC Project

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ABSTRACT

This paper presents the results of a recent low rank coal 850 MW class IGCC ("Integrated Gasification Combined Cycle") feasibility study for the 50 Hz market. The study aimed to position the Transport Integrated Gasification ("TRIG™") technology for power generation in the China market where coal gasification has been widely practiced. It assumed a mine mouth project in eastern Inner Mongolia, China and used a low rank coal from the area. Results from the study indicate that the low rank coal TRIG™ IGCC is more efficient and with a superior environmental performance and less water usage than the best available conventional ultra-supercritical ("USC") technology in the China market. With environmental regulation compliance costs increasing in China, the low rank coal TRIG™ IGCC will become competitive as one of the viable clean coal technologies for power generation. Converting the large reserve of low cost and low heating value coals located in remote areas to electricity for the coastal areas will certainly help these areas manage the increasing pressure for further reductions in emissions from coal firing power plants. The paper also provides an update on Southern Company's Kemper IGCC project in the USA that includes CO_2 capture and is currently in its final stage of construction.

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1. Introduction

Many countries such as China, Indonesia, Australia, Germany, Poland and Turkey have a significant amount of low rank coal reserves. These low rank coals are typically not a traded commodity due to low heating value and high moisture content, and therefore, are available at low cost. With a viable technology for processing low rank coals that addresses efficiency and environmental constraints, the advantage with a low cost feedstock can help offset the high capital requirements of a coal gasification project. China, which was the focus of this study, has expanded its power generation capacity from 390 GW in 1990 to 1140 GW in 2012. Out of the 1140 GW, 758 GW are coal-fired power plants [1]. Coal is the dominant energy source in China's economy and will continue to be for years to come. In the meantime, China's coal-fired power fleet is facing increasing pressure to further reduce emissions such as SO_x, NO_x and particulate matter. This has become extremely important as haze or smog lingers more frequently than in past years over many cities both inland and coastal.

Being the No. 1 coal user in the world, China consumed 3.6 billion tons of coal in 2012 [2]. Such a demand has pushed low rank coal to the market place. The Chinese government has established an incentive policy to encourage an effective utilization of low rank coal resources in its 12th Five Year Plan. In addition to a technological challenge, the remote location of the low rank coals has created an additional barrier in transporting the coals far away. Transport Integrated Gasification ("TRIG™") technology, developed as one of the clean coal technologies for low rank coals by KBR and Southern Company, seems an ideal choice to effectively utilize the low rank coal resources.

2. TRIG™ background

Southern Company and KBR in the mid-1990's commissioned a demonstration facility called the Power Systems Development Facility ("PSDF"), funded by the United States Department of Energy ("DOE"), to develop a coal-based power generation technology that was cost effective and efficient using low rank coals [3]. The PSDF was designed to process 50 tons of coal daily ("TPD"). The alliance included National Energy Technology Laboratory ("NETL") and industrial players including the Electric Power Research Institute ("EPRI"), Siemens Westinghouse Power Corp., Peabody Energy, the Lignite Energy Council, and Burlington Northern Santa Fe Railway. The TRIG™ unit was originally designed by KBR and integrated into the facility, which includes coal receiving, drying, gasification and downstream syngas cleanup. During the following 16 years, a variety of coals were tested at the PSDF. Mississippi lignite and Powder River Basin ("PRB") subbituminous were two coals tested extensively. These two coals, representative of low rank coals, achieved consistently high carbon conversion (98 + %) from many test campaigns. The PSDF has logged more than 20,000 h of operation. The scale of 50 TPD is essentially a small commercial plant. So far, TRIG™ has been utilized in two licensed projects currently under construction in China; one for power and the other for chemicals. Southern Company itself has deployed this technology to build a 582 MW (net) IGCC facility in Kemper County, Mississippi, USA. The project is slated for commercial operation before the middle of 2015.

3. TRIG™ overview

Different from most others in commercial operation, TRIG™ is a partially dried feed, dry ash (non-slagging) discharge and refractory lined gasification technology. It operates below the ash deformation temperature of a low rank coal while maintaining the temperature as high as possible to maximize carbon conversion into carbon monoxide, hydrogen and methane while destroying large hydrocarbon molecules such as tars formed from the decomposition of volatile matter. TRIG™ is flexible as it may use either air or oxygen as oxidant depending on the requirements of downstream applications. As shown in Fig. 1, air or oxygen is injected into the lower Mixing Zone where it reacts with unreacted carbon circulated back from the Standpipe via the J-Leg. The resultant hot circulating ash and gas flow then mixes in the upper Mixing Zone with coal introduced via a proprietary pneumatic feeding system. The coal is heated quickly, dehydrated, devolatilized and gasified while moving up the Riser section. After exiting the Riser, solids and syngas enter the 1st Cyclone. Solids disengaged from syngas at the 1st Cyclone are returned to the Standpipe through the Loop Seal. Smaller particles are collected in the second cyclone and are routed to the Standpipe for further processing. Syngas exiting the 2nd Cyclone contains fine ash particles and is routed downstream to recover heat for HP steam generation and to remove the fine ash. Coarse ash is discharged as required to maintain the solids inventory in the gasifier. To maintain the normal operation of the TRIG™ gasifier, a significant solids circulation is required. The solids circulation rate is designed to accommodate specific coal properties such as the low heating value of low rank coals, while keeping the system at the desired gasification temperature.

Considering TRIG™ as a circulating fluidized bed technology is an oversimplification. Although the circulation flow suggests fluidization, many other aspects in both design and operation distinguish TRIG™ from fluidized bed gasifiers. One of the major differences is that the relative superficial velocity between gaseous phase and solids phase is very small. The ratio of the gaseous velocity to solids velocity ranges between 1 and 2 while fluidized bed technology operates with a very high ratio, if not close to infinite. The solids phase essentially travels at a velocity close to that of the gaseous phase in the gasification section of the Riser. The gaseous phase velocity is well above that for fluidization so that gasification achieves the desired carbon conversion in a matter of single digit seconds in the Riser Section. Hence, TRIG™ is prefixed with

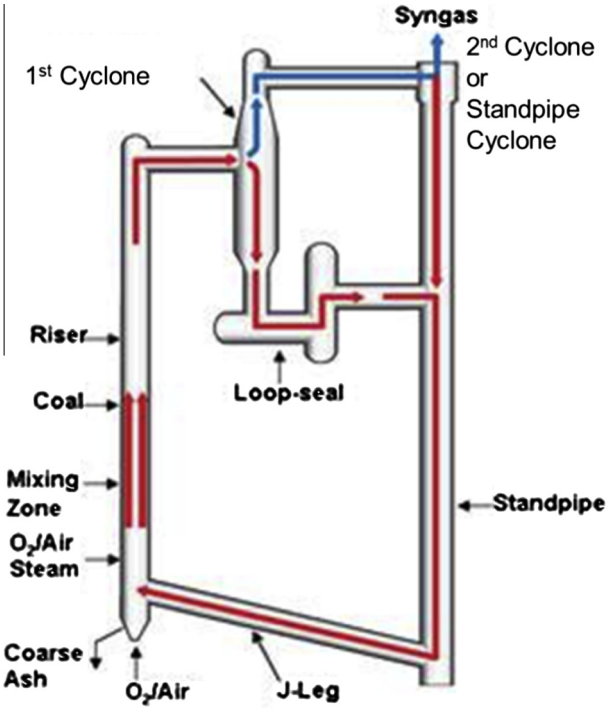

Fig. 1. A schematic TRIG™ gasifier.