N78-13269

THE USE OF TWIN SCREW EXTRUDERS FOR FEEDING COAL AGAINST PRESSURES OF UP TO 1500 PSI

W. Wiedmann

Werner & Pfleiderer
Stuttgart, West Germany

W. A. Mack

Werner & Pfleiderer Corp.
Waldwick, New Jersey

To date, oil and natural gas have served most of the world's energy needs. Diminished supplies, however, mean that a return to coal will be essential to fulfill the energy needs of the coming decades. Gasification of coal provides a ready and economic solution to our immediate energy needs.

The processes for gasification of coal were first developed in the mid-thirties and successfully used throughout World War II. Since then, however, very little development was undertaken to improve production methods. Consequently, considerable work must be done to adapt the processes to today's standards.

One process step which has never been satisfactorily resolved is the feeding of the coal against the pressure in a gasification reactor. A variety of devices had been tested, however, none provided an effective commercial solution.

Single-screw extruders have been used for feeding coal, but basic disadvantages have been observed, such as: bridging of the coal in feed section, a high degree of surging in the extruder, very high energy consumption (up to 10 times higher than twin-screw equipment). In addition, it is difficult to maintain steady state pressure build-up conditions, especially with the larger diameter (single-screw) extruders required for commercial size plants.

Also, the pumping efficiency of a single-screw is dependent on tight clearances between the screw crest and barrel. As a result of the high conditioning involved with processing coal, these clearances are lost after very short operative time, leading to frequent shutdowns for repair. This is especially true for processes where an absolute minimum of water is needed for efficient operation of the gasification reaction.

Twin-screw mechanisms have been known to provide significantly improved coal conveying capabilities. They can also develop the required pressures for steady state conditions even with larger machine sizes. However, the initial development work performed with counter-rotation twin-screw mechanisms also produced negative results. The primary reason is that counter-rotating screws act as a grinder and change the particle size distribution of the coal considerably. As a side effect, a high amount of layering in the screws was observed.

This paper will describe recent tests with a twin-screw, co-rotating extruder which was successfully used to convey and feed coal against pressures of up to 1500 psi. Intermeshing and self-wiping, co-rotating twin-screws give greatly improved conveying and pressure built-up capabilities and avoid hangup and eventual decomposition of coal particles in the screw flights.

The conveying action of intermeshing, self- wiping, co-rotating extruder systems approaches that of a positive displacement pump. With this feature, it is possible to maintain very accurate control over all aspects of product conveyance in the extruder, i.e., intake, conveyance and pressure buildup.

In the co-rotating systems, the product is moved from one screw to the other in the form of an 8-shaped path and downstream, depending on screw pitch. Very little, if any, material passes through the clearance between the screws because the two screws have opposing directions in the area of intermesh. Very little product pressure exists that would create leak flow through this area. All of the material is, therefore, transferred from one screw to the other at each revolution. The 8-shaped path itself is a very long one, allowing ample opportunity for heat exchange between the material and the barrel walls. In effect, a great variety of different coals can be processed with little or no water addition required to achieve conveyance and pressure buildup.

The improved conveying capabilities of twin-screw mechanisms allow generation of very high extrusion pressures with a very short backup length required. For example, in a well designed twin-screw system, extrusion pressures of 3,000 to 5,000 psi can be easily generated over a screw length of 2 to 3 D. The pressures can be adjusted without drastically affecting the throughput. This provides added processing flexibility.

The basic advantage of twin-screw mechanisms, therefore, results from superior conveying capabilities, which in turn greatly help in maintaining control over energy input into the material and retention time distribution.

TEST SET-UP

Figure 1 shows the test set-up used to convey the coal with a co-rotating twin-screw system. The coal is metered via a weigh belt feeder into the extruder. Two 58mm (screw diameter) screws with an L/D ratio of 15 were used. Water was metered into the second barrel section. This was done to provide the proper proportion of water for the reaction and also so that the water could be used as a lubricant in the process. Special kneading elements are installed at Sections 2 and 3 to intensively mix the water and coal. Two different coals were tested, lignite coal (particle size 0-6mm, 59% capillary water) see Figure 2, and bituminous coal (particle size 0-.2 mm, no water content) see Figure 3.

TEST RESULTS

In processing lignite coal with the 58 mm extruder, a throughput rate of 170 kg/hr. was achieved. Successful runs were made against 59 atmospheres of pressure. A continuous flow through a transfer pipe of 10 foot length was achieved, thus stimulating actual delivery condition in large gasification reactors. The appearance of the coal strand was very regular.

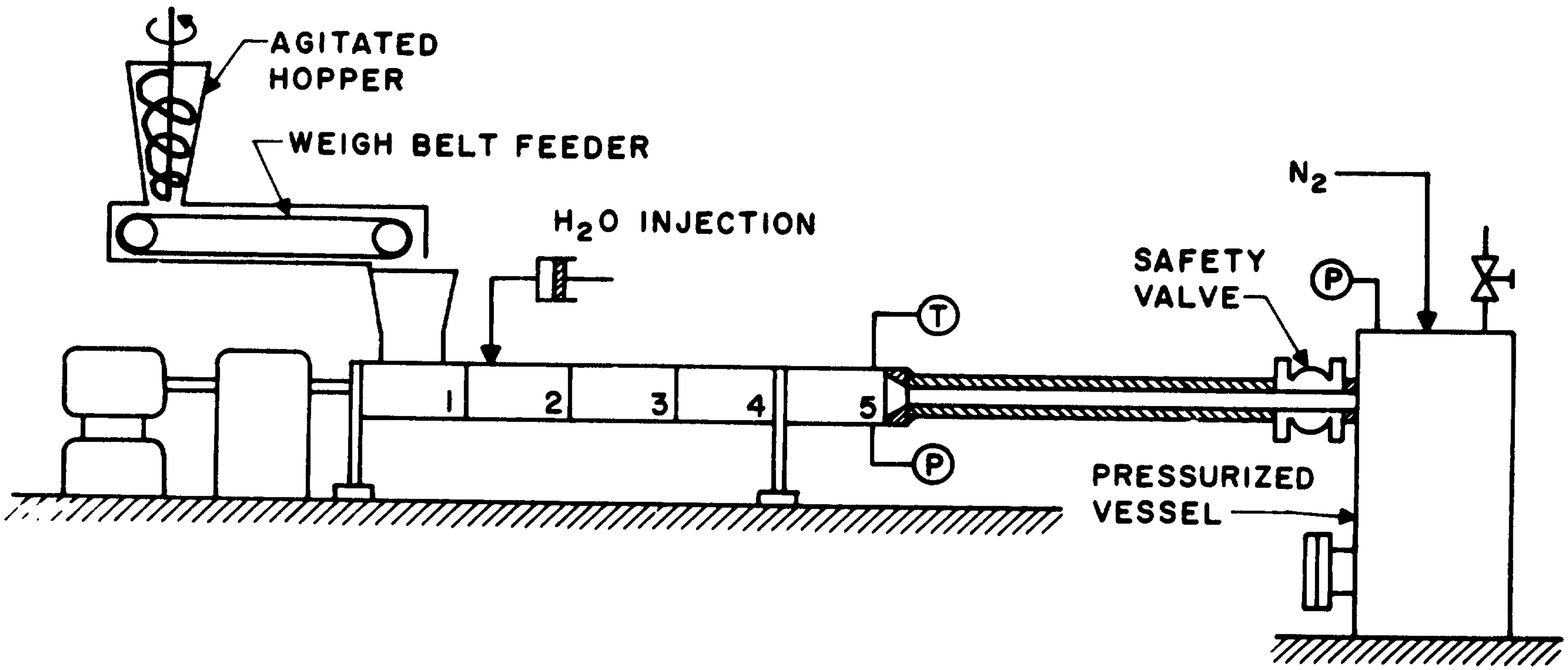
The bituminous coal was processed with up to 3 percent capillary water. The addition of the water was required to generate a gas-tight paste in the extruder. Special kneading and mixing elements were required in order to homogeneously incorporate the water into the coal. Most of the required energy for mixing was introduced by mechanical energy through the motor. The energy consumption is approximately .03 KW per Kg coal.

Figure 4 shows mechanical energy consumption versus reactor gas pressure. As expected, the energy consumption increases with rising reactor gas pressure. The water in the coal acts as a lubricant, consequently, the pressure decreases with increased water content, see Figure 5.

In addition to conveying of coal through a pipe against pressure, a series of tests were conducted to study the behavior of the coal at discharge. To economically operate a coal gasifier, it is necessary to obtain uniform particle size distribution of the coal in the gasifier. Figure 6 shows a thermal disintegration of the coal leaving the pipe following extrusion. In order to convey against 1500 psi, the temperature of the coal must reach at least 310^{o}C. Usually, gasification temperatures are mugh higher. This type of disintegration of coal can be applied in fluidized bed reactors.

In the tests, throughput rates of up to 250 Kg/hr. were obtained. The tests demonstrated that co-rotating, twin-screw extruders can be successfully used to convey and feed coal against pressures of up to 100 atmospheres.

Requirements for commercial coal gasification reactors are between 100 and 200 tons per hour. In the plastics industry, today's commercial size extruders have throughput rates of up to 25 metric tons an hour. In order to scale up to commercial requirements, more work must be done to study the behavior of coal conveyed against pressure. The next test series will be carried out on a 120 mm twin-screw extruder which has a throughput rate of up to 1½ metric tons an hour. In this test the extruder will be mounted directly on a gasification reactor. The results of this second phase of scale-up will provide a definite basis regarding the feasibility of a commercial size operation.



CONVEYING OF COAL AGAINST PRESSURE IN A CO-ROTATING TWIN-SCREW EXTRUDER

FIGURE 1

Figure 2
Typical lignite moisture

Mined at Hambacher Forst
Water Content 59%
Particle Size 0-6 mm
Ash Content 2%

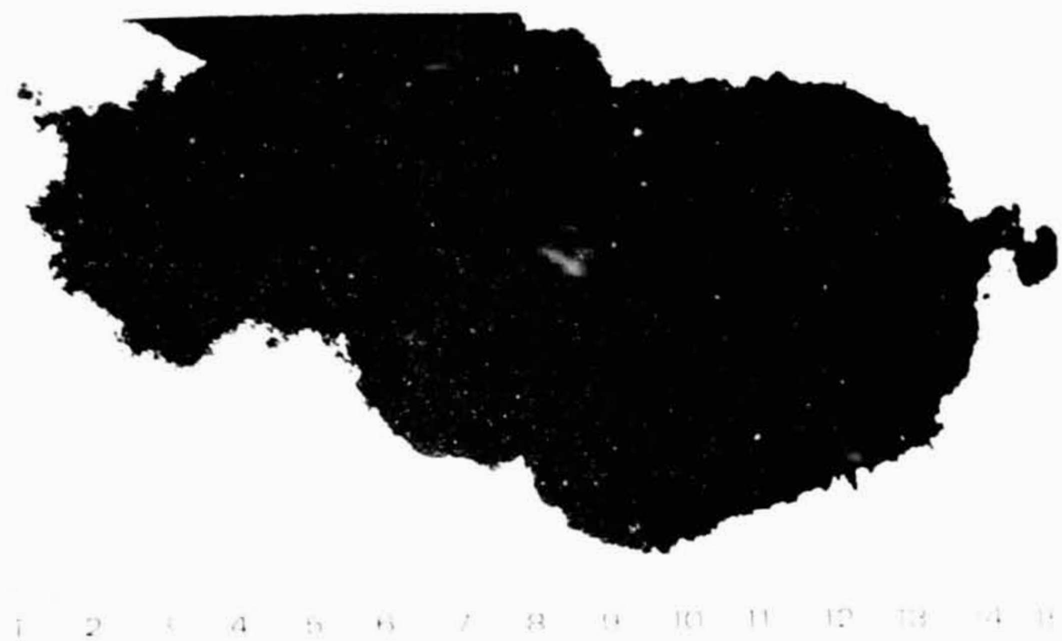
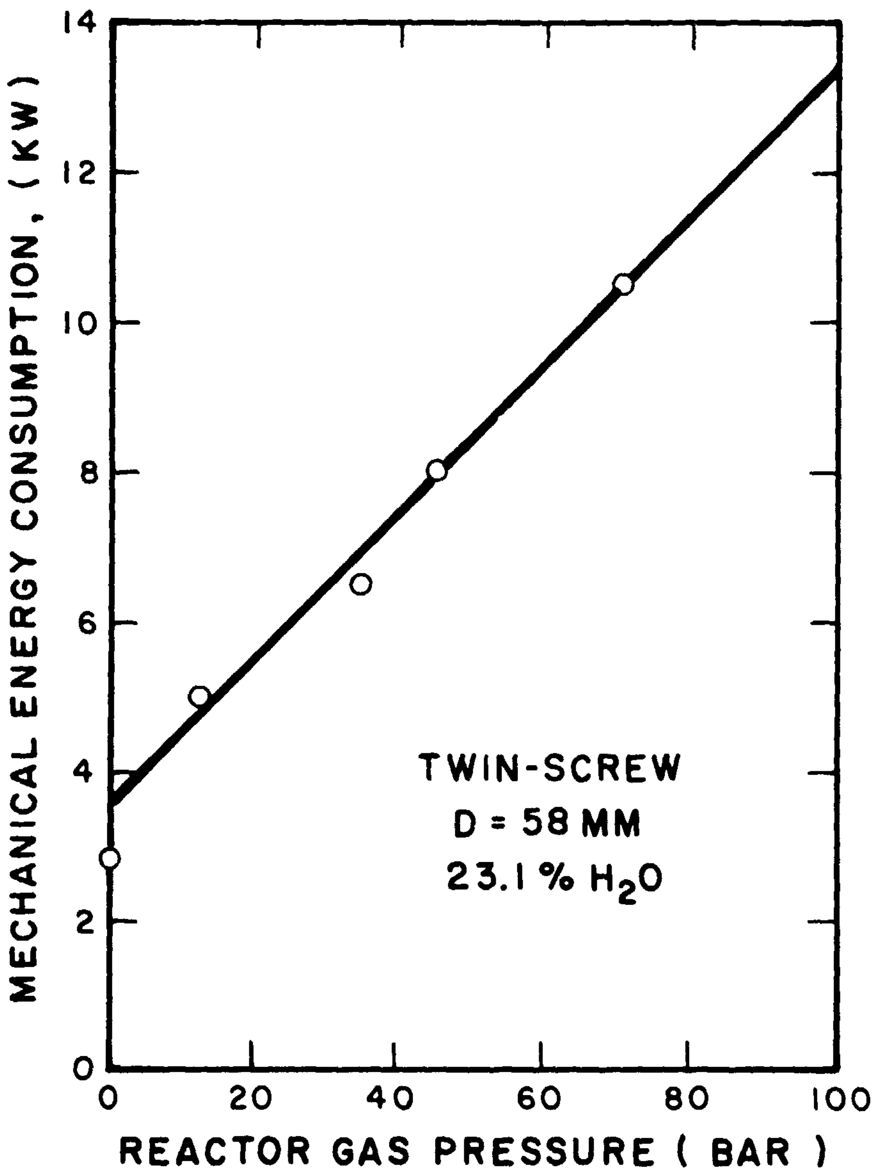


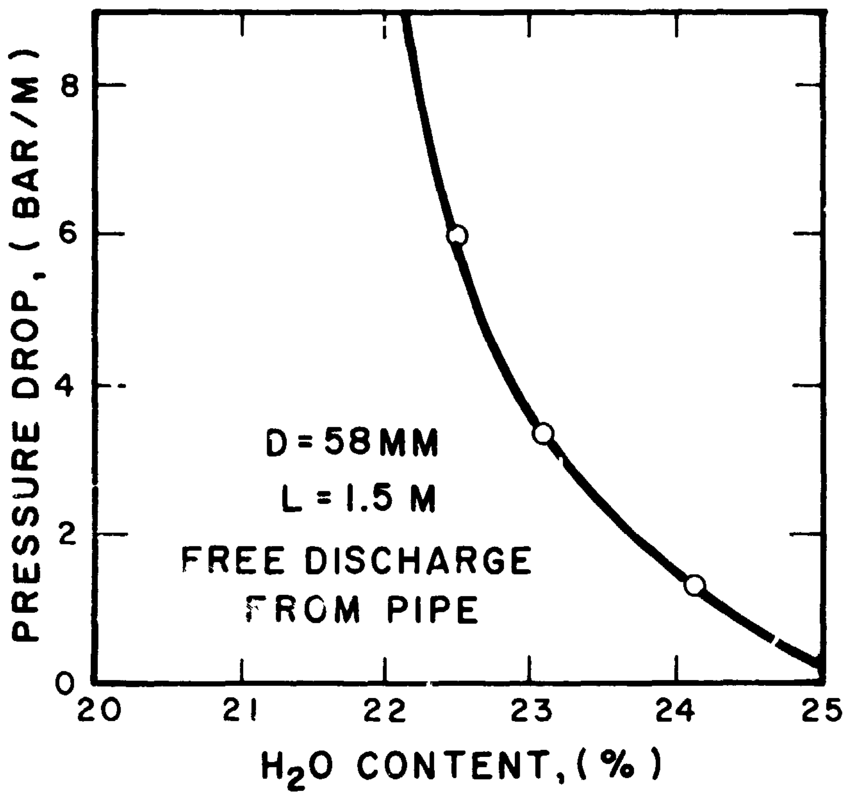
Figure 3
Bituminous Coal

Particle Size IKO-N: 0,2
Ash Content 3 %



ENERGY CONSUMPTION VS REACTOR PRESSURE FOR HIGH VOLATILE BITUMINUS COAL

FIGURE 4



PRESSURE DROP VS H_2O CONTENT

FIGURE 5

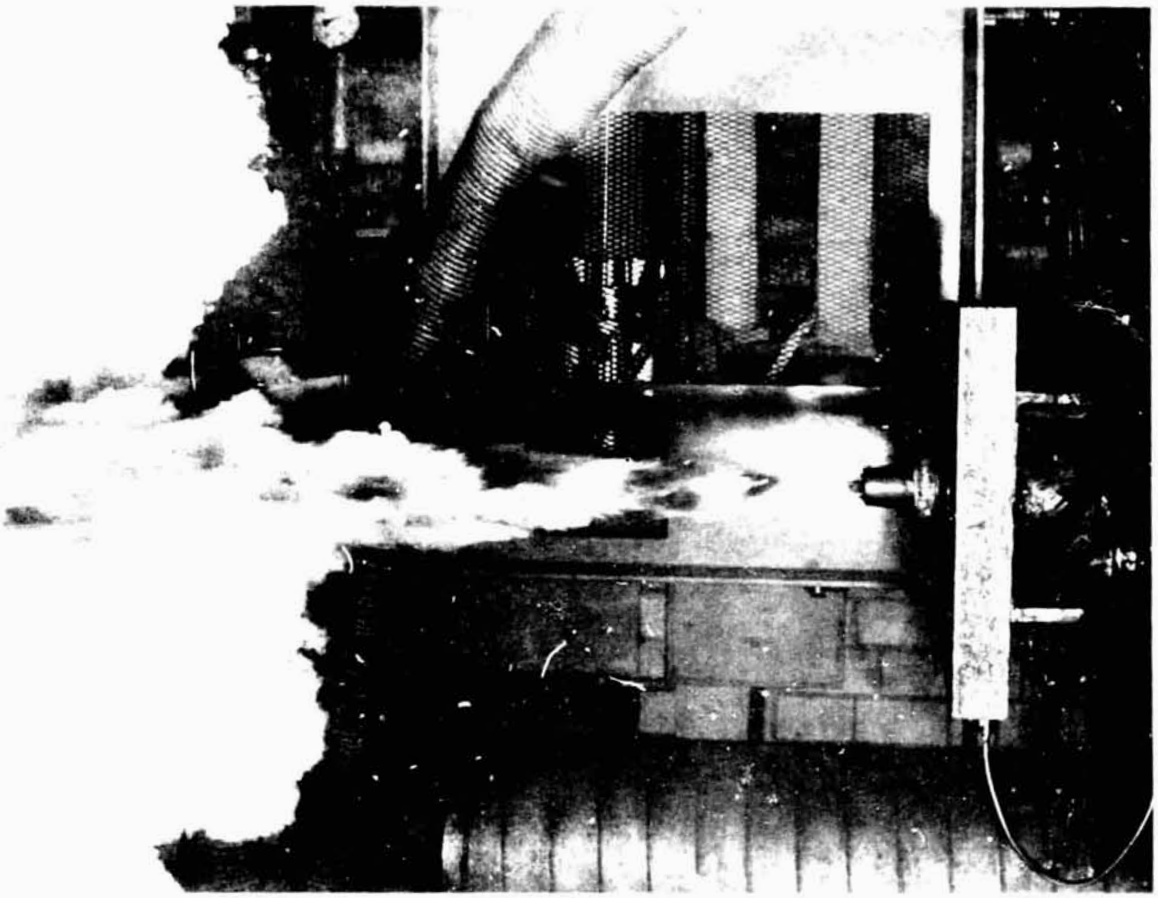


Figure 6
Disintegration of the coal and water mixture at the discharge end of a Continua twin-screw machine.