

7. TECHNOLOGY NEEDS

7.1 Trace Elements in Coal

The results of the Phase 1 study on trace elements in coal brought out several gaps in existing data. These are summarized here.

1. Little or no data have been obtained on the content of the hazardous elements F, As, Se, Cd, and Hg in appropriate U.S. coals. This lack has been partially filled for mercury by recent studies, and it is being found in quantities much lower than those commonly quoted in the literature. Results for the other toxic elements noted are spotty at best, and methods for As, Se, and Cd are still in the research stage.
2. Reliable data are needed and not yet available on coals representing large future reserves which are not yet in production, such as those in Wyoming. These data should be on a basis which is directly comparable with the data for other regions. This means that they should either be obtained using the previous standard methods of analysis, or if newer methods are used after sufficient evaluation, correlation must be assured.
3. Changes have been noted in some stored samples on re-analysis by the original standard procedures, so it is not enough to re-examine old samples by a new method. The situation to be particularly avoided is analyzing the new samples only by a new method of analysis, which is not tied in any way into the present bank of basic data.
4. There is a similar need for basic data on the effects of coal conversions on the fate of trace elements, including the effect of operating conditions on the distribution of elements between fly ash (overhead) and bottom ash in combustion, in gasification, and in all other forms of processing. For these studies it is not as important to tie newer methods of analysis to older results. The method must be calibrated well enough within the range of concentrations and interferences concerned to be sure that it gives differential results which are reliable.
5. Major differences exist in the physical and chemical properties of the forms in which potentially pollutant elements are emitted on combustion. This includes such questions as the ionic state of fluorine, the oxidation state of beryllium, the formation of spinels from oxides, and the physical/chemical effects of the surfaces of sub-micron particles. In each of these cases one form may be metabolically active, and another in equal amounts inactive. These effects will

require special attention if the list of toxic hazards is extended to include elements whose presence in minute traces is recognized as essential to health.

7.2 Trace Elements and Other Potential Pollutants in Coal Conversion

The information shown in the tables of Section 6 is an indication of the lack of data regarding trace elements and other low concentration pollutants in the various streams of coal conversion plants. Little information is available for gasification, even though commercial plants exist, and even less information is available for liquefaction plants.

In the area of coal storage there is a need for analyses of rain run-off and ambient air. The water run-off can be expected to approximate mine drainage water but this is not certain. Along these lines, analyses of seepage from coal piles would be of interest. It might be expected that dust from coal piles would have the same trace element concentration as the gross coal, but this is not certain. Due to oxidation, there is the possibility that organic materials are present in small amounts in the air over coal piles. Analysis for these should be explored.

In the area of acid gas removal a knowledge of the traces of product removed would be helpful. Even though the solubility of such materials as carbon monoxide, methane, hydrogen, etc. is small in hot carbonate, amines, etc., a small quantity passes out with the acid gas and special precautions must be taken to prevent the eventual escape of these materials into the atmosphere. A cheap, efficient, high temperature acid gas removal system would be useful in conserving energy. Work is in progress to develop such systems (59-61). A system that would remove the CO_2 in such purity that it could be vented and which did this cheaply would be useful. It is recognized that a liquid that absorbs sulfur compounds and CO_2 to a different degree can produce a CO_2 stream with any designed degree of purity by adding more plates to the column. This, however, can become expensive as the degree of purity increases. The presence of sulfur compounds other than H_2S also adds complications. Other problems arise when there are reactions of impurities with the absorption medium. This results in purges that may be difficult to handle. The magnitude of this problem is difficult to evaluate at present due to lack of information. As more information becomes available, this problem can be considered in more detail. If the sulfur compounds can be removed in sufficient concentrations to use a single stream Claus plant for sulfur recovery, then the problems connected with carbonyl sulfide, organic sulfur, trace hydrocarbons, etc. will be minimized.

From a pollution point of view there is little concern with the shift and methanation sections of gasification, but from an overall environmental viewpoint, the saving in thermal efficiency of producing methane directly from carbon monoxide and water would be desirable.

If no technique is available that cheaply produces a highly concentrated hydrogen sulfide stream, then there is a need for an efficient technique of converting sulfur containing compounds to sulfur. Even a Claus

plant, operating on a concentrated stream of H_2S , produces a tail gas that may require cleanup. A desirable process would convert all sulfur compounds to sulfur, incinerate or recover all hydrogen, carbon monoxide, and hydrocarbons and produce a tail gas that could be vented directly to the atmosphere. It would have no obnoxious liquid or solid effluents and could be built and operated at reasonable costs.

Another area where there are technology needs has to do with waste water treatment. More details are needed as to the trace element and compound composition of waste water streams. Certainly, if water is to be conserved, it is necessary to have a better definition of what is in the water in order to devise techniques for its re-use. A measurement of biological oxygen demand is not sufficient for this. Cleaning the dirty water may not be a simple matter (38).

Of special need are detailed analyses of effluents from waste water treatment facilities treating water from coal conversion facilities. One unknown is the effluent to the air from biological oxidation. The possibility of transfer of water pollutants to the air has been considered (37). A special problem involves cooling tower blowdown. This waste water contains large amounts of dissolved solids and is difficult to treat. Techniques for using this water directly in the process or to make steam would be desirable.

Solids disposal is another general area where more data are needed and better disposal techniques are desirable. The leaching characteristics of ash, slag, flue gas scrubbing materials, incinerated sludges, and others are needed. The rates of leaching and concentration of potentially hazardous materials in the leachate would indicate whether or not a disposal technique was sufficient. One study on leaching of spent oil shale (62) shows considerable leaching of minor elements.

A number of other areas exist for which little if any information is available. One, for example, is the concentration of volatile trace elements in coal dryers. Another is the possible use of chars to remove polluting materials from waste water.

In general, much more information is needed about the composition of streams in coal conversion plants. The only way to obtain this information is by sampling and analyzing these streams. Once it is known what is present, then decisions can be made as to what is needed in the way of control technology. If this technology is not available, then programs can be initiated to develop it.

7.3 Improvements in Thermal Efficiency

To relieve the load on the environment caused by heat losses, a number of areas exist for research to make improvements in thermal efficiency. Table 56 is an indication that no discovery will change the overall thermal efficiency in a major way as the heat losses are so evenly distributed over so many plant areas. Nevertheless, improvements are possible in many areas and research could lead to such improvements.

Oxygen production is a large source of heat loss. Better techniques for oxygen production are possible. One possibility is the thermal decomposition of water by cyclic chemical reactions. This also produces hydrogen that would find wide use in the production of synthetic fuels.

A sulfur insensitive catalyst that would carry out the water gas shift and methanation reactions in one step would make a great contribution to the concept of heat conservation. Gases would then have to be cooled only once in the gasification sequence.

The need for better, more efficient techniques for sulfur removal have been discussed previously. This is an old area of technology, however, and improvements may be difficult without a fresh approach.

The area of water cleanup has also been discussed previously. When more is known of the composition of wastewater streams, there should be many areas of research that would improve thermal efficiency.

Most of the processes studied in this work have relatively large streams containing on the order of 500 million Btu/hr of sensible and latent heat at temperatures of about 300°F. This heat is worth recovering but at present no uses for it are obvious. The temperature level of this heat is greater than that available in some schemes such as energy recovery from temperature gradients in the ocean, but the quantity of heat available at any one site is such that no grand plan comes to mind on how it could be used. This area is worth further thought.