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The application of granulation to fine coal preparation

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CHAPTER I
INTRODUCTION

I.1 General

History readily reveals that coal was the king of energy in the nineteenth century. In the twentieth century, however, oil took the role of coal as the new king of energy. During this period most energy consumed was oil energy. The cheaper oil price in the period from 1950's and 1960 led to the abandonment of coal as the dominant energy source. Since the oil crisis in 1973, however, coal energy started to be attractive again. The public generally realized that the oil shortage was about to begin with the oil supplies being rapidly depleted. Consequently, current coal energy demand trends indicate considerable increase in coal utilization. An indication of this interest may be judged by the Workshop on Alternative Energy Strategies (WAES) held by industrial countries in 1977 which concluded that coal and nuclear energy will be the prospective energy sources relative to oil energy. These two energy sources have more than ample reserves to provide the energy requirement until the end of this century [1].

Furthermore, WAES predicted that an oil shortage will occur again before the year 2000, because by that time energy supplies will fail to meet increasing energy demands. The World Coal Study (WOCOL), constituting a subset of WAES, concluded that during the critical period between now and the year 2000, coal can provide the energy bridge to the future. In the industrial countries coal will become the essential fuel for economic growth replacing oil in many cases. For many developing countries, desiring to avoid dependency on oil, coal is the only fuel for electric power and industrial development [1].
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The improved situation for coal is not only affected by oil prices or the oil shortage, but is also influenced by the use of other energy sources, particularly nuclear and solar energy [2]. Nuclear energy has a great opposition in regard to its catastrophic possibility and extremely serious environmental problems. Solar energy, on the other hand, requires complex and expensive technology. These limiting factors restrict the economic use of nuclear and solar energy. On the other hand the same factors lead to an increase in the use of coal energy. But it should be mentioned that the future of coal is strongly determined by its reserve and its competitiveness with oil and natural gas. It is well known that these energy sources are finite. However, it is not right to assume that coal has sufficient reserves to supply the world energy requirements for the long term. Coal just offers substitution for oil and gas energy in the intervening period. It can bridge the present to the future wherein other sources such as nuclear (particularly fusion) and solar energy can be used safely and economically.

It is worthwhile considering that the world political and economic situations contribute a significant impact on coal utilization. Notably the WAES prediction is too optimistic, because now the public realize that oil prices are down to about US$ 16 a barrel (1989) causing the competitiveness of coal to be reduced. But one should be aware of the dynamics of the world politics and economics which have temporary effects on the world energy situation. In particular the current low oil price is only generated by the economic hardships faced by several countries. Once this economic hardship eases coal will gradually regain its key role. Furthermore improvement in coal technology will further cause coal to be the single option for oil substitution.

Fortunately coal has abundant reserves to contribute to the future energy supplies. However its efficient utilization requires a proper program of development and recovery. Many challenges must be faced to fulfil current requirements in so far as the public require both quality and quantity of coal. The consequence of the
extensive coal utilization in the 19th century was that the public was unaware that the coal quality was deteriorating. Therefore, future coal preparation should aim to improve the quality of coal to fulfil society requirements.

High ash content leads to the need to prepare coal using fine coal processes to liberate impurities. The coal cleaning process, which usually employ wet processes to remove coal contaminants should be conveniently incorporated into existing coal preparation plants. Unfortunately, the impurities contained in current coal deposits tend to be included within the microstructure [5], the subsequent liberation of which suggests the production of fines cannot be avoided.

Currently considerable attention is paid to the recovery of fine coal. This is not only due to the increased demand for coal, but also as a result of the use of continuous mechanical mining methods. Furthermore the degradation of coal causes vitrinite to concentrate in the fine coal fraction [3]. This micro lithotype is paramount for generating high quality coke. Typically coking coal normally contains 40 to 60% vitrinite [4]. Therefore effective coal fines recovery is paramount.

Although high quality fine coal can be obtained by fine coal processes, extensive problems arise from the characteristics of fine coal. The consequence of these adverse characteristics is that special coal preparation, coal fines handling and utilization techniques are necessary. Generally speaking, many difficulties such as environmental aspects, spontaneous combustion, explosions, transportation and storage problems arise due to the presence of fine coal. In addition, extensive coal fines production without treatment will require significant waste disposal areas which, in turn, must be managed to comply with environmental requirements.

In coal preparation fine coal is a major cause of poor carbon recovery, product quality and dewatering problems. It retains high moisture content and tends to associate with impurities leading to high waste disposal costs. The strong
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moisture affinity adversely affects fine coal dewatering. Furthermore coal fines existing in a wide range size distribution cause segregation in coal flows which, in turn, produces widespread effects including the non-uniformity of coal beds and coal piles. In material handling, in addition to fine coal generating dust emissions, it also creates coal flow difficulties due to the significant cohesiveness of coal fines.

One method of overcoming the problem associated with fine coal is size enlargement. The use of this technique is valid since agglomeration is currently used to recover fine coal after slurry transportation [139, 140] and also in regard to size enlargement after various fine coal processes [6, 7, 8]. Another type of size enlargement is granulation. Granulation is a specific type of size enlargement applied to enlarge particle sizes by using a liquid or a solid binder in combination with low magnitude external stresses. This size enlargement, of the fine coal fractions, has many advantages. These advantages will improve the use of fine coal such as a prospective fuel resource.

Granulation treatment of fine coals will not only suppress coal dust generation and losses, but will also improve fine coal quality if used in combination with an agglomeration process. This feed pretreatment will improve both product ash and moisture content. This hazard will be significantly reduced when the fines are granulated. In view of these benefits and with economics changing rapidly, it is logical to assume that the application of granulation in the coal industry will increase commercially. Granulation dealing with otherwise lost fines in reject stream promises to increase the yield of preparation plants and to reduce the quantity of tailing disposal and requirements. These improvements will reduce environmental problems associated with coal preparation plant operation. However, the full benefits and characteristics of granulated fine coal must be determined before full scale application. This evaluation must also consider the stability, flow characteristics and
economies of coal granulation. This evaluation constitutes a major aspect of this investigation.

1.2 Definition and Scope

Capes [6] stated that size enlargement, in the broadest sense of granulation, is a method used to improve the bulk properties of particulates. It can be defined as a method to combine small particles into larger sizes with or without using stresses, heat or binding materials. Capes added that the product of size enlargement should be stable enough to meet downstream requirements. Moreover, it should also be mentioned that size enlargement is a secondary step as a result of some processes wherein fine particles are produced. Size enlargement can be described by many terms depending on the desired purpose and process used such as flocculation, agglomeration, granulation, nodulation, globulation and pelletizing. In specific relation to granulation, many authors use this term with slight difference in definition and interpretation. They use granulation for size enlargement of powder or powder-binder mixtures by using spraying, compaction or heating in a fluidized bed process for agriculture or pharmaceutical purposes. Recently, Capes [7, 8] suggested that spherical agglomeration be used to describe fine coal size enlargement incorporating beneficiation of coal fines using oil selective agglomeration followed by granulation which applies mechanical forces. Hence it is necessary to define granulation as applied in this thesis.

In view of this need two processes namely pretreatment of granulator feed and post treatment of granulation products must be included. Notably the scope of the current investigation covers the granulation of fine clean coal produced by coal beneficiation (size classification, flotation and oil agglomeration). By use of this process three simultaneous results are expected: increased carbon recovery of low ash fine coal, size enlargement and the production of strong and stable granules.
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Granulation can, therefore, be defined as size enlargement of finely divided coal particles using low magnitude mechanical forces at ambient temperature. This definition should be distinguished from briquetting in which large magnitude external mechanical forces are applied at the ambient or elevated temperature. It should also be noted that this definition excludes the use of heat. In terms of this definition green pelletizing or balling of coal fines compares closest to fine coal granulation. Furthermore the specific purposes for granulation and agglomeration must be distinguished. In particular the latter term involves a particular fine coal beneficiation process as well as size enlargement.

1.3 The Objectives of the Research

Considering the above initial evaluation, it is apparent that granulation is an effort to:

1. improve the handling characteristics of fine coal,
2. enhance fine coal transportation,
3. enhance fine coal utilization,
4. increase coal preparation plant carbon recovery,
5. increase the saleable products from coal preparation plants,
6. reduce the ash content of fine coal products,
7. increase the calorific value of fine coal products,
8. reduce the need for tailing disposal facilities,
9. reduce dust emissions during coal handling and storage,
10. reduce calorific value losses during fine coal storage,
11. reduce environmental problems associated with coal preparation and utilization.

In comparison the disadvantages of granulation include:

1. extra processing,
2. need to incorporate additional plant into existing coal preparation plants,
3. increase product cost,
4. marginal product improvements apply,
5. product remain relatively friable,
6. added plant complexity and control, etc

In view of above advantages and disadvantages, it is essential to fully investigate the technical and economical aspects of fine coal granulation. This investigation will include the examination of the use and feasibility of applying granulation to actual coal preparation plants.

Particular emphasis will be placed on the technical aspects associated with granulation. The paramount variables governing granulation of fine hard coal will be identified. The significance of each of the identified variables will then be examined. This examination will seek to optimize the granulation process. Such an examination will require the full description and measurement of granulated product properties; including strength, stability and utilization characteristics.

Attention will also be given to minimizing binder addition whilst maintaining high granule strength. This aspect of the investigation will ensure the granulation process is economical.

However, in order to provide a suitable granulation feed, it is first necessary to consider the beneficiation of reject fine coal using size classification, flotation and agglomeration processes. In view of the need to generate suitable feed, the operating variables governing the recovery and quality of granulator feed product will be investigated.