THE PETROCARB PNEUMATIC FEEDING SYSTEM--A PROVEN METHOD FOR FEEDING PARTICULATE SOLIDS AT CONTROLLED RATES

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ABSTRACT

The Petrocarb Injection System is a pneumatic feeding system having proven capability for feeding solids at controlled rates into processes which operate up to 60 atmospheres pressure. A single system can be provided which can feed a single or multiple feed points with substantially equal distribution between the various feed lines. The system is completely automatic and is normally supplied with a solids rate control system.

A summary description of the system elements is presented together with an outline of the principal features of the system.

The paper refers to early development which started approximately twenty years ago and outlines various commercial applications.

The history of successful applications and experience leads to the conclusion that the Petrocarb Injection System is capable of feeding dry solids into most of the processes being developed for utilizing coal.

1. INTRODUCTION

Petrocarb has supplied Injectors for feeding particulate solids at controlled rates since 1959. Most applications of this early technology were in the iron making industry where hundreds of units are in use today on a world-wide basis.

Some of the basic requirements for the feeders used in these applications are that they:

a) be capable of supplying constant and reproducible flow rates for short intervals of a few minutes duration
b) have the ability to feed against back pressure such as developed by a head of several feed of molten iron
c) be available in a range of sizes and be capable of feeding solids at rates from a few pounds per minute to several tons per hour
d) can be easily and quickly stopped and started
e) use high solids to gas ratios in order to conserve expensive gases such as argon and to minimize metal splash from submerged lances.

Technological developments of the early 1960's prompted the introduction of more sophisticated custom designed systems capable of feeding against pressures of over 60 atmospheres, such as may be encountered in coal gasifiers and combustors, at rates up to about 150 tons per hour in a single, shop fabricated feed system. Early applications required only a single feed line but as technology was advanced, units having multiple lines, feeding continuously, were developed and commercialized. A brief description of a basic Petrocarb Coal Injection System, together with some applications, follows.

2. DESCRIPTION OF PETROCARB INJECTION SYSTEM

Please refer to Figure No. 1, which is a simplified flow diagram of a typical system for feeding against intermediate pressures. Modifications of this system are sometimes used depending on the particular application. The Petrocarb Injection System provides continuous and automatic injection of prepared solids into a process reactor at any designated rate, distributed uniformly among the feed lines. The Primary Injector is the heart of the system. This unit is a pressure vessel of proprietary design with multiple feed outlets, one for each injection nozzle of the reactor. Each of the multiple feed outlets from the Primary Injector has an individual injection air line, equipped with both gas and solids flow indicating instruments. After initial adjustments are completed, substantially equal quantities of solids will be delivered to each nozzle.

The total injection rate is a direct function of the differential pressure between the continuously pressurized Primary Injector and the point of delivery of the solids. The characteristic is stable, smooth, and repeatable, thereby providing a means of controlling solids feed rate without introducing variable restrictions or other equipment in the solids stream, with their attendant problems. The Primary Injector is mounted on load cells which provide necessary signals for a weight rate control system. In automatic mode, the desired feed rate is automatically maintained as set by the operator at the control panel. The operator can override the weight rate control action by placing the system in manual mode and setting the differential pressure controller set-point manually. In some installations the more sophisticated provision for automatic resetting of the rate control instrument is unnecessary.

Above the Primary Injector is the Storage Injector, which automatically replenishes the solids fed from the Primary Injector without interrupting or disturbing the injection process. This functions as a lock hopper. Lock hoppers, traditionally, have been somewhat unreliable for the same reasons that one cannot assume that a vessel or storage bin, provided with an inlet and outlet, assures that solids will flow from the vessel when the outlet valve is opened.

Our Storage Injector overcomes such problems, and is an integral part of the system. When the Storage Injector is emptied of material, it is automatically depressurized and refilled either by a Feed Injector located at grade level below a prepared materials storage bin, or from an elevated storage bin. When a Feed Injector is used, material from the storage bin is fed and conveyed to a receiver-filter above the Storage Injector where the solids and conveying gas are separated. Solids flow is by gravity into the Storage Injector and the filtered transport gas is discharged to the atmosphere.

The size of the solids batch, mechanical equipment, valves, and time increment for each function are all designed and coordinated to provide feed to the process, up to the maximum design rate, while maintaining a reserve capability in the Primary Injector. All operations are automatic, being supervised and controlled by a specially designed logic system. Solids flow in any feed line can be stopped or started by the manual operation of a remote switch for that line. Also the flow can be stopped automatically in an individual line or any desired multiple thereof by programmed process requirements or system safeguards.

A section from a strip chart recorder showing the net weight of coal being fed from a Primary Injector mounted on load cells, with the system functioning in the equivalent of the manual mode, is shown in Figure 2. Note the smooth line with only one irregularity which was caused by automatic stopping of coal feed for a brief period because of a process requirement. The feed rate can be commanded to follow a downstream process signal such as temperature, bed level, or production rate.

3. APPLICATIONS

Let us now look at some of the applications of the Petrocarb Injection System where the process application demands continuous feed under automatic control.

Petrocarb pioneered the first commercial sized blast furnace coal injection system at the Hanna Furnace Corporation No. 2 Furnace in 1961. This was a merchant iron plant and economics unfortunately dictated the closing down of this furnace. The coal injection operation was described in a paper [1] by Strassburger et al in 1962.

In 1963 the National Coal Board in England purchased a Petrocarb Coal Injection System which was installed at the Stanton & Staveley Ltd. No. 5 Blast Furnace. This system was operated successfully for about three years and was the subject of a prize winning paper by E. M. Summers at the AIME Iron Making Conference in 1964. [2] The installation and operation were technically very successful, but unfavorable economics resulting from the relative costs of coal and fuel oil at the time, plus the discovery of oil in the North Sea, prompted the discontinued operation of the coal injection system and abandonment of a plan to install coal injection systems on blast furnaces throughout the U.K. The injection unit was dismantled and moved to Leatherhead where it has been used in test operations by National Research Development Corporation, London, England, for feeding coal in a pressurized fluid bed combustor experimental program. A portion of this work was sponsored by the U.S. Office of Coal Research and the British Coal Utilization Research Association Ltd. (BCURA) and is covered in an OCR Report. [3]

Since 1967 two zinc slag fuming furnaces have been in substantially continuous operation at Port Pirie, South Australia, using the Petrocarb Injection System. The furnaces require dependable feeding of pulverized coal which serves a dual role of providing heat, and acting as a reducing agent in the process. Each of these two furnaces has thirty (30) submerged tuyeres which are fed with coal from a single injection unit (one for each furnace). The most difficult problem

in the design of this system was to cope with the feed rate of three to five pounds per minute in each of the thirty lines. A larger system would have been less difficult to design. This operation was the subject of a paper by I. D. Brett presented in 1968. [4]

Petrocarb's Injection System is used in a modern copper-nickel plant located in Botswana which uses the Outokumpu Flash Smelting Process. Pulverized coal is being fed to multiple burners to produce heat for the process. It is essential that the coal injection equipment used to feed coal into the burners provide smooth, steady flow and uniform distribution among the burners. In this facility, the coal feed rate is automatically controlled by a single rate-setting on the control panel. The rate control instrumentation automatically adjusts the instrument primarily responsible for the delivery rate of coal. The net weight of coal in the Primary Injector is continuously recorded on a strip-chart so that the operator has visual evidence of the performance of the feeding system.

A copper and nickel smelter complex being constructed in Russia, which also uses the Outokumpu Flash Smelting Process, will utilize Petrocarb Injection Systems for feeding pulverized coal to the process. This application i interesting in that the coal is to be used as a reducing agent for converting sulfur dioxide in the high temperature exit gas from each of two smelters (one copper and the other nickel) to elemental sulfur which will be condensed and recovered in waste heat boilers.

The application of Petrocarb Injection Units for high feed rates has been fully demonstrated in a multiple unit installation in Venezuela where very abrasive iron ore is fed at the rate of about 77 tons per hour in each unit against a pressure of three atmospheres. As a result of this installation, hardware has been developed which has good abrasion resistance. Reference is made to the units in Venezuela as the reason for the selection of the Petrocarb System by The Lummus Company for use on the Synthane Coal Gasification Project in a paper by R. T. Whitehead in 1974. [5]

The use of coal as a replacement for oil and gas in the production of electric power, and the production of pipe-line gas from coal, is a subject with which we are all concerned. Many different processes are being investigated. While the basic approach to solving the problems associated with each process is quite varied, there is one common denominator — each must have a dependable coal feeding system.

Petrocarb is involved with major pilot projects as the supplier of solids feeders dealing with

a) Pressurized fluid bed combustor development,
b) MHD reactor development, and
c) Coal gasification

An example of the latter is the Synthane Process for high pressure coal gasification being developed by the Pittsburgh Engineering Research Center (ERDA). This application is the subject of a paper by Mr. Robert Lewis et al. [6]

With reference to pressurized fluid bed combustor projects, Petrocarb is supplying coal and dolomite feed systems to Curtiss-Wright on its current contract with ERDA, and has been awarded a contract to supply the coal dolomite feeding system for the Grimethorpe Project in England which is being co-sponsored by ERDA, the National Coal Board of England, and West Germany.[7]

4. STATUS OF FEEDER DEVELOPMENT

Petrocarb's current position is that it can provide dependable feed systems using existing knowledge and equipment components without large scale development work. We believe our feeder designs will be able to keep up with any realistic requirements of the coal utilization program without large scale government funding. These systems can readily be scaled up to large throughputs and incorporate components which for the most part are currently being manufactured or utilize proven designs. Certainly there is a requirement for specialized know-how in the design of a dependable feeding system. Such factors as solids to gas ratios, feed rates, reactor pressure, particle size and particle size distribution, flow characteristics of the solids, and moisture content, all enter into the design of a dependable feed system. Furthermore there are no known published data which could be utilized to treat all of such variables and permit one to design a successful installation. Fortunately, Petrocarb's experience (as partially related above) plus a considerable amount of development work carried out in its own test facility permits it to confidently claim the position as stated above.

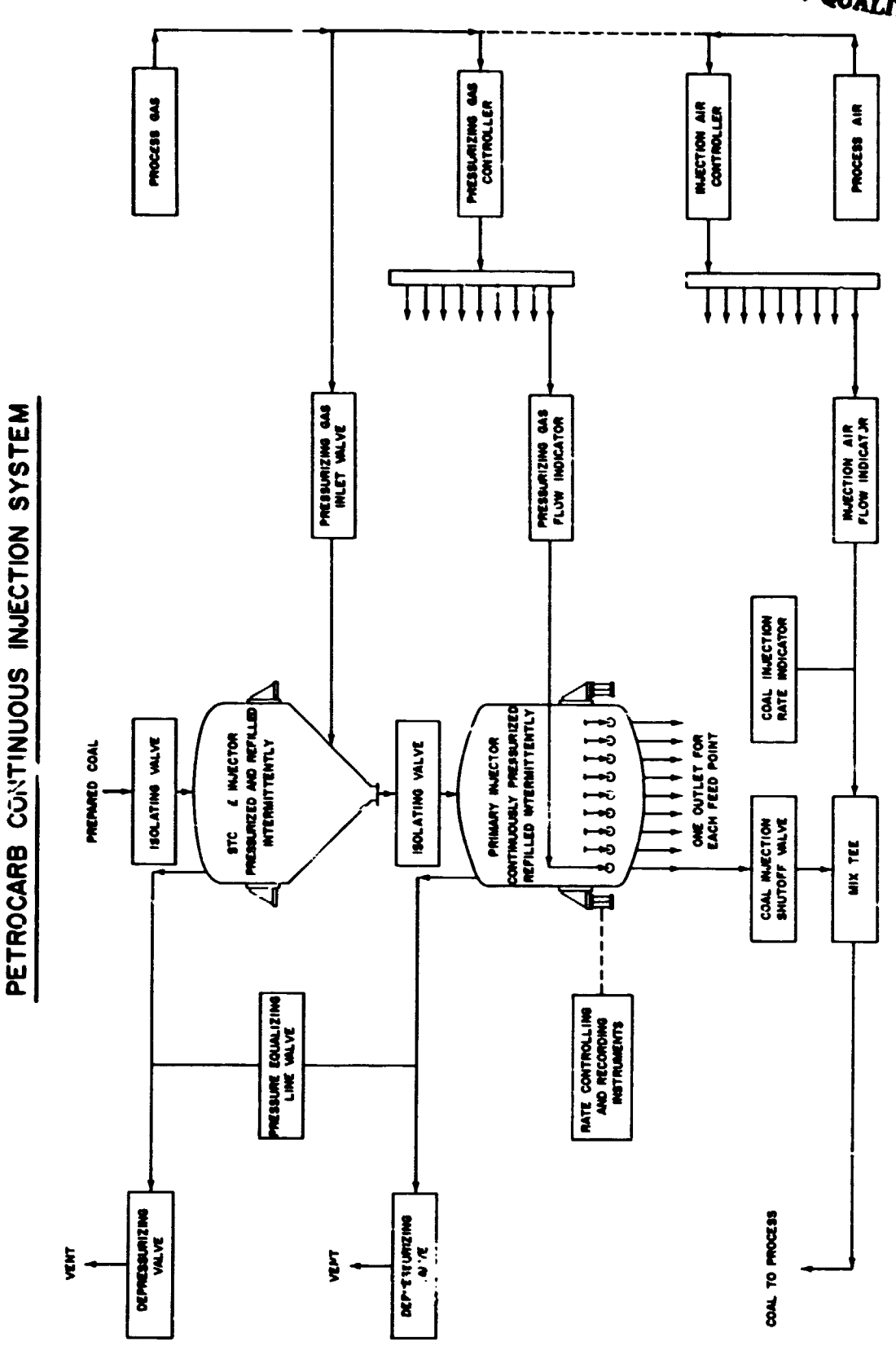

Figure No. 1 - Simplified Flow Diagram of a Typical Petrocarb System for feeding against intermediate pressures.

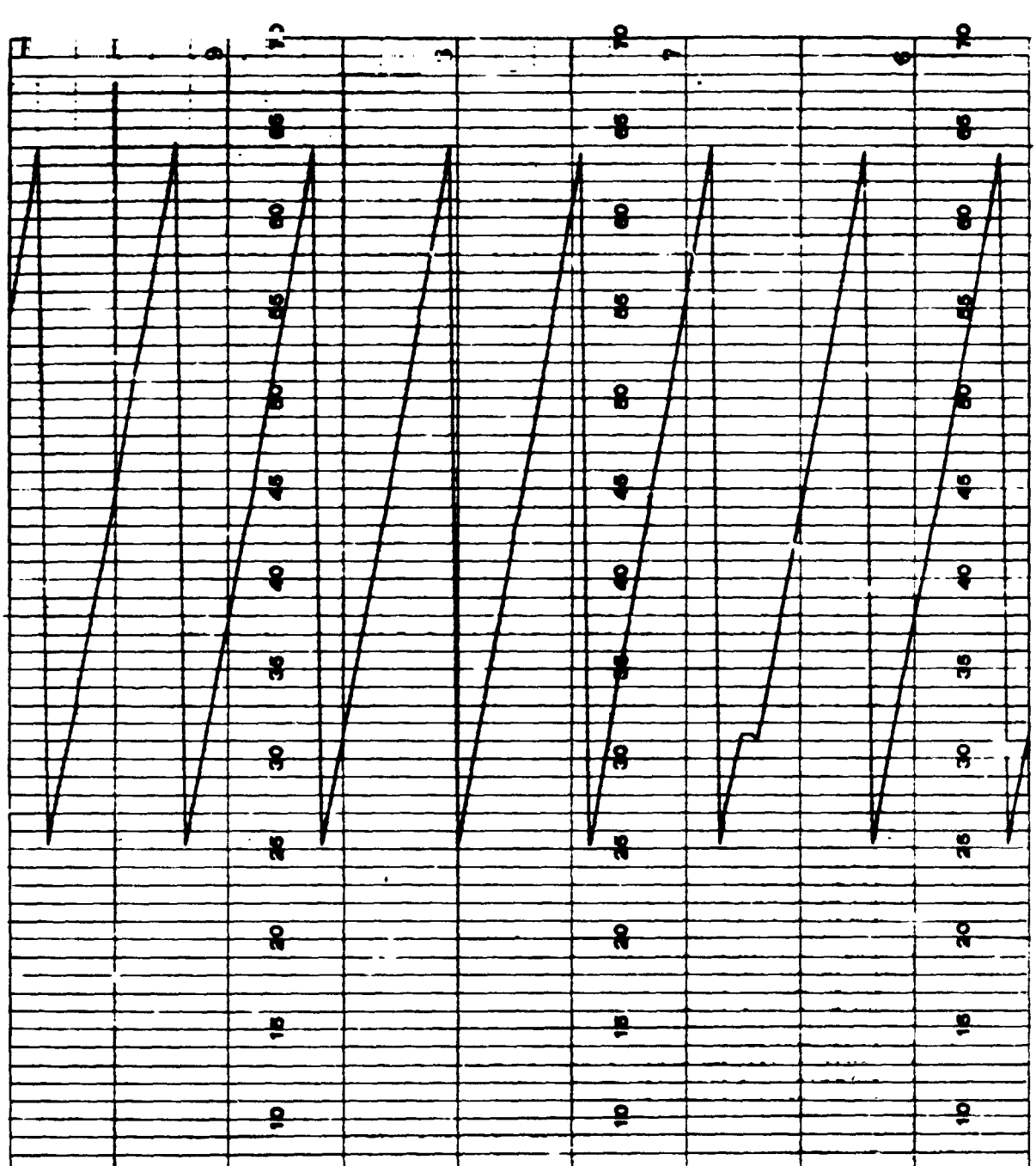

Figure No. 2 - Section from a strip chart recorder showing the net weight of coal being fed from a Primary Injector mounted on load cells.

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