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Project Summary

Batch Pretreatment Process Technology for Abatement of Emissions and Conservation of Energy in Glass Melting Furnaces: Phase I. Process Design Manual

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The Environmental Protection Agency contracted with Corning Glass Works for the development of a glass batch pretreatment process which would abate emissions and reduce energy usage in the melting furnace. The project is funded by the Environmental Protection Agency, the Department of Energy, and the Corning Glass Works.

This project was initiated to demonstrate the feasibility of the glass batch preheating concept and to provide preliminary economic data on full-scale implementation of the concept.

The contract consists of two phases of work. Phase I, now completed and reported in this document, was a laboratory phase to supply the information needed to design a pilot plant system, and based on this design, to estimate the energy, pollution, and economic advantages of the program.

Phase II will consist of constructing and operating a batch preheating pilot plant test facility to confirm the bench scale test results and to provide the necessary design and operating information for a full-scale production facility. The Phase II results will also be used to update the energy, pollution, and economic advantages of the process.

This report is submitted in fulfillment of the Phase I portion of Contract #68-02-2640 by Corning Glass Works under the sponsorship of the U.S. Environmental Protection Agency. The report covers the period from August 15, 1977 to November 1, 1978.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Phase I consisted of eight tasks and was primarily concerned with soda-lime glass batch since over 75 percent of the glass produced in the United States is of this composition. A limited amount of work was performed with borosilicate glass batch. These tasks are described below:

Task 1 — Information Analysis

An information and patent search was completed to document available literature concerning glass batch agglomeration and preheating.

Task 2 — Material Selection

Batch materials were investigated and selected to conform with present glass making practices, taking into account geographic locations and tonnages.

Task 3 — Consolidation

The process of pelletizing was characterized in terms of optimum materials, water content, type of equipment and equipment operations. Pellets and briquettes were made from soda-lime and borosilicate glass batches.

Task 4 — Drying and Preheating

A laboratory static bed preheater was constructed and operated to test the drying and heating of soda-lime glass batch pellets. Requirements for a production system were developed, and dried and preheated soda-lime glass batch pellets were supplied for subsequent tasks.

Task 5 — Pollutant Capture

The preheater was operated to determine the capture of sulfur dioxide (SO_2) and sodium sulfate (Na_2SO_4) particulates by a static bed of soda-lime glass batch pellets at 800°C. Typical flow rates and pollutant concentrations from a production glass melting furnace waste heat system were simulated. Preheated and partially prereacted pellets were supplied for analysis and melting studies.

Task 6 — Hot Transfer

The handling, flow, and sticking behavior of pellets were studied. Full-scale testing was conducted feeding loose batch and cold pellets through a batch charger and a simulated furnace backwall.

Task 7 — Melting Studies

Comparative quality evaluations were made of crucible melts of preheated pellets, dried pellets, and various loose batch formations.

Task 8 — Process Design Manual

A technology potential was completed, based on expected benefits for energy, pollution, and economics and information was developed to establish specifications and costs for a pilot plant system in Phase II.

Conclusions

The conclusions derived from the Phase I studies are based on detailed experimental results on each aspect of the glass batch preheating technology. They include studies made on raw material acquisition and handling, chemical and physical properties of glass batch and batch materials, batch melting properties and glass melts quality. The following conclusions are based on the results of these experiments and studies.

Raw Materials

Soda-lime glass batch materials can be pelletized and preheated prior to the introduction into a melting furnace. Although minor changes in batch composition will be necessary, studies have shown that the raw materials required to produce pelletized batch are commercially available. The additional cost of the materials will be offset by the savings derived from improved furnace output. Studies of preheated pellets made from these batch materials have also shown that there should be an increase in glass productivity without a sacrifice in glass quality.

Consolidation

Both briquetting and pelletizing are viable methods of consolidating (agglomerating) soda-lime glass batch. Neither method is clearly superior to the other.

Drying

Drying temperatures and rates for batch pellets were investigated to determine the importance of pellet strength and integrity. Since pellets when first formed are wet and weak, partial drying will be required for pellets to survive further handling.

Preheating

Soda-lime glass batch pellets preheated to 800°C were judged to have strengths satisfactory for feeding glass melting furnaces. No pellet sticking problem is anticipated at that temperature. From the static bed preheater experiments, relationships were developed for designing the pilot plant preheater. This work confirmed Columbia Gas pilot plant design equations for preheated batch.

Pre-reaction

Pre-reaction of preheated pellets was investigated using a thermogravimetric analyzer. Pre-reaction is considered important because it means that the actual melting process will begin with some gaseous reaction products escaping before the materials are introduced in the melting furnace. Less gas introduced with the pre-reacted pellets requires less gas to be fined or removed from the molten glass bath, and hence melting rates may be increased or melting temperatures may be decreased. Studies showed that pre-reaction occurring below 600°C was insignificant, but that half of the possible pre-reaction occurred at 800°C.

Pollutant Capture

Using a static bed preheater, studies indicated that 800°C soda-lime glass batch pellets can capture from 75-85 percent of the SO_2 in a gas stream flowing at 0.43 m/sec. (17 in./sec.) through the bed.

Hot Transfer

The static bed studies indicated that at least 32 percent of the Na_2SO_4 particulate matter in the gas stream can be captured, based on particulate in the 10 micron range.

Melting Studies

The combined effect of a 50°C reduction in melting temperature and the associated 15 percent reduction in fuel results in an overall 65 percent reduction in expected NO_x emissions.

Pilot Plant Design Study

The average regenerative, soda-lime furnace stack, gas temperature is not high enough to preheat pellets to 800°C, although the energy lost through inefficiences is sufficient to do so. However, there are means to modify existing furnaces to achieve the desired temperature, while new furnaces can be specifically constructed to achieve the desired 800°C temperature. The pilot plant design will utilize a direct-fired furnace capable of achieving 800°C without modifications. Use of this type of furnace will not negate the results of the pilot study to verify the viability of the technology.

Energy and Cost Savings

Energy savings are projected to be 8.5 x 10^{15} joules/year (1.4 x 10^{6} barrels of oil equivalent) if 35 percent of the soda-lime container furnaces utilized this technology.

Recommendations

The completion of the Phase I portion of the program has resulted in the identification of additional background requirements to the basic program. However, the results do indicate that the concept is both feasible and viable and that the final demonstration should be undertaken. Therefore, based on the Phase I results the following program actions are recommended:

1. The pilot plant, Phase II, should be pursued to confirm the pollution, energy, and cost savings benefits indicated and projected in Phase I and define and identify the operating characteristics of a production system. Furthermore, this demonstration will decrease costs and risks in developing a full-scale production application. Development of this concept will involve a major investment of capital. This magnitude of R&D investment is typically not possible in the glass industry which usually operates on a relatively low profit margin. Thus, this program would remove a significant part of the capital risks associated with R&D effort and would permit proceeding to the full-scale system with a minimum of risk.
2. Pelletized batch is the recommended method for batch agglomeration, however, additional studies could be conducted to verify the advantages of this procedure.
3. Prior to initiation of the demonstration, packed bed studies utilizing pelletized glass batch should be run to predict the particulate capture efficiency of a packed bed preheater. These studies should be conducted using actual operating regenerative furnace exhaust emissions.

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The complete report, entitled "Batch Pretreatment Process Technology for Abatement of Emissions and Conservation of Energy in Glass Melting Furnaces: Phase I. Process Design Manual," (Order No. PB 81-175 929; Cost: $23.00, subject to change) will be available only from:
National Technical Information Service
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