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AIR RECIRCULATION FROM FOUNDRY OPERATIONS

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Abstract

The American Foundrymen's Society is an organization sponsored by private industry to develop and communicate technology critical to the foundry industry. Foundries, like other segments of the business community, have become increasingly concerned with energy availability and efficient use of this increasingly scarce resource. To help answer this need, the AFS has formed The Task Force on Energy Conservation Through Exhaust Recirculation. The goal of this group is to fully demonstrate air recirculation from foundry process exhaust. This paper will describe the present state-of-the-art of foundry air recirculation and describe the engineering effort presently being done aiming at installation of properly engineered air recirculation systems.

To many laymen and engineers alike, it is surprising to find that one of the major uses of energy by all foundries is for heating and distributing makeup air. On a yearly basis, heating, ventilation, and air conditioning (HVAC) energy usage averages over 15 percent of the total energy used by an iron foundry, and during a winter month this percentage may exceed 50 percent. The amount of energy going to HVAC has accelerated in recent years because of increasing pressure from the Occupational Safety and Health Administration (OSHA) and from employees to meet contaminant standards and improve worker comfort. The major efforts in this regard were made before the energy crisis; therefore, little attention was paid to air recirculation or other heat recovery means. Now because of high energy costs, better equipment, improved hood design, less toxic resins, and improved maintenance practice, the time has come to make a serious effort in air recirculation.

First, why air recirculation as an energy conservation means? The majority of the air exhausted from foundries is near ambient temperature. The volume may be in the order of 10 million ft^3/min in some of the large automotive casting facilities. The fact that we are dealing with large air volumes with low temperature makes the cost effectiveness of heat recovery marginal. Also, heat recovery equipment--heat wheels, heat pipes, air-to-air heat exchangers, etc--only offers a 40 to 60 percent Btu recovery potential, whereby air recirculation approaches 100 percent recovery of the energy of the airstream.

To help coordinate the metal casting industry's efforts on air recirculation, the American Foundrymen's Society's (AFS) Environmental Affairs Director,

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William Huelsen, acted as a catalyst to organize some of the industry's leading ventilation engineers and industrial hygienists into the AFS Task Force for Energy Conservation Through Exhaust Recirculation. For those not familar with AFS, it is an engineering society sponsored by private industry for the purpose of communicating and advancing technology critical to the metal casting industry. The Recirculation Committee has been active since January 1977. The committee's first decision was to focus its efforts on reintroduction of exhaust air into the workplace to conserve energy. We would not consider utilization of dirty exhaust in other processes or the use of unheated makeup air around ventilation hoods to provide the needed draft and exhaust volume. Also, because of reasons previously mentioned, and the fact that suppliers, engineers, and engineering societies are addressing indirect heat recovery, these areas would not be considered.

The day has now come when the ventilation engineer can supersede production, and everything should be done to reduce exhaust from buildings. However, throughout the foundry industry, there has been a minimum of engineering idea exchange on air recirculation and a lack of coordinated effort by industry, government, and equipment suppliers. Hopefully, this task force can coordinate a research and development (R & D) effort and influence suppliers to provide air filtration and monitoring equipment to meet the requirements of air recirculation.

Foundries, as all complex multiprocess facilities, have numerous exhaust streams, all with different temperatures and contaminants. Exhaust emanates from the mold room, core room, shakeout, sand handling systems, cleaning room, and other processes. To obtain a background on present recirculation installations and past attempts, a questionnaire was sent to 3,500 industry executives in February 1977. Based on this survey and on the fact that the exhaust from the cleaning room should have no products of combustion, it was decided that the first process to be fully investigated for recirculation would be the cleaning room.

The cleaning room operations are a conglomerate of processes such as grinding and deburring. They employ the largest percentage of people and run production during periods when other heat-producing operations of the foundry would not be able to supply heat, necessitating the use of outside energy or makeup to replenish exhaust. Generally, the exhaust volume is about 20 percent of the total foundry exhaust.

Of the 3,500 questionnaires sent, a little over 100 were completed and returned; of these, 47 admitted to either having or having tried recirculation systems. The majority doing so were from cleaning room exhaust. No installation was found that we felt represented good engineering practice, which is poorly specified air filtration equipment followed by a return air monitoring system and a bypass to atmosphere in case of efficiency problems. Some of the newer recirculation installations from blast cleaning in the cleaning room are using opacity meters to monitor the cleanliness of the exhaust before return to the work space. However, the sensitivity of opacity meters is quite limited. It would require a path length of 10 ft between the light source and sensor to enable a 1 percent opacity change to relate to a rise in particulate concentration from 1 mg/m^3 to 2 mg/m^3. Because opacity is an optical measurement, it is dependent on particle size distribution and reflectivity characteristics of the particulates in the gas stream. So, to use an opacity meter, the instrument has to be calibrated versus in-stack mass measurements and the particle characteristics must remain constant over all conditions.

Getting back to the results of the survey, it was found that some foundries have attempted to recirculate from different operations without success. In one case, the recirculation was in operation for a year before it was discovered that the concentration of free silica in the breathing zone was too high due to the recirculation. From this background, it was decided that a demonstration recirculation system be installed on the cleaning room exhaust following these steps: (1) emission characterization, (2) filtration equipment specification, (3) monitoring equipment specification, (4) integration of a complete system, (5) building and installation, and (6) performance testing. This type of engineering sequence would be recommended for all recirculation system installations even if a similar process presently had a system which could be copied.

The AFS research funds are being used to accomplish the first task of emissions analysis. Five foundries have agreed to participate and provide required test ports and access scaffolding. The test will be run in the following manner and the data will not be identified as to their source except to the committee.

Simultaneous inlet and outlet process emission samples of one cleaning room exhaust stack and collector discharge are to be performed in duplicate at each of five foundries. The facilities were selected on the basis of providing a cross section of iron foundries from the large, highly automated to the small operation and a variety of ventilation and collection systems. Each emissions sample is to include all of the following parameters and be performed in the prescribed manner:

Parameter	Method
Total particulate concentration and stack conditions, temperature, velocity, etc.	EPA Methods 1-5
Particle size distribution	In-stack cascade impaction
Carbon monoxide	Wet chemistry
Phenols	Wet impingement, distillation and gas chromatography
Formaldehyde	Wet chemistry
Particulate chemical analysis on fraction $\geq$ 5 μm and < 5 μm	
a. Free silica	X-ray diffraction
b. Cristobalite	"
c. Quartz	"
d. Tridymite	"

e. Cu	Atomic absorption spectrophotometry
f. Zn	"
g. Fe	"
h. Organics	Hexane extraction
i. Total inorganics	Difference

The emissions testing is to be completed by November 1, 1977. Following this, a specification will be written for the filtration and monitoring equipment. If these specs can be met by suppliers, a foundry will be sought to install the demonstration system. If equipment development is required, AFS will seek the best route to meet the need. The maximum contaminant concentration in the recirculation airstream is targeted at 10 percent of threshold limit value (TLV). Of course, by using the "Guidelines for the Recirculation of Industrial Exhaust" (ref. 1), this limit may change depending on the actual facility where the equipment is to be installed. We hope that by the April 1978 Casting Congress Meeting, we can make a complete report on this project and then move on to other process exhausts.

REFERENCE

1. Arthur D. Little, Inc., "Guidelines for the Recirculation of Industrial Exhaust," Draft Report, Contract No. 210-76-0129, July 1977.

DISCUSSION

MR. JOHN TALTY (NIOSH, Cincinnati, Ohio): Are the task force and the demonstration projects going to be addressing operation maintenance requirements of the systems that should be installed, because I think that is a very important aspect, and are they going to be public?

MR. POTOKAR: Yes, certainly. One of the things we would tend to get upset by is the kind of guidelines that are often put out by NIOSH and other government agencies, which give you the very broad concept of what should be done, but when it comes down to how the engineer in the plant should do it and what he has to take into consideration, he is really lost. What we want to do is provide a total system, and try to demonstrate what type of cost, capital and maintenance might be involved so that he would know what to look out for.

MR. JEFF GREEN (Kohler Co., Kohler, Wisconsin): Have you conducted any cost analyses? When do you expect to see your capital recovery?

MR. POTOKAR: You can't do a cost analysis until you know what kind of equipment you need. As soon as the emissions analysis is completed, the next step is to put that into a bid package and go out to vendors and find out what it is going to cost.

MR. GREEN: You haven't done your preliminary?

MR. POTOKAR: Yes, we've done evaluations ourselves. As a committee we have put together a cost evaluation, such as how much energy is used by foundries in different processes, how much is going out the door, that type of thing, so we know the potential is there.

MR. GREEN: You have no preliminary estimates to, say, 5 years for capital recovery?

MR. POTOKAR: Typical ball park figure for the cost of recirculating makeup air is 40 cents per cfm per year, which means if you're blowing the cfm out every day of the year it is going to cost you 40 cents in energy to put that back, so with any type of recirculation system you're not going to get it for a dollar a cfm. You're talking about a minimum of a 3-year payback, and at one time, if it didn't mean a 2-year payback, industries didn't consider it. Now that energy is a big factor, if you're going to shut down during the winter, you had better start considering 5-year paybacks and 10-year paybacks.

MR. PETER PULLEN (Rio Algom Limited, Toronto, Canada): We are looking at energy conservation, and I'm just wondering whether we shouldn't also look at the other end of the cycle, that probably we should evaluate the potential of reducing the quantity of air we are handling. In other words, tighten up on our design criteria to reduce the air and yet still get the same control over our contaminants. I'm thinking particularly of dust control.

MR. POTOKAR: The type of work we are doing, AFS or NIOSH work, is best done on an individual plant basis, so that if it requires a high velocity, low-volume system, it's up to the working engineer to try to put that in. If it needs a process change to cut down the amount of cfm, still it's up to those at the individual plant level to try to do that. You can't address every particular situation, but certainly before you ever attempt recirculation, the first thing to do is make sure you are using the right amount of air to begin with. There has been a lot of talk about further contaminating the work environment. We feel, as recirculation becomes more feasible, it may actually be the opposite way. Because of recirculation and because you're recovering energy, you can now afford more face velocity at the hood, thereby removing the contaminant more effectively from the worker's breathing zone. Therefore, across the board you may come up with lower levels at the worker's breathing zone.

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FOREWORD

These proceedings of the symposium on "The Recirculation of Industrial Exhaust Air" are submitted under Contract No. 210-77-0056 to the National Institute for Occupational Safety and Health of the U.S. Department of Health, Education, and Welfare. The symposium was held in Cincinnati, Ohio, on 6-7 October 1977.

The objective of this symposium was to discuss the development of technical criteria for the recirculation of industrial exhaust air. With emphasis on the protection of the worker's health, technical subject matter discussed included: (1) decision logic for determining recirculation feasibility; (2) design and performance guidelines for recirculation systems; (3) availability of air cleaning and monitoring systems; and (4) maintenance guidelines.

Mr. Robert T. Hughes, Chemical Agents Control Section, Control Technology Research Branch, Division of Physical Sciences and Engineering, National Institute for Occupational Safety and Health, Cincinnati, Ohio, was the Symposium General Chairman.

Mr. Alfred A. Amendola, Control Technology Research Branch, Division of Physical Sciences and Engineering, National Institute for Occupational Safety and Health, Cincinnati, Ohio, was the Symposium Vice-Chairman and Project Officer.

Mr. Franklin A. Ayer, Manager, Technology and Resource Management Department, Center for Technology Applications, Research Triangle Institute, Research Triangle Park, North Carolina, was the Symposium Coordinator and Compiler of the proceedings.