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Project Summary

Hydrocarbon Solvent Recovery in the Presence of Resin Contaminants

Jim L. Turpin

A system was developed to recover acetone from an air stream in which there were suspended epoxy resin particles. This recovery problem is encountered in the manufacture of fiber glass reinforced plastic pipe. It is representative of many other industrial situations that require the recovery of hydrocarbon solvents from a gaseous stream containing resin particles in order to eliminate atmospheric pollution.

The system developed was a three-state low temperature condensation process preceded by a cascade impactor. A scale model of the system was designed and constructed. It was tested in the laboratory and on a split stream of an actual plant process.

Roughly 95 percent of the resin particles were removed in the impactor. The first stage condenser operated at 42°F and removed the residual resin particles and roughly 80 percent of the water brought in with the ambient air. The second stage operated at -31°F and achieved residual water removal. Acetone of 99 percent purity was recovered in the third stage operating at -85°F.

A full-scale system was designed to process 3800 cfm of air containing 0.92 (vol) percent acetone and 1.25 x 10^{-5} lb/ft^3 of resin particles. The fixed capital investment for this system was estimated to be $758,000.

The developed impactor-condenser system is a technically feasible process. It may be considered as a possible alternative in any solvent recovery application. An economic evaluation will be required for each potential application, with the final decision to utilize the process being based on the economics of the specific recovery problem.

The full report was submitted by the University of Arkansas to fulfill Grant No. CR807577-01-0 under the joint sponsorship of the U.S. Environmental Protection Agency and A. O. Smith-Inland, Inc. It covers the period August 15, 1980 to September 15, 1982, and work was completed September 15, 1982.

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

Hydrocarbon solvents are utilized in many industrial processing schemes which require recovery of these solvents from a gaseous stream in order to eliminate atmospheric pollution. Much is known about solvent recovery, and it is practiced widely in the chemical industries. However, recovery solutions are complicated in instances where certain contaminants are present in the discharge stream.

One process for manufacturing reinforced plastic pipe utilizes acetone as a solvent for the resin. The gaseous discharge from the process is an acetone-contaminated air stream, which also contains resin particles and certain other chemical decomposition products. These resin particles plug conventional recovery equipment such as adsorption beds and filters. Other examples of this type of recovery problem are found in the plastics industry, especially in the production and utilization of epoxy resins.

It is concluded from available production figures that the problem of hydrocarbon recovery in the presence of resin contaminants is potentially very large. Extensive consultation with leading manufacturers of recovery and cleanup equipment reveals that commercially available off-the-shelf systems are not satisfactory. Thus, the objectives of this research project were:

(1) to develop a system which will economically recover a solvent from a gaseous stream containing suspended contaminants such resins,

(2) to construct and test a scale model of the recovery system, and

(3) to design, specify equipment, and estimate installed costs for a full-scale recovery system.

The A. O. Smith-Inland (AOS-I) Inc. manufactures fiber glass reinforced plastic pipe at their Little Rock, Arkansas, plant. In the AOS-I process, glass fibers are pulled through a vat of epoxy resin and acetone solvent where they are impregnated with the resin. The resin-coated fibers travel from the vat over hot drums.

A continuous strip of fiber glass reinforced plastic (which is later processed into plastic pipe) is formed on the drums. The solvent, acetone, is vaporized from the hot drums, picked up by a blower-induced air stream passing up over the drums, moved into the hood covering the tape machine, and exhausted from the process. The violent vaporization of the acetone on the hot drum surface erupts resin particles into the air stream, where they are captured and ultimately transported into the exhaust ductwork. Ambient water vapor enters with the air stream.

AOS-I had previously installed an acetone recovery system which included a water scrubber, parallel carbon adsorption beds, and a distillation column. This unit became permanently inoperative after only a very short time. Due to the low efficiency of the water scrubber, resin carry-over plugged the adsorption beds and corroded the distillation unit. Scrubber screens and spray nozzles were also plugged with epoxy.

Because this acetone-resin system is representative and because difficulty was encountered in dealing with it, the system was studied in this project. The acetone concentration in the air stream is well below the lower explosive limit, and it is expected that other such processes exhibit air stream concentrations comparable to these. It is likely that these air streams are discharged directly to the atmosphere by most, if not all, of the industry.

Methodology for Acetone Recovery

Several alternatives were considered, including incineration, water spray scrubbers, bag and panel filters, and molecular sieves. It was concluded that the optimum methodology for acetone recovery would involve the use of a cascade impactor to remove the bulk of the resin particle contaminants, followed by a staged condenser system to recover high purity acetone.

A system using three condenser stages was conceived. The first stage would operate with a water pool of 42-50°F to remove roughly 80 percent of the water plus the residual resin particles escaping the impactor. The second stage would operate with a glycol-water mixture at -31°F to remove essentially all of the remaining water. The third stage would operate with a liquid acetone pool at -85°F to remove up to 90 percent of the acetone at greater than 98 percent purity.

A scale model impactor and condenser system was designed and constructed. The design basis for the model was 90 cfm air flow. The impactor was a flat-plate, cascade type, with provision for variation of the number of plates, the spacing between plates, the plate-to-bottom clearance, and the slot dimensions of the plate.

A 55-gallon barrel with a removable top was used for each of the three stages. The process air stream from the impactor was sparged into the bottom of stage one and then passed overhead and sparged into the bottom of stages two and three in order.

The model was tested utilizing a simulated process stream. This was followed by extensive experimental testing on a split-stream of the main process stream at the Little Rock, Arkansas, plant of A. O. Smith-Inland.

Results

For the impactor, resin removal efficiencies of close to 95 percent were common. Impactor pressure drops were approximately three inches of water. Drainage of the resin from the impactor was good, and extended periods of operation could be achieved without plugging.

A linear velocity of 2000 ft/min in the baffle slots appeared to be a feasible compromise value as the design basis for the full-scale impactor. Lower velocities reduce the collection efficiency, whereas pressure drop increases as the velocity increases.

For the model condenser system, stable operation with pool temperature near the desired values was achieved. The experimental program demonstrated that low temperature condensation is a technically viable process for recovery of acetone. The required heat transfer, mass transfer, and component separation can be achieved in three stages.

Several different types of equipment can be used to achieve the three-stage recovery. The required heat and mass transfer can occur in liquid baths of the sort that were utilized in this experimental program, in counter-current flow packed beds, or in finned-tube heat exchangers. Calculations were made for each in order to compare the three processes.

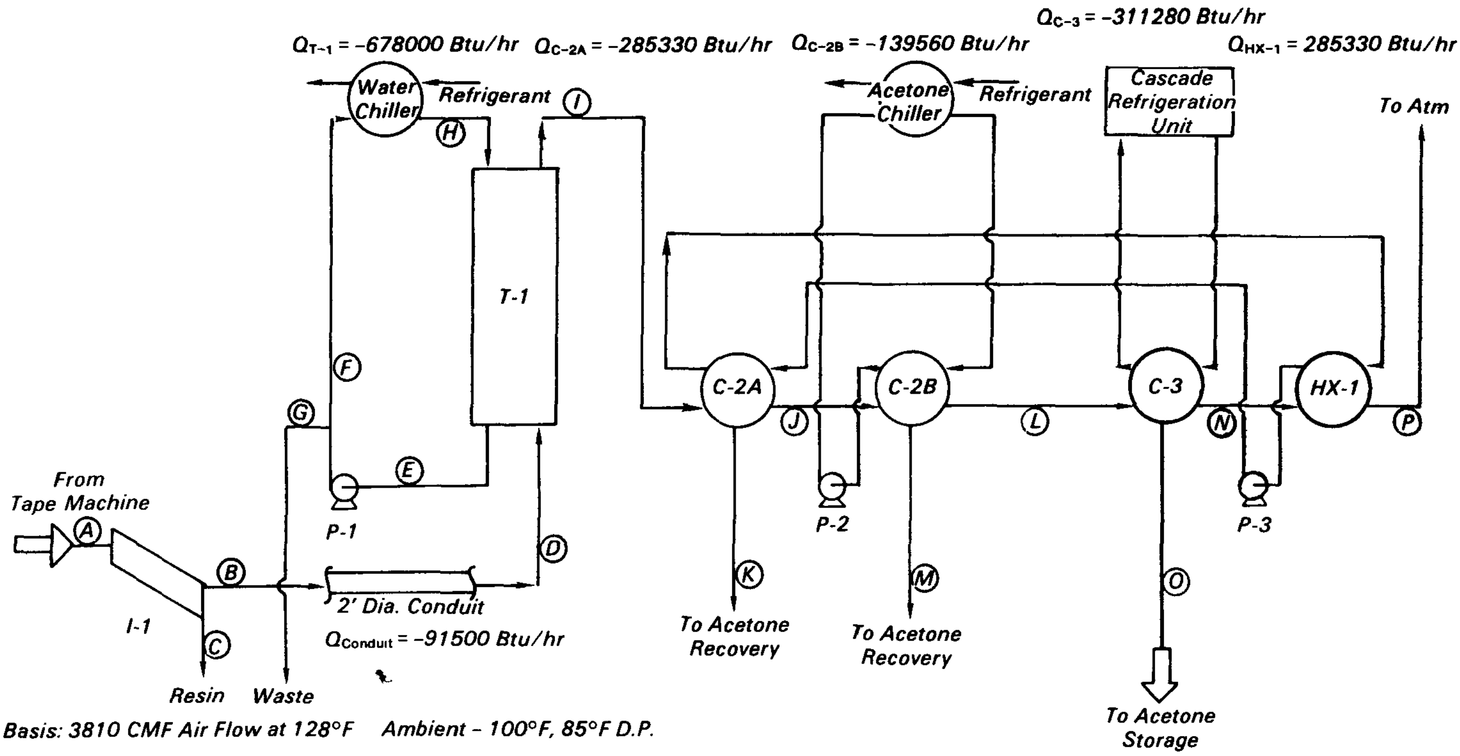
The conclusions drawn from these preliminary calculations are that either packed columns or finned exchangers would be satisfactory for stages two and three, with the decision to be based on the economics of the two systems. Stage one would require a packed bed with a few inches of liquid pool in the bottom for removal of the residual resin particles. A finned exchanger would not be acceptable for stage one because of its susceptibility to plugging by the resin.

Several changes were evaluated in the processing sequence in order to get better heat integration. The finalized process flow sheet, including a material and energy balance summary, is included in Figure 1.

The process flow sheet and process description were submitted to several companies for a price quotation on the equipment. From these quotes, it was estimated that the total installed cost of the project would be $758,000.

Conclusions

The three-stage low temperature condensation process may be considered as a possible alternative in any solvent recovery application. Stage temperatures and other operating parameters are fixed by the particular system involved, by the



Basis: 3810 CMF Air Flow at 128°F   Ambient - 100°F, 85°F D.P.

Stream	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Air, lb/hr	15400	15400		15400					15400	15400		15400		15400		15400
Acetone, lb/hr	310	310		310	3760	3760	10	3750	300	290	10	281	9	21	260	21
Water, lb/hr	404	404		404	119448	119130	318	119130	86	12	74	3	9	Trace	3	Trace
Resin, lb/hr	2 85	0 15	2 70				0 15									
Temperature, °F	128	128		105	43	43	43	38	42	0	0	-25	-25	-85	-85	-16

Figure 1. *Process flow sheet for Acetone Recovery Project.*

specifications on the final effluent, and by the specifications on the recovered component. The process would be adapted to meet these specifications and the technical feasibility affirmed. Technical feasibility can probably be attained for most recovery problems by proper selection of operating parameters.

Material and energy balances would then be completed, equipment selected and sized, and the economics determined. The final decision for any potential application would be made at that point.

Jim L. Turpin is with the University of Arkansas, Fayetteville, AR 72701.
***Mark J. Stutsman** is the EPA Project Officer (see below).*

The complete report, entitled "Hydrocarbon Solvent Recovery in the Presence of Resin Contaminants," (Order No. PB 84-148 170; Cost: $8.50, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:
Industrial Environmental Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, OH 45268

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