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BETHLEHEM STEEL

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SUBJECT TESTING OF A NEW DRYER FOR TOP GAS ANALYSIS

Summary

The ability of the Perma Pure Dryer to continuously dry top gas samples going into gas analyzers was examined. Drying by the Perma Pure Dryers was found to be considerably better than drying by the Hankison Dryer and Drierite system now in use. Furthermore, the Perma Pure Dryers have no moving parts and require no maintenance. On the basis of our study, we recommend purchase of Perma Pure Dryers to replace the drying systems currently in use on all top gas analyzers.

Introduction

Dissatisfaction has existed with the current continuous drying system (Figure 1) for top gas samples going to gas analyzers because of the system's questionable and non-uniform performance, the maintenance needed to regenerate the Drierite and the cost of new Drierite. Perma Pure Products, Inc. claimed that their new type of dryer would provide us with more efficient drying and would require no maintenance or operating costs. The purpose of our study was to test their dryers.

Description of Drying Process

Perma Pure Dryers use permeation distillation to dry gases. With this new technique, a wet gas flows continuously into a bundle of tubes which are permeable to water vapor and are enclosed in a shell. Continuous drying can be accomplished by using plant compressed air, which has been expanded to atmospheric pressure, to purge the permeated water vapor out of the shell. The Perma Pure Dryer has a configuration similar to a shell and tube heat exchanger as shown in Figure 2. Instead of transferring heat, water vapor is transported continuously across a semi-permeable membrane. The driving force is a difference in water vapor pressure between the gas streams.

Curves relating product dew point with flow rate for a feed at a 72-75°F dew point were provided by the manufacturer and are shown in Figure 3 for the 12", 48" and 72" 50 tube dryers. According to the manufacturer, only two requirements must be met to reach the dew points shown in Figure 3: (1) the volumetric flow rate of purge gas must be at least 50% greater than the volumetric flow rate of wet feed gas and (2) the dew point of the purge gas must be less than the dew points shown in Figure 3 for the given flow.

Drying Experiments

Saturated air, saturated calibrating gas and blast furnace gas were dried in the Bethlehem Plant using a 48" Perma Pure Dryer with a plant air purge. An Alnor dew point meter was used to determine dew points. The basic experimental set-up is shown in Figure 2 and the results are shown in Table 1. Note from Table 1 that the outlet dew points were limited by the dew points of the purge gas. At the Bethlehem Plant the compressed air used for purge gas had a dew point of 70°F at 80 psig. Two methods were used to reduce the dew point of the purge gas: (1) passing it through the Hankison dryer at 80 psig and expanding it to atmospheric conditions and (2) expanding it to 18" Hg. of vacuum. The dew points obtained were similar for the two methods.

Dew points of blast furnace gas were also taken at various points in the current drying system and are shown in Figure 1. The Drierite used when the readings were taken was one day old and the 17°F final dew point was higher than anticipated.

Finally, we examined the accuracy of gas analyses which were made on gases dried by the current drying system and on gases dried by the Perma Pure Dryer. Table 2 compares the compositions and dew points of "bone dry" calibrating gas and calibrating gas which was saturated and then passed through the drying system currently in use. Differences between the two readings are considerable and result in a 30 lb. error in the calculated coke rate. In Table 3, the compositions and dew points of "bone dry" calibrating gas and saturated calibrating gas which were passed through the 48" dryer are compared. The differences between the readings are smaller but are still significant. Perma Pure personnel informed us that moisture has a larger effect on the CO_2 analysis with an infrared cell than on the CO analysis. The results shown in Tables 2 and 3 are in agreement with this.

Conclusions

A new dryer has been tested for the top gas analysis system at the Bethlehem Plant and was found to be superior to the drying system currently in use. A 48" Perma Pure Dryer was tested at the Bethlehem Plant as a replacement for the Drierite unit. Plant compressed air used to purge the Perma Pure Dryer was passed through a Hankison dryer to reduce its moisture content before it was expanded. A consistent blast furnace gas dew point of 0°F to -3°F was obtained using this new system during the 5-week test period.

Recommendations

We recommend the purchase of Model PD-625-72 Perma Pure Dryers to replace existing Drierite systems. These 72-inch dryers provide the capability to attain gas sample dew points of -40°F. Accuracy of the gas analysis is unaffected by the small amount of water vapor remaining in the gas sample at this low dew point. Where low dew point gas samples cannot be attained, because of purge air limitations, the gas analyzer can be calibrated to compensate for the water vapor or additional drying of the purge air can be installed. The latter could take the form of either self-regenerating chemical dryers or the installation of vacuum purge.

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Attachments

TABLE 1. DATA ON DRYING EXPERIMENTS USING A 48" PERMA PURE DRYER*

Wet Feed						Purge		
Component	Dew Pt. (°F) Inlet	Outlet	Test Period	Pressure (psig)	Temp. °F	Component	Dew Pt. (°F)	Pressure (in. Hg.) Vacuum
Air	65	-8	2 days	0	74	Air	≃ -8	18
Calibrating Gas	65	-3	6 hrs.	0	74	Hankison Dryer	-3	0
Blast Furnace Gas	65	-7	1 week	6	79	Air	≃ -8	18
Blast Furnace Gas	65	-15	3 days	6	79	Hankison Dryer	≤-15	18
Blast Furnace Gas	65	0--3	>5 weeks	6	79	Hankison Dryer	-3	0

* Note: The wet feed flow rate and the purge rate were 3.0 SCFH and 6.0 SCFH, respectively, for all the runs.

TABLE 2. ACCURACY OF GAS ANALYSES USING CURRENT DRYING SYSTEM

	Dew Point	CO	CO_2	H_2
"Bone dry" calibrating gas	-55 °F	28.17	20.7	8.03
Saturated calibrating gas going through current system	17 °F	28.00	19.65	8.08

TABLE 3. ACCURACY OF GAS ANALYSES USING A PERMA PURE DRYER

	Dew Point	CO	CO_2	H_2
"Bone dry" calibrating gas	-55 °F	28.48	20.20	8.01
Saturated calibrating gas passed through Perma Pure Dryer	- 3 °F	28.43	20.00	8.03

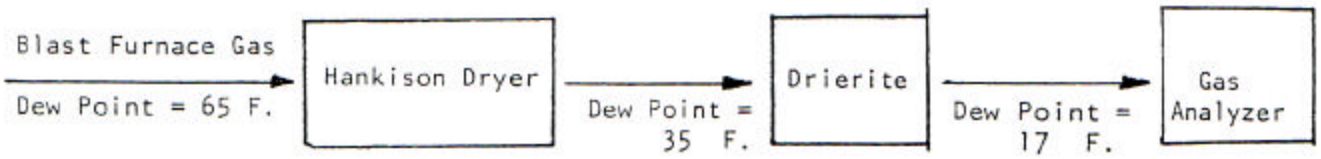

Fig. 1. CURRENT BLAST FURNACE SAMPLE GAS DRYING SYSTEM AND DEW POINTS TAKEN WHEN DRIERITE WAS ONE DAY OLD

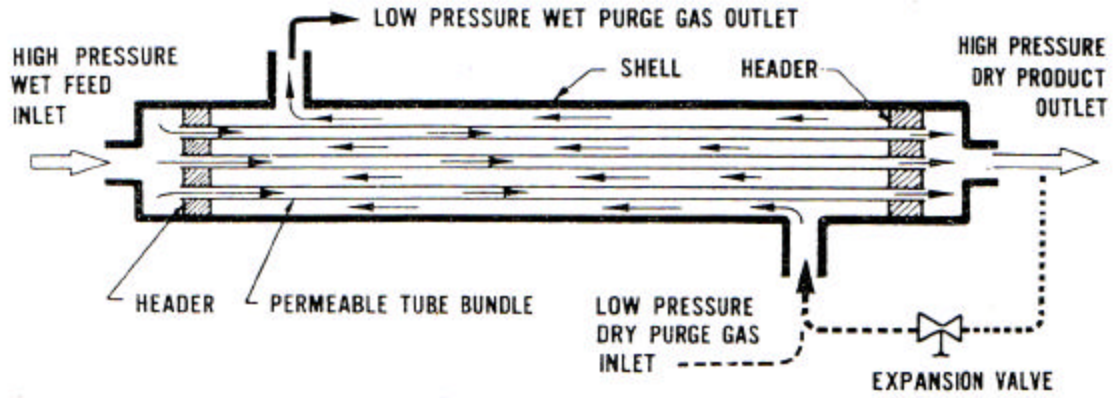

Fig. 2. DRYING SYSTEM USING PERMA PURE DRYER AND PLANT COMPRESSED AIR