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AN-04
IMPROVING ARGON RECOVERY IN AIR SEPARATION PLANTS WITH THE USE OF PROPER PROCESS ANALYTICAL TOOLS

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BACK TO THE BASICS

Argon is produced by air separation plants. Air constituents are nitrogen (78.09%) oxygen (20.94%) and argon (0.934%). These constituents are not chemically bonded together but are moving freely. A distillation process can separate the constituents of a mixture if their respective vapor pressures are different. This process is based on distillation columns where the most volatile components exit at the top and the less volatile ones exit from the bottom of the column. Argon is taken off from a low pressure column and introduced in a separate smaller distillation column called the crude argon column. Figure 1 shows a typical curve for vapor pressure of N_2, O_2 and Ar. Since the vapor pressure of the argon is close to the oxygen vapor pressure and is between nitrogen and oxygen, argon will be extracted between these two constituents in the low pressure column.

A typical concentration distribution of N_2/O_2/Ar in the low pressure column is shown in figure 2. According to the curve in figure 2, it is clear that argon should be extracted at the level where the concentration is maximum. However, at this point the nitrogen concentration is almost the same as argon and there is also a lot of oxygen. The curves show 14% of argon, 14% of N_2, and 72% for O_2. It is not possible in this column to find a point where argon is pure. In order to have a mixture which can be processed in a single distillation column, the low pressure column must be adjusted in such a way that the nitrogen concentration at the argon extraction point will be at a minimum. In this way, the. extracted mixture will be almost binary (i.e. Ar 10%/O_2 90%/N_2< 2000 PPm).

This mixture is then fed to the crude argon column where it will be processed. In some plants, the process stops there, so the final product is crude argon. In other plants, there is an extra cycle to produce pure argon, called the warm argon cycle. In this cycle O_2 in argon will be reduced with H_2. Today there are also. higher performance distillation columns without the need to have the warm argon cycle column. In such columns, packing is used instead of trays.

THE PROBLEM

In order to have and maintain the optimum argon extraction efficiency, the argon draw-off mixture must be properly controlled. It is not an easy task, and there are two possible problems. First, if the column profile is too low, i.e. the nitrogen contents in the mixture draw-off from the low pressure column is high (> 2000.ppm), the crude argon column will stop working. At the limit, too much nitrogen will block the condenser of the crude argon column, eliminating the reflux. The liquid held in the trays (essentially argon) will fall in the low pressure column. There will be a fast drop in O_2 concentration in the low pressure column. The result is loss of O_2 and argon production. Many hours must be spent to restart the process.

Secondly, adjusting the low pressure profile too high i.e. O_2 level is high, results in a loss of argon in the waste nitrogen. Furthermore, doing so increases O_2 level in the crude argon column. The challenge is to monitor the level of nitrogen in the argon draw-off from the low pressure column. Until now, the analytical tools available for this application were relatively complex, custom built systems in process control interface. So most of the time the plants are operating with a poor argon recovery efficiency by maintaining a low level of nitrogen in the crude argon to avoid to crash the plant.

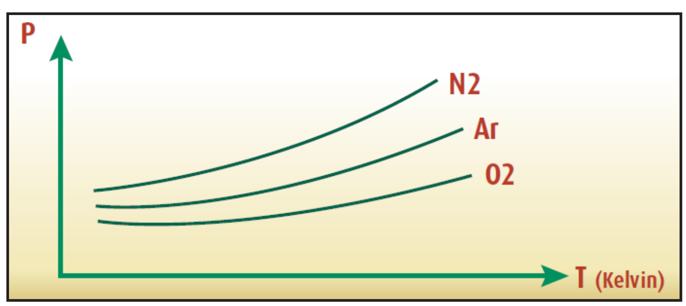

Figure 1: Vapor Pressure of Air Constituents

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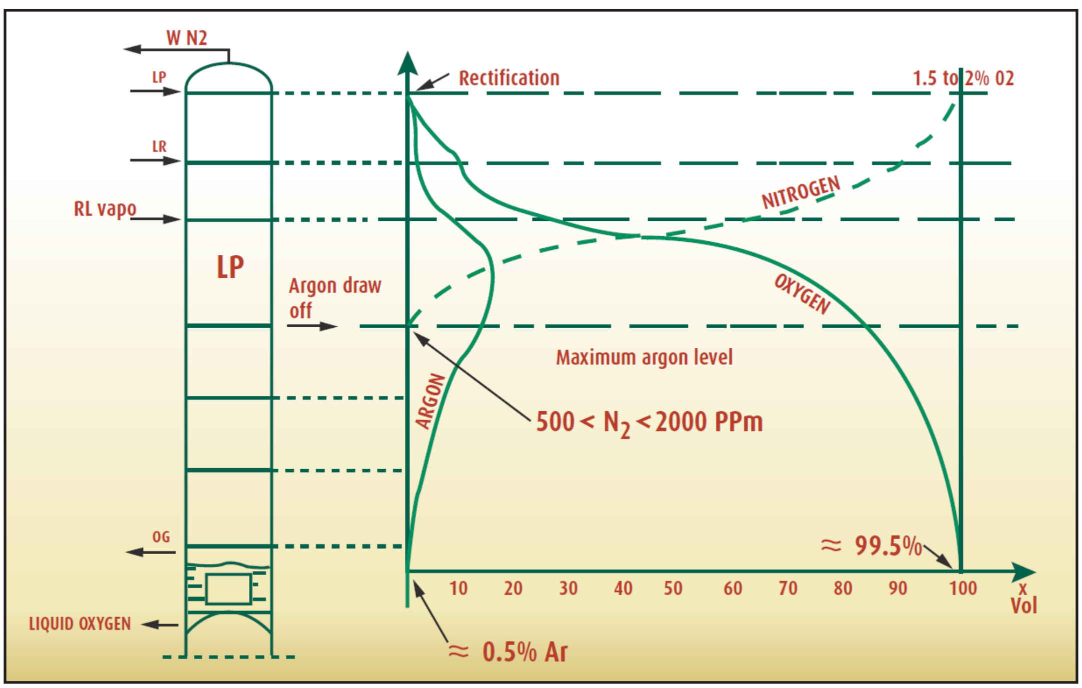
THE SOLUTION

The Kontrol Analytik, KAPlus8000 or GC Sense Series trace gas analyzer system can be configured to measure trace nitrogen in any mixture of oxygen and argon. The GC Sense Series analyzer uses a separation column at the front end of the system to roughly isolate the oxygen from nitrogen. The detector is based ASDevices Epd technology which is tuned to be very selective to N_2 compared to O_2. Refresh times less than 60 seconds are easily achieved thanks to the built-in spectral compensation algorithm, that eliminate the need of a heart-cut column and extra valve. The GC Sense Series configured for this application has two operating range, user configurable. All necessary industrial interfaces are standard, i.e. 4–20 mA isolated current output, remote range identification and system status contact. Remote Ethernet/Internet control software are standard. Optional industrial protocol like MODBUS, PRO-BIBUS, etc. are available. These provide easy interfaces to any SCADA, PLC, and DCS systems.

Complete auto-calibration/sample selection and remote control are easily integrated without special efforts from on site operating personnel. The system follows plug and play philosophy with its user friendly interface, and its almost maintenance free. When installed properly, it will operate many years without problems.

When the analyzer is interfaced with the process control system, the plant may be operated at its optimum efficiency, resulting in an increased argon recovery of up to 5% in some situations. It is obvious that the payback is fast. Normally, the sample connection is made at the point where the argon mixture is extracted from the low pressure column. When the process is stable there is no problem to do so even if the level of N_2 is a little bit high. But in some plants there are two big "desiccation bottles" to dry the compressed incoming air and to remove the CO_2. One bottle is alternatively switched into the process when the other one is being regenerated. Before bringing back the newly regenerated bottle in the process, this one must be pressurized. Pressurizing this bottle involves sudden changes in pressure which can lead to an increased level of N_2 in the crude argon up to the limit where the crude argon column may dump.

This event may happen in a very short period of time. To help avoiding such situations, it is a good idea to monitor the low pressure column from a sample connection located physically higher than the argon draw-off point. This can be done just after the next tray section. Doing so will give time to react when a.fast column upset occurs.



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Many Air separation plants are monitoring the N_2 level in the argon draw off stream with a GC Sense Series. However, it is also possible with the same instrument to monitor the level of argon in the waste gas. It results in a better control of the low pressure distillation column and higher level of argon recovery.

Table 1 shows a typical data for a small and large air separation plant where a GC Sense Series was set up to contact the low pressure distillation column profile. The sample point was done in the argon draw off stream. The table 1 considers only the benefits coming from plant power economy. The overall benefit is even better, if one calculates the supplementary net income generated by higher argon production.

Table 1

Small ASU Plant	Large ASU Plant	
150	750	tpd 02
150 000	750 000	gox
20,95%	20,95%	% 02 in Air
715 990	3 579 952	air required for oxygen
1 718	8 234	kw required for Air
3%	3%	increase in argon recovery
52	247	kw power savings
$0,06	$0,06	$/kwh power cost
$48 600,00	$129 823,00	$/yr benefit
$32 000,00	$32 000,00	$ initial cost (excludes installation)
0,66	0,24	yr payback
7,90	2,9	mo payback

Table 1: Performance data, assumed with an electricity cost of 0.06$/kWh

CONCLUSION

Better control of existing Air Separation plant low pressure column.with the help of GC Sense Series results in overall operations cost reduction and higher argon production. The integration of KA GC Sense Series in a process control loop is easily in any air separation plant generation. Many Air Separation plants around the world have already benefited of such installations. With the increase in energy cost and Argon demands on the market, it becomes even more obvious that the KA GC Sense Series system is an excellent tool that pays back by itself.

REFERENCES

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