Overview on the use of liquid oxygen to Pulp and Paper Industries

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1. Description of the basic customer process and our application

Most of the pulp mills that produce bleached Kraft pulp worldwide, majority of the kraft plant use oxygen delignification stage and use oxygen in their bleach plants. The advantage of using oxygen stems from the fact that it can substantially reduce the cost of reagents to bleach the pulp while improving pulp mill effluent quality significantly. As a major drawback, the oxygen bleaching systems, particularly the oxygen delignification require significant capital investment to be installed.

Oxygen delignification is a process between cooking and bleaching sequences, where part of the residual lignin left in pulp after cooking is removed using oxygen and alkali. The reaction oxidized the lignin and helps portion of lignin to dissolve in alkaline solution. The colour is also mostly destroyed due to removal of lignin and resins. This process of lowing kappa number of the cooked pulp also reduces the chemicals in subsequent bleaching. Oxygen in its normal state is a weak oxidizing agent and in order to increase the oxidizing efficiency, one has to raise the temperature and pressure of the oxygen delignification reactor.

Medium consistency oxygen delignification can be executed in one or two stage reactor and typical kappa number reduction can be between 35 to 40%.

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The above application consists of applying oxygen to a bleaching sequence through one of the three modes aforementioned. Depending upon the pulp mill, all three modes may be present, whereas in others only one or two modes will be present. In some cases none of the modes will be present, i.e., the mill will not use oxygen.

1. Customer Needs and Benefits Being Addressed

- **The customer needs a process that will decrease their effluent pollution load and reduce their bleaching costs while facilitating mill closure.**
- **By using oxygen, the customer will be able to meet environmental regulations, by decreasing pollution loads by about 40-50%**
- **Will decrease bleaching costs by about 25-30% and,**
- **Will be able to partially close the loop when using ECF and/or TCF bleaching processes.**

3. Expected Gas Consumption

Total oxygen consumption in this application is difficult to predict because pulp mills may vary significantly in size and bleaching process. In general, the specific consumption of oxygen per ton of bleached pulp is about 15-25 kg/t for the oxygen delignification (O or O/O), 4-6 kg/t for the oxidative extraction (Eo) and 2-3 kg/t (EOP) .

4 How is the Oxygen introduced

Basically, oxygen is applied in pressurized reactors that run at medium (10-12%) or high consistency (25-30%). The oxygen is mixed to the pulp slurry through special mixers and the slurry containing oxygen is pumped to the pressurized reactor. The pressurized reactor may vary depending upon the application. In the O-stage and the EOP-stage, the pressure runs at about 4-8 bars for 1-2 hours whereas in the Eo application the pressure is only about 2 bars and the retention is only for 5-15 min

5. Oxygen partial pressure in the delignification reactor controls the rate and amount of delignication of the pulp that would take place. As long as the gas pressure is increased to maintain the constant partial pressure of oxygen , low purity oxygen (90-92%) would produce the same results as that of high purity liquid oxygen one.

Oxygen reactors are designed to provide sufficient retention time for the oxygen to react with the pulp. Incase VPSA oxygen is used, extra inert gas will occupy the reactor volume which would reduce the retention time. At a typical reactor pressure of 550 kPa (80 psig) at the bottom, and 275 kPa (40 psig) , the inert gas in a 25 kg per delivered oxygen is equal to 3% of the pulp volume at bottom and 5% at the top.

Another possible effect is the entrapment of extra gas volume when mixed up with the pulp may cause channeling problem in the reactor. One can increase the back pressure by 10% and thus the entire volume from VPSA entering into the reactor can be reduced to the same volume as that of cryogenic oxygen. By the time the gas reached to the top of the reactor, most of the oxygen would be consumed. The bubble size from VPSA would be 1.5 times bigger then the bubbles generated by cryogenic oxygen assuming that both will have 90% transfer from surface to the liquid mass which might cause some disturbance in the upper section of the reactor. The smaller size bubbles created due to cryogenic oxygen will have larger uniform surface area and hence will travel without much hindrance through the reactor.

The oxygen requirement from 15 to 130 TPD can be supplied most economically by VPSA PLANT. Cryogenic oxygen can be most economically and reliably supplied with bulk liquid oxygen trunked from nearby air separation unit. The economics of cryogenic liquid largely depends on distance, power factor and usage pattern ,Ref 1

PSA plant generally does not have liquid back up which could be a bottleneck to the production incase of breakdown. VPSA plants have liquid oxygen back up to ensure uninterrupted oxygen supply.

6. Benefits of using Liquid oxygen over PSA oxygen plant.

- Eliminate maintenance problem in PSA.
- Shut down during molecular sieve replacement resulting into loss of productivity.
- Eliminate capital investment for oxygen plant
- 99.95% purity oxygen from liquid oxygen would require lesser gas flow compared to PSA oxygen (92% purity)
- Possibility of improving chemical savings due to higher purity using liquid oxygen
- Liquid oxygen tank operation is flexible and instant both in terms of flowrate and pressure maintenance Liquid oxygen cost is not very significant compared to pulp production cost
- Pulp operator can focus on the core pulp making rather than managing the oxygen plant

Liquid oxygen storage tanks

Ref: 1990 oxygen delignification Symposium, Toronto, Oct-17-19