INTRODUCTION
Carbon capture methods are classified as post-combustion capture, pre-combustion capture and oxy-fuel combustion.

OBJECTIVE
With the increase in duty of lower reboiler, operating pressure requirement of HPC reduces and recovery of oxygen at a fixed purity also reduces.

1. Medium pressure dual-reboiler ASU is designed that produces GOX at 41 bara and GAN at 23 bara.
2. A control strategy is formulated for operating engineers, how to achieve variation of reboiler duties with the decrease in demand of oxygen.
3. The sizing of equipment is carried out so that these are capable of functioning in the fluctuating operating conditions of oxygen demand.
4. In the designed dual reboiler plant, operating parameters are again varied to find least possible oxygen production at a fixed purity.

Explanation behind mitigation in increase of spc with addition of a second reboiler
For heat integration to be possible in condenser-reboiler for a ST min. approach = 1.3K, HPC has to operates at 5.3 bara and LPC at 1.3 bara.
As at 5.3 bara saturation temperature of N₂ vapours present at the top of HPC is higher than saturation temperature of LOX present at the bottom of HPC.
This requires air to be compressed to 5.6 bara which consumes power.
Reboiler-1 boils up by air coming from Main HX which has higher saturation temperature than liquid present at bottom of LPC.
Reboiler-2 boils up by GAN vapours coming from HPC and impure liquid in second WN2 sub-cooler reduces.

So saturation temperature of liquids reduces.

Fluctuation of pumped LOX gasifying in main HX reduces.

So requirement of HP air reduces as we are obtaining non-separated O₂ from WN2.

This reduction can be seen as a direct consequence of lesser irreversibilities in LPC.

For a fixed size of main HX requirement of HP air was calculated as depicted in Figure 3. using simulation platform Aspen Hysys 8.6.

This graph can be used by operating engineers to control flow diversion to booster air compressor and diversion to low pressure stage of main air compressor.

Sizing of waste nitrogen sub-coolers
Pressure of waste nitrogen remains constant, but pressure of rich liquid in first WN2 sub-cooler and pressure of impure liquid in second WN2 sub-cooler reduces.

So saturation temperature of liquids reduces.

Liquid are entering WN2 sub-cooler at lesser pressure but are leaving at same temperature.

The temperature profiles go farther, that reduces requirement size of sub-coolers.

Thus maximum size of subcoolers was fixed as geometrical parameter as depicted in Figure 4.

Sizing of first condenser-reboiler
With the reduction in pressure of LP air entering in CR-1, its saturation temperature also reduces.

Due to this BT min. app. reduces which leads to increase in size requirement of CR-1 as observed in Figure 5.

By pumping liquid entering in CR-1, we can maintain a constant BT min. app.

Heat duty of CR-1 can be controlled just by varying pressure ratio of pump as shown in Figure 6.

The purity of oxygen is kept constant then its recovery remains constant, Oxygen production is reduced by using different operating techniques. However, total power consumption does not reduce proportionally.

Data in Figure 3 depicts the variation of size of CR and BT min with CR duty ratio of CR-1.

Thus CR-1 to CR-2 and CR-2 to CR-3 is a consistent set with CR duty ratio of CR-1 to CR-3.

However, this reduction was observed by the 11.1% if O₂ is vented to atmosphere via waste nitrogen stream by drawing higher GAN and lesser GOX from the plant.

The increase is 8.4% percentage points lesser than conventional case.

Then IL, the reflux for LPC, was reduced to obtain a least GOX recovery of 77%.

Sizing of equipments that can accumulate fluctuation of operating pressure of air streams and production of GOX has been done. The design methodology might help to modify a fine double column configuration to a dual reboiler configuration.

Data table of modeled dual-reboiler ASU might become handbook to control distribution of condenser-reboilers duties to obtain lesser cost at lesser demand but not at the expense of high spc.

REFERENCES

CONCLUSIONS
- Net decrease in power consumption is lesser as compared to decrease in production of oxygen. So, specific power consumption (spc) increases by 1.7%.
- However, spc would have increased by 11.1% if O₂ is vented to atmosphere via waste nitrogen stream by drawing higher GAN and lesser GOX from the plant.
- The increase is 8.4% percentage points lesser than conventional case.
- Then IL, the reflux for LPC, was reduced to obtain a least GOX recovery of 77%.
- Sizing of equipments that can accumulate fluctuation of operating pressure of air streams and production of GOX has been done. The design methodology might help to modify a fine double column configuration to a dual reboiler configuration.
- Data table of modeled dual-reboiler ASU might become handbook to control distribution of condenser-reboilers duties to obtain lesser cost at lesser demand but not at the expense of high spc.

Figure 8. Sizing of second condenser-reboiler

<table>
<thead>
<tr>
<th>Condition</th>
<th>MAC power consumption (kW)</th>
<th>GAN power consumption (kW)</th>
<th>GOX recovery (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR-1</td>
<td>8256</td>
<td>7460</td>
<td>9.63</td>
</tr>
<tr>
<td>CR-2</td>
<td>5654</td>
<td>5392</td>
<td>4.63</td>
</tr>
</tbody>
</table>

Table 1. Comparison of specific power consumption (spc) of 41 bara GAN and 23 bara GAN ASU by increasing CR-1 duty.

Figure 1. Cryogenic air separation unit (ASU)

Figure 2. Cryogenic air separation unit (ASU)

Figure 3. Variation of requirement of free flow rate of HP Air and pressure of LP Air with CR duty ratio.

Figure 4. Variation of task of WN2 sub-cooler having a BT min approach = 13K with increase in CR duty ratio.

Figure 5. Variation of size of waste nitrogen sub-cooler with CR duty ratio of CR-2 (day 1) to CR-1 (day 1)

Figure 6. Variation of size of waste nitrogen sub-cooler with CR duty ratio of CR-1 (day 2) to CR-1 (day 1)

Figure 7. Variation of size of GOX and BT min with CR duty ratio of CR-1 (day 1) to CR-1 (day 2)