Process variables data from the lean vapour compressor campaign at Technology Centre Mongstad

Fosbøl, Philip; Neerup, Randi; Almeida, Susana; Rezazadeh, Amirali; Gaspar, Jozsef; Knarvik, Anette; Flo, Nina

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The lean vapor compressor (LVC) unit at Technology Centre Mongstad (TCM), Norway has been tested. The aim of this research has been to create knowledge on the process performance of LVC on the CO₂ capture efficiency and energy profile of the TCM plant.

The dataset gives unique information on the LVC campaign in which 16 cases have been tested with various campaign process parameters such as LVC pressure, solvent flow, inlet flue gas CO₂ concentration, and stripper pressure. Absorber and stripper process conditions were recorded during these tests and are presented.

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The data presented in this article is providing the supplementary information from the lean vapor compression (LVC) campaign at Technology Centre Mongstad, Norway. A detailed description of the LVC campaign is presented in the work by Fosbøl et al. [1]. The LVC campaign was performed in June 2018. The campaign was divided into two main phases a base case and a LVC test phase. Cases from 1A to 1F represent the base cases and the cases ranging from 2A to 2F are the LVC test phase. The process variables from the pilot campaign are shown in Table 1. The standard deviations given in the table are based on averaged raw data given over 5 min intervals. The table gives information such as the inlet conditions to absorber and stripper. It also provides details on temperatures around the main heat exchanger.

The absorber temperature profiles for the base cases are given in Tables 2 and 3. The stripper temperature profiles for the base and the LVC cases are listed in Tables 4 and 5 respectively.

1. Data

The data presented in this article is providing the supplementary information from the lean vapor compression (LVC) campaign at Technology Centre Mongstad, Norway. A detailed description of the LVC campaign is presented in the work by Fosbøl et al. [1]. The LVC campaign was performed in June 2018. The campaign was divided into two main phases a base case and a LVC test phase. Cases from 1A to 1F represent the base cases and the cases ranging from 2A to 2F are the LVC test phase. The process variables from the pilot campaign are shown in Table 1. The standard deviations given in the table are based on averaged raw data given over 5 min intervals. The table gives information such as the inlet conditions to absorber and stripper. It also provides details on temperatures around the main heat exchanger.

The absorber temperature profiles for the base cases are given in Tables 2 and 3. The stripper temperature profiles for the base and the LVC cases are listed in Tables 4 and 5 respectively.

2. Experimental design, materials, and methods

A lean vapor compressor (LVC) campaign was performed at Technology Centre Mongstad using 30 wt% aqueous monoethanolamine (MEA) and flue gas, with a CO₂ content of 3.5% supplied by the combined heat and power (CHP) plant at the nearby Equinor refinery.

The amine plant was designed and constructed by Aker Solutions and Kværner. The LVC compressor (Pinnacle LF2140 single stage) was manufactured by Sundyne Compressors. The packing height of absorber and stripper were 18 m and 8 m respectively. Both columns were packed with structured Flexipac 2X.

A simplified process flow diagram illustrating the TCM amine plant configuration with CCGT based CHP flue gas feed, CO₂ recycle, and the large stripper designed for high CO₂ content flue gas is exemplified in Fig. 1. This set-up was utilized in the LVC test campaign.
| Description                              | Unit          | Case 1A-1 | Case 1B | Case 1C | Case 1D | Case 1E | Case 1F | Case 2A | Case 2B | Case 2C-1 | Case 2C-2 | Case 2C-3 | Case 2D-1 | Case 2D-2 | Case 2E | Case 2F |
|------------------------------------------|---------------|-----------|---------|---------|---------|---------|---------|---------|---------|-----------|-----------|-----------|-----------|-----------|---------|---------|
| CHP Flue gas flow rate                  | Sm$^3$/h      | mean 34985 | 34983   | 34996   | 34997   | 34985   | 34984   | 34995   | 34986   | 34888     | 34898     | 34995     | 35001     | 34991    | 34996   | 34991   |
|                                          | stdev 60      | 45        | 50      | 51      | 61      | 63      | 60      | 63      | 60      | 61        | 42        | 53        | 65        | 47       | 60      | 47      |
| CO$_2$ concentration into absorber      | vol%, dry     | mean 13.5  | 13.7    | 13.6    | 13.5    | 13.7    | 13.5    | 11.0    | 13.9    | 13.7      | 13.7      | 13.8      | 13.9      | 13.7     | 13.6    | 11.2    |
|                                          | stdev 0.04    | 0.06      | 0.04    | 0.05    | 0.03    | 0.09    | 0.02    | 0.03    | 0.02    | 0.03      | 0.04      | 0.03      | 0.02      | 0.03     | 0.04    | 0.04    |
| Flue gas temperature                    | °C            | mean 30.2  | 30.1    | 30.0    | 30.1    | 30.0    | 30.1    | 30.1    | 30.1    | 30.1      | 29.9      | 30.9      | 30.9      | 30.0     | 30.0    | 30.0    |
|                                          | stdev 0.25    | 0.04      | 0.04    | 0.04    | 0.05    | 0.04    | 0.05    | 0.04    | 0.04    | 0.04      | 0.04      | 0.04      | 0.04      | 0.05     | 0.04    | 0.05    |
| Flue gas into absorber in temperature    | °C            | mean 54    | 54.0    | 54.0    | 52.5    | 54.0    | 54.0    | 50.8    | 54.0    | 54.0      | 54.0      | 54.0      | 54.0      | 54.0     | 54.0    | 54.0    |
| Lean solvent density                    | kg/m$^3$      | mean 1047  | 1058    | 1060    | 1067    | 1060    | 1067    | 1064    | 1059    | 1059      | 1065      | 1063      | 1062      | 1070     | 1069    | 1063    |
| Lean solvent out of absorber            | °C            | mean 31.4  | 30.7    | 30.7    | 34.0    | 31.4    | 32.1    | 31.6    | 31.6    | 30.8      | 31.5      | 31.4      | 32.3      | 33.7     | 30.9    | 31.6    |
| Rich amine T out from absorber          | °C            | mean 43.4  | 47.6    | 51.3    | 43      | 49.8    | 51.2    | 41.7    | 43.2    | 48.1       | 50.9      | 51.4      | 49.6      | 48.7     | 51.4    | 51.8    |
| Rich amine liquid going to HE           | °C            | mean 127.3 | 168.0   | 208.0   | 128.0   | 207.5   | 207.5   | 128.0   | 173.0   | 208.0      | 208.0     | 208.0     | 208.0     | 208.0    | 208.0   | 208.0   |
| Rich amine density to kg/m$^3$          |               | mean 1107  | 1109    | 1103    | 1104    | 1097    | 1096    | 1096    | 1107    | 1099      | 1095      | 1109      | 1099      | 1106     | 1097   | 1092    |
| Lean amine out from HE                  | °C            | mean 109.3 | 108.9   | 108.3   | 110.3   | 106.6   | 106.8   | 106.1   | 95.1    | 93.9       | 93.3      | 96.1      | 92.1      | 91.9     | 94.8    | 93.1    |
| Lean amine to HE                        | °C            | mean 120.6 | 119.1   | 118.3   | 120.4   | 116.7   | 116.5   | 117.8   | 103.2   | 101.8      | 101       | 104.3     | 99.5      | 99.8     | 103.1   | 100.7   |
| Lean amine to sea water cooler          | °C            | mean 51.9  | 57.3    | 60.9    | 52.5    | 59.3    | 60.6    | 61.2    | 50.8    | 55.4       | 58.3      | 58.6      | 58.3      | 56.9     | 57.4    | 58.6    |
| P in stripper bottom                    | barg          | mean 0.98  | 0.98    | 0.98    | 0.98    | 0.98    | 0.98    | 0.98    | 0.98    | 0.98       | 0.98      | 0.98      | 0.98      | 0.98     | 0.98    | 0.98    |
| Temperature in stripper bottom          | °C            | mean 120.9 | 119.4   | 118.5   | 120.9   | 116.9   | 116.7   | 118.2   | 120.8   | 118.6      | 117.1     | 117.5     | 117.6     | 115      | 115.2   | 116.7   |
| Top stripper outlet pressure            | °C            | mean 96.9  | 97.5    | 98.7    | 98.1    | 96.7    | 97.2    | 99.9    | 88.8    | 88.7       | 89.1      | 91.1      | 88.5      | 87.2     | 89.3    | 89.2    |
| Lean amine outlet from HE               | °C            | mean 94.5  | 95.9    | 95.9    | 95.9    | 95.4    | 95.4    | 95.4    | 95.4    | 95.4       | 95.4      | 95.4      | 95.4      | 95.4     | 95.4    | 95.4    |

(continued on next page)
| Description                                      | Unit | Case 1A-1       | Case 1B       | Case 1C       | Case 1A-2      | Case 1D       | Case 1E       | Case 1F       | Case 2A       | Case 2B       | Case 2C-1      | Case 2C-2      | Case 2D-1      | Case 2D-2      | Case 2E       | Case 2F       |
|--------------------------------------------------|------|----------------|--------------|--------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Top stripper outlet flow                         | kg/h | mean 8623       | 8655         | 8971         | 8842           | 7474           | 9511           | 7543           | 7357           | 7084           | 6979           | 7431           | 7159           | 5935           | 6404           | 7728           | 5997           |
|                                                 | stdev | 40              | 77            | 35            | 55             | 26             | 66             | 41             | 36             | 33             | 49             | 64             | 34             | 52             | 32             | 40             | 43             |
| CO2 Outlet overhead system pressure              | barg | mean 0.90       | 0.90          | 0.90          | 0.90           | 0.90           | 0.75           | 0.90           | 0.90           | 0.90           | 0.90           | 0.90           | 0.90           | 0.90           | 0.90           | 0.90           | 0.90           |
| Temperature out of reboiler (HE)                 | °C   | mean 123.3       | 122.7         | 122.5         | 123            | 119.7          | 118.4          | 120.1          | 122.6         | 121.8          | 119.6          | 119.6          | 119.6          | 119.6          | 119.6          | 119.6          | 119.3          |
|                                                 | stdev | 0.09            | 0.04          | 0.03          | 0.03           | 0.11           | 0.05           | 0.02           | 0.02          | 0.03           | 0.04           | 0.05           | 0.02           | 0.03           | 0.02           | 0.02           | 0.03           |
| Pressure out of reboiler (HE)                    | barg | mean 0.95        | 0.96          | 0.96          | 0.96           | 0.96           | 0.83           | 0.97           | 0.96           | 0.97           | 0.97           | 0.97           | 0.97           | 0.83           | 0.97           | 0.83           | 0.97           |
| Pressure into reboiler (HE)                      | barg | mean 1.1         | 1.2           | 1.2           | 1.2            | 1.1            | 1.2            | 1.2            | 1.2           | 1.2            | 1.2            | 1.2            | 1.2            | 1.2            | 1.2            | 1.2            | 1.2            |
| Temperature into reboiler (HE)                   | °C   | mean 120.8        | 119.1         | 118.2         | 120.6          | 116.7          | 116.6          | 117.9          | 120.5         | 118.3          | 116.8          | 117.2          | 117.4          | 114.7          | 114.9          | 115.5          | 116.5          |
| Pressure of steam into reboiler                  | barg | mean 3.3          | 2.8           | 2.9           | 2.7            | 2.3            | 2.5            | 2.4            | 2.3           | 2.3            | 2.1            | 2.3            | 2.2            | 1.9            | 2.0            | 2.0            | 2.0            |
| Flow of steam into reboiler                      | kg/h | mean 12088        | 12629         | 13282         | 12141          | 11527          | 12628          | 11649          | 9652          | 9770          | 9960          | 11011         | 10147         | 9089          | 7923          | 10656         | 8898          |
| Temperature of steam upstream                    | °C   | mean 156.7        | 150.6         | 168.2         | 153.0          | 159.3          | 170.4          | 163.2          | 160.8         | 161.1          | 161.8          | 154.5          | 157.6          | 156.9          | 155.6         | 155.4         | 155.8         |
| Reboiler outlet                                  | °C   | mean 122.7        | 120.9         | 119.8         | 122.0          | 117.9          | 117.3          | 118.8          | 122.5         | 120.5          | 118.1          | 118.1          | 118.5          | 116.1          | 116.1          | 116.2         | 117.6         |
| Condenser bottom flow                            | kg/h | mean 2878         | 2977          | 3254          | 3123           | 2484           | 3415           | 2893           | 1746          | 1689          | 1708          | 1999          | 1706          | 1413          | 1619          | 1991          | 1600          |
| Condenser bottom temperature, hot side           | °C   | mean 16.7         | 16.6          | 16.4          | 16.1           | 16.4           | 16.3           | 15.7           | 16.7          | 16.7          | 16.4          | 16.4          | 16.1          | 16.1          | 16.7          | 16.7          | 15.7          |
| Flow of seawater to condenser inlet              | kg/h | mean 92278        | 98716         | 104193        | 105040         | 81885          | 128612         | 90363          | 55781         | 47816         | 49786         | 54966         | 51890         | 34865         | 40070         | 59047         | 43988         |
| Temperature of seawater to condenser inlet       | °C   | mean 7.7          | 7.6           | 7.6           | 7.7            | 8.6            | 8.4            | 8.4            | 7.7           | 7.7           | 7.7           | 7.7           | 7.6           | 7.7           | 7.7           | 7.8           | 8.0           |
| Temperature of seawater to condenser outlet      | °C   | mean 28.3         | 27.4          | 28.0          | 27.2           | 28.4           | 25.7           | 29            | 28.7          | 31.0          | 30.1          | 30.3          | 29.1          | 33.6          | 32.5          | 29.6          | 31.2          |
| Flow of CO2 out of condenser drum                | kg/h | mean 7553         | 7468          | 7404          | 7443           | 6589           | 7408           | 6038           | 7726          | 7473          | 7290          | 7419          | 7539          | 6627          | 6627          | 7409          | 6114          |
|                                | barg mean | barg stdev | °C mean | °C stdev | °C mean | °C stdev | °C mean | °C stdev | °C mean | °C stdev | °C mean | °C stdev | °C mean | °C stdev |
|--------------------------------|-----------|------------|---------|----------|---------|----------|---------|----------|---------|----------|---------|----------|---------|----------|
| Amine flash vessel pressure    | 1.0       | 0.001      | 1.0     | 0.001    | 1.0     | 0.001    | 1.0     | 0.001    | 1.0     | 0.001    | 1.0     | 0.001    | 1.0     | 0.001    |
| Flash vessel inlet temperature | 112.0     | 0.07       | 108.5   | 0.06     | 101.7   | 0.06     | 100.8   | 0.05     | 100.3   | 0.06     | 103.8   | 0.03     | 99.1    | 0.06     |
| Lean amine temperature to      | 120.8     | 0.05       | 118.4   | 0.03     | 116.8   | 0.06     | 116.6   | 0.03     | 117.9   | 0.05     | 102.3   | 0.04     | 101.4   | 0.04     |
| antisurge HE                  |           |            |         |          |         |          |         |          |         |          |         |          |         |          |
| Lean amine flow to             | 114.9     | 0.05       | 152.6   | 0.3      | 190.3   | 0.1     | 116.0   | 0.6      | 188.5   | 0.3      | 190.6   | 0.4      | 190.0   | 0.5      |
| vessel                          |           |            |         |          |          |          |         |          |         |          |         |          |         |          |
| Inlet pressure to              | 0.95      | 0.005      | 0.94    | 0.006    | 0.94    | 0.001    | 0.90    | 0.004    | 0.94    | 0.001    | 0.90    | 0.001    | 0.90    | 0.001    |
| compressor                     |           |            |         |          |          |          |         |          |         |          |         |          |         |          |
| Inlet temperature to           | 35.6      | 0.74       | 44.5    | 0.52     | 42.7    | 0.60     | 60.4    | 0.25     | 42.3    | 0.58     | 100.4   | 0.73     | 98.9    | 0.04     |
| compressor                     |           |            |         |          |          |          |         |          |         |          |          |          |         |          |
| Outlet pressure from           | 0.92      | 0.06       | 0.86    | 0.01     | 0.86    | 0.01     | 0.70    | 0.02     | 0.87    | 0.03     | 1.05    | 0.04     | 1.06    | 0.01     |
| compressor                     |           |            |         |          |          |          |         |          |         |          |          |          |         |          |
| Outlet temperature             | 25.0      | 0.86       | 17.8    | 0.17     | 18.9    | 0.16     | 29.3    | 1.0      | 22.0    | 1.0      | 192.2   | 0.33     | 190.7   | 0.06     |
| from compressor                |           |            |         |          |          |          |         |          |         |          |         |          |         |          |
| Lean loading                   | 0.215     | 0.507      | 0.290   | 0.507    | 0.290   | 0.507    | 0.290   | 0.507    | 0.290   | 0.507    | 0.290   | 0.507    | 0.290   | 0.507    |
| mol/mol                        |           |            |         |          |          |          |         |          |         |          |          |          |         |          |
| Rich loading                   | 0.483     | 0.360      | 0.577   | 0.483    | 0.577   | 0.483    | 0.577   | 0.483    | 0.577   | 0.483    | 0.577   | 0.483    | 0.577   | 0.483    |
| mol/mol                        |           |            |         |          |          |          |         |          |         |          |          |          |         |          |
| CO2 capture %                  | 90.1      | 0.64       | 89.7    | 0.5      | 88.9    | 0.2      | 88.7    | 0.3      | 89.8    | 0.2      | 89.5    | 0.3      | 89.4    | 0.2      |
| QSRD                           | 3.60      | 0.06       | 4.00    | 0.04     | 3.66    | 0.02     | 3.90    | 0.03     | 3.83    | 0.03     | 4.34    | 0.02     | 2.99    | 0.02     |
| (Mj/kg CO2)                    |           |            |         |          |          |          |         |          |         |          |         |          |         |          |
| QLVC                           | 0.000     | 0.000      | 0.000   | 0.000    | 0.000   | 0.000    | 0.000   | 0.000    | 0.000   | 0.000    | 0.000   | 0.000    | 0.000   | 0.000    |
| (Gj electric/ton CO2)          |           |            |         |          |          |          |         |          |         |          |         |          |         |          |
| Antisurge cooler inlet         | 121.9     | 0.05       | 119.1   | 0.03     | 118.3   | 0.03     | 116.7   | 0.05     | 116.5   | 0.05     | 117.8   | 0.05     | 103.2   | 0.05     |
| cold side temperature          |           |            |         |          |          |          |         |          |         |          |         |          |         |          |
| Antisurge cooler outlet         | 120.6     | 0.03       | 119.1   | 0.03     | 120.4   | 0.03     | 116.7   | 0.03     | 116.5   | 0.03     | 103.2   | 0.03     | 101.8   | 0.03     |
| cold side temperature          |           |            |         |          |          |          |         |          |         |          |         |          |         |          |
| Antisurge cooler outlet         | 117.6     | 0.06       | 161.7   | 0.26     | 201.52  | 0.27    | 122.7   | 0.13    | 199.4   | 0.16    | 200.6   | 0.09    | 195.5   | 0.09    |
| cold side temperature          |           |            |         |          |          |          |         |          |         |          |         |          |         |          |
| Seawater flow to antisuage     | 33294     | 72        | 33218   | 32        | 33218   | 32       | 33242   | 32       | 33243   | 32       | 33208   | 32      | 33253   | 32      |
| kg/h                           |           |            |         |          |          |          |         |          |         |          |         |          |         |          |
| Temp. of seawater out of       | 7.8       | 0.009      | 7.7     | 0.003    | 7.6     | 0.005    | 8.6     | 0.015   | 8.4     | 0.015   | 8.9     | 0.009    | 8.8     | 0.015   |
| antisuage                      |           |            |         |          |          |          |         |          |         |          |         |          |         |          |
| Temp. of seawater to            | 7.7       | 0.002      | 7.6     | 0.006    | 7.7     | 0.002    | 8.6     | 0.017   | 8.4     | 0.017   | 7.7     | 0.002   | 7.7     | 0.002   |
| antisuage inlet                |           |            |         |          |          |          |         |          |         |          |         |          |         |          |

*a* Uncertainty on the lean- and rich loading determination of 4%.

*b* Lean and rich loading not measured for case 1A-2.

*c* SRD is thermal energy consumption.

*d* LVC is electrical energy consumption.
| h (m) | Position of temperature probe | Case 1A-1 | | Case 1A-2 | | Case 1B | | Case 1C | | Case 1D | | Case 1E | | Case 1F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Below lower packing | 48 0.12 | 48 0.37 | 54 0.36 | 58 0.3 | 56 0.2 | 59 0.22 | 59 0.27 |
| 0.5 | a | 48 0.14 | 47 0.38 | 53 0.34 | 57 0.18 | 55 0.18 | 57 0.23 | 57 0.21 |
| | b | 39 0.14 | 39 0.29 | 45 0.09 | 48 0.05 | 47 0.06 | 47 0.11 | 49 0.06 |
| | c | 36 0.19 | 36 0.15 | 42 0.09 | 46 0.06 | 45 0.05 | 46 0.12 | 47 0.07 |
| | d | 36 0.18 | 36 0.1 | 40 0.07 | 44 0.09 | 44 0.1 | 44 0.1 | 45 0.07 |
| 1.5 | a | 48 0.13 | 48 0.41 | 54 0.17 | 58 0.1 | 56 0.12 | 57 0.13 | 59 0.11 |
| | b | 38 0.13 | 39 0.27 | 45 0.08 | 49 0.05 | 48 0.06 | 48 0.11 | 50 0.04 |
| | c | 47 0.11 | 47 0.24 | 57 0.22 | 64 0.08 | 60 0.11 | 64 0.19 | 66 0.05 |
| | d | 38 0.13 | 38 0.14 | 45 0.1 | 50 0.08 | 49 0.07 | 50 0.14 | 51 0.05 |
| 2.5 | a | 57 0.18 | 56 0.53 | 64 0.26 | 67 0.09 | 64 0.15 | 66 0.16 | 67 0.08 |
| | b | 41 0.1 | 41 0.34 | 49 0.1 | 53 0.06 | 52 0.07 | 53 0.12 | 54 0.05 |
| | c | 48 0.11 | 48 0.47 | 55 0.15 | 58 0.08 | 57 0.13 | 58 0.11 | 59 0.06 |
| | d | 46 0.1 | 46 0.36 | 55 0.13 | 59 0.1 | 57 0.1 | 59 0.15 | 61 0.04 |
| 3.5 | a | 55 0.17 | 55 0.55 | 62 0.22 | 66 0.08 | 63 0.14 | 65 0.13 | 66 0.06 |
| | b | 46 0.1 | 46 0.45 | 54 0.13 | 58 0.07 | 56 0.07 | 58 0.14 | 59 0.05 |
| | c | 43 0.09 | 43 0.26 | 52 0.14 | 57 0.07 | 56 0.07 | 57 0.17 | 59 0.04 |
| | d | 46 0.1 | 46 0.23 | 55 0.18 | 62 0.1 | 59 0.09 | 61 0.22 | 63 0.05 |
| 4.5 | a | 62 0.24 | 61 0.61 | 68 0.27 | 71 0.08 | 68 0.13 | 71 0.14 | 71 0.05 |
| | b | 52 0.15 | 52 0.56 | 61 0.2 | 64 0.08 | 62 0.1 | 64 0.16 | 65 0.06 |
| | c | 44 0.09 | 44 0.2 | 53 0.14 | 60 0.11 | 57 0.09 | 59 0.2 | 61 0.05 |
| | d | 48 0.11 | 48 0.34 | 59 0.22 | 66 0.08 | 62 0.08 | 65 0.2 | 67 0.07 |
| 5.5 | a | 63 0.27 | 62 0.63 | 69 0.29 | 72 0.08 | 69 0.13 | 72 0.14 | 72 0.05 |
| | b | 52 0.16 | 51 0.55 | 61 0.2 | 65 0.08 | 62 0.09 | 65 0.16 | 66 0.08 |
| | c | 49 0.13 | 49 0.25 | 59 0.21 | 66 0.09 | 63 0.12 | 65 0.22 | 67 0.08 |
| | d | 47 0.1 | 46 0.23 | 56 0.19 | 63 0.1 | 60 0.09 | 63 0.22 | 65 0.09 |
| 6.5 | a | 64 0.28 | 63 0.64 | 70 0.28 | 73 0.06 | 70 0.13 | 73 0.13 | 73 0.06 |
| | b | 55 0.18 | 54 0.62 | 64 0.23 | 68 0.07 | 65 0.1 | 68 0.17 | 69 0.06 |
| | c | 49 0.12 | 48 0.25 | 58 0.44 | 65 0.1 | 62 0.13 | 65 0.34 | 67 0.08 |
| | d | 51 0.13 | 51 0.37 | 63 0.25 | 69 0.08 | 65 0.09 | 68 0.22 | 69 0.04 |
| 7.5 | a | 68.8 0.28 | 67.3 0.63 | 73.8 0.26 | 76 0.06 | 72.5 0.12 | 75.8 0.12 | 74.8 0.03 |
| | b | 57.3 0.22 | 56.7 0.66 | 66.8 0.22 | 70.5 0.08 | 66.8 0.12 | 70 0.15 | 70.6 0.05 |
| | c | 55 0.18 | 54.4 0.56 | 66.1 0.28 | 70.6 0.07 | 66.9 0.1 | 70.3 0.19 | 70.7 0.03 |
| | d | 54.7 0.16 | 54 0.37 | 65.1 0.26 | 71 0.09 | 67.1 0.11 | 70.5 0.18 | 71.2 0.04 |
| 8.5 | a | 70.4 0.31 | 68.8 0.66 | 74.9 0.25 | 76.8 0.05 | 73.5 0.11 | 76.6 0.11 | 75.3 0.03 |
| | b | 64.2 0.3 | 63 0.73 | 71.4 0.24 | 74.1 0.06 | 70.4 0.12 | 73.7 0.14 | 73.3 0.04 |
| | c | 57.1 0.21 | 56.3 0.57 | 68 0.25 | 72.4 0.06 | 68.6 0.11 | 72 0.16 | 72 0.04 |
| | d | 57.1 0.21 | 56.6 0.38 | 67.4 0.25 | 72.7 0.09 | 68.9 0.1 | 72.5 0.15 | 72.4 0.04 |
| 9.5 | a | 70.5 0.28 | 69 0.65 | 74.9 0.22 | 76.7 0.05 | 73.4 0.11 | 76.5 0.11 | 75 0.03 |
|   |   |   |   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| b | 62.1 | 0.26 | N/A | N/A | 70.6 | 0.22 | N/A | N/A | N/A | N/A | N/A | N/A |
| c | 61.3 | 0.28 | 60 | 0.4 | 70.1 | 0.29 | 75.1 | 0.06 | 71.2 | 0.1 | 74.8 | 0.15 |
| d | 61.7 | 0.23 | 60.6 | 0.54 | 71.1 | 0.22 | 74.8 | 0.05 | 71.3 | 0.11 | 74.6 | 0.13 |

**10.5 a**

| b | 73.1 | 0.26 | 71.7 | 0.58 | 76.5 | 0.18 | 77.8 | 0.04 | 75 | 0.09 | 77.7 | 0.09 |
| c | 68.3 | 0.26 | 67 | 0.71 | 74.2 | 0.17 | 76.1 | 0.04 | 73.2 | 0.09 | 75.9 | 0.09 |
| d | 65.1 | 0.26 | 63.9 | 0.45 | 72.6 | 0.24 | 76.3 | 0.05 | 72.9 | 0.08 | 76.1 | 0.12 |

**11.5 a**

| b | 72.1 | 0.24 | 70.9 | 0.53 | 75.7 | 0.15 | 77.2 | 0.03 | 74.8 | 0.07 | 77.2 | 0.09 |
| c | 71 | 0.22 | 69.7 | 0.52 | 75 | 0.14 | 76.9 | 0.03 | 74.4 | 0.07 | 76.8 | 0.08 |
| d | 67.7 | 0.27 | 66.3 | 0.46 | 73.9 | 0.19 | 76.6 | 0.04 | 73.8 | 0.07 | 76.5 | 0.09 |

**12** Below middle packing

| b | 69 | 0.29 | 68.7 | 0.44 | 74.7 | 0.23 | 77.3 | 0.04 | 74.1 | 0.09 | 77.2 | 0.09 |
| c | 73.7 | 0.19 | 72.6 | 0.38 | 76.4 | 0.1 | 77.7 | 0.03 | 75.5 | 0.06 | 77.5 | 0.08 |
| d | 67.5 | 0.2 | 71.5 | 0.43 | 75.8 | 0.12 | 77.4 | 0.03 | 75.2 | 0.06 | 77.4 | 0.09 |

**12.5 a**

| b | 72.6 | 0.2 | 71.5 | 0.43 | 75.8 | 0.12 | 77.4 | 0.03 | 75.2 | 0.06 | 77.5 | 0.08 |
| c | 69.8 | 0.27 | 68.5 | 0.47 | 74.6 | 0.2 | 77.4 | 0.04 | 74.6 | 0.08 | 77.3 | 0.09 |
| d | 71.9 | 0.21 | 70.7 | 0.42 | 75.3 | 0.14 | 77.5 | 0.03 | 75.2 | 0.06 | 77.5 | 0.09 |

**13.5 a**

| b | 75.2 | 0.13 | 74.4 | 0.29 | 77.2 | 0.07 | 78.1 | 0.03 | 76.5 | 0.05 | 78.1 | 0.08 |
| c | 74.3 | 0.15 | 73.4 | 0.34 | 76.6 | 0.08 | 77.7 | 0.03 | 75.9 | 0.05 | 77.7 | 0.08 |
| d | 71.6 | 0.27 | 70.3 | 0.46 | 75.5 | 0.16 | 77.7 | 0.03 | 75.2 | 0.07 | 77.6 | 0.08 |

**14.5 a**

| b | 75.3 | 0.14 | 74.6 | 0.26 | 77.2 | 0.06 | 78.1 | 0.03 | 76.6 | 0.04 | 78.2 | 0.08 |
| c | 73 | 0.23 | 71.9 | 0.38 | 76 | 0.13 | 77.7 | 0.03 | 75.6 | 0.07 | 77.6 | 0.08 |
| d | 74.7 | 0.16 | 73.8 | 0.28 | 76.8 | 0.08 | 78.1 | 0.03 | 76.4 | 0.04 | 78.1 | 0.08 |

**15.5 a**

| b | 76.7 | 0.06 | 76.2 | 0.14 | 77.8 | 0.04 | 78.1 | 0.03 | 77.1 | 0.03 | 78.1 | 0.08 |
| c | 76.1 | 0.08 | 75.6 | 0.18 | 77.5 | 0.04 | 78.2 | 0.03 | 77 | 0.04 | 78 | 0.08 |
| d | 69.3 | 2.4 | 73.4 | 0.3 | 76.7 | 0.09 | 78 | 0.03 | 76.6 | 0.38 | 77.9 | 0.08 |
| 16.5 a | 75.6 | 0.1 | 74.9 | 0.19 | 77 | 0.05 | 78 | 0.03 | 76.7 | 0.03 | 78 | 0.08 |

**17.5 a**

| b | 73 | 0.19 | 72.2 | 0.41 | 70.5 | 0.29 | 67.1 | 0.28 | 66.5 | 0.37 | 67.4 | 0.41 |
| c | 75 | 0.12 | 74 | 0.22 | 73.3 | 0.12 | 70.8 | 0.16 | 70.3 | 0.12 | 71.3 | 0.18 |
| d | 73.1 | 0.12 | 72.3 | 0.18 | 72.7 | 0.19 | 70.4 | 0.18 | 69 | 0.12 | 70.4 | 0.17 |

**18 Below upper packing**

| b | 72.2 | 0.08 | 71.2 | 0.23 | 71.9 | 0.04 | 70.3 | 0.03 | 68.9 | 0.03 | 70.1 | 0.08 |

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*a* There are four parallel temperature sensors, where the legends A, B, C, and D refer to the temperature sensor close to the column wall and inside the packing at horizontal 1 m distance from each other. N/A: Data not available
Table 3
Absorber temperature profiles for LVC cases.

| h (m) | Position of temperature probe | Case 2A | Case 2B | Case 2C-1 | Case 2C-2 | Case 2C-3 | Case 2D-1 | Case 2D-2 | Case 2E | Case 2F |
|-------|--------------------------------|--------|--------|----------|----------|----------|----------|----------|--------|--------|
|       |                                | T (°C) Std. Dev. | T (°C) Std. Dev. | T (°C) Std. Dev. | T (°C) Std. Dev. | T (°C) Std. Dev. | T (°C) Std. Dev. | T (°C) Std. Dev. | T (°C) Std. Dev. | T (°C) Std. Dev. |
| 0     | Below lower packing             |        |        |          |          |          |          |          |        |        |
| 0.5   | a                               | 48     | 0.13   | 54       | 0.15     | 56       | 0.22     | 57       | 0.23   | 58     | 0.12   |
|       | b                               | 39     | 0.07   | 45       | 0.08     | 48       | 0.11     | 48       | 0.07   | 48     | 0.06   |
|       | c                               | 36     | 0.05   | 43       | 0.07     | 46       | 0.14     | 46       | 0.08   | 46     | 0.06   |
|       | d                               | 36     | 0.04   | 41       | 0.08     | 44       | 0.15     | 44       | 0.09   | 44     | 0.08   |
| 1.5   | a                               | 48     | 0.09   | 55       | 0.11     | 57       | 0.12     | 57       | 0.14   | 58     | 0.09   |
|       | b                               | 38     | 0.07   | 46       | 0.08     | 49       | 0.12     | 49       | 0.06   | 48     | 0.05   |
|       | c                               | 47     | 0.06   | 58       | 0.15     | 63       | 0.2      | 63       | 0.25   | 64     | 0.08   |
|       | d                               | 38     | 0.04   | 46       | 0.07     | 50       | 0.18     | 50       | 0.14   | 50     | 0.09   |
| 2.5   | a                               | 57     | 0.15   | 64       | 0.14     | 66       | 0.12     | 66       | 0.22   | 67     | 0.16   |
|       | b                               | 41     | 0.08   | 50       | 0.08     | 53       | 0.13     | 53       | 0.09   | 53     | 0.05   |
|       | c                               | 48     | 0.09   | 56       | 0.12     | 58       | 0.13     | 58       | 0.09   | 59     | 0.06   |
|       | d                               | 46     | 0.07   | 55       | 0.13     | 59       | 0.13     | 59       | 0.23   | 59     | 0.17   |
| 3.5   | a                               | 55     | 0.12   | 63       | 0.12     | 65       | 0.15     | 65       | 0.18   | 66     | 0.16   |
|       | b                               | 45     | 0.1    | 55       | 0.1      | 58       | 0.14     | 58       | 0.13   | 58     | 0.11   |
|       | c                               | 42     | 0.06   | 53       | 0.08     | 57       | 0.18     | 57       | 0.13   | 57     | 0.07   |
|       | d                               | 45     | 0.06   | 56       | 0.11     | 61       | 0.19     | 61       | 0.23   | 62     | 0.1    |
| 4.5   | a                               | 62     | 0.2    | 69       | 0.15     | 70       | 0.12     | 70       | 0.23   | 71     | 0.06   |
|       | b                               | 52     | 0.13   | 61       | 0.14     | 64       | 0.13     | 64       | 0.2    | 64     | 0.06   |
|       | c                               | 44     | 0.04   | 54       | 0.08     | 59       | 0.21     | 59       | 0.2    | 60     | 0.07   |
|       | d                               | 48     | 0.09   | 61       | 0.14     | 65       | 0.19     | 65       | 0.21   | 66     | 0.08   |
| 5.5   | a                               | 63     | 0.21   | 70       | 0.16     | 72       | 0.11     | 72       | 0.21   | 72     | 0.05   |
|       | b                               | 51     | 0.13   | 62       | 0.14     | 64       | 0.14     | 64       | 0.21   | 65     | 0.06   |
|       | c                               | 49     | 0.07   | 60       | 0.15     | 65       | 0.2      | 65       | 0.26   | 66     | 0.09   |
|       | d                               | 46     | 0.08   | 58       | 0.11     | 63       | 0.22     | 63       | 0.26   | 63     | 0.09   |
| 6.5   | a                               | 64     | 0.21   | 71       | 0.16     | 73       | 0.11     | 73       | 0.2    | 73     | 0.05   |
|       | b                               | 55     | 0.15   | 65       | 0.17     | 67       | 0.14     | 67       | 0.24   | 68     | 0.06   |
|       | c                               | 48     | 0.06   | 59       | 0.13     | 65       | 0.24     | 64       | 0.38   | 66     | 0.13   |
|       | d                               | 51     | 0.12   | 64       | 0.15     | 68       | 0.18     | 68       | 0.24   | 69     | 0.07   |
| 7.5   | a                               | 68     | 0.26   | 74       | 0.15     | 75       | 0.08     | 75       | 0.18   | 76     | 0.04   |
|       | b                               | 57     | 0.17   | 67       | 0.17     | 70       | 0.13     | 70       | 0.24   | 71     | 0.06   |
|       | c                               | 55     | 0.17   | 67       | 0.16     | 70       | 0.16     | 70       | 0.22   | 71     | 0.07   |
|       | d                               | 54     | 0.1    | 66       | 0.14     | 70       | 0.16     | 70       | 0.26   | 71     | 0.08   |
| 8.5   | a                               | 70     | 0.24   | 75       | 0.14     | 76       | 0.07     | 76       | 0.16   | 77     | 0.03   |
|       | b                               | 64     | 0.22   | 72       | 0.16     | 73       | 0.1     | 73       | 0.21   | 74     | 0.04   |
|       | c                               | 57     | 0.17   | 69       | 0.15     | 72       | 0.14     | 72       | 0.21   | 72     | 0.06   |
|       | d                               | 57     | 0.12   | 68       | 0.17     | 72       | 0.15     | 72       | 0.22   | 73     | 0.06   |
| Packing Level | Temperature Sensor Location |
|---------------|-----------------------------|
| 9.5           | A 70, B 75, C 76, D 77     |
| 10.5          | A 73, B 67, C 68, D 64     |
| 11.5          | A 73, B 72, C 74, D 75     |
| 12 Below middle packing | A 68, B 72, C 74, D 76 |
| 12.5          | A 74, B 72, C 69, D 71     |
| 13.5          | A 75, B 74, C 71, D 74     |
| 14 Below middle packing | A 74, B 75, C 73, D 74 |
| 14.5          | A 76, B 75, C 73, D 74     |
| 15 Below middle packing | A 74, B 76, C 76, D 77 |
| 15.5          | A 77, B 76, C 76, D 77     |
| 16 Below middle packing | A 77, B 77, C 76, D 77 |
| 16.5          | A 77, B 77, C 76, D 77     |
| 17 Below middle packing | A 77, B 77, C 76, D 77 |
| 17.5          | A 72, B 75, C 73, D 73     |

*a* There are four parallel temperature sensors, where the legends A, B, C, and D refer to the temperature sensor close to the column wall and inside the packing at horizontal 1 m distance from each other. N/A: Data not available.
| h (m) | Position of temperature probe\(^a\) | Case 1A-1 | Case 1A-2 | Case 1B | Case 1C | Case 1D | Case 1E | Case 1F |
|------|------------------------------------|-----------|-----------|---------|---------|---------|---------|---------|
|      |                                    | T (°C)    | T (°C)    | T (°C)  | T (°C)  | T (°C)  | T (°C)  | T (°C)  |
|      |                                    | Std. Dev. (°C) | Std. Dev. (°C) | Std. Dev. (°C) | Std. Dev. (°C) | Std. Dev. (°C) | Std. Dev. (°C) | Std. Dev. (°C) |
| 0    |                                    | 121.03    | 121.02    | 119.03  | 118.02  | 117.05  | 117.04  | 118.03  |
| 0.5  | a                                  | 120.35    | 118.08    | 117.41  | 115.11  | 112.02  | 114.37  | 110.13  |
|      | b                                  | 120.05    | 120.03    | 119.01  | 118.06  | 114.39  | 115.01  | 114.11  |
|      | c                                  | 119.04    | 118.07    | 113.32  | 113.17  | 103.01  | 107.37  | 111.18  |
|      | d                                  | N/A       | N/A       | N/A     | N/A     | N/A     | N/A     | N/A     |
| 1.5  | a                                  | 118.06    | 117.15    | 114.07  | 110.19  | 105.02  | 111.6  | 107.01  |
|      | b                                  | 119.06    | 119.03    | 118.21  | 115.12  | 111.63  | 114.13  | 110.17  |
|      | c                                  | 117.08    | 117.09    | 107.41  | 108.23  | 102.03  | 103.21  | 107.16  |
|      | d                                  | 117.11    | 119.07    | 110.24  | 109.17  | 102.04  | 107.27  | 106.11  |
| 2.5  | a                                  | 118.05    | 118.01    | 117.53  | 112.26  | 107.27  | 113.14  | 107.17  |
|      | b                                  | 118.07    | 119.05    | 111.29  | 109.18  | 102.04  | 107.28  | 106.09  |
|      | c                                  | N/A       | N/A       | N/A     | N/A     | N/A     | N/A     | N/A     |
|      | d                                  | N/A       | N/A       | N/A     | N/A     | N/A     | N/A     | N/A     |
| 3.5  | a                                  | 116.12    | 115.23    | 113.11  | 106.2   | 103.1   | 110.29  | 105.07  |
|      | b                                  | 114.17    | 117.01    | 104.23  | 105.07  | 102.03  | 103.13  | 105.05  |
|      | c                                  | 113.23    | 107.04    | 105.55  | 0.05    | 102.03  | 103.03  | 105.06  |
|      | d                                  | N/A       | N/A       | N/A     | N/A     | N/A     | N/A     | N/A     |
| 4.5  | a                                  | 117.38    | 115.43    | 113.52  | 107.22  | 105.09  | 109.31  | 107.13  |
|      | b                                  | N/A       | N/A       | N/A     | N/A     | N/A     | N/A     | N/A     |
|      | c                                  | 113.26    | 106.44    | 104.46  | 104.04  | 102.03  | 103.24  | 105.05  |
|      | d                                  | N/A       | N/A       | N/A     | N/A     | N/A     | N/A     | N/A     |
| 5.5  | a                                  | 110.29    | 109.6     | 107.19  | 104.06  | 102.03  | 104.22  | 105.06  |
|      | b                                  | N/A       | N/A       | N/A     | N/A     | N/A     | N/A     | N/A     |
|      | c                                  | 108.32    | 103.19    | 103.15  | 104.04  | 102.03  | 102.11  | 105.05  |
| 6.5  | a                                  | 106.34    | 103.19    | 103.12  | 104.04  | 102.03  | 102.09  | 105.05  |
|      | b                                  | 113.03    | 112.49    | 112.57  | 111.06  | 110.03  | 110.14  | 113.07  |
|      | c                                  | 110.31    | 117.42    | 104.13  | 104.12  | 113.79  | 103.15  | 106.39  |
|      | d                                  | N/A       | N/A       | N/A     | N/A     | N/A     | N/A     | N/A     |
| 7    | Above stripper packing             | 108.12    | 110.12    | 109.21  | 110.09  | 109.04  | 109.08  | 112.09  |
| 8    | Top stripper outlet                | 97.12     | 98.11     | 97.15   | 99.05   | 97.07   | 97.11   | 100.07  |

\(^a\) There are four parallel temperature sensor, where the legends A, B, C, and D refer to the temperature sensor close to the column wall and inside the packing at horizontal 1 m distance from each other. N/A: Data not available.
### Table 5
Stripper temperature profiles for LVC cases.

| h (m) | Position of temperature probe<sup>a</sup> | Case 2A | Case 2B | Case 2C-1 | Case 2C-2 | Case 2C-3 | Case 2D-1 | Case 2D-2 | Case 2E | Case 2F |
|-------|----------------------------------------|--------|--------|----------|----------|----------|----------|----------|--------|--------|
|       | T (°C) | Std. Dev. | T (°C) | Std. Dev. | T (°C) | Std. Dev. | T (°C) | Std. Dev. | T (°C) | Std. Dev. | T (°C) | Std. Dev. | T (°C) | Std. Dev. | T (°C) | Std. Dev. |
| 0     | 121 0.01 | 119 0.04 | 117 0.05 | 117 0.11 | 118 0.02 | 115 0.05 | 115 0.05 | 116 0.05 | 118 0.03 |
| 0.5   | 120 0.05 | 116 0.1 | 112 0.43 | 113 0.41 | 114 0.09 | 102 0.24 | 103 0.26 | 111 0.11 | 110 0.13 |
|       | 120 0.02 | 118 0.05 | 115 0.14 | 115 0.21 | 116 0.07 | 110 0.27 | 111 0.35 | 114 0.07 | 114 0.11 |
|       | 119 0.02 | 115 0.14 | 109 0.27 | 111 0.45 | 112 0.19 | 98 0.2 | 100 0.25 | 111 0.13 | 111 0.18 |
|       | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 1.5   | 118 0.03 | 112 0.2 | 103 0.41 | 105 0.83 | 107 0.27 | 94 0.08 | 97 0.1 | 107 0.31 | 107 0.1 |
|       | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 2.5   | 118 0.04 | 113 0.19 | 103 0.45 | 106 0.89 | 107 0.27 | 94 0.12 | 97 0.12 | 108 0.27 | 107 0.17 |
|       | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 3.5   | 119 0.06 | 101 0.36 | 98 0.11 | 100 0.3 | 99 0.11 | 96 0.04 | 98 0.05 | 100 0.25 | 108 0.07 |
|       | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 4.5   | 115 0.16 | 97 0.35 | 98 0.09 | 99 0.18 | 99 0.04 | 95 0.03 | 97 0.07 | 97 0.09 | 107 0.13 |
|       | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 5.5   | 110 0.35 | 95 0.09 | 95 0.08 | 97 0.14 | 95 0.03 | 93 0.04 | 95 0.05 | 95 0.08 | 105 0.05 |
|       | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 6.5   | 109 0.32 | 94 0.08 | 95 0.09 | 97 0.13 | 95 0.03 | 93 0.05 | 95 0.05 | 95 0.07 | 105 0.06 |
|       | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 7     | 101 0.39 | 94 0.06 | 95 0.08 | 97 0.13 | 95 0.03 | 93 0.05 | 95 0.05 | 95 0.07 | 105 0.05 |
|       | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 8     | 105 0.38 | 95 0.96 | 131 26.54 | 97 0.12 | 95 0.04 | 93 0.03 | 97 0.18 | 95 0.06 | 106 0.34 |
|       | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
|       | 99 0.09 | 99 0.08 | 100 0.07 | 102 0.1 | 99 0.04 | 98 0.08 | 100 0.13 | 100 0.06 | 112 0.09 |
|       | 89 0.09 | 89 0.05 | 89 0.08 | 91 0.11 | 89 0.04 | 87 0.08 | 89 0.16 | 89 0.06 | 100 0.07 |

<sup>a</sup> There are four parallel temperature sensor, where the legends A, B, C, and D refer to the temperature sensor close to the column wall and inside the packing at horizontal 1 m distance from each other. N/A: Data not available.
The CHP flue gas is conditioned in a direct contact cooler (DCC) after being enriched with CO₂ from the CO₂ product recycle stream. The conditioned flue gas is contacted counter-currently with amine solvent in the absorber. CO₂ is absorbed, yielding a solvent rich in CO₂ and a depleted flue gas with low CO₂ content. The depleted flue gas is released to the atmosphere after being conditioned in the water wash sections. The rich solvent loaded with CO₂ is pre-heated in the lean/rich cross heat exchanger before entering the stripper column. Additional heat is supplied by steam to the stripper reboiler in

**Fig. 1.** Simplified process flow diagram of the TCM amine plant.

**Fig. 2.** Simplified process flow diagram of the LVC.
order to desorb CO₂ and regenerate the solvent. The product CO₂ gas is released to the atmosphere, while the regenerated lean solvent is pumped back to the absorber via the lean/rich cross heat exchanger and the lean cooler. The amine plant is described in detail elsewhere. The large stripper section designed for high CO₂ content flue gas is also equipped with an optional lean vapor compressor system, as illustrated in Fig. 1. In the LVC system (see Fig. 2), hot lean amine exiting the stripper bottom is throttled to a lower pressure and fed to a flash drum generating vapor. The vapor is compressed and returned to the stripper bottom, while the lean amine is circulated back to the lean amine solvent loop. The LVC has for safety reasons a built-in anti-surge option which is used when flow to the compressor is below design flow. The control of the LVC automatically recycles gas in order to maintain correct compressor operation.

The superheated steam provides additional energy for regeneration of solvent in the stripper, which has the potential of reducing consumption of low pressure steam in the stripper reboiler.

Table 6 gives an overview of the adjustable process parameters applied in the LVC campaign at TCM. The LVC campaign was operated in a way that only one parameter was adjusted at a time allowing the plant to reach steady state faster. The campaign was performed with case durations between 3 and 24 hours out of which 1–8 hours were used for calculation of average steady state conditions.

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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