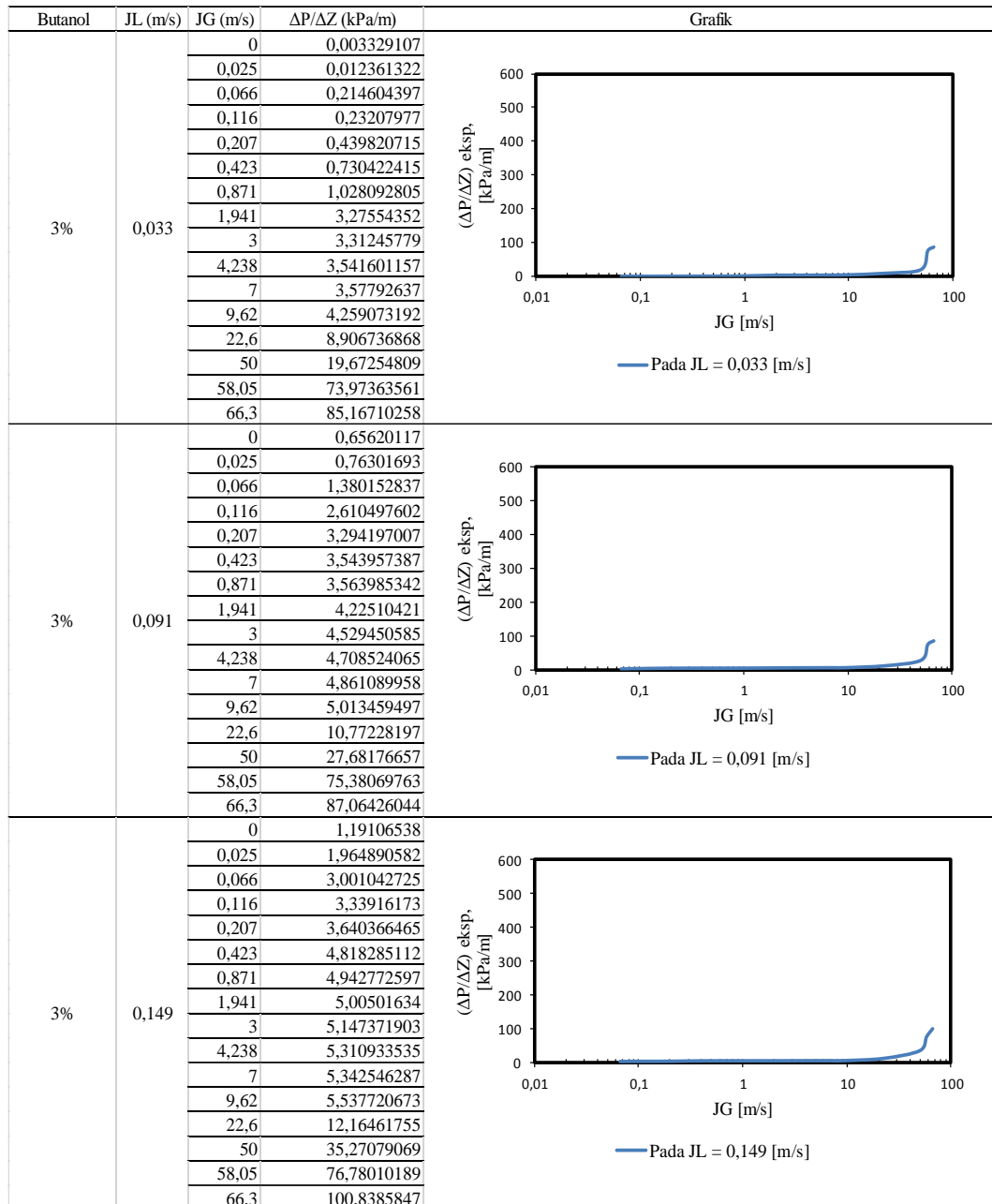
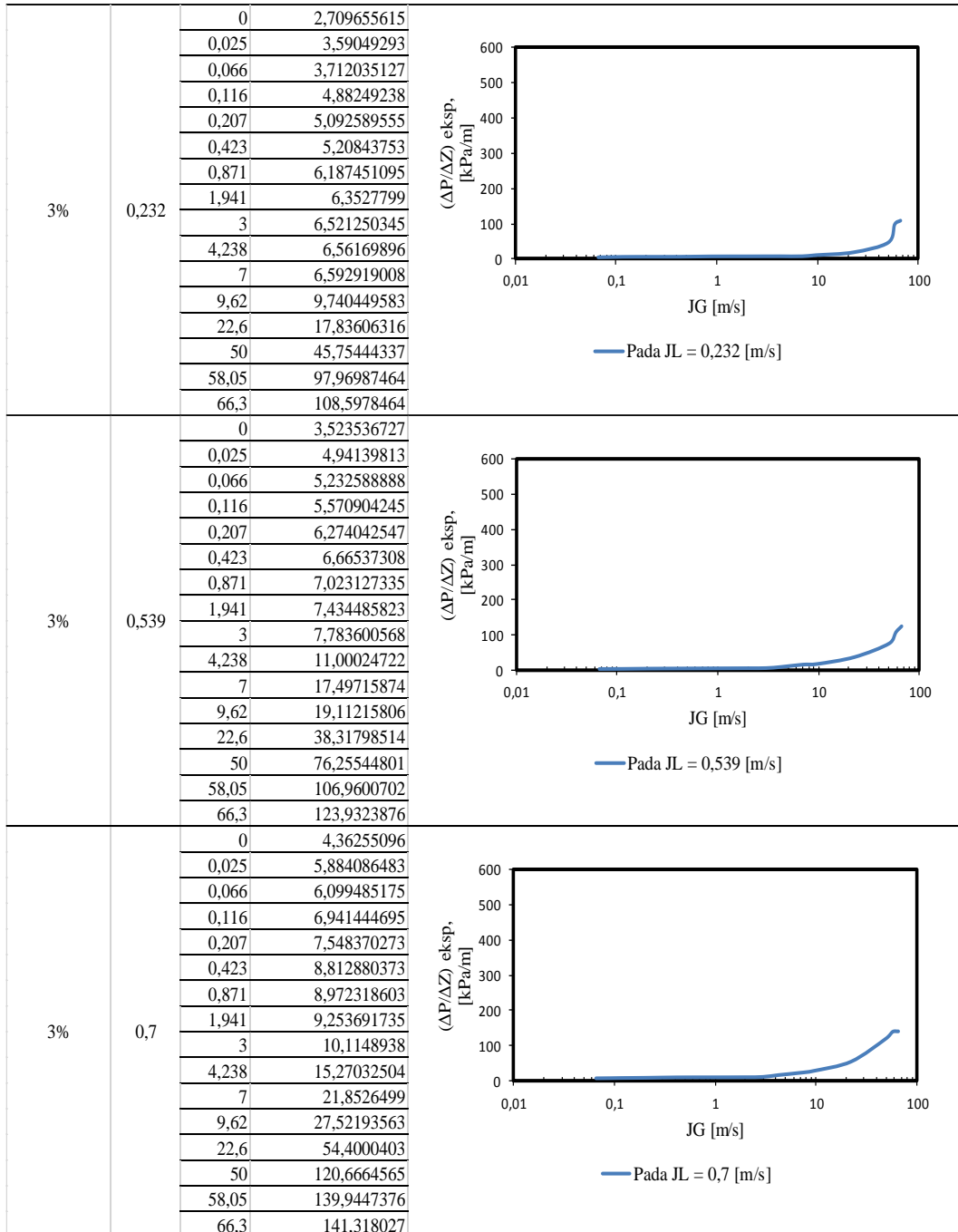


## LAMPIRAN

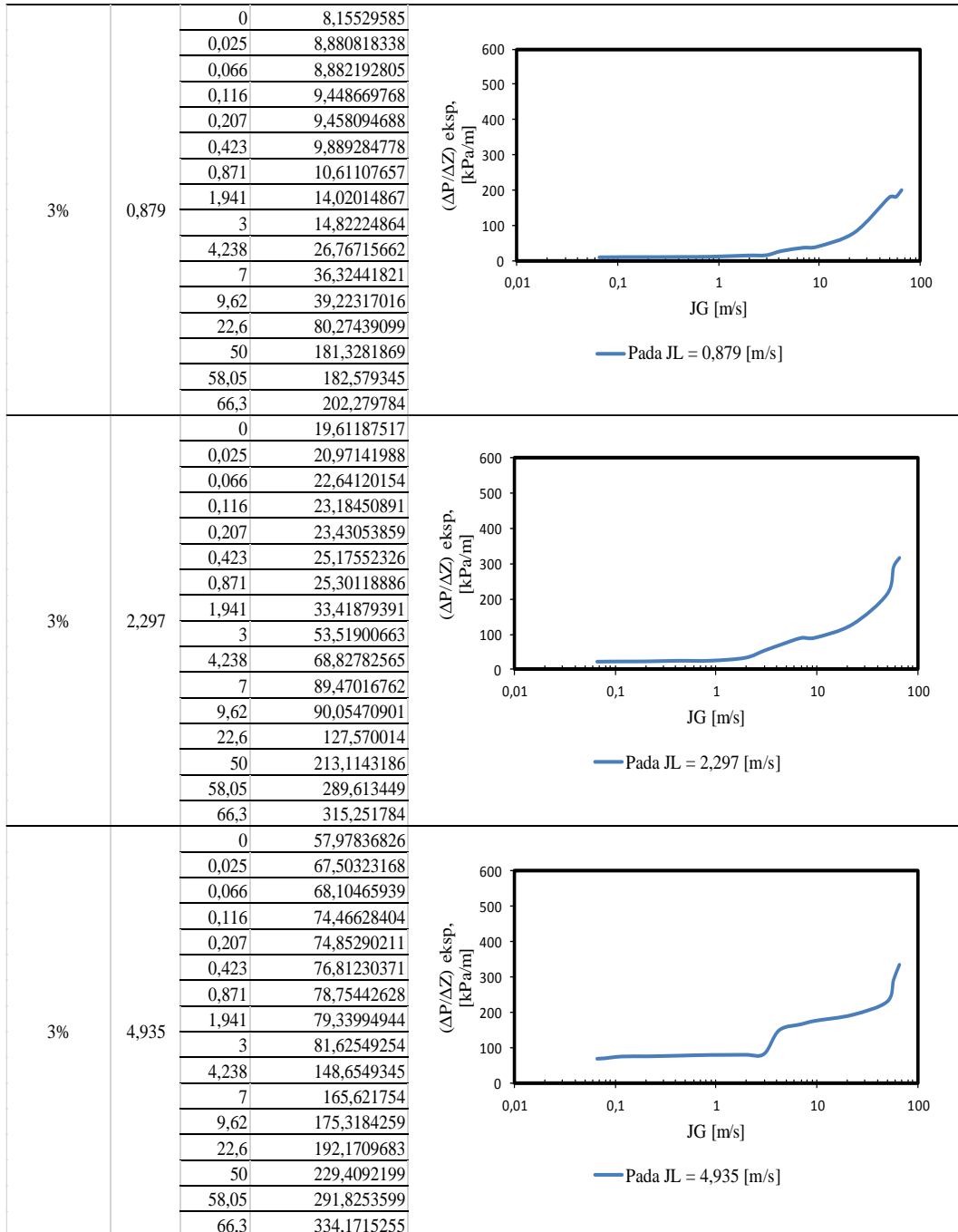
Lampiran 1. Tabel Variasi Kecepatan Superfisial Gas ( $J_G$ ) Terhadap Gradien Tekanan Pada Butanol 3%



Lampiran 1. Tabel Variasi Kecepatan Superfisial Gas ( $J_G$ ) Terhadap Gradien Tekanan Pada Butanol 3% (lanjutan)



Lampiran 1. Tabel Variasi Kecepatan Superfisial Gas ( $J_G$ ) Terhadap Gradien Tekanan Pada Butanol 3%



Lampiran 2. Tabel Variasi Kecepatan Superfisial cairan ( $J_L$ ) Terhadap Gradien Tekanan Pada Udara-Akuades Campuran Butanol 3%

| Butanol | JG (m/s) | $J_L$ (m/s) | $\Delta P/\Delta Z$ (kPa/m) | Grafik                         |
|---------|----------|-------------|-----------------------------|--------------------------------|
| 3%      | 0        | 0,033       | 0,003329107                 | <p>— Pada JG = 0 [m/s]</p>     |
|         |          | 0,091       | 0,65620117                  |                                |
|         |          | 0,149       | 1,19106538                  |                                |
|         |          | 0,232       | 2,709655615                 |                                |
|         |          | 0,539       | 3,523536727                 |                                |
|         |          | 0,7         | 4,36255096                  |                                |
|         |          | 0,879       | 8,15529585                  |                                |
|         |          | 2,297       | 19,61187517                 |                                |
|         |          | 4,935       | 57,97836826                 |                                |
| 3%      | 0,025    | 0,033       | 0,012361322                 | <p>— Pada JG = 0,025 [m/s]</p> |
|         |          | 0,091       | 0,76301693                  |                                |
|         |          | 0,149       | 1,964890582                 |                                |
|         |          | 0,232       | 3,59049293                  |                                |
|         |          | 0,539       | 4,94139813                  |                                |
|         |          | 0,7         | 5,884086483                 |                                |
|         |          | 0,879       | 8,880818338                 |                                |
|         |          | 2,297       | 20,97141988                 |                                |
|         |          | 4,935       | 67,50323168                 |                                |
| 3%      | 0,066    | 0,033       | 0,214604397                 | <p>— Pada JG = 0,066 [m/s]</p> |
|         |          | 0,091       | 1,380152837                 |                                |
|         |          | 0,149       | 3,001042725                 |                                |
|         |          | 0,232       | 3,712035127                 |                                |
|         |          | 0,539       | 5,232588888                 |                                |
|         |          | 0,7         | 6,099485175                 |                                |
|         |          | 0,879       | 8,882192805                 |                                |
|         |          | 2,297       | 22,64120154                 |                                |
|         |          | 4,935       | 68,10465939                 |                                |
| 3%      | 0,116    | 0,033       | 0,23207977                  | <p>— Pada JG = 0,116 [m/s]</p> |
|         |          | 0,091       | 2,610497602                 |                                |
|         |          | 0,149       | 3,33916173                  |                                |
|         |          | 0,232       | 4,88249238                  |                                |
|         |          | 0,539       | 5,570904245                 |                                |
|         |          | 0,7         | 6,941444695                 |                                |
|         |          | 0,879       | 9,448669768                 |                                |
|         |          | 2,297       | 23,18450891                 |                                |
|         |          | 4,935       | 74,46628404                 |                                |

Lampiran 2. Tabel Variasi Kecepatan Superfisial cairan ( $J_L$ ) Terhadap Gradien Tekanan Pada Udara-Akuades Campuran Butanol 3% (lanjutan)

|    |       |       |             |  |
|----|-------|-------|-------------|--|
| 3% | 0,207 | 0,033 | 0,439820715 | <p>— Pada <math>J_G = 0,207</math> [m/s]</p> |
|    |       | 0,091 | 3,294197007 |  |
|    |       | 0,149 | 3,640366465 |  |
|    |       | 0,232 | 5,092589555 |  |
|    |       | 0,539 | 6,274042547 |  |
|    |       | 0,7   | 7,548370273 |  |
|    |       | 0,879 | 9,458094688 |  |
|    |       | 2,297 | 23,43053859 |  |
|    |       | 4,935 | 74,85290211 |  |
| 3% | 0,423 | 0,033 | 0,730422415 | <p>— Pada <math>J_G = 0,423</math> [m/s]</p> |
|    |       | 0,091 | 3,543957387 |  |
|    |       | 0,149 | 4,818285112 |  |
|    |       | 0,232 | 5,20843753  |  |
|    |       | 0,539 | 6,66537308  |  |
|    |       | 0,7   | 8,812880373 |  |
|    |       | 0,879 | 9,889284778 |  |
|    |       | 2,297 | 25,17552326 |  |
|    |       | 4,935 | 76,81230371 |  |
| 3% | 0,871 | 0,033 | 1,028092805 | <p>— Pada <math>J_G = 0,871</math> [m/s]</p> |
|    |       | 0,091 | 3,563985342 |  |
|    |       | 0,149 | 4,942772597 |  |
|    |       | 0,232 | 6,187451095 |  |
|    |       | 0,539 | 7,023127335 |  |
|    |       | 0,7   | 8,972318603 |  |
|    |       | 0,879 | 10,61107657 |  |
|    |       | 2,297 | 25,30118886 |  |
|    |       | 4,935 | 78,75442628 |  |
| 3% | 1,941 | 0,033 | 3,27554352  | <p>— Pada <math>J_G = 1,941</math> [m/s]</p> |
|    |       | 0,091 | 4,22510421  |  |
|    |       | 0,149 | 5,00501634  |  |
|    |       | 0,232 | 6,3527799   |  |
|    |       | 0,539 | 7,434485823 |  |
|    |       | 0,7   | 9,253691735 |  |
|    |       | 0,879 | 14,02014867 |  |
|    |       | 2,297 | 33,41879391 |  |
|    |       | 4,935 | 79,33994944 |  |

Lampiran 2. Tabel Variasi Kecepatan Superfisial cairan ( $J_L$ ) Terhadap Gradien Tekanan Pada Udara-Akuades Campuran Butanol 3% (lanjutan)

|    |       |       |             |                                |
|----|-------|-------|-------------|--------------------------------|
| 3% | 3     | 0,033 | 3,31245779  | <p>— Pada JG = 3 [m/s]</p>     |
|    |       | 0,091 | 4,529450585 |                                |
|    |       | 0,149 | 5,147371903 |                                |
|    |       | 0,232 | 6,521250345 |                                |
|    |       | 0,539 | 7,783600568 |                                |
|    |       | 0,7   | 10,1148938  |                                |
|    |       | 0,879 | 14,82224864 |                                |
|    |       | 2,297 | 53,51900663 |                                |
|    |       | 4,935 | 81,62549254 |                                |
| 3% | 4,238 | 0,033 | 3,541601157 | <p>— Pada JG = 4,238 [m/s]</p> |
|    |       | 0,091 | 4,708524065 |                                |
|    |       | 0,149 | 5,310933535 |                                |
|    |       | 0,232 | 6,56169896  |                                |
|    |       | 0,539 | 11,00024722 |                                |
|    |       | 0,7   | 15,27032504 |                                |
|    |       | 0,879 | 26,76715662 |                                |
|    |       | 2,297 | 68,82782565 |                                |
|    |       | 4,935 | 148,6549345 |                                |
| 3% | 7     | 0,033 | 3,57792637  | <p>— Pada JG = 7 [m/s]</p>     |
|    |       | 0,091 | 4,861089958 |                                |
|    |       | 0,149 | 5,342546287 |                                |
|    |       | 0,232 | 6,592919008 |                                |
|    |       | 0,539 | 17,49715874 |                                |
|    |       | 0,7   | 21,8526499  |                                |
|    |       | 0,879 | 36,32441821 |                                |
|    |       | 2,297 | 89,47016762 |                                |
|    |       | 4,935 | 165,621754  |                                |
| 3% | 9,62  | 0,033 | 4,259073192 | <p>— Pada JG = 9,62 [m/s]</p>  |
|    |       | 0,091 | 5,013459497 |                                |
|    |       | 0,149 | 5,537720673 |                                |
|    |       | 0,232 | 9,740449583 |                                |
|    |       | 0,539 | 19,11215806 |                                |
|    |       | 0,7   | 27,52193563 |                                |
|    |       | 0,879 | 39,22317016 |                                |
|    |       | 2,297 | 90,05470901 |                                |
|    |       | 4,935 | 175,3184259 |                                |

Lampiran 2. Tabel Variasi Kecepatan Superfisial cairan ( $J_L$ ) Terhadap Gradien Tekanan Pada Udara-Akuades Campuran Butanol 3% (lanjutan)

|    |       |       |             |                                |
|----|-------|-------|-------------|--------------------------------|
| 3% | 22,6  | 0,033 | 8,906736868 | <p>— Pada JG = 22,6 [m/s]</p>  |
|    |       | 0,091 | 10,77228197 |                                |
|    |       | 0,149 | 12,16461755 |                                |
|    |       | 0,232 | 17,83606316 |                                |
|    |       | 0,539 | 38,31798514 |                                |
|    |       | 0,7   | 54,4000403  |                                |
|    |       | 0,879 | 80,27439099 |                                |
|    |       | 2,297 | 127,570014  |                                |
|    |       | 4,935 | 192,1709683 |                                |
| 3% | 50    | 0,033 | 19,67254809 | <p>— Pada JG = 50 [m/s]</p>    |
|    |       | 0,091 | 27,68176657 |                                |
|    |       | 0,149 | 35,27079069 |                                |
|    |       | 0,232 | 45,75444337 |                                |
|    |       | 0,539 | 76,25544801 |                                |
|    |       | 0,7   | 120,6664565 |                                |
|    |       | 0,879 | 181,3281869 |                                |
|    |       | 2,297 | 213,1143186 |                                |
|    |       | 4,935 | 229,4092199 |                                |
| 3% | 58,05 | 0,033 | 73,97363561 | <p>— Pada JG = 58,05 [m/s]</p> |
|    |       | 0,091 | 75,38069763 |                                |
|    |       | 0,149 | 76,78010189 |                                |
|    |       | 0,232 | 97,96987464 |                                |
|    |       | 0,539 | 106,9600702 |                                |
|    |       | 0,7   | 139,9447376 |                                |
|    |       | 0,879 | 182,579345  |                                |
|    |       | 2,297 | 289,613449  |                                |
|    |       | 4,935 | 291,8253599 |                                |
| 3% | 66,3  | 0,033 | 85,16710258 | <p>— Pada JG = 66,3 [m/s]</p>  |
|    |       | 0,091 | 87,06426044 |                                |
|    |       | 0,149 | 100,8385847 |                                |
|    |       | 0,232 | 108,5978464 |                                |
|    |       | 0,539 | 123,9323876 |                                |
|    |       | 0,7   | 141,318027  |                                |
|    |       | 0,879 | 202,279784  |                                |
|    |       | 2,297 | 315,251784  |                                |
|    |       | 4,935 | 334,1715255 |                                |

Lampiran 3. Hasil Kalibrasi *Pressure Transducer MPX System*

| No | h (m) | Beda Tekanan (Volt) | Tekanan (Pa) | Tekanan (Kpa) | $\rho$ (g/cm <sup>3</sup> ) | g (m/s <sup>2</sup> ) |
|----|-------|---------------------|--------------|---------------|-----------------------------|-----------------------|
| 1  | 0     | 0.033494959         | 0            | 0             | 996                         | 9.81                  |
| 2  | 0.2   | 0.036206748         | 1954.152     | 1.954152      | 996                         | 9.81                  |
| 3  | 0.4   | 0.038415708         | 3908.304     | 3.908304      | 996                         | 9.81                  |
| 4  | 0.6   | 0.04096836          | 5862.456     | 5.862456      | 996                         | 9.81                  |
| 5  | 0.8   | 0.043403393         | 7816.608     | 7.816608      | 996                         | 9.81                  |
| 6  | 1     | 0.045901646         | 9770.76      | 9.77076       | 996                         | 9.81                  |
| 7  | 1.2   | 0.048378447         | 11724.912    | 11.724912     | 996                         | 9.81                  |
| 8  | 1.4   | 0.05076496          | 13679.064    | 13.679064     | 996                         | 9.81                  |
| 9  | 1.6   | 0.053245502         | 15633.216    | 15.633216     | 996                         | 9.81                  |
| 10 | 1.8   | 0.055694268         | 17587.368    | 17.587368     | 996                         | 9.81                  |
| 11 | 2     | 0.058473666         | 19541.52     | 19.54152      | 996                         | 9.81                  |
| 12 | 2.2   | 0.060975207         | 21495.672    | 21.495672     | 996                         | 9.81                  |
| 13 | 2.4   | 0.063400916         | 23449.824    | 23.449824     | 996                         | 9.81                  |
| 14 | 2.6   | 0.065966688         | 25403.976    | 25.403976     | 996                         | 9.81                  |
| 15 | 2.8   | 0.068292817         | 27358.128    | 27.358128     | 996                         | 9.81                  |
| 16 | 3     | 0.070786566         | 29312.28     | 29.31228      | 996                         | 9.81                  |



Lampiran 4 Matriks Pengambilan Data Pola Aliran

| JG(ml/menit) | JL(ml/menit) |       | 3,979008 | 10,97242 | 17,96582 | 27,97363 | 64,99046 | 84,4032 | 105,9863 | 276,9631 | 595,0426 |
|--------------|--------------|-------|----------|----------|----------|----------|----------|---------|----------|----------|----------|
|              | JL           | JG    | 0,033    | 0,091    | 0,149    | 0,232    | 0,539    | 0,7     | 0,879    | 2,297    | 4,935    |
| 0            | 0            | 0     | 1        | 2        | 3        | 4        | 5        | 6       | 7        | 8        | 9        |
| 3,0144       | 0,025        | 0,025 | 10       | 11       | 12       | 13       | 14       | 15      | 16       | 17       | 18       |
| 7,958016     | 0,066        | 0,066 | 19       | 20       | 21       | 22       | 23       | 24      | 25       | 26       | 27       |
| 13,98682     | 0,116        | 0,116 | 28       | 29       | 30       | 31       | 32       | 33      | 34       | 35       | 36       |
| 24,95923     | 0,207        | 0,207 | 37       | 38       | 39       | 40       | 41       | 42      | 43       | 44       | 45       |
| 51,00465     | 0,423        | 0,423 | 46       | 47       | 48       | 49       | 50       | 51      | 52       | 53       | 54       |
| 105,0217     | 0,871        | 0,871 | 55       | 56       | 57       | 58       | 59       | 60      | 61       | 62       | 63       |
| 234,038      | 1,941        | 1,941 | 64       | 65       | 66       | 67       | 68       | 69      | 70       | 71       | 72       |
| 361,728      | 3            | 3     | 73       | 74       | 75       | 76       | 77       | 78      | 79       | 80       | 81       |
| 511,0011     | 4,238        | 4,238 | 82       | 83       | 84       | 85       | 86       | 87      | 88       | 89       | 90       |
| 844,032      | 7            | 7     | 91       | 92       | 93       | 94       | 95       | 96      | 97       | 98       | 99       |
| 1159,941     | 9,620        | 9,620 | 100      | 101      | 102      | 103      | 104      | 105     | 106      | 107      | 108      |
| 2725,018     | 22,6         | 22,6  | 109      | 110      | 111      | 112      | 113      | 114     | 115      | 116      | 117      |
| 6028,8       | 50           | 50    | 118      | 119      | 120      | 121      | 122      | 123     | 124      | 125      | 126      |
| 6999,437     | 58,05        | 58,05 | 127      | 128      | 129      | 130      | 131      | 132     | 133      | 134      | 135      |
| 7994,189     | 66,3         | 66,3  | 136      | 137      | 138      | 139      | 140      | 141     | 142      | 143      | 144      |

Lampiran 5. Tabel Kecepatan Superfisial Terbentuknya Pola Aliran

| PLUG |       |       | CHURN |      |       | SLUG ANNULAR |       |     |
|------|-------|-------|-------|------|-------|--------------|-------|-----|
| No.  | JG    | JL    | No.   | JG   | JL    | No.          | JG    | JL  |
| 10   | 0,025 | 0,033 | 80    | 3    | 2,297 | 73           | 3     | 0   |
| 11   | 0,025 | 0,091 | 81    | 3    | 4,935 | 74           | 3     | 0,1 |
| 12   | 0,025 | 0,149 | 89    | 4,24 | 2,297 | 75           | 3     | 0,1 |
| 13   | 0,025 | 0,232 | 90    | 4,24 | 4,935 | 76           | 3     | 0,2 |
| 14   | 0,025 | 0,539 | 96    | 7    | 0,7   | 82           | 4,238 | 0   |
| 15   | 0,025 | 0,7   | 97    | 7    | 0,879 | 83           | 4,238 | 0,1 |
| 16   | 0,025 | 0,879 | 98    | 7    | 2,297 | 84           | 4,238 | 0,1 |
| 19   | 0,066 | 0,033 | 99    | 7    | 4,935 | 85           | 4,238 | 0,2 |
| 20   | 0,066 | 0,091 | 104   | 9,62 | 0,539 | 86           | 4,238 | 0,5 |
| 21   | 0,066 | 0,149 | 105   | 9,62 | 0,7   | 87           | 4,238 | 0,7 |
| 22   | 0,066 | 0,232 | 106   | 9,62 | 0,879 | 88           | 4,238 | 0,9 |
| 23   | 0,066 | 0,539 | 107   | 9,62 | 2,297 | 91           | 7     | 0   |
| 24   | 0,066 | 0,7   | 108   | 9,62 | 4,935 | 92           | 7     | 0,1 |
| 25   | 0,066 | 0,879 | 113   | 22,6 | 0,539 | 93           | 7     | 0,1 |
| 28   | 0,116 | 0,033 | 114   | 22,6 | 0,7   | 94           | 7     | 0,2 |
| 29   | 0,116 | 0,091 | 115   | 22,6 | 0,879 | 95           | 7     | 0,5 |
| 30   | 0,116 | 0,149 | 116   | 22,6 | 2,297 | 100          | 9,62  | 0   |
| 31   | 0,116 | 0,232 | 117   | 22,6 | 4,935 | 101          | 9,62  | 0,1 |
| 32   | 0,116 | 0,539 | 122   | 50   | 0,539 | 102          | 9,62  | 0,1 |
| 33   | 0,116 | 0,7   | 123   | 50   | 0,7   | 103          | 9,62  | 0,2 |
| 34   | 0,116 | 0,879 | 124   | 50   | 0,879 |              |       |     |
| 37   | 0,207 | 0,033 | 125   | 50   | 2,297 |              |       |     |
| 38   | 0,207 | 0,091 | 126   | 50   | 4,935 |              |       |     |
| 39   | 0,207 | 0,149 | 131   | 58,1 | 0,539 |              |       |     |
| 40   | 0,207 | 0,232 | 132   | 58,1 | 0,7   |              |       |     |
| 41   | 0,207 | 0,539 | 133   | 58,1 | 0,879 |              |       |     |
| 42   | 0,207 | 0,7   | 134   | 58,1 | 2,297 |              |       |     |
| 46   | 0,423 | 0,033 | 135   | 58,1 | 4,935 |              |       |     |
| 47   | 0,423 | 0,091 | 140   | 66,3 | 0,539 |              |       |     |
| 48   | 0,423 | 0,149 | 141   | 66,3 | 0,7   |              |       |     |
| 49   | 0,423 | 0,232 | 142   | 66,3 | 0,879 |              |       |     |
| 50   | 0,423 | 0,539 | 143   | 66,3 | 2,297 |              |       |     |
| 51   | 0,423 | 0,7   | 144   | 66,3 | 4,935 |              |       |     |
| 55   | 0,871 | 0,033 |       |      |       |              |       |     |
| 56   | 0,871 | 0,091 |       |      |       |              |       |     |
| 57   | 0,871 | 0,149 |       |      |       |              |       |     |
| 58   | 0,871 | 0,232 |       |      |       |              |       |     |
| 59   | 0,871 | 0,539 |       |      |       |              |       |     |
| 64   | 1,941 | 0,033 |       |      |       |              |       |     |
| 65   | 1,941 | 0,091 |       |      |       |              |       |     |
| 66   | 1,941 | 0,149 |       |      |       |              |       |     |
| 67   | 1,941 | 0,232 |       |      |       |              |       |     |
| 68   | 1,941 | 0,539 |       |      |       |              |       |     |
| 69   | 1,941 | 0,7   |       |      |       |              |       |     |
| 77   | 3     | 0,539 |       |      |       |              |       |     |
| 78   | 3     | 0,7   |       |      |       |              |       |     |
| 79   | 3     | 0,879 |       |      |       |              |       |     |

Lampiran 5. Tabel Kecepatan Superfisial Terbentuknya Pola Aliran (lanjutan)

| BUBLLY |       |       | ANNULAR |       |       |
|--------|-------|-------|---------|-------|-------|
| No.    | JG    | JL    | No.     | JG    | JL    |
| 17     | 0,025 | 2,297 | 109     | 22,6  | 0,033 |
| 18     | 0,025 | 4,935 | 110     | 22,6  | 0,091 |
| 26     | 0,066 | 2,297 | 111     | 22,6  | 0,149 |
| 27     | 0,066 | 4,935 | 112     | 22,6  | 0,232 |
| 35     | 0,116 | 2,297 | 118     | 50    | 0,033 |
| 36     | 0,116 | 4,935 | 119     | 50    | 0,091 |
| 43     | 0,207 | 0,879 | 120     | 50    | 0,149 |
| 44     | 0,207 | 2,297 | 121     | 50    | 0,232 |
| 45     | 0,207 | 4,935 | 127     | 58,05 | 0,033 |
| 52     | 0,423 | 0,879 | 128     | 58,05 | 0,091 |
| 53     | 0,423 | 2,297 | 129     | 58,05 | 0,149 |
| 54     | 0,423 | 4,935 | 130     | 58,05 | 0,232 |
| 60     | 0,871 | 0,7   | 136     | 66,3  | 0,033 |
| 61     | 0,871 | 0,879 | 137     | 66,3  | 0,091 |
| 62     | 0,871 | 2,297 | 138     | 66,3  | 0,149 |
| 63     | 0,871 | 4,935 | 139     | 66,3  | 0,232 |
| 70     | 1,941 | 0,879 |         |       |       |
| 71     | 1,941 | 2,297 |         |       |       |
| 72     | 1,941 | 4,935 |         |       |       |

Lampiran 6. Hasil Uji Laboratorium Campuran Akuades dan Butanol

| <b>Fluida</b>             | <b>SurfaceTension<br/>[mN/m]</b> | <b>Index</b> |
|---------------------------|----------------------------------|--------------|
| 100% Akuades              | 71.00                            | A100         |
| 99% Akuades + 1% Butanol  | 55.07                            | B1           |
| 98% Akuades + 2% Butanol  | 46.03                            | B2           |
| 97% Akuades + 3% Butanol  | 42.90                            | B3           |
| 96% Akuades + 4% Butanol  | 36.50                            | B4           |
| 95% Akuades + 5% Butanol  | 33.10                            | B5           |
| 94% Akuades + 6% Butanol  | 30.85                            | B6           |
| 93% Akuades + 7% Butanol  | 30.40                            | B7           |
| 92% Akuades + 8% Butanol  | 26.57                            | B8           |
| 90% Akuades + 10% Butanol | 25.03                            | B10          |
| 100% Butanol              | 24.37                            | B100         |