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# LAMPIRAN

## **LAMPIRAN A –** DATA SEKUNDER

**Table 2**
Sample data of engine performance data.

| Fuel | Biodiesel % | Diesel % | ZnO % | Load (kg) | $NO_x$ (PPM) | CO (PPM) | $CO_2$(PPM) | HC (PPM) | BP (kW) | BSFC (kg/kW.h) | BTE(%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pure Diesel | 0 | 100 | 0 | 0 | 123 | 0.039 | 2.94 | 18.2 | 0.051 | 0.59 | 14.53 |
| | 0 | 100 | 0 | 3 | 277 | 0.042 | 1.67 | 30.1 | 0.508 | 0.35 | 24.49 |
| | 0 | 100 | 0 | 6 | 583 | 0.048 | 5.66 | 40 | 1.017 | 0.28 | 30.61 |
| | 0 | 100 | 0 | 9 | 1103 | 0.055 | 5.46 | 73 | 1.525 | 0.3 | 28.57 |
| | 0 | 100 | 0 | 12 | 2580 | 0.059 | 6.62 | 85.2 | 2.033 | 0.33 | 25.97 |
| BDD | 10 | 90 | 0 | 0 | 119 | 0.035 | 2.91 | 17.7 | 0.051 | 0.73 | 11.83 |
| | 10 | 90 | 0 | 3 | 268 | 0.039 | 1.60 | 28.70 | 0.508 | 0.45 | 19.18 |
| | 10 | 90 | 0 | 6 | 567 | 0.043 | 5.55 | 34 | 1.017 | 0.36 | 23.98 |
| | 10 | 90 | 0 | 9 | 1075 | 0.051 | 5.32 | 62 | 1.525 | 0.38 | 22.72 |
| | 10 | 90 | 0 | 12 | 2562 | 0.055 | 6.49 | 73.9 | 2.033 | 0.42 | 20.55 |
| | 20 | 80 | 0 | 0 | 115 | 0.033 | 2.76 | 16.1 | 0.051 | 0.63 | 13.80 |
| | 20 | 80 | 0 | 3 | 255 | 0.035 | 1.49 | 27.2 | 0.508 | 0.39 | 22.30 |
| | 20 | 80 | 0 | 6 | 551 | 0.042 | 5.41 | 32.08 | 1.017 | 0.31 | 28.05 |
| | 20 | 80 | 0 | 9 | 1021 | 0.05 | 5.18 | 57.7 | 1.525 | 0.33 | 26.35 |
| | 20 | 80 | 0 | 12 | 2487 | 0.052 | 6.31 | 71.3 | 2.033 | 0.36 | 24.15 |
| | 30 | 70 | 0 | 0 | 121 | 0.36 | 2.81 | 17.4 | 0.051 | 0.64 | 13.59 |
| | 30 | 70 | 0 | 3 | 273 | 0.042 | 1.54 | 28.9 | 0.508 | 0.4 | 21.74 |
| | 30 | 70 | 0 | 6 | 572 | 0.048 | 5.51 | 34.3 | 1.017 | 0.33 | 26.35 |
| | 30 | 70 | 0 | 9 | 1032 | 0.057 | 5.27 | 58 | 1.525 | 0.35 | 24.84 |
| | 30 | 70 | 0 | 12 | 2576 | 0.06 | 6.39 | 72.6 | 2.033 | 0.39 | 22.30 |
| $N_2$BDD | 10 | 90 | 2 | 0 | 111 | 0.029 | 2.71 | 15.2 | 0.051 | 0.63 | 13.74 |
| | 10 | 90 | 2 | 3 | 260 | 0.031 | 1.37 | 26.4 | 0.508 | 0.39 | 22.19 |
| | 10 | 90 | 2 | 6 | 558 | 0.037 | 5.34 | 31.8 | 1.017 | 0.32 | 27.04 |
| | 10 | 90 | 2 | 9 | 989 | 0.04 | 5.01 | 56.3 | 1.525 | 0.33 | 26.22 |
| | 10 | 90 | 2 | 12 | 2491 | 0.03 | 6.22 | 68.2 | 2.033 | 0.38 | 22.77 |
| | 20 | 80 | 2 | 0 | 103 | 0.026 | 2.21 | 14.4 | 0.051 | 0.6 | 14.53 |
| | 20 | 80 | 2 | 3 | 243 | 0.029 | 1.62 | 24.8 | 0.508 | 0.35 | 24.90 |
| | 20 | 80 | 2 | 6 | 538 | 0.038 | 5.18 | 29.7 | 1.017 | 0.29 | 30.06 |
| | 20 | 80 | 2 | 9 | 972 | 0.042 | 4.89 | 55.2 | 1.525 | 0.27 | 32.28 |
| | 20 | 80 | 2 | 12 | 2432 | 0.027 | 6.04 | 66.8 | 2.033 | 0.28 | 31.13 |
| | 30 | 70 | 2 | 0 | 107 | 0.027 | 2.36 | 14.9 | 0.051 | 0.62 | 14.20 |
| | 30 | 70 | 2 | 3 | 253 | 0.03 | 1.87 | 25.1 | 0.508 | 0.38 | 23.16 |
| | 30 | 70 | 2 | 6 | 549 | 0.037 | 5.26 | 30.2 | 1.017 | 0.26 | 33.85 |
| | 30 | 70 | 2 | 9 | 996 | 0.042 | 5.18 | 56 | 1.525 | 0.37 | 23.79 |
| | 30 | 70 | 2 | 12 | 2444 | 0.028 | 6.16 | 67.4 | 2.033 | 0.39 | 22.57 |
| $N_3$BDD | 10 | 90 | 3 | 0 | 99 | 0.024 | 2.08 | 14.1 | 0.051 | 0.58 | 14.90 |
| | 10 | 90 | 3 | 3 | 222 | 0.026 | 1.35 | 23.6 | 0.508 | 0.33 | 26.19 |
| | 10 | 90 | 3 | 6 | 517 | 0.033 | 4.93 | 28.2 | 1.017 | 0.25 | 34.57 |
| | 10 | 90 | 3 | 9 | 962 | 0.036 | 4.72 | 54.1 | 1.525 | 0.27 | 32.01 |
| | 10 | 90 | 3 | 12 | 2412 | 0.024 | 5.81 | 65.6 | 2.033 | 0.274 | 31.55 |
| | 20 | 80 | 3 | 0 | 94 | 0.023 | 1.87 | 13.2 | 0.051 | 0.56 | 15.55 |
| | 20 | 80 | 3 | 3 | 212 | 0.025 | 1.26 | 22.1 | 0.508 | 0.32 | 27.21 |
| | 20 | 80 | 3 | 6 | 501 | 0.03 | 4.79 | 26.5 | 1.017 | 0.24 | 36.28 |
| | 20 | 80 | 3 | 9 | 954 | 0.032 | 4.66 | 52.3 | 1.525 | 0.26 | 33.49 |
| | 20 | 80 | 3 | 12 | 2407 | 0.03 | 5.58 | 63.1 | 2.033 | 0.25 | 34.82 |
| | 30 | 70 | 3 | 0 | 101 | 0.025 | 1.92 | 13.9 | 0.051 | 0.57 | 15.40 |
| | 30 | 70 | 3 | 3 | 229 | 0.027 | 1.39 | 23.4 | 0.508 | 0.34 | 25.82 |
| | 30 | 70 | 3 | 6 | 521 | 0.034 | 4.87 | 27.4 | 1.017 | 0.25 | 35.12 |
| | 30 | 70 | 3 | 9 | 986 | 0.036 | 4.75 | 54.6 | 1.525 | 0.26 | 33.77 |
| | 30 | 70 | 3 | 12 | 2431 | 0.032 | 5.71 | 65.9 | 2.033 | 0.27 | 32.52 |
| $N_4$BDD | 10 | 90 | 4 | 0 | 108 | 0.054 | 2.26 | 16.6 | 0.051 | 0.61 | 14.14 |
| | 10 | 90 | 4 | 3 | 235 | 0.057 | 1.47 | 26.2 | 0.508 | 0.38 | 22.69 |
| | 10 | 90 | 4 | 6 | 518 | 0.035 | 5.18 | 31.3 | 1.017 | 0.29 | 29.73 |
| | 10 | 90 | 4 | 9 | 1042 | 0.038 | 5.29 | 57.8 | 1.525 | 0.3 | 28.74 |
| | 10 | 90 | 4 | 12 | 2386 | 0.04 | 5.31 | 68.2 | 2.033 | 0.32 | 26.95 |
| | 20 | 80 | 4 | 0 | 102 | 0.051 | 2.17 | 16.1 | 0.051 | 0.6 | 14.48 |
| | 20 | 80 | 4 | 3 | 221 | 0.053 | 1.38 | 25.3 | 0.508 | 0.34 | 25.54 |
| | 20 | 80 | 4 | 6 | 502 | 0.039 | 5.01 | 30.5 | 1.017 | 0.26 | 33.40 |
| | 20 | 80 | 4 | 9 | 1031 | 0.042 | 5.12 | 56.4 | 1.525 | 0.27 | 32.17 |
| | 20 | 80 | 4 | 12 | 2354 | 0.041 | 5.20 | 67.7 | 2.033 | 0.28 | 31.02 |
| | 30 | 70 | 4 | 0 | 105 | 0.053 | 2.22 | 19.9 | 0.051 | 0.61 | 14.32 |
| | 30 | 70 | 4 | 3 | 238 | 0.055 | 1.45 | 31.9 | 0.508 | 0.37 | 23.62 |
| | 30 | 70 | 4 | 6 | 518 | 0.042 | 5.14 | 39.6 | 1.017 | 0.29 | 30.13 |
| | 30 | 70 | 4 | 9 | 1052 | 0.045 | 5.39 | 61.5 | 1.525 | 0.28 | 31.21 |
| | 30 | 70 | 4 | 12 | 2387 | 0.046 | 5.42 | 79.7 | 2.033 | 0.3 | 29.13 |

**LAMPIRAN B-** NORMALISASI DATA TRAINING

| Data | Biodiesel | Diesel | Zno | Load | Nox | CO | CO2 | HC | BP | BSFC | BTE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | 1.00000000 | 0.00000000 | 0.75000000 | 1.00000000 | 0.94006436 | 0.24324324 | 0.83022388 | 0.73194444 | 1.00000000 | 0.06122449 | 0.84621677 |
| 46 | 1.00000000 | 0.00000000 | 0.75000000 | 0.00000000 | 0.00281577 | 0.05405405 | 0.12313433 | 0.00972222 | 0.00000000 | 0.67346939 | 0.14601227 |
| 13 | 0.66666670 | 0.33333330 | 0.00000000 | 0.50000000 | 0.18382945 | 0.51351351 | 0.77425373 | 0.26222222 | 0.48738650 | 0.14285714 | 0.66339468 |
| 12 | 0.66666670 | 0.33333330 | 0.00000000 | 0.25000000 | 0.06476267 | 0.32432432 | 0.04291045 | 0.19444444 | 0.23057520 | 0.30612245 | 0.42822086 |
| 10 | 0.33333330 | 0.66666670 | 0.00000000 | 1.00000000 | 0.99275945 | 0.86486486 | 0.97574627 | 0.84305556 | 1.00000000 | 0.36734694 | 0.35664622 |
| 59 | 0.66666670 | 0.33333330 | 1.00000000 | 0.75000000 | 0.37691070 | 0.51351351 | 0.72014925 | 0.60000000 | 0.74369320 | 0.06122449 | 0.83190184 |
| 61 | 1.00000000 | 0.00000000 | 1.00000000 | 0.00000000 | 0.00442478 | 0.81081081 | 0.17910448 | 0.09305556 | 0.00000000 | 0.75510204 | 0.10184049 |
| 29 | 0.66666670 | 0.33333330 | 0.50000000 | 0.75000000 | 0.35317780 | 0.51351351 | 0.67723881 | 0.58333333 | 0.74369320 | 0.06122449 | 0.83640082 |
| 51 | 0.33333330 | 0.66666670 | 1.00000000 | 0.00000000 | 0.00563154 | 0.83783784 | 0.18656716 | 0.04722222 | 0.00000000 | 0.75510204 | 0.09447853 |
| 4 | 0.00000000 | 1.00000000 | 0.00000000 | 0.75000000 | 0.40587289 | 0.86486486 | 0.78358209 | 0.83055556 | 0.74369320 | 0.12244898 | 0.68466258 |
| 48 | 1.00000000 | 0.00000000 | 0.75000000 | 0.50000000 | 0.17176187 | 0.29729730 | 0.67350746 | 0.19722222 | 0.48738650 | 0.02040816 | 0.95255624 |
| 49 | 1.00000000 | 0.00000000 | 0.75000000 | 0.75000000 | 0.35880933 | 0.35135135 | 0.65111940 | 0.57500000 | 0.74369320 | 0.04081633 | 0.89734151 |
| 3 | 0.00000000 | 1.00000000 | 0.00000000 | 0.50000000 | 0.19670153 | 0.67567568 | 0.82089552 | 0.37222222 | 0.48738650 | 0.08163265 | 0.76809816 |
| 32 | 1.00000000 | 0.00000000 | 0.50000000 | 0.25000000 | 0.06395817 | 0.18918919 | 0.11380597 | 0.16527778 | 0.23057520 | 0.28571429 | 0.46339468 |
| 26 | 0.66666670 | 0.33333330 | 0.50000000 | 0.00000000 | 0.00362027 | 0.08108108 | 0.17723881 | 0.01666667 | 0.00000000 | 0.73469388 | 0.11042945 |
| 54 | 0.33333330 | 0.66666670 | 1.00000000 | 0.75000000 | 0.38133548 | 0.40540541 | 0.75186567 | 0.61944444 | 0.74369320 | 0.12244898 | 0.69161554 |
| 64 | 1.00000000 | 0.00000000 | 1.00000000 | 0.75000000 | 0.38535801 | 0.59459459 | 0.77052239 | 0.67083333 | 0.74369320 | 0.08163265 | 0.79263804 |
| 40 | 0.33333330 | 0.66666670 | 0.75000000 | 1.00000000 | 0.93242156 | 0.02702703 | 0.84888060 | 0.72777778 | 1.00000000 | 0.06938776 | 0.80654397 |
| 17 | 1.00000000 | 0.00000000 | 0.00000000 | 0.25000000 | 0.07200322 | 0.51351351 | 0.05223881 | 0.21805556 | 0.23057520 | 0.32653061 | 0.40531697 |
| 62 | 1.00000000 | 0.00000000 | 1.00000000 | 0.25000000 | 0.05792438 | 0.86486486 | 0.03544776 | 0.25972222 | 0.23057520 | 0.26530612 | 0.48220859 |
| 35 | 1.00000000 | 0.00000000 | 0.50000000 | 1.00000000 | 0.94529364 | 0.13513514 | 0.91417910 | 0.75277778 | 1.00000000 | 0.30612245 | 0.43926380 |
| 33 | 1.00000000 | 0.00000000 | 0.50000000 | 0.50000000 | 0.18302494 | 0.37837838 | 0.74626866 | 0.23611111 | 0.48738650 | 0.04081633 | 0.90061350 |
| 5 | 0.00000000 | 1.00000000 | 0.00000000 | 1.00000000 | 1.00000000 | 0.97297297 | 1.00000000 | 1.00000000 | 1.00000000 | 0.18367347 | 0.57832311 |
| 41 | 0.66666670 | 0.33333330 | 0.75000000 | 0.00000000 | 0.00000000 | 0.00000000 | 0.11380597 | 0.00000000 | 0.00000000 | 0.65306122 | 0.15214724 |
| 25 | 0.33333330 | 0.66666670 | 0.50000000 | 1.00000000 | 0.96419952 | 0.18918919 | 0.92537313 | 0.76388889 | 1.00000000 | 0.28571429 | 0.44744376 |
| 1 | 0.00000000 | 1.00000000 | 0.00000000 | 0.00000000 | 0.01166533 | 0.43243243 | 0.31343284 | 0.06944444 | 0.00000000 | 0.71428571 | 0.11042945 |
| 55 | 0.33333330 | 0.66666670 | 1.00000000 | 1.00000000 | 0.92196299 | 0.45945946 | 0.75559701 | 0.76388889 | 1.00000000 | 0.16326531 | 0.61840491 |
| 18 | 1.00000000 | 0.00000000 | 0.00000000 | 0.50000000 | 0.19227675 | 0.67567568 | 0.79291045 | 0.29305556 | 0.48738650 | 0.18367347 | 0.59386503 |
| 11 | 0.66666670 | 0.33333330 | 0.00000000 | 0.00000000 | 0.00844731 | 0.27027027 | 0.27985075 | 0.04027778 | 0.00000000 | 0.79591837 | 0.08057260 |
| 9 | 0.33333330 | 0.66666670 | 0.00000000 | 0.75000000 | 0.39460982 | 0.75675676 | 0.75746269 | 0.67777778 | 0.74369320 | 0.28571429 | 0.44539877 |
| 20 | 1.00000000 | 0.00000000 | 0.00000000 | 1.00000000 | 0.99839099 | 1.00000000 | 0.95708955 | 0.82500000 | 1.00000000 | 0.30612245 | 0.42822086 |
| 34 | 1.00000000 | 0.00000000 | 0.50000000 | 0.75000000 | 0.36283186 | 0.51351351 | 0.73134328 | 0.59444444 | 0.74369320 | 0.26530612 | 0.48916155 |
| 19 | 1.00000000 | 0.00000000 | 0.00000000 | 0.75000000 | 0.37731295 | 0.91891892 | 0.74813433 | 0.62222222 | 0.74369320 | 0.22448980 | 0.53210634 |
| 38 | 0.33333330 | 0.66666670 | 0.75000000 | 0.50000000 | 0.17015286 | 0.27027027 | 0.68470149 | 0.20833333 | 0.48738650 | 0.02040816 | 0.93006135 |
| 63 | 1.00000000 | 0.00000000 | 1.00000000 | 0.50000000 | 0.17055511 | 0.51351351 | 0.72388060 | 0.36666667 | 0.48738650 | 0.10204082 | 0.74846626 |
| 14 | 0.66666670 | 0.33333330 | 0.00000000 | 0.75000000 | 0.37288817 | 0.72972973 | 0.73134328 | 0.61805556 | 0.74369320 | 0.18367347 | 0.59386503 |
| 53 | 0.33333330 | 0.66666670 | 1.00000000 | 0.50000000 | 0.17055511 | 0.32432432 | 0.73134328 | 0.25138889 | 0.48738650 | 0.10204082 | 0.73210634 |
| 27 | 0.66666670 | 0.33333330 | 0.50000000 | 0.25000000 | 0.05993564 | 0.16216216 | 0.06716418 | 0.16111111 | 0.23057520 | 0.22448980 | 0.53456033 |
| 21 | 0.33333330 | 0.66666670 | 0.50000000 | 0.00000000 | 0.00683829 | 0.16216216 | 0.27052239 | 0.02777778 | 0.00000000 | 0.79591837 | 0.07811861 |
| 15 | 0.66666670 | 0.33333330 | 0.00000000 | 1.00000000 | 0.96259051 | 0.78378378 | 0.94216418 | 0.80694444 | 1.00000000 | 0.24489796 | 0.50388548 |
| 28 | 0.66666670 | 0.33333330 | 0.50000000 | 0.50000000 | 0.17860016 | 0.40540541 | 0.73134328 | 0.22916667 | 0.48738650 | 0.10204082 | 0.74560327 |
| 30 | 0.66666670 | 0.33333330 | 0.50000000 | 1.00000000 | 0.94046661 | 0.10810811 | 0.89179104 | 0.74444444 | 1.00000000 | 0.08163265 | 0.78936605 |
| 6 | 0.33333330 | 0.66666670 | 0.00000000 | 0.00000000 | 0.01005632 | 0.32432432 | 0.30783582 | 0.06250000 | 0.00000000 | 1.00000000 | 0.00000000 |
| 56 | 0.66666670 | 0.33333330 | 1.00000000 | 0.00000000 | 0.00321802 | 0.75675676 | 0.16977612 | 0.04027778 | 0.00000000 | 0.73469388 | 0.10838446 |
| 47 | 1.00000000 | 0.00000000 | 0.75000000 | 0.25000000 | 0.05430410 | 0.10810811 | 0.02425373 | 0.14166667 | 0.23057520 | 0.20408163 | 0.57218814 |
| 60 | 0.66666670 | 0.33333330 | 1.00000000 | 1.00000000 | 0.90909091 | 0.48648649 | 0.73507463 | 0.75694444 | 1.00000000 | 0.08163265 | 0.78486708 |

**Lampiran C-** SCRIPT PROGRAM RSTUDIO:

```
#membaca data excel
library(readxl)
data2 <- read_excel("ann04.xlsx")
#normalisasi
normalisasi<-function(x){(x-min(x))/(max(x)-min(x))}
skala2<-as.data.frame(lapply(data2[1:11],FUN = normalisasi))
data3<-skala2
#menampilkan all data
#data3
#pembagian data untuk training, validasi dan test
n1<- round(nrow(data3)*0.70)

#pengaturan banyaknya pengacakan
set.seed(30)
samp1=sample(1:nrow(data3),n1)
traininga20a = data3[samp1,]
#trainc5= data.frame(trainingc5)
#View(trainc5)
valtestdataa20a= data3[-samp1,]
#valtestdata

#pembagian sisa data training untuk data validasi dan data
testing (masing-masing 50%)
n2<- round(nrow(valtestdataa20a)*0.5)
samp2=sample(1:nrow(valtestdataa20a),n2)
validasia20a = valtestdataa20a[samp2,]
#validc5= data.frame(validasic5)
#View(validc5)
testinga20a= valtestdataa20a[-samp2,]
#testc5= data.frame(testingc5)
#View(testc5)

#buat rumus
feats <- names(data3[,1:4])
f <- paste(feats,collapse=' + ')
f <- paste('Nox+CO+CO2+HC+BP+BSFC+BTE~',f)
f <- as.formula(f);f


#memanggil fungsi neuralnet
library(neuralnet)
anna20a <- neuralnet(f,traininga20a,hidden=c(20),
threshold=0.001, stepmax=1e+10, algorithm = "rprop+",
                      act.fct = "logistic", err.fct= "sse",
linear.output=T)
#menampilkan error
anna20a$result.matrix[1,]
```

```
#ann15$result.matrix
#summary(ann15)
#menampilkan arsitektur ann
#plot (anna20a)

#prediksi hasil ann1 menggunakan data validasi
preda20a <- predict(anna20a, data3[,1:4])

#menampilkan hasil data validasi
akta20a<-data.frame(data3[,5:11])

#komparasi nox hasil pemodelan data train dengan data validasi
Nox<-data.frame(data2[,5])
predictednoxa20a=preda20a[,1] * abs(diff(range(Nox))) +
min(Nox)
actualnoxa20a=akta20a[,1] * abs(diff(range(Nox))) + min(Nox)
comparisonnoxa20a=data.frame(predictednoxa20a,actualnoxa20a)
View(comparisonnoxa20a)

#memanggil fungsi metrics
library(Metrics)
#prediksi NOX
#koefisien korelasi
cornoxa20a=cor(predictednoxa20a,actualnoxa20a)
#cornox
#koefisien determinasi
detnoxa20a=cornoxa20a^2
detnoxa20a
#error rmse
rmsenoxa20a=rmse(predictednoxa20a,actualnoxa20a)
rmsenoxa20a
#error mape
mapenoxa20a=mape(predictednoxa20a,actualnoxa20a)
mapenoxa20a

#komparasi CO hasil pemodelan data train dengan data validasi
CO<-data.frame(data2[,6])
predictedcoa20a=preda20a[,2] * abs(diff(range(CO))) + min(CO)
actualcoa20a=akta20a[,2] * abs(diff(range(CO))) + min(CO)
comparisoncoa20a=data.frame(predictedcoa20a,actualcoa20a)
View(comparisoncoa20a)

#prediksi CO
#koefisien korelasi
corcoa20a=cor(predictedcoa20a,actualcoa20a)
#corco
#koefisien determinasi
detcoa20a=corcoa20a^2
```

```
detcoa20a
#error rmse
rmsecoa20a=rmse(predictedcoa20a,actualcoa20a)
rmsecoa20a
#error mape
mapecoa20a=mape(predictedcoa20a,actualcoa20a)
mapecoa20a

#komparasi CO2 hasil pemodelan data train dengan data validasi
CO2<-data.frame(data2[,7])
predictedco2a20a=preda20a[,3] * abs(diff(range(CO2))) +
min(CO2)
actualco2a20a=akta20a[,3] * abs(diff(range(CO2))) + min(CO2)
comparisonco2a20a=data.frame(predictedco2a20a,actualco2a20a)
View(comparisonco2a20a)

#prediksi CO2
#koefisien korelasi
corco2a20a=cor(predictedco2a20a,actualco2a20a)
#corco20a
#koefisien determinasi
detco2a20a=corco2a20a^2
detco2a20a
#error rmse
rmseco2a20a=rmse(predictedco2a20a,actualco2a20a)
rmseco2a20a
#error mape
mapeco2a20a=mape(predictedco2a20a,actualco2a20a)
mapeco2a20a

#komparasi HC hasil pemodelan data train dengan data validasi
HC<-data.frame(data2[,8])
predictedhca20a=preda20a[,4] * abs(diff(range(HC))) + min(HC)
actualhca20a=akta20a[,4] * abs(diff(range(HC))) + min(HC)
comparisonhca20a=data.frame(predictedhca20a,actualhca20a)
View(comparisonhca20a)

#prediksi HC
#koefisien korelasi
corhca20a=cor(predictedhca20a,actualhca20a)
#corhc
#koefisien determinasi
dethca20a=corhca20a^2
dethca20a
#error rmse
rmsehca20a=rmse(predictedhca20a,actualhca20a)
rmsehca20a
#error mape
```

```
mapehca20a=mape(predictedhca20a,actualhca20a)
mapehca20a

#komparasi BP hasil pemodelan data train dengan data validasi
BP<-data.frame(data2[,9])
predictedbpa20a=preda20a[,5] * abs(diff(range(BP))) + min(BP)
actualbpa20a=akta20a[,5] * abs(diff(range(BP))) + min(BP)
comparisonbpa20a=data.frame(predictedbpa20a,actualbpa20a)
View(comparisonbpa20a)

#prediksi BP
#koefisien korelasi
corbpa20a=cor(predictedbpa20a,actualbpa20a)
#corbp
#koefisien determinasi
detbpa20a=corbpa20a^2
detbpa20a
#error rmse
rmsebpa20a=rmse(predictedbpa20a,actualbpa20a)
rmsebpa20a
#error mape cara 1
mapebpa20a=mape(predictedbpa20a,actualbpa20a)
mapebpa20a

#error mape cara 2
#mapebp151 = mean(abs((actualbp15-predictedbp15)
#                      /actualbp15))
#mapebp151

#komparasi BSFC hasil pemodelan data train dengan data validasi
BSFC<-data.frame(data2[,10])
predictedbsfca20a=preda20a[,6] * abs(diff(range(BSFC))) +
min(BSFC)
actualbsfca20a=akta20a[,6] * abs(diff(range(BSFC))) + min(BSFC)
comparisonbsfca20a=data.frame(predictedbsfca20a,actualbsfca20a)
View(comparisonbsfca20a)

#prediksi BSFC
#koefisien korelasi
corbsfca20a=cor(predictedbsfca20a,actualbsfca20a)
#corbsfc
#koefisien determinasi
detbsfca20a=corbsfca20a^2
detbsfca20a
#error rmse
rmsebsfca20a=rmse(predictedbsfca20a,actualbsfca20a)
rmsebsfca20a
#error mape
```

```
mapebsfca20a=mape(predictedbsfca20a,actualbsfca20a)
mapebsfca20a

#komparasi BTE hasil pemodelan data train dengan data validasi
BTE<-data.frame(data2[,11])
predictedbtea20a=preda20a[,7] * abs(diff(range(BTE))) +
min(BTE)
actualbtea20a=akta20a[,7] * abs(diff(range(BTE))) + min(BTE)
comparisonbtea20a=data.frame(predictedbtea20a,actualbtea20a)
View(comparisonbtea20a)

#prediksi BTE
#koefisien korelasi
corbtea20a=cor(predictedbtea20a,actualbtea20a)
#corbte
#koefisien determinasi
detbtea20a=corbtea20a^2
detbtea20a
#error rmse
rmsebtea20a=rmse(predictedbtea20a,actualbtea20a)
rmsebtea20a
#error mape
mapebtea20a=mape(predictedbtea20a,actualbtea20a)
mapebtea20a
```

**LAMPIRAN D** – HASIL RUN PROGRAM ANN

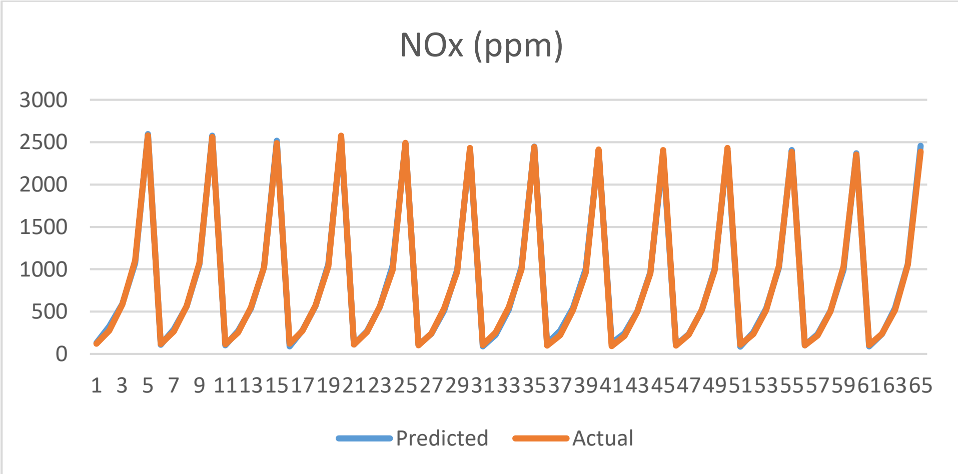
```
error                       1.273407e-01
reached.threshold           9.881815e-04
steps                       2.175400e+05
Intercept.to.1layhid1       1.116954e+00
Biodiesel.to.1layhid1      -9.720008e-01
Diesel.to.1layhid1         -1.413272e+00
ZnO.to.1layhid1            -1.392019e+00
Load.to.1layhid1           -2.473435e+00
Intercept.to.1layhid2      -2.464780e+00
Biodiesel.to.1layhid2      -2.408573e+00
Diesel.to.1layhid2         -2.715380e+00
ZnO.to.1layhid2            -3.678010e-02
Load.to.1layhid2            1.849275e+01
Intercept.to.1layhid3       2.785510e+00
Biodiesel.to.1layhid3       1.301492e+00
Diesel.to.1layhid3          1.181098e+00
ZnO.to.1layhid3            -8.902134e+00
Load.to.1layhid3           -4.975302e-01
Intercept.to.1layhid4       4.383509e+00
Biodiesel.to.1layhid4       2.766944e+00
Diesel.to.1layhid4          2.171856e+00
ZnO.to.1layhid4             4.363802e+00
Load.to.1layhid4           -8.928446e+00
Intercept.to.1layhid5       1.872659e-01
Biodiesel.to.1layhid5       8.325474e-01
Diesel.to.1layhid5         -5.343770e-01
ZnO.to.1layhid5            -3.031334e+00
Load.to.1layhid5            8.243264e-01
Intercept.to.1layhid6       5.781662e-01
Biodiesel.to.1layhid6      -1.367735e+00
Diesel.to.1layhid6         -2.898113e-01
ZnO.to.1layhid6             2.727165e+00
Load.to.1layhid6            3.071227e+00
Intercept.to.1layhid7      -4.427267e-01
Biodiesel.to.1layhid7       2.255993e-01
Diesel.to.1layhid7         -3.382650e-01
ZnO.to.1layhid7            -9.512645e-01
Load.to.1layhid7            7.790546e+00
Intercept.to.1layhid8      -1.934843e+00
Biodiesel.to.1layhid8      -4.377072e-01
Diesel.to.1layhid8         -2.124363e+03
ZnO.to.1layhid8             1.109062e-01
Load.to.1layhid8            4.314281e-01
Intercept.to.1layhid9       2.292834e+00
Biodiesel.to.1layhid9      -5.105454e-02
Diesel.to.1layhid9         -2.848497e-01
ZnO.to.1layhid9             1.549948e-01
Load.to.1layhid9           -2.651883e+00
Intercept.to.1layhid10     -8.123203e-01
```

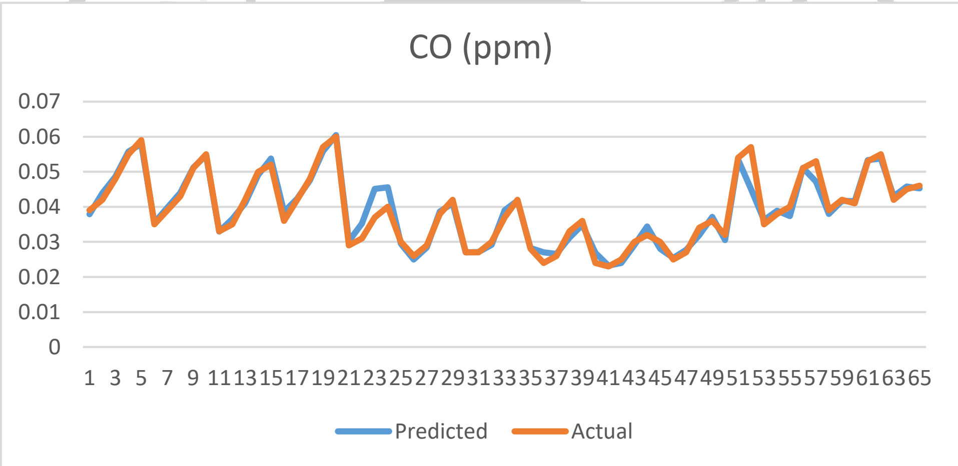
```
Biodiesel.to.1layhid10 -1.136634e+00
Diesel.to.1layhid10    -1.004391e+00
ZnO.to.1layhid10        4.810719e+00
Load.to.1layhid10      -7.428267e-01
Intercept.to.1layhid11 -5.194360e-01
Biodiesel.to.1layhid11  1.052621e+00
Diesel.to.1layhid11     9.130285e-01
ZnO.to.1layhid11       -1.266376e+00
Load.to.1layhid11      -1.406681e+00
Intercept.to.1layhid12  7.668106e+00
Biodiesel.to.1layhid12 -2.474762e-01
Diesel.to.1layhid12    -7.078210e-02
ZnO.to.1layhid12        6.959714e-01
Load.to.1layhid12      -7.544749e+00
Intercept.to.1layhid13 -1.518888e+00
Biodiesel.to.1layhid13 -2.623990e-01
Diesel.to.1layhid13    -2.825900e-01
ZnO.to.1layhid13       -1.130196e-01
Load.to.1layhid13      -5.595386e+00
Intercept.to.1layhid14 -2.366331e-01
Biodiesel.to.1layhid14 -6.636335e-01
Diesel.to.1layhid14    -1.520150e-01
ZnO.to.1layhid14        2.992347e+00
Load.to.1layhid14      -2.410920e+00
Intercept.to.1layhid15 -1.426907e+00
Biodiesel.to.1layhid15 -1.118424e+00
Diesel.to.1layhid15    -1.620082e+00
ZnO.to.1layhid15        3.781375e+00
Load.to.1layhid15       3.576164e+00
Intercept.to.Nox        1.184993e+00
1layhid1.to.Nox         6.293648e+00
1layhid2.to.Nox         4.288437e-01
1layhid3.to.Nox         1.984535e-01
1layhid4.to.Nox        -7.865619e-04
1layhid5.to.Nox        -1.915856e-01
1layhid6.to.Nox         1.790084e+00
1layhid7.to.Nox        -1.156181e+00
1layhid8.to.Nox         1.940075e-01
1layhid9.to.Nox        -1.277571e+00
1layhid10.to.Nox        2.768466e-01
1layhid11.to.Nox       -2.037948e+00
1layhid12.to.Nox       -1.276889e+00
1layhid13.to.Nox       -6.460578e+00
1layhid14.to.Nox       -2.101093e-01
1layhid15.to.Nox        1.266586e-03
Intercept.to.CO         8.980206e-01
1layhid1.to.CO         -4.060170e+00
1layhid2.to.CO          3.180898e-01
1layhid3.to.CO          4.937218e+00
1layhid4.to.CO          7.799018e-02
1layhid5.to.CO         -2.848406e+00
```

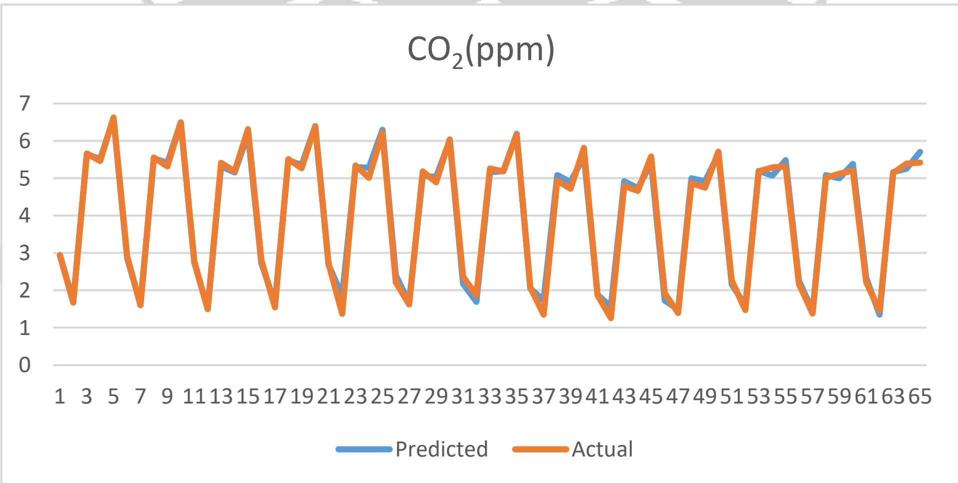
```
1layhid6.to.CO          -2.485619e+00
1layhid7.to.CO          -3.756451e+00
1layhid8.to.CO           1.272660e+00
1layhid9.to.CO           1.965597e+00
1layhid10.to.CO          4.002891e+00
1layhid11.to.CO          1.116279e+00
1layhid12.to.CO          3.899596e-01
1layhid13.to.CO         -9.372455e+00
1layhid14.to.CO         -3.856238e+00
1layhid15.to.CO          2.986810e+00
Intercept.to.CO2         6.034145e-01
1layhid1.to.CO2          3.164233e+00
1layhid2.to.CO2          1.705636e+00
1layhid3.to.CO2          1.036129e-01
1layhid4.to.CO2         -7.931110e-02
1layhid5.to.CO2         -2.351953e-01
1layhid6.to.CO2          5.510753e-01
1layhid7.to.CO2         -6.596016e-01
1layhid8.to.CO2          3.561503e-01
1layhid9.to.CO2          9.666436e-01
1layhid10.to.CO2        -7.266011e-01
1layhid11.to.CO2        -4.119754e+00
1layhid12.to.CO2        -5.958535e-01
1layhid13.to.CO2         4.473586e+00
1layhid14.to.CO2         7.782299e-03
1layhid15.to.CO2        -3.403394e-01
Intercept.to.HC          1.575348e+00
1layhid1.to.HC          -6.414637e-01
1layhid2.to.HC          -6.954059e-01
1layhid3.to.HC           5.464895e-01
1layhid4.to.HC          -2.466176e-01
1layhid5.to.HC          -3.014237e-02
1layhid6.to.HC          -1.420309e-01
1layhid7.to.HC           8.555556e-01
1layhid8.to.HC           6.502462e-01
1layhid9.to.HC          -8.732130e-01
1layhid10.to.HC          1.969889e-01
1layhid11.to.HC         -3.547545e+00
1layhid12.to.HC          8.219326e-01
1layhid13.to.HC          3.595614e+00
1layhid14.to.HC         -5.083274e-01
1layhid15.to.HC         -3.703837e-01
Intercept.to.BP          9.929227e-01
1layhid1.to.BP          -2.962606e-02
1layhid2.to.BP          -9.786271e-03
1layhid3.to.BP           4.529381e-02
1layhid4.to.BP           8.339779e-02
1layhid5.to.BP           3.387045e-01
1layhid6.to.BP           1.133605e-01
1layhid7.to.BP           3.084676e-01
1layhid8.to.BP          -1.313658e-02
```

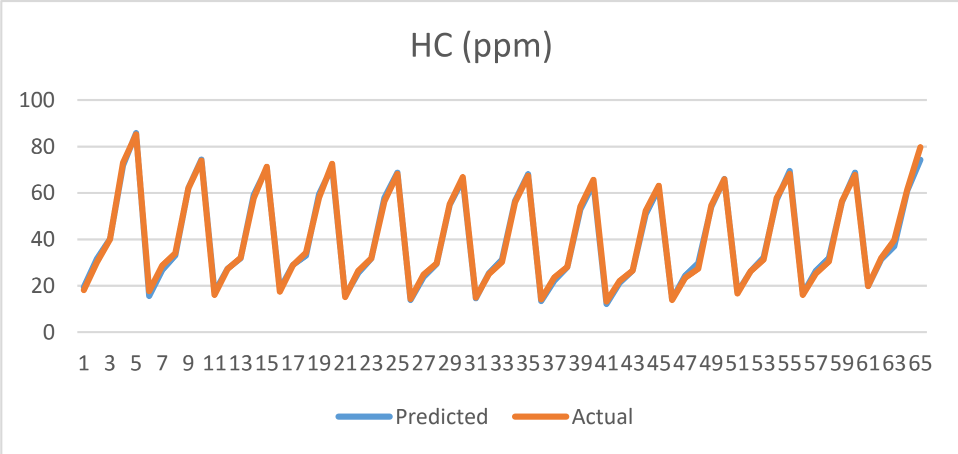
```
1layhid9.to.BP          -1.361503e+00
1layhid10.to.BP          1.868746e-01
1layhid11.to.BP         -5.468299e-01
1layhid12.to.BP         -5.051815e-02
1layhid13.to.BP          5.391612e-01
1layhid14.to.BP         -7.321817e-03
1layhid15.to.BP         -4.349657e-02
Intercept.to.BSFC       -4.930336e-01
1layhid1.to.BSFC        -2.155584e+00
1layhid2.to.BSFC        -5.262077e-01
1layhid3.to.BSFC         1.420748e-01
1layhid4.to.BSFC         9.950043e-01
1layhid5.to.BSFC         3.086542e-01
1layhid6.to.BSFC         2.627494e-01
1layhid7.to.BSFC         1.278081e+00
1layhid8.to.BSFC         7.732871e-01
1layhid9.to.BSFC        -6.426675e-01
1layhid10.to.BSFC       -1.768353e+00
1layhid11.to.BSFC       -4.308039e-01
1layhid12.to.BSFC       -6.384061e-01
1layhid13.to.BSFC        1.092381e+01
1layhid14.to.BSFC        1.812461e+00
1layhid15.to.BSFC        1.279902e-01
Intercept.to.BTE         1.818395e+00
1layhid1.to.BTE         -1.270085e+00
1layhid2.to.BTE          7.251216e-01
1layhid3.to.BTE          1.302484e-01
1layhid4.to.BTE         -1.647880e+00
1layhid5.to.BTE         -7.556598e-01
1layhid6.to.BTE         -2.015049e+00
1layhid7.to.BTE         -9.932761e-01
1layhid8.to.BTE         -1.424612e+00
1layhid9.to.BTE          2.753346e+00
1layhid10.to.BTE         3.549783e+00
1layhid11.to.BTE         1.200327e+00
1layhid12.to.BTE         6.382572e-01
1layhid13.to.BTE        -6.769656e+00
1layhid14.to.BTE        -3.945693e+00
1layhid15.to.BTE        -1.503133e-01
```

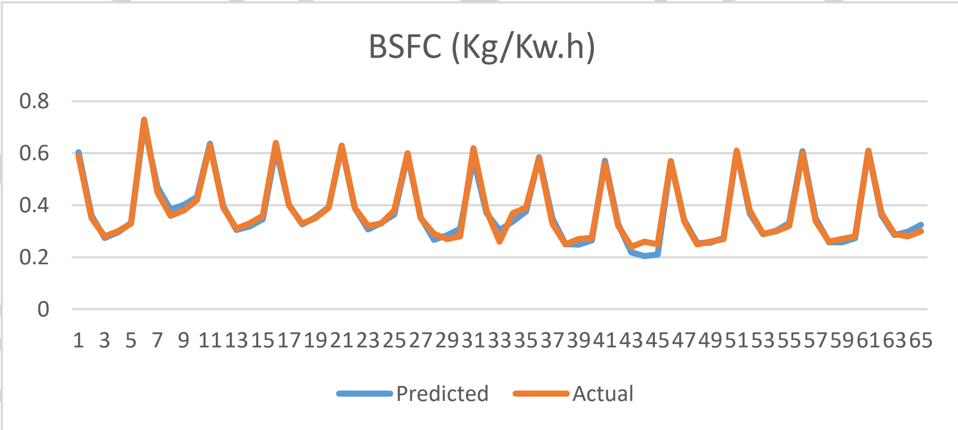
**LAMPIRAN E** – GRAFIK PREDIKSI VS AKTUAL

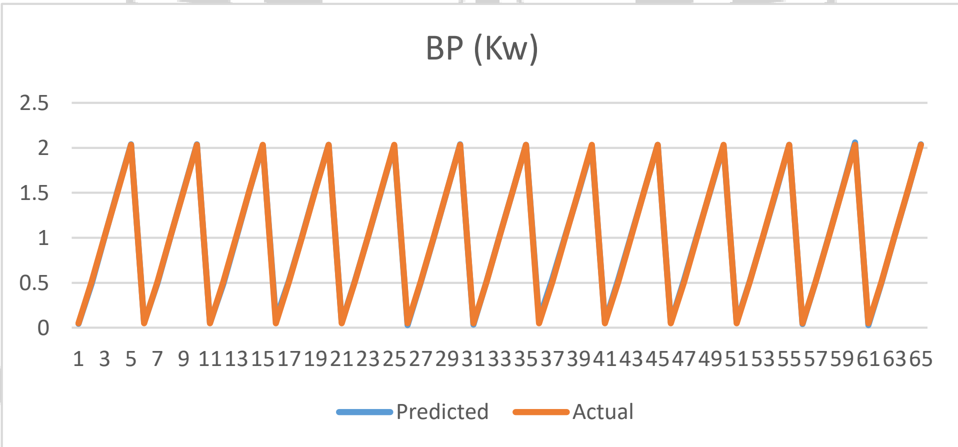


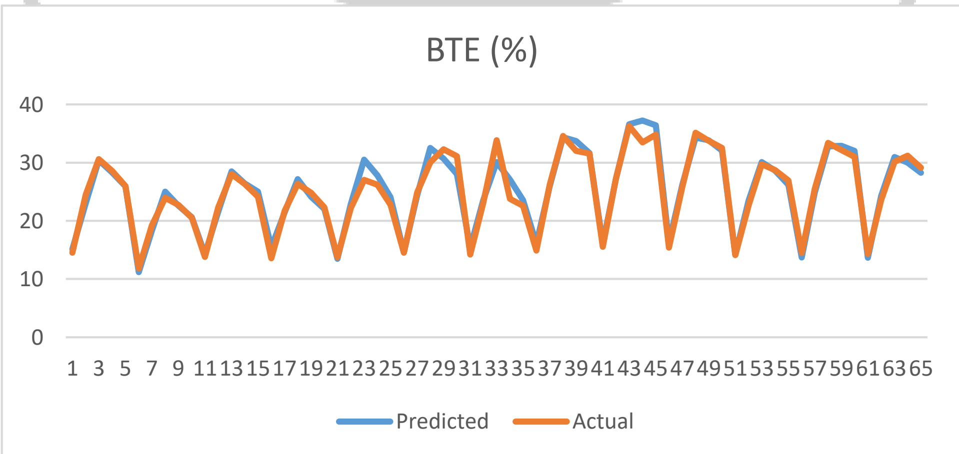




HC (ppm)
100
80
60
40
20
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65
Predicted
Actual


BSFC (Kg/Kw.h)
0.8
0.6
0.4
0.2
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65
Predicted
Actual


BP (Kw)
2.5
2
1.5
1
0.5
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65
Predicted
Actual


BTE (%)
40
30
20
10
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65
Predicted
Actual

## **LAMPIRAN F** – DATA PREDIKSI

Prediksi kinerja dan emisi mesin diesel bahan bakar B0 s.d B50 (Load 0%)

| Bxx | Input | | | Output | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | BD | D | ZnO | Nox | CO | $CO_2$ | HC | BP | BSFC | BTE |
| 0% | 0 | 100 | 2 | 112.8 | 0.044 | 3.02 | 24.4 | 0.032 | 0.57 | 15.78 |
| 10% | 10 | 90 | 2 | 122.4 | 0.041 | 2.96 | 22.5 | 0.033 | 0.61 | 13.66 |
| 20% | 20 | 80 | 2 | 133.7 | 0.039 | 2.90 | 21.0 | 0.035 | 0.646 | 11.58 |
| 30% | 30 | 70 | 2 | 144.5 | 0.037 | 2.86 | 19.7 | 0.037 | 0.679 | 9.73 |
| 40% | 40 | 60 | 2 | 150.8 | 0.036 | 2.80 | 18.9 | 0.038 | 0.700 | 8.52 |
| 50% | 50 | 50 | 2 | 147.8 | 0.035 | 2.72 | 18.4 | 0.039 | 0.702 | 8.40 |

Prediksi kinerja dan emisi mesin diesel bahan bakar B10 dengan variasi ZnO (Load 12%)

| Input | | | Output | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| BD | D | ZnO | NOx | CO | CO2 | HC | BP | BSFC | BTE |
| 10 | 90 | 0 | 2586.3 | 0.056 | 6.61 | 81.2 | 2.03 | 0.36 | 24.3 |
| 10 | 90 | 2 | 2583.8 | 0.035 | 6.80 | 79.4 | 1.96 | 0.40 | 19.2 |
| 10 | 90 | 3 | 2445.7 | 0.035 | 6.46 | 76.6 | 2.00 | 0.34 | 25.5 |
| 10 | 90 | 4 | 2376.1 | 0.029 | 5.94 | 71.9 | 2.02 | 0.27 | 30.9 |
| 10 | 90 | 5 | 2334.0 | 0.026 | 5.52 | 68.3 | 2.03 | 0.23 | 33.5 |
| 10 | 90 | 6 | 2291.7 | 0.029 | 5.31 | 67.0 | 2.02 | 0.23 | 33.0 |