Data Article

Dataset for influence of CNG and HCNG on engine performance and emission parameters at diverse injection pressure

Ameer Suhel, A.R. Norwazan, Mohd Rosdzimin Abdul Rahman, Khairol Amali Bin Ahmad

Faculty of Engineering, Universiti Pertahanan Nasional Malaysia, Kem, Sungai Besi, Kuala Lumpur-57000, Malaysia

A R T I C L E   I N F O

Article history:
Received 22 November 2020
Revised 29 January 2021
Accepted 2 February 2021
Available online 6 February 2021

Keywords:
CNG
HCNG
Performance
Emission
Diesel engine

A B S T R A C T

Present data article based on the investigation which enumerates the influence of CNG (compressed natural gas) and HCNG (hydrogen enriched compressed natural gas) on performance and emission parameters of direct injection diesel engine at 200, 220, and 240 bar injection pressures. The CNG and HCNG gaseous alternative fuels were injected in amount (by mass) of 10%, 20% and 30% as secondary fuels to enrich the pilot fuel (pure diesel) during the operation. The performance and emission data of dual fuel (CNG + pure diesel, HCNG + pure diesel) operation was analysed to compare with the pure diesel data. The data for present investigational work were assessed at 25%, 50%, 75% and 100% diverse engine loads for all trials under diverse injection pressures. Eddy current dynamometer was employed to raise the engine load from quartile to maximum. AVL DiGAS 444 N multi gas analyser was used to measure the values of carbon monoxide (CO), unburned hydrocarbon (UHC), and oxides of nitrogen (NOx) detrimental emissions in engine exhaust.

© 2021 Published by Elsevier Inc.

This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/)

* Corresponding authors.

https://doi.org/10.1016/j.dib.2021.106838
2352-3409/© 2021 Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/)
Specifications Table

| Subject       | Internal combustion engine                                                                 |
|---------------|-------------------------------------------------------------------------------------------|
| Specific Subject Area | Alternative fuel, performance, emission                                                   |
| Types of data | Table                                                                                     |
|               | Graph                                                                                     |
|               | Figure                                                                                     |
| How data were acquired | Performance (BTE, BSFC) and emission (CO, UHC, NOx) data were acquired by experimental analysis in engine testing lab. |
| Data format   | Raw analysed                                                                              |
| Parameters for data collection | The data for all trials was collected at constant engine speed of 1500 rpm under 25%, 50%, 75% and 100% loads. Firstly, data were collected at 200 bar injection pressure followed by 220 bar, and eventually at 240 bar injection pressure. |
| Description for data collection | All the data were recorded from Kirloskar, TV-1, 3.5 kW rated power, water-cooled, 4-stroke, vertical 1-cylinder, direct-injection dual fuel diesel engine. The data of engine performance was determined by numerical method using various relations which are mentioned in “Experimental Design and Procedure” section. Emission data was collected by using of AVL DiGAS 444 N multi gas analyser. |
| Data source location | 17.3422695°N  78.3674037420472°E                                                   |
| Data accessibility | The experimental repeats data file is available online in “Mendeley Data” repository: http://dx.doi.org/10.17632/987rs78d8j.2 |

Value of the Data

- The data enumerates the influence of pure diesel and dual fuels on engine behaviour at different injection pressure, identifying which fuel and injection pressure offer superior behaviour.
- The data are vital to the research community since it analysed and compared the performance and emission parameters of dual fuels at different injection pressure and loads with the pure diesel.
- The data can be employed by the researchers to compare the CNG and HCNG values of BTE, BSFC, CO, UHC and NOx to the other alternative gaseous fuel.
- Scientific community working in IC engine field can utilize the present data for comparing with the data produced at different compression ratios.

1. Data Description

Only few researchers have performed experiments with CNG and HCNG as secondary fuel in diesel engine [1,2]. In present research investigation, various experiments for data analysis are performed on single-cylinder, direct injection dual fuel mode diesel engine fuelled with pure diesel, pure diesel with CNG, and pure diesel with HCNG to assess the performance and emission behaviour at 200 bar, 220 bar, and 240 bar injection pressure of pilot fuel. The schematic sketch and photograph of an experimental test setup are represented in Figs. 1 and 2 respectively. The comprehensive specifications of an experimental test setup are mentioned in Table 1. Figs. 3–5 depict the deviation of BTE for tested fuels (PD, CNG10, CNG20, CNG30, HCNG10, HCNG20, and HCNG30) under various loads at 200 bar, 220 bar and 240 bar injection pressures respectively while Tables 2–4 presented the data for BTE correspondingly. In the same way, Figs. 6–8 shows the disparities of BSFC among the tested fuels at different injection pressures and the data associated with BSFC are tabulated in Tables 5–7 respectively. Similarly, the variation in CO emission are depicted in Figs. 9–11 whereas the data associated with CO emission are mentioned in Tables 8–10 at injection pressures of 200 bar, 220 bar and 240 bar respectively. Subsequently, the
Fig. 1. Schematic sketch of experimental setup.

Fig. 2. Photograph of an experimental setup.
Table 1
Experimental test setup specifications.

| Make                        | Kirloskar Oil Engines |
|-----------------------------|------------------------|
| Model                       | TV-1                   |
| Fuel injection              | Direct                 |
| Ignition Type               | Compression            |
| Speed (rpm)                 | 1500 (constant)        |
| Bore (mm)                   | 87.5                   |
| Stroke (mm)                 | 110                    |
| Crank radius (mm)           | 55                     |
| Connecting rod length (mm)  | 234                    |
| Compression ratio           | 17.5:1                 |
| Cylinder capacity (cc)      | 661                    |
| Injection timing (bTDC)     | 23°                    |
| Dynamometer                 | Eddy Current Type      |
| Orifice diameter            | 20 mm                  |

Fig. 3. BTE Vs. Load at 200 bar injection pressure.

Fig. 4. BTE Vs. Load at 220 bar injection pressure.
Table 2  
Data’s for BTE (%) at 200 bar injection pressure.

| Load | PD     | CNG10  | CNG20  | CNG30  | HCNG10 | HCNG20 | HCNG30 |
|------|--------|--------|--------|--------|--------|--------|--------|
| 25%  | 16.50  | 15.06  | 14.20  | 13.36  | 17.16  | 17.93  | 18.07  |
| 50%  | 22.22  | 21.21  | 20.25  | 19.08  | 22.94  | 23.11  | 23.27  |
| 75%  | 27.94  | 26.53  | 25.34  | 23.56  | 28.05  | 28.24  | 28.70  |
| 100% | 30.93  | 30.21  | 29.31  | 27.54  | 31.16  | 31.89  | 32.18  |

Table 3  
Data’s for BTE (%) at 220 bar injection pressure.

| Load | PD     | CNG10  | CNG20  | CNG30  | HCNG10 | HCNG20 | HCNG30 |
|------|--------|--------|--------|--------|--------|--------|--------|
| 25%  | 17.15  | 15.93  | 15.68  | 14.34  | 17.85  | 18.17  | 18.75  |
| 50%  | 22.90  | 21.68  | 20.94  | 19.87  | 23.55  | 24.16  | 24.55  |
| 75%  | 28.21  | 27.21  | 26.25  | 24.76  | 28.88  | 29.52  | 30.27  |
| 100% | 31.17  | 30.27  | 29.66  | 28.66  | 32.83  | 33.05  | 33.59  |

Table 4  
Data’s for BTE (%) at 240 bar injection pressure.

| Load | PD     | CNG10  | CNG20  | CNG30  | HCNG10 | HCNG20 | HCNG30 |
|------|--------|--------|--------|--------|--------|--------|--------|
| 25%  | 15.67  | 14.73  | 13.40  | 12.70  | 16.62  | 17.09  | 17.16  |
| 50%  | 20.34  | 19.99  | 19.50  | 18.21  | 21.83  | 22.34  | 23.05  |
| 75%  | 26.27  | 25.66  | 24.58  | 23.98  | 26.59  | 27.08  | 27.60  |
| 100% | 28.41  | 28.04  | 27.88  | 27.50  | 30.12  | 30.64  | 31.30  |

UHC emission variation are displayed in Figs. 12-14 and the variation in NOx emissions are portrayed in Figs. 15-17 at 200 bar, 220 bar and 240 bar injection pressure correspondingly. The data associated with Figs. 12-17 are presented in Tables 11-16 respectively.

2. Experimental Design and Procedure

For this research work, a kirloskar (model: TV1), single-cylinder, water-cooled, 4-stroke direct-injection duel fuel diesel engine was employed. Eddy current dynamometer was utilised to raise the engine load. The experiments are conducted for pure diesel, CNG and HCNG fuels at diverse injection pressures of 200 bar, 220 bar, and 240 bar. The design of experiments is presented in Table 17. Initially, the engine was fuelled with pure diesel and running with constant
Fig. 6. BSFC Vs. Load at 200 bar injection pressure.

Fig. 7. BSFC Vs. Load at 220 bar injection pressure.

Fig. 8. BSFC Vs. Load at 240 bar injection pressure.
Fig. 9. CO Vs. Load at 200 bar injection pressure.

Fig. 10. CO Vs. Load at 220 bar injection pressure.

Fig. 11. CO Vs. Load at 240 bar injection pressure.
1500 rpm speed at 17.5 compression ratio and 200 bar injection pressure under 25%, 50%, 75% and 100% engine loads. The performance and emission parameters values for pure diesel at all loads were recorded. After recording the values for pure diesel, CNG (10%, 20% and 30% by mass) and HCNG (10%, 20% and 30% by mass) were introduced via intake manifold to enrich the pure diesel at those identical conditions and record the engine behaviour. Similarly, the performance and emission values were recorded at 220 bar and 240 bar injection pressures for all tested fuels at all loads. AVL DiGAS 444 N multi gas (MN-05) analyser is used to record the emission parameters (CO, UHC and NOx). The numerical method is used to determine the engine’s performance by applying the following relations;

\[
Brake\ power\ (BP) = \frac{2\pi \times \text{speed}(N) \times \text{torque}(T)}{60,000} \text{kW}
\]  

(1)
### Table 10
Data’s for CO emission (% vol.) at 240 bar injection pressure.

| Load | PD  | CNG10 | CNG20 | CNG30 | HCNG10 | HCNG20 | HCNG30 |
|------|-----|-------|-------|-------|--------|--------|--------|
| 25%  | 0.122 | 0.142 | 0.171 | 0.191 | 0.102  | 0.092  | 0.072  |
| 50%  | 0.092 | 0.111 | 0.132 | 0.162 | 0.082  | 0.072  | 0.065  |
| 75%  | 0.086 | 0.097 | 0.111 | 0.122 | 0.074  | 0.066  | 0.056  |
| 100% | 0.260 | 0.270 | 0.279 | 0.290 | 0.230  | 0.191  | 0.131  |

#### Fig. 12
UHC Vs. Load at 200 bar injection pressure.

#### Fig. 13
UHC Vs. Load at 220 bar injection pressure.

\[
\text{BTE (diesel)} = \frac{\text{Brake power (BP)} \times 3600 \times 100}{\text{mass flow rate of diesel} \times \text{calorific value of diesel}} \% \quad (2)
\]

\[
\text{BTE (dual)} = \frac{\text{Brake power (BP)} \times 3600 \times 100}{\text{mass flow rate of diesel} \times \text{calorific value of diesel} + \text{mass flow rate of CNG or HCNG} \times \text{calorific value of CNG or HCNG}} \% \quad (3)
\]

\[
\text{BSFC (diesel)} = \frac{\text{mass flow rate of diesel fuel}}{\text{Brake power (BP)}} \left( \frac{\text{kg}}{\text{kW} \cdot \text{hr}} \right) \quad (4)
\]

\[
\text{BSFC (dual)} = \frac{\text{mass flow rate of CNG or HCNG}}{\text{Brake power}} \left( \frac{\text{kg}}{\text{kW} \cdot \text{hr}} \right) \quad (5)
\]
Fig. 14. UHC Vs. Load at 240 bar injection pressure.

Fig. 15. NOx Vs. Load at 200 bar injection pressure.

Table 11
Data’s for UHC emission (ppm) at 200 bar injection pressure.

| Load | PD     | CNG10 | CNG20 | CNG30 | HCNG10 | HCNG20 | HCNG30 |
|------|--------|-------|-------|-------|--------|--------|--------|
| 25%  | 68     | 77    | 82    | 89    | 63     | 60     | 56     |
| 50%  | 55     | 59    | 65    | 70    | 52     | 50     | 47     |
| 75%  | 51     | 55    | 59    | 63    | 49     | 48     | 45     |
| 100% | 60     | 65    | 70    | 75    | 57     | 55     | 52     |

BP data of an operated engine for all fuels was calculated at all loads by using Eq. (1). BTE data when the engine operated with pure diesel (PD) was obtained from Eq. (2) calculations, whereas for dual fuel (PD+CNG or PD+HCNG) mode operation BTE data was attained from Eq. (3) calculations. Similar to the BTE data calculations, BSFC data for pilot fuel was obtained from Eq. (4) calculations and for dual fuel, the data was acquired from Eq. (5) calculations. Each test was performed thrice to check the uncertainty error in the results. For the first experimental repeat, figures and associated data are mentioned below in this article. Moreover, figures and corresponding data of second and third experimental repeats are available in “Mendeley Data” repository; the link direct to data access is provided in the “Data accessibility” section of specification table.
Table 12
Data’s for UHC emission (ppm) at 220 bar injection pressure.

| Load  | PD  | CNG10 | CNG20 | CNG30 | HCNG10 | HCNG20 | HCNG30 |
|-------|-----|-------|-------|-------|--------|--------|--------|
| 25%   | 63  | 72    | 79    | 85    | 58     | 53     | 51     |
| 50%   | 51  | 57    | 62    | 67    | 49     | 44     | 42     |
| 75%   | 49  | 52    | 58    | 61    | 45     | 41     | 39     |
| 100%  | 55  | 62    | 67    | 72    | 52     | 48     | 46     |

Table 13
Data’s for UHC emission (ppm) at 240 bar injection pressure.

| Load  | PD  | CNG10 | CNG20 | CNG30 | HCNG10 | HCNG20 | HCNG30 |
|-------|-----|-------|-------|-------|--------|--------|--------|
| 25%   | 69  | 79    | 84    | 90    | 65     | 61     | 57     |
| 50%   | 56  | 61    | 64    | 71    | 53     | 52     | 49     |
| 75%   | 52  | 56    | 60    | 63    | 50     | 49     | 47     |
| 100%  | 62  | 67    | 71    | 76    | 58     | 56     | 54     |

Table 14
Data’s for NOx emission (ppm) at 200 bar injection pressure.

| Load  | PD  | CNG10 | CNG20 | CNG30 | HCNG10 | HCNG20 | HCNG30 |
|-------|-----|-------|-------|-------|--------|--------|--------|
| 25%   | 142 | 126   | 116   | 98    | 197    | 281    | 334    |
| 50%   | 522 | 496   | 456   | 430   | 575    | 606    | 675    |
| 75%   | 802 | 759   | 734   | 686   | 886    | 936    | 1052   |
| 100%  | 1113| 1030  | 988   | 931   | 1200   | 1345   | 1432   |

Table 15
Data’s for NOx emission (ppm) at 220 bar injection pressure.

| Load  | PD  | CNG10 | CNG20 | CNG30 | HCNG10 | HCNG20 | HCNG30 |
|-------|-----|-------|-------|-------|--------|--------|--------|
| 25%   | 193 | 183   | 150   | 119   | 249    | 311    | 400    |
| 50%   | 559 | 521   | 488   | 470   | 590    | 652    | 728    |
| 75%   | 865 | 814   | 784   | 715   | 912    | 996    | 1103   |
| 100%  | 1151| 1101  | 1055  | 1003  | 1260   | 1360   | 1485   |

Table 16
Data’s for NOx emission (ppm) at 240 bar injection pressure.

| Load  | PD  | CNG10 | CNG20 | CNG30 | HCNG10 | HCNG20 | HCNG30 |
|-------|-----|-------|-------|-------|--------|--------|--------|
| 25%   | 273 | 237   | 214   | 196   | 332    | 408    | 527    |
| 50%   | 543 | 513   | 484   | 436   | 652    | 720    | 801    |
| 75%   | 842 | 814   | 786   | 711   | 959    | 1077   | 1137   |
| 100%  | 1165| 1112  | 1062  | 1011  | 1261   | 1375   | 1490   |

Table 17
Design of experiments.

| Fuel     | Gaseous fuel (% by mass) | Injection pressure (bar) | Compression ratio |
|----------|--------------------------|--------------------------|-------------------|
| Diesel   | –                        | 200                      | 17.5              |
| Diesel + CNG | 10                      | 200                      |                  |
| Diesel + HCNG | Hydrogen (%) 2% | 10                       |                  |
|           |                         | 20                       |                  |
|           |                         | 30                       |                  |
|           |                         | 10%                      |                  |
|           |                         | 20%                      |                  |
|           |                         | 24%                      |                  |
Fig. 16. NOx Vs. Load at 220 bar injection pressure.

Fig. 17. NOx Vs. Load at 240 bar injection pressure.

CRediT Author Statement

Ameer Suhel: Conceptualization, Writing-original draft; Norwazan A.R.: Supervision, Writing-review & editing; Mohd Rosdzimin Abdul Rahman: Visualization & validation; Khairol Amali Bin Ahmad: Draft review & editing.

Declaration of Competing Interest

The authors have no conflicts of interest to declare.

Acknowledgments

The authors would like to acknowledge the financial support provided by Universiti Pertahanan Nasional Malaysia (UPNM), Malaysia under the Short Term Grant (J0234-UPNM/2020/GPJP/TK/10). The authors would like to thank Incharge of IC Engine Lab to support in conducting the experiments.
References

[1] M. Channappagoudra, K. Ramesh, G. Manavendra, Effect of injection timing on modified direct injection diesel engine performance operated with dairy scum biodiesel and Bio-CNG, Renew. Energy. 147 (2020) 1019–1032, doi: 10.1016/j.renene.2019.09.070.

[2] J. Zareei, M. Haseeb, K. Ghadamkheir, S.A. Farkhondeh, The effect of hydrogen addition to compressed natural gas on performance and emissions of a DI diesel engine by a numerical study, Int. J. Hydrogen Energy. (2020), doi: 10.1016/j.ijhydene.2020.09.027.