Jurnal Media Mesin, Vol. 23 No. 2
Printed-ISSN: 1411-4348
Online-ISSN: 2541-4577

NOISE EFFECTS USING TRANSITION METAL CATALYTIC CONVERTER CHROME-COATED COPPER ON FOUR STROKE MOTORCYCLES

Sudirman Rizki Ariyanto
Faculty of Science and Technology, Automotive Technology Vocational Education
Universitas Bhinneka PGRI
Email: sudirmanrizki11@ubhi.ac.id

Wahyu Robby Cahyadi
Faculty of Science and Technology, Automotive Technology Vocational Education
Universitas Bhinneka PGRI
Email: r0_0bby@ubhi.ac.id

Bagas Surya Hadi
Faculty of Science and Technology, Automotive Technology Vocational Education
Universitas Bhinneka PGRI
Email: bgosh9@ubhi.ac.id

Warju
Faculty of Engineering, Department of Mechanical Engineering
Universitas Negeri Surabaya
Email: warju@unesa.ac.id

Muhammad Yandi Pratama
Faculty of Engineering, Department of Mechanical Engineering
Universitas Negeri Malang
Email: m.yandipratama@gmail.com

ABSTRAK

Selama beberapa tahun terakhir, *Transition Metal Catalytic Converter* (TMCC) telah menjadi standar dalam sistem pembuangan mesin pembakaran dalam. Selain mengurangi emisi gas buang, TMCC juga secara eksplisit mempengaruhi kebisingan yang dihasilkan. Dalam penelitian ini, pengaruh kebisingan dalam penggunaan TMCC *chrome-plated copper* (CuCr) diselidiki. Uji kebisingan dilakukan dalam dua kondisi dengan kendaraan yang tepat, menggunakan Honda Supra Fit 2005 dengan kondisi knalpot standar dan TMCC CuCr. Pengujian kebisingan dilakukan berdasarkan standar ISO/FDIS 5130, kemudian hasilnya dibandingkan dengan standar kebisingan yang tercantum dalam Peraturan Pemerintah (PERMEN) LH No. 7 Tahun 2009. Temuan menunjukkan bahwa penggunaan TMCC CuCr kurang efisien dalam mengurangi kebisingan. Hal ini dibuktikan dengan hasil perbandingan yang menunjukkan bahwa rata-rata suara knalpot TMCC CuCr cenderung 10% lebih keras dari knalpot standar. Hasil pengujian kebisingan menunjukkan bahwa kebisingan terukur pada RPM 5000 adalah 82.2 dBA untuk knalpot standar dan 95.4 dBA untuk knalpot TMCC CuCr. Sebagai perbandingan, standar kebisingan yang diatur dalam Peraturan Menteri No. 7 Tahun 2009 hanya 90 dBA. Melalui hasil tersebut dapat disimpulkan bahwa penggunaan knalpot TMCC CuCr tidak mengikuti standar pemerintah dan termasuk dalam kategori "Tidak Lulus Uji Kebisingan".
Kata kunci: *catalytic converter* logam transisi, kebisingan, sepeda motor empat tak.

ABSTRACT

Over the past few years, the Transition Metal Catalytic Converter (TMCC) has become a standard in the exhaust system of internal combustion engines. Besides reducing exhaust emissions, TMCC also affects explicitly the noise produced. In this study, the effect of noise in the use of TMCC chrome-plated copper (CuCr) was investigated. The noise test was carried out in two conditions with the exact vehicle, using a 2005 Honda Supra Fit with standard exhaust conditions and TMCC CuCr. Noise testing was carried out based on the ISO/FDIS 5130 standard, and then the results were compared with the noise standard stated in Government Regulation (PERMEN) LH No. 7 of 2009. The findings show that using TMCC CuCr is less efficient in reducing vehicle noise. This result is proven by the comparison results, which show that, on average, the TMCC CuCr exhaust tends to be 10% louder than the standard exhaust. The noise test results show that the measured noise at RPM 5000 is 82.2 dBA for standard exhaust and 95.4 dBA for TMCC CuCr exhaust. In comparison, the noise standard stipulated in Ministerial Regulation No. 7 of 2009 is only 90 dBA. Through these results, it can be concluded that the use of TMCC CuCr exhaust does not follow the government standards and is included in the "Not Passed Noise Test" category.

Keywords: *transition metal catalytic converter, noise, four stroke motorcycle.*

1. INTRODUCTION

Transition Metallic Catalytic Converter (TMCC) is an after-treatment technology that is installed on the exhaust system of motorized vehicles, such as cars and motorcycles. This technology aims to reduce the amount of pollution so that it is more environmentally friendly [1]. However, as an integral part of the modern exhaust system, the TMCC also has a relevant role and must be taken into account from the point of view of controlling the noise coming out of the exhaust tip [2]. Therefore, it is necessary to study the effect of noise on vehicles that have applied TMCC to the exhaust system. Thus, the researchers have sufficient knowledge when designing a TMCC, which can reduce exhaust emissions and noise [3].

Most research generally focuses on the ability of TMCC to oxidize CO and HC emissions. Although almost every new vehicle has been equipped with TMCC and various TMCC designs, have been devised by the manufacturers. However, relatively few papers are concerned with discussing the TMCC noise generated. Sulistiyono & Warju [4] applies TMCC made of nickel-plated brass, where the results show an increase in noise of 8.61%. In contrast to these results, Lavrentjev & Rämmal [3] the application of TMCC in the form of a honeycomb is proven to reduce noise significantly. Then, Lavrentjev & Rammal's [4] research also showed that the use of a catalytic converter was able to reduce the noise level in each design of different sizes with a decrease in the noise level between 7-8 db. These two studies show that applying technology such as a catalytic converter or similar TMCC can significantly reduce the noise produced. These two studies are also corroborated by other studies on using TMCC to reduce the noise level produced. Like research by Gunawan & Warju [5], designing TMCC made of brass plated copper, the application of TMCC on motorcycle exhausts can reduce the noise level by an average of 3,5%. By developing a TMCC made of brass plated copper, the application of TMCC to motorcycle exhausts reduced noise levels by an average of 8% in three different arch designs. Control of noise generated by internal combustion engines is generally carried out in several studies based on modifications to vehicle exhaust design; one example is the use of a catalytic converter or TMCC [6].

In this study, the noise effect of using TMCC was investigated by analyzing the amount of noise produced and the back pressure in the TMCC. Thus, the relation between noise and backpressure can be studied. The TMCC analyzed in this study is made of copper coated with chrome (CuCr). By its ability to reduce exhaust emissions, Ariyanto et al. [7] found that using TMCC CuCr reduced CO emissions by 24% and HC emissions by 30% compared to standard exhaust. Thus, it can be concluded that TMCC CuCr can offer a reasonably efficient design to reduce exhaust emissions. However, the big question is how efficient is TMCC against noise. In this paper, the efficiency of TMCC CuCr is investigated experimentally, and

noise data from both standard and experimental test results are presented to characterize TMCC CuCr to noise. Furthermore, the noise produced at the exhaust tip was analyzed based on the Minister of Environment Regulation No. 7 of 2009 concerning the Noise Threshold for New Types of Motorized Vehicles [8]. It aims to ensure that the TMCC CuCr design produced has not following the standards set by the government or not.

2. METHODOLOGY

2.1 *TMCC Design*

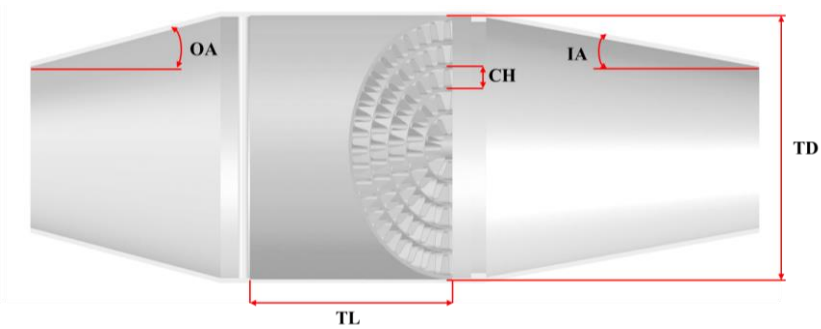

Figure 1. The TMCC Configuration inside the Case.

This experimental research aims to analyze further the effects of noise generated by motorcycle exhaust before and after TMCC technology is installed. The motorcycle used as the research object was the 2005 Honda Supra Fit. Furthermore, the TMCC, whose capabilities were analyzed, came from copper coated with chrome (CuCr) with a tube diameter (TD) configuration of 63.4 mm, tube length (TL) of 103.6 mm, and curvature height (CH) of 10 mm. Moreover, the inlet (IA) and outlet (OA) angles of the casing are also configured according to the design recommended by A. Graham Bell. [9], which are 11^{o} and 22^{o}, respectively (Figure 1). The purpose of adjusting the angle configuration of the TMCC CuCr casing is to minimize flue gas flow turbulence.

2.2. *Noise Testing Instruments*

Noise testing instruments may include digital tachometers, chassis dynamometer, sound level meter, and blower. Research equipment consists of a blower that represents the engine's cooling process (Figure 2) [10]. The noise testing process is based on the ISO/FDIS 5130:2006 (E) standard [11]. Then, the test results data are compared with the Decree of the State Minister of the Environment Number 7 of 2009 concerning the Noise Threshold for New Types of Motorized Vehicles [8], where the permissible noise for the motorcycle is 90 dBA for the first stage and 80 dBA for the second stage. From the results of these comparisons, it can be analyzed further whether the application of TMCC CuCr to noise is comparable to standard exhaust. Moreover, it can also be ascertained that the application of TMCC CuCr is in accordance with the noise threshold set by the government.

Figure 2. Noise Testing Instruments.

2.3. *Data Collection and Analysis Techniques*

Data collection techniques by using experimental studies were carried out to test the noise generated by the exhaust before and after applying TMCC CuCr. Noise testing is done with the help of a sound level meter (SLM). The testing process was carried out three times at each RPM which was then taken on average both in the standard exhaust test and the TMCC CuCr experiment. The test results are then analyzed using quantitative descriptive methods to describe the facts obtained after the test [12]. The research data obtained are presented in a table and displayed as a graph of the relationship between engine speed (rpm) vs noise level (dBA). Then, it is described in simple sentences so that it is easy to understand as an effort to get answers to the problems studied. This activity was carried out to provide an overview of the phenomenon that occurred after applying TMCC CuCr to the exhaust gas line of a 2005 Honda Supra Fit motorcycle.

3. RESULTS AND DISCUSSIONS

In general, the use of TMCC CuCr causes an increase in the Honda Supra Fit 2005 motorcycle noise, as shown in Table 1. From the data test, after using TMCC CuCr, the average noise from the exhaust tip at each RPM increased by 10% compared to the standard. Noise reduction occurs after using TMCC CuCr, but it only happens at idle speed. The noise it produces tends to increase, where the highest increase is at 5000 RPM, which is 16%. In detail, the trend of growing noise can be seen in Figure 3.

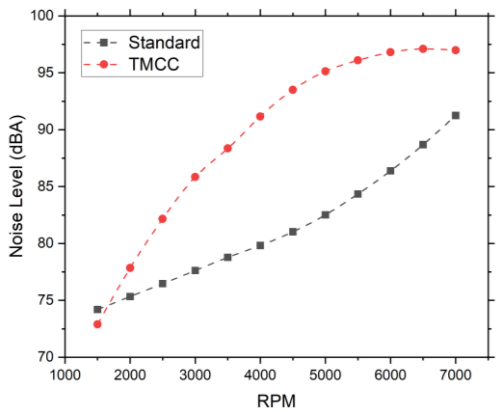

Figure 3. Noise test results.

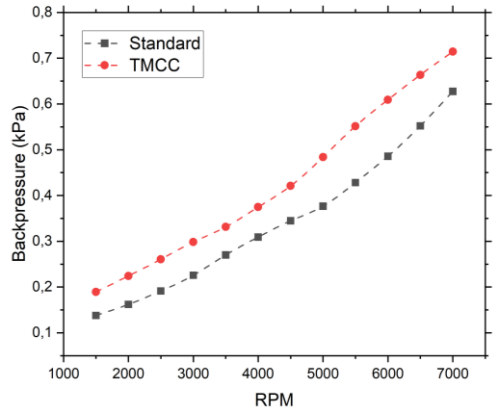

Figure 4. Back pressure test results.

Referring to Figure 3, we can see that the increase in noise is simultaneously affected by the rise in engine speed. Jang et al. [13] evealed that the noise generated by the exhaust is directly proportional to the engine speed. When at low to medium speed, the noise produced is relatively quiet. However, when the engine speed continues to be increased, the noise produced tends to be higher. Several factors have been identified as the cause of noise in the exhaust. According to Berge et al. [14] and Grubesa et al. [15], one of the main factors is the sudden release of gases in the exhaust system to assist in opening the exhaust valve. This results in relatively high pressure in the exhaust system and makes the sound produced tend to be louder at the exhaust tip [16]. This explanation is in line with the back pressure test results (Table 2 and Figure 4), where the back pressure generated by exhaust using TMCC CuCr tends to be higher when compared to standard exhaust.

Based on the results of the study, it was found that there was an increase in noise after the installation of TMCC CuCr. Several causative factors have been identified. Through their research, Lavrentjev et al. [3] suggested that the increased noise was caused by a change in the exhaust system's cross-sectional area resulting in sound waves' dissipation. Reinforcing these results, Prajapati & Desai [17] found that the presence of flow resistance due to the addition of a catalytic converter causes a dissipative effect that affects the sound transmitted at the exhaust tip. This, of course, affects the back pressure in the exhaust pipe. Mohiuddin et al. [18] showed that the higher the back pressure created by the exhaust system, the less net power available to the crankshaft and, therefore, the more fuel required. Thus, it can be stated that an increase in the noise level is correlated with an increase in back pressure in the exhaust pipe. Then, it is possible to cause a decrease in vehicle performance with the use of fuel that tends to be more wasteful.

This study's results align with the research by Sulistiyono & Warju where noise increases after applying TMCC made of nickel-coated brass. Naufal et al. [19] also found similar results, where the findings showed that the use of TMCC significantly affected the noise coming out of the exhaust tip. However, in contrast to this study, two studies by Lavrentjev & Rammal [3], [4] stated that catalytic converters could reduce noise. Furthermore, the fundamental question in this research is, does the use of TMCC on the 2005 Honda Supra FIT motorcycle meet the noise standards set by the government? To answer this question, a comparison is made between the standard and the noise test results.

The applicable noise standard refers to the Minister of Environment Regulation No. 7 of 2009 concerning the Noise Threshold for New Types of Motorized Vehicles. Meanwhile, the noise testing standard used is ISO/FDIS 5130 [11], where the noise measurement for motorcycles is carried out at 50% of the total engine speed, which is 5000 RPM. The detailed comparison results are shown in Table 3.

Table 3. Comparison of noise test results with minister of environment regulation.

Exhaust	Result	Threshold	Description
Standard	82.2 dBA	90 dBA	Pass the Noise Test
TMCC CuCr	95.4 dBA		Did Not Pass Noise Test

Based on the data in Table 3, it is known that the regulation on the noise threshold for the 2005 Honda Supra FIT vehicle is 90 dBA. However, the noise test results show that the standard exhaust produces a noise of 82.2 dBA, while the TMCC CuCr exhaust produces a noise of 95.4 dBA. These results indicate that the TMCC CuCr exhaust tends to be 16% louder than the standard exhaust. Then, through these results, it can be stated that the use of TMCC CuCr exhaust does not meet government standards and is included in the "Not Passed Noise Test" category, which has been regulated in the Minister of Environment Regulation No. 7 of 2009 concerning the Noise Threshold for New Type Motor Vehicles. In line with these results, Kamat et al., [20] showed that applying experimental mufflers such as the addition of a catalytic converter tends to produce a higher noise level than the noise produced in a standard exhaust.

4. CONCLUSIONS

In this study, the noise effect of using TMCC CuCr was investigated by analyzing the amount of noise produced and the back pressure in the TMCC CuCr. Noise testing is carried out on a chassis dynamometer using a sound level meter as a noise tester. The findings of this study indicate that the use of TMCC CuCr is not efficient when used in reducing vehicle noise. This result is evidenced by the comparison results, which show that, on average, the TMCC CuCr exhaust tends to be 10% louder than the standard exhaust. The noise test results show that the measured noise at RPM 5000 is 82.2 dBA for standard exhaust and 95.4 dBA for TMCC CuCr exhaust. In comparison, the noise standard stipulated in Ministerial Regulation No. 7 of 2009 is only 90 dBA. These results show that the use of TMCC CuCr exhaust does not meet government standards and is in the "Not Passed Noise Test" category.

ACKNOWLEDGEMENTS

Acknowledgements are given to the Universitas Bhinneka PGRI, which has provided funding for this research in the Internal Fund Research scheme for the Fiscal Year 2022 with contract number 123/ST/LPPM/UBHI/III/2022. Besides, we also thank the Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Surabaya for facilitating the data collection process at the Engine Performance Laboratory.

REFERENCES

[1] W. Warju, N. S. Drastiawati, S. R. Ariyanto, and M. Nurtanto, “The Effect of Titanium Dioxide (TiO2) Based Metallic Catalytic Converter on the Four-Stroke Motorcycle Engine Performance,” 2020.

[2] F. D. Denia, J. Martínez-Casas, J. Carballeira, E. Nadal, and F. J. Fuenmayor, “Computational performance of analytical methods for the acoustic modelling of automotive exhaust devices incorporating monoliths,” *J. Comput. Appl. Math.*, vol. 330, pp. 995–1006, Mar. 2018, doi: 10.1016/j.cam.2017.03.010.

[3] J. Lavrentjev, H. Rämmal, and H. Tiikoja, “The passive acoustic effect of automotive catalytic converters,” *SAE Tech. Pap.*, 2011, doi: 10.4271/2011-24-0219.

[4] J. Lavrentjev and H. Rämmal, “Acoustic analysis of small engine catalytic converters,”

SAE Tech. Pap., 2010, doi: 10.4271/2010-32-0022.

[5] S. Gunawan, W. Warju, S. P. Anisa, E. D. Pratiwi, and M. D. Saputra, "Pengaruh Penggunaan Dual Bed Catalytic Converter Berbahan Tembaga dan Kuningan Terhadap Tingkat Kebisingan dan Performa Mesin," *Mach. J. Tek. Mesin*, vol. 6, no. 2, pp. 12–17, 2020.

[6] C. Wu, L. Chen, J. Ni, and J. Xu, "Modeling and experimental verification of a new muffler based on the theory of quarter - wavelength tube and the Helmholtz muffler," *Springerplus*, pp. 1–14, 2016, doi: 10.1186/s40064-016-3060-1.

[7] S. R. Ariyanto, R. Wulandari, Suprayitno, and P. I. Purboputro, "Pengaruh Metallic Catalytic Converter Tembaga Berlapis Chrome Dalam Menurunkan Emisi Gas Buang Mesin Sepeda Motor Empat Langkah," *J. Media Mesin*, vol. 23, no. 1, pp. 44–51, 2022, doi: 10.23917/mesin.v23i1.16604.

[8] Minister of the Environment, *Regulation of the State Minister of the Environment Number 7 of 2009 concerning the Noise Threshold for Old Motorized Vehicles*. Minister of the Environment, 2009.

[9] A. G. Bell, *Four-Stroke Performance Tuning in Theory and Practice*. California: Haynes Publishing, 1981.

[10] R. S. Hidayatullah, I. W. Susila, I. M. Arsana, Warju, and S. R. Ariyanto, "The Effectiveness of Using Variations in Fuel Against Engine Performance 4 Steps 100 CC with Compression Ratio 8:1," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 1125, no. 1, p. 012120, May 2021, doi: 10.1088/1757-899X/1125/1/012120.

[11] ISO/FDIS 5130:2006 and ISO/FDIS 5130, *Acoustics – Measurements of Sound Pressure Level Emitted by Stationary Road Vehicles*. Swiss: International Organization for Standardization, 2006, pp. 1–17.

[12] J. W. Creswell, *Research design: Qualitative, quantitative and mixed approaches (3rd Edition)*, 3rd ed. Los Angeles: SAGE Publications, Inc., 2009. doi: 10.2307/1523157.

[13] J. Jang *et al.*, "Research for intake and exhaust system parameterization of 2-cylinder gasoline engine for RE-EV," *Int. J. Energy Res.*, vol. 42, no. 9, pp. 3007–3016, Jul. 2018, doi: 10.1002/er.4066.

[14] T. Berge and V. Henriksen, "NEMO project: acoustic detection of vehicle engine speed," *INTER-NOISE NOISE-CON Congr. Conf. Proc.*, vol. 263, no. 5, pp. 970–980, Aug. 2021, doi: 10.3397/IN-2021-1718.

[15] S. Grubesa and M. Suhanek, "Traffic Noise," in *Noise and Environment*, IntechOpen, 2021. doi: 10.5772/intechopen.92892.

[16] Warju, S. R. Ariyanto, and Soeryanto, "Studi eksperimental tentang pengaruh diesel particulate filter terhadap reduksi tingkat kebisingan mesin diesel empat langkah," *Din. Tek. Mesin*, vol. 10, no. 2, pp. 134–143, 2020.

[17] V. D. Prajapati and A. J. Desai, "Design and Analysis of Automotive Muffler," *Int. J. Eng. Res. Technol.*, vol. 5, no. 05, pp. 384–389, 2016.

[18] A. K. M. Mohiuddin, M. R. Ideres, and S. M. Hashim, "Experimental Study of Noise and Back Pressure for Silencer Design Characteristics," *J. Appl. Sci.*, vol. 5, no. 7, pp. 1292–

1298, Jun. 2005, doi: 10.3923/jas.2005.1292.1298.

[19] B. Naufal, E. E. Poerwanto, and W. Irdianto, "Pengaruh Katalitik Konverter Terhadap Intensitas Suara Dan Konsumsi Bahan Bakar Pada Motor Sebaris 4 Silinder 4 Langkah 1500 Cc Konvensional," *J. Tek. Otomotif Kaji. Keilmuan dan Pengajaran*, vol. 5, no. 1, p. 45, 2022, doi: 10.17977/um074v5i12021p45-50.

[20] S. Kamat, R. Jadhav, J. Katta, and V. Kshirsagar, "Semi Active Muffler," *Int. J. Sci. Res. Sci. Eng. Technol.*, vol. 03, no. 02, 2017.