Gradus Vol 12, No 2 (2025)
ISSN 2064-8014

DEVELOPMENT OF A NEXT GENERATION, .50 CALIBRE SUPPRESSOR

Dávid A. Kovács 0009-0002-0510-7870 [1*], *Zsolt F. Kovács* 0000-0002-6995-6508 [1]

[1] Department of Innovative Vehicles and Materials, GAMF Faculty of Engineering and Computer Science, John von Neumann University, Hungary
https://doi.org/10.47833/2025.2.ENG.007

Keywords:
Suppressor
Ballistics
Muzzle Device
Intermediate Ballistics
Additive Manufacturing

Article history:
Received 10 May 2025
Revised 1 October 2025
Accepted 7 October 2025

Abstract

For well over 100 years, firearm suppressors have been utilized as means of decreasing the muzzle report and muzzle flash, commonly associated with the discharge of a firearm. The relevance of these muzzle devices has increased exponentially in recent decades, both in the world of military, and civilian users. This tendency can be attributed to the recent legalization – in Hungarian legislature - of these devices as well as the advancements in military doctrines and technology. With the increasing prevalence of said technologies – those being CAx and Metal 3D printing technologies. – it is possible to develop smaller, lighter, and better suppressors, than ever before: with the help of simulations and CAD softwares, the most efficient design can be created and chosen in a cost-effective manner. Then, with the help of additive manufacturing processes, such complex geometries can be manufactured that no other conventional manufacturing method could ever produce. This paper aims to introduce how these technologies can be integrated into the development of a large calibre firearm suppressor, that represents the next generation of such muzzle devices.

1 Introduction

A firearm suppressor is a muzzle device that serves the purpose of trapping, and decreasing the pressure of the propellant gases escaping from the bore of said firearm. The very loud muzzle report that is associated with the discharge of a firearm is the product of these escaping propellant gases rapidly normalizing and creating shockwaves in the surrounding air. The human ear perceives this as noise, and it can reach magnitudes equal to, or greater than 175 dB [1].

The advantages of utilizing suppressors, and decreasing the magnitude of this muzzle report are manifold:

The auditory health of the operator is preserved. Besides the operator, a suppressor also preserves the hearing of surrounding personnel, and other assets of tactical units, such as service dogs. The decreased noise generated by gunfire also enhances communication in tactical scenarios [2].

The concealment of military units in tactical contexts is enhanced. Besides decreasing the muzzle report, suppressors are also effective at diminishing bright muzzle flashes that can give away the positions of military personnel [2].

Noise pollution of areas surrounding shooting ranges and training centres – either natural, or urban – is decreased [3] [4].

* 1 E-mail address: dkovacs150@gmail.com

A suppressor achieves the goal of decreasing the pressure of the exiting propellant gases by providing a relatively large, enclosed volume with so called „baffles" for said gases to expand, and cool in [5] [6]. Considering the presumed purpose of the suppressor – that can be for recreational shooting, hunting, and military, law enforcement applications – the number, and geometry of these baffles, and the volume of the suppressor can vary greatly.

While the noise generated by a firearm has other elements, such as the noise of the self-loading mechanism, and the supersonic crack of the bullet in flight, the suppressor is only suitable for decreasing the actual muzzle report associated with the normalization of propellant gases [1][7].

2 Development

The suppressor developed in context of the research is of a metal 3D printed, flow-through-type, that has 5 conical baffles. These serve the purpose of deflecting propellant gases, while providing surface area for said gases to exchange heat with – hence decreasing pressure. Separated from the baffles, the suppressor also houses a system of helical channels. Thanks to a variety in pitch along the length of the suppressor, the channels' cross sections decrease, to half of the initial value. This system serves 3 main purposes:

It introduces surplus material – hence, heat capacity and surface area – in the suppressor, further aiding in it's function.

In accordance with Bernoulli's law, the decreasing cross section gradually decreases the pressure of propellant gases, while increasing flow speed.

And finally, it serves as a quasi-bore evacuator commonly seen on modern tanks' main armaments: practically making the suppressor flow-through. As seen on Fig. 4, the propellant gases exiting the helical grooves retain a higher pressure value than those emerging from among the baffles. When these meet at the 4 outlets near the muzzle, the higher pressure flow creates a vacuum in the suppressor-barrel system. This vacuum extracts the residual fumes through the muzzle of the suppressor.

Such functionality – and the usage of low-backpressure suppressors - is important due to the toxic and carcinogenic nature of propellant gases that can get "blown back" towards the operator of the firearm during firing, typically through the ejection port of the firearm. Inhaling these gases, the operator is exposed to CO, HCN, and NH3, and aerosolized metallic elements such as lead or copper. In low volumes of fire these cause irritation in the eyes and respiratory organs. In the long run however, they can cause serious illnesses, such as cancer.

The attachment method of the suppressor is of a direct, thread-on type. Additionally, the suppressor can be retrofitted with a muzzle brake to further utilize the exiting gases' energy for decreasing felt recoil.

The host of the suppressor is the GM-6 Lynx, a 12.7x99 mm NATO caliber anti-materiel rifle, developed by SERO Kft. based in Hungary. It is a recoil operated, semi-automatic, magazine fed firearm. The operation of the firearm posed certain requirements and limitations that had to be considered during development. These were limited size, and weight. The following image depicts the suppressor attached to the described firearm:

Figure 1: The suppressor attached to the GM-6 Lynx anti-materiel rifle

Understanding the past, and current state of suppressor technology in tandem with measurement methods and standards related to suppressors - MIL-STD 1474D and MIL-STD 1474E, and NATO AEP-4785 [3] [8] [9]– the author of this paper was able to devise a „proof of concept” suppressor design that was sufficiently effective while aiming to preserve both the auditory and respiratory health of the operator. The available metal additive manufacturing technologies – those being WAAM, and SLM - posed definitive guidelines to create proper CAD models of this suppressor.

The design of the suppressor was devised based on these guidelines, the mechanical properties of predetermined metallic printing materials, and the ballistic properties of the M33 Ball, 12.7 x 99 mm NATO round. The section of the final design can be seen on the following image, with the dotted line depicting the trajectory of the projectile in the suppressor:

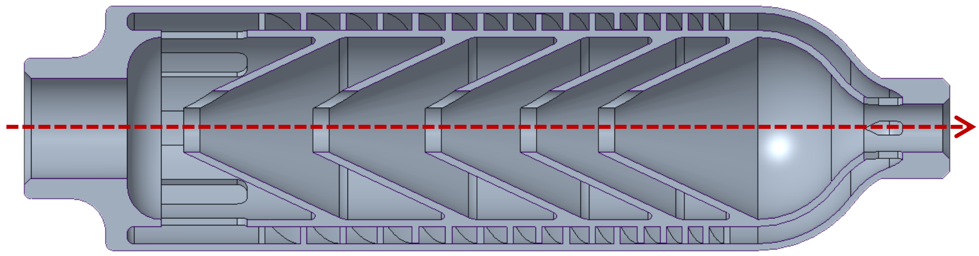

Figure 2: Section of the suppressor developed in the context of the research, detailed in this paper. The muzzle device was dubbed the „Lidérc .50”.

3 CFD Simulation results

The CFD simulations had the purpose of verifying the functionality of the suppressor. Input data for the initialization of this simulation was calculated from the ballistic properties of the M33 Ball, 12.7 x 99 mm NATO round, fired from a hypothetical gun barrel, with a length of 730 mm – equal to that of the Lynx.

The functionality of the baffle geometries is verified by the following result:

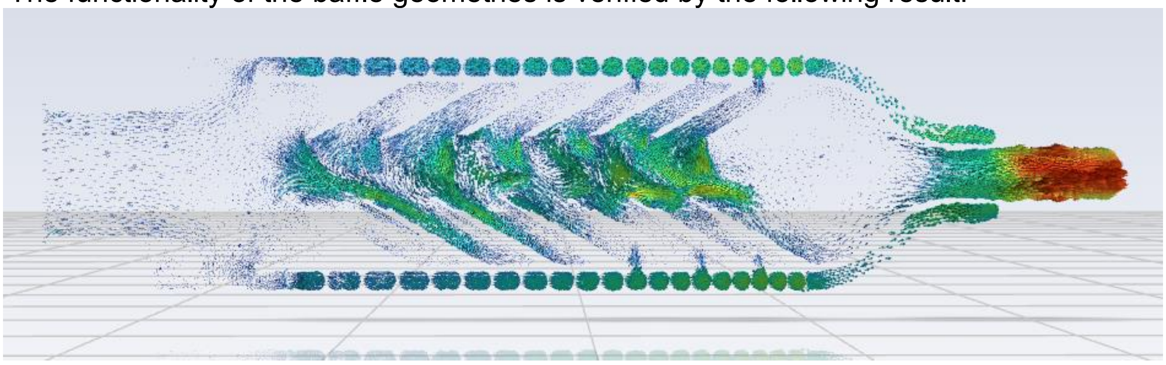

Figure 3: CFD simulation result image depicting the speed vectors of the flow.

It is apparent that the baffles trap the exiting propellant gases, and create turbulence in their flow. The following result primarily verifies the functionality of the helical channels:

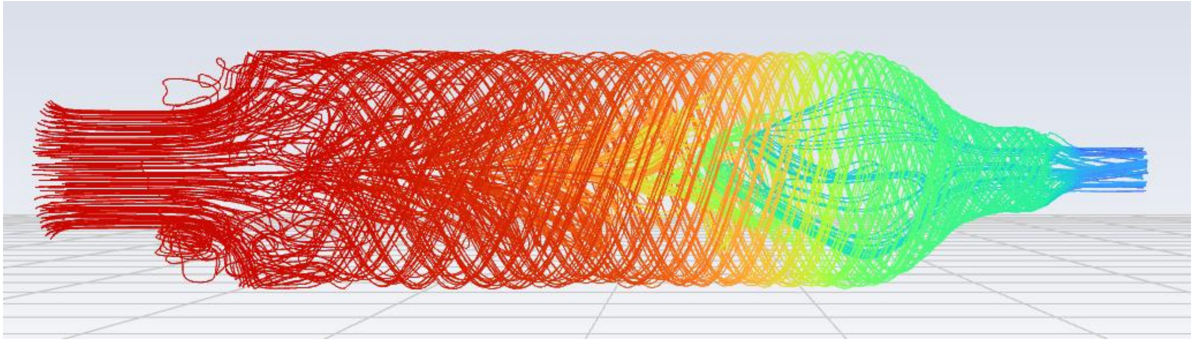

Figure 4: CFD simulation result image depicting the total pressure of the flow.

The colour of the flow lines indicates the total pressure of the flow. It is apparent, that the flow exiting the helical grooves is of a lower pressure than at the intake. The result also shows that these gases will have a higher pressure than those exiting the baffle stack: this creates vacuum behind the outlets at the muzzle, giving the suppressor a “bore evacuator” functionality. This is supposed to reduce the amount of propellant gases escaping in the direction of the operator during ejection of the spent cartridge casing. This, and the fact that the helical grooves grant a path of lesser resistance of the gases to escape through, makes the suppressor a flow-through-type.

4 Structural simulation results

The structural simulations done on the model of the suppressor had the aim to verify its structural integrity, and safe operation – which was of utmost importance. To guarantee this quality, a minimum safety factor of 1.5 was determined, that was based on empirical data. The simulations were done using the Student license of Ansys 2024 R2.

With the highly limited (128 000) number of elements/nodes the model’s mesh could have, it was decided to only simulate the expansion chamber, and the first baffle of the suppressor; this part faces the highest temperature and pressure levels. If this part is structurally sound, the further sections of the suppressor are also safe due to the necessarily lower temperature and pressure levels. Furthermore, by decreasing the size of the simulated object, the relative density of elements could be increased, that is directly proportional to the accuracy of the simulations. To further guarantee the accuracy of the simulations, three iterations were run with element sizes being halved in each iteration. Convergence of equivalent stress values was already apparent after 3 iterations of element size. The most accurate stress levels being: $\sigma_{steel} = 433.8\ MPa$, $\sigma_{titanium} = 429.6\ MPa$ The following images depict visual results of the simulations.:

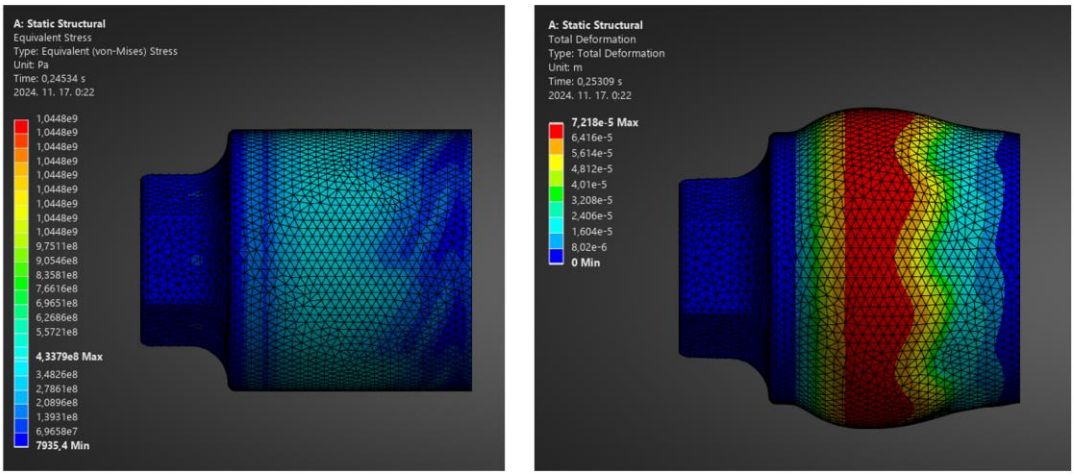

Figure 5: Left: von-Mises Equvalent Stress in the walls of the suppressor. Right: total deformation of the suppressor’s walls, multiplied by the magnitude of 100.

In the simulations it was presumed that the internal faces of the model are exposed to a homogenous, constant pressure of ~95 MPa for 0.25 seconds.

The resulting stress levels measured in the walls of the suppressor were way below the yield strength of the chosen materials. Both in the case of the titanium and steel printing materials, the safety factor was $n > 1.65$, which conforms to the formerly specified n > 1.5 safety factor.

5 Conclusion

In context of the research detailed in this paper, a next generation, metal 3D printed, flow-through, prototype large calibre suppressor was successfully developed.

The simulations ran on the CAD models – generated in accordance to the chosen additive manufacturing methods' manufacturing guidelines - verified both the intricate functionalities of the suppressor, and its structural integrity. The suppressor's safety factors have been calculated to be equal to, or over 1.65 both in case of a titanium, and steel base materials. These conform to the minimum 1.5 safety factor determined in the research.

Acknowledgement

This research was carried out in the framework of the project 2024-2.1.1-EKÖP-2024-00008. The project 2024-2.1.1-EKÖP-2024-00008 was funded by the Ministry of Culture and Innovation with support from the National Research Development and Innovation Fund under the 2024-2.1.1-EKÖP grant scheme.

References

[1] W. J. Murphy, G. A. Flamme, A. R. Campbell, E. L. Zechmann, S. M. Tasko, J. E. Lankford, D. K. Meinke, D. S. Finan and M. & Stewart, “The reduction of gunshot noise and auditory risk through the use of firearm suppressors and low-velocity ammunition,” *International journal of audiology,* pp. 28-41, 2018. DOI: 10.1080/14992027.2017.1407459

[2] O. Simonyi, A Mesterlövész, 1. kötet70, Budapest: Belügyi Szemle, 2022, pp. 1577-1580. DOI:10.38146/BSZ.2022.7.13

[3] NATO, AEP-4785 Volume I Edition B - Testing Protocol on Acoustic Signature Measurement of Small Arms Suppressors, 2021.

[4] R. Pääkkönen, “Environmental noise reduction means of weapons,” *The Journal of the Acoustical Society of America,* vol. 123, p. 3822, 01. 06. 2008.. DOI:10.1121/1.2935577

[5] A. Kilikevičius, V. Giedraitis, K. Kilikevičienė, J. Matijošius, J. Selech, G. Buckiūnas and M. Rucki, “Performance Analysis of Different Gun Silencers.,” *Appl. Sci.,* vol. 4426, 2023. DOI: 10.3390/app13074426

[6] W. A. Openshaw and A. B. Chiples, Multi-Platform Suppressor Design Project, Williams Honors College, Honors Research Projects., 2022, p. 1570.

[7] E. Courtney, R. Couvillion, A. Courtney and M. Courtney, Effects of Sound Suppressors on Muzzle Velocity, Bullet Yaw and Drag, 2017. DOI: 10.12783/ballistics2017/16879

[8] U. S. DoD, MIL-STD-1474D DEPARTMENT OF DEFENSE DESIGN CRITERIA STANDARD NOISE LIMITS, 1997.

[9] U. S. DoD, MIL-STD-1474E - DEPARTMENT OF DEFENSE DESIGN CRITERIA STANDARD NOISE LIMITS, 2015.