XXIII Conference of PhD Students and Young Scientists

Interdisciplinary topics in Mining, Geology and Geomatics

Comparison of Hexcore and Poly-Hexcore computational grids in the aspect of air flow modeling based on the actual geometry of mining excavations



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PAN POLSKA AKADEMIA NAUK ODDZIAŁ WE WROCŁAWIU KOMISJA NAUK GÓRNICZYCH

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Introduction

Discrete models are used in industry for many applications. In one of the most frequently used Finite Element Method (FEM) for Computational Fluid Dynamics (CFD) calculations, these models may be two-dimensional or three-dimensional [1].

2D models are used as a simplification to achieve satisfied results in the shortest computational time. 3D models, on the other hand, are used for more complex calculations. These models are real-world domains representation that have been appropriately simplified to make the calculations accurate and correct. The calculation time of a 3D model is significantly longer compared to 2D . For this reason, to reduce the calculation time, different types of simplifications and various types of discrete model meshes are used [1].

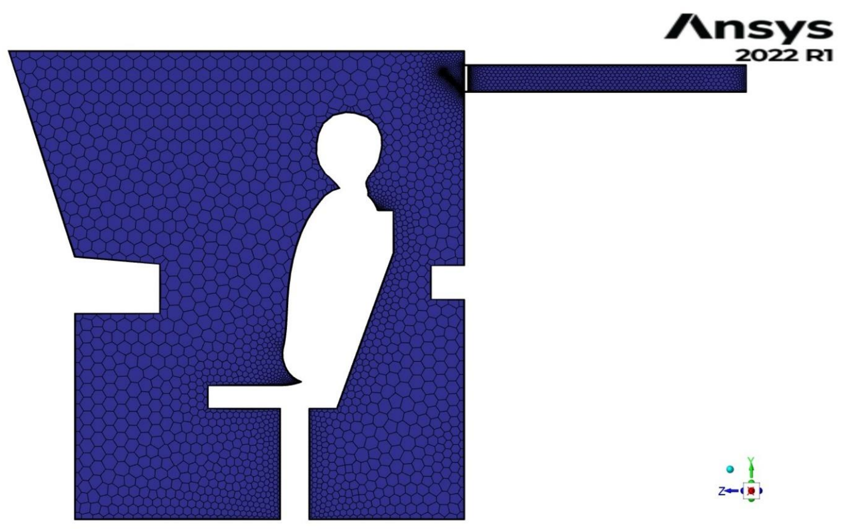

Figure 1. 2D Discrete models used for Computational fluid dynamics (CFD) calculations [2]

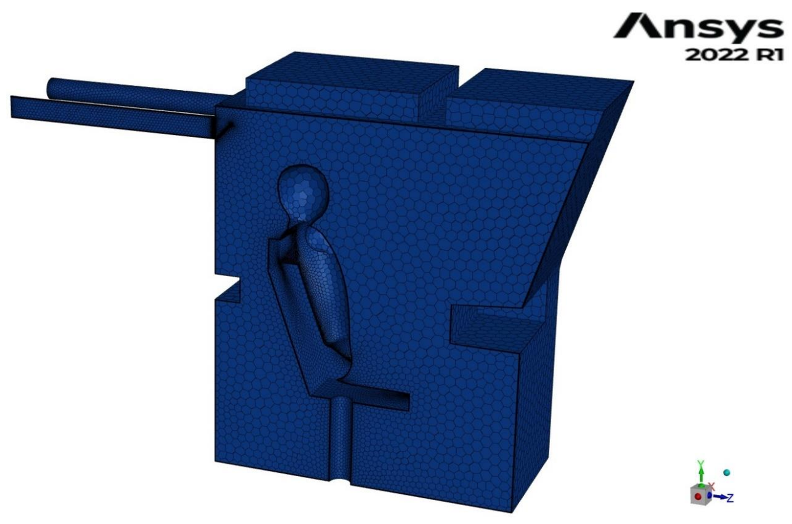

Figure 2. 3D Discrete models used for Computational fluid dynamics (CFD) calculations [2]

Description of mesh models

Figure 3. Hexcore mesh

Figure 4. Poly-Hexcore mesh

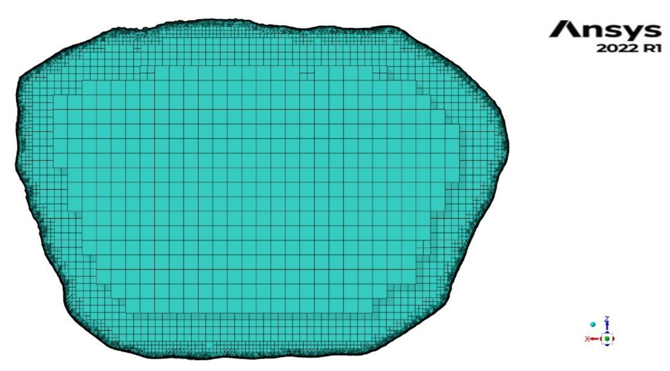

Figure 5. Hexcore mesh - cross-section

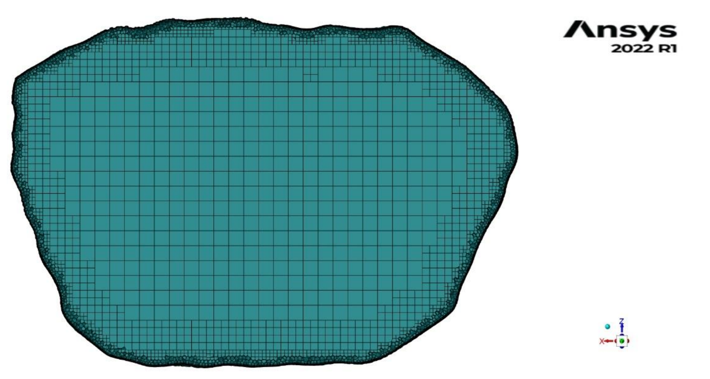

Figure 6. Poly-Hexcore mesh - cross-section

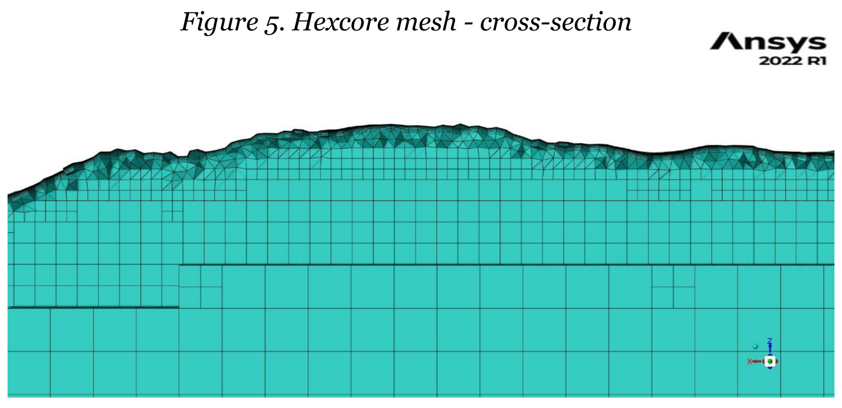

Figure 7. Hexcore mesh - view of boundary elements

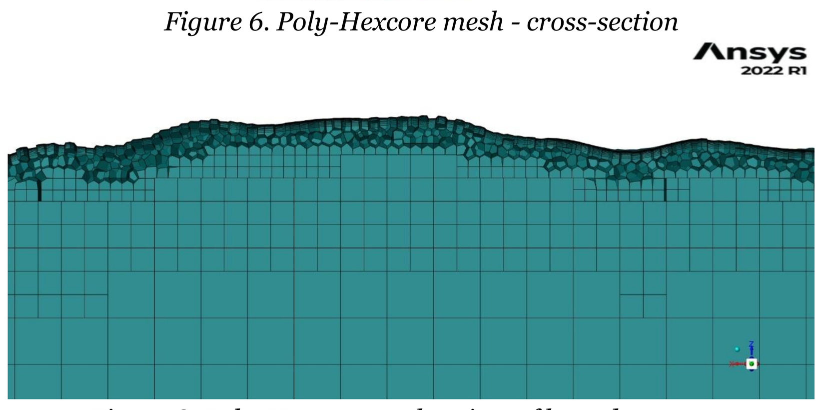

Figure 8. Poly-Hexcore mesh - view of boundary elements

Two test mesh models were developed in Ansys Fluent 2021r1 software. The meshes are shown in Figures 3, 4, 5, 6. The meshes are based on a surface mesh with the same parameters. However, the way they are made in volume is significantly different. Table 1. shows the parameters of the Hexa and Poly meshes . The Hexcore mesh is built from twice the number of elements compared to the Poly-Hexcore mesh. In addition, the preparation time of Poly-mesh is shorter by 40 percent compared with Hexa-mesh [3].

Table 1. Comparison of mesh parameters and preparation time.

Type of mesh	Hexcore	Poly-Hexcore
Number of elements	11625040	5606780
Elements size	$2\cdot10^{-2}$ - $2.5\cdot10^{-1}$ [m]	$2\cdot10^{-2}$ - $2.5\cdot10^{-1}$ [m]
Boundary layer thickness	$2.7\cdot10^{-2}$ [m]	$2.7\cdot10^{-2}$ [m]
First layer	$6.8\cdot10^{-4}$ [m]	$6.8\cdot10^{-4}$ [m]
Number of prism layers	12	12
Orthogonal Quality (minimum quality)	0.32	0.38
Skewness (maximum quality)	0.68	0.70
Preparation time	10h (on 8 core processor)	6h (on 8 core processor)

Results

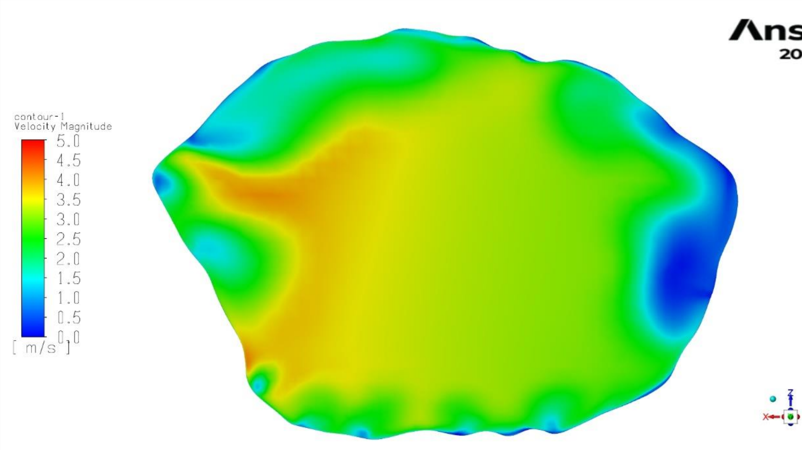

Figure 9. Hexcore mesh - velocity field at 15 [m]

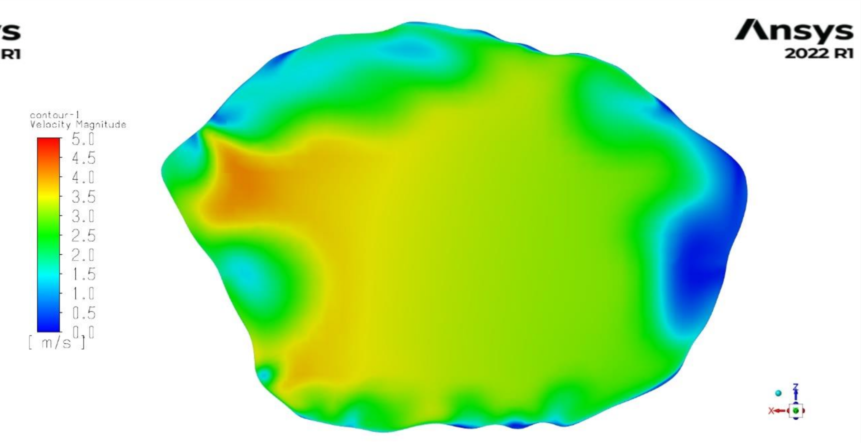

Figure 10. Poly-Hexcore mesh - velocity field at 15 [m]

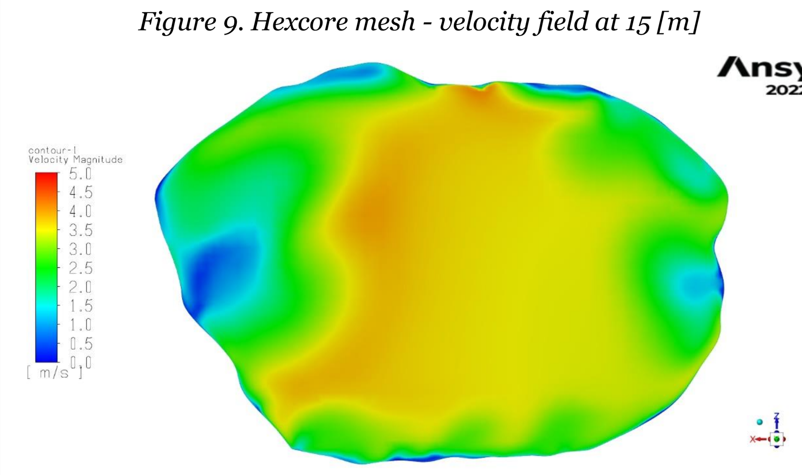

Figure 11. Hexcore mesh - velocity field at 20 [m]

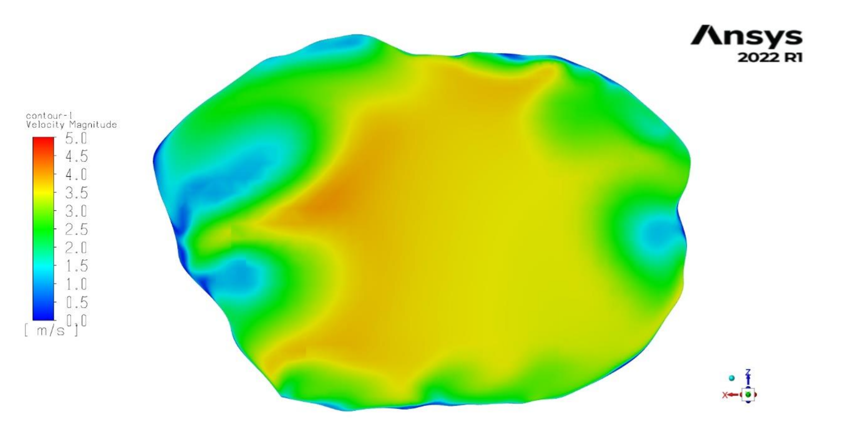

Figure 12. Poly-Hexcore mesh - velocity field at 20 [m]

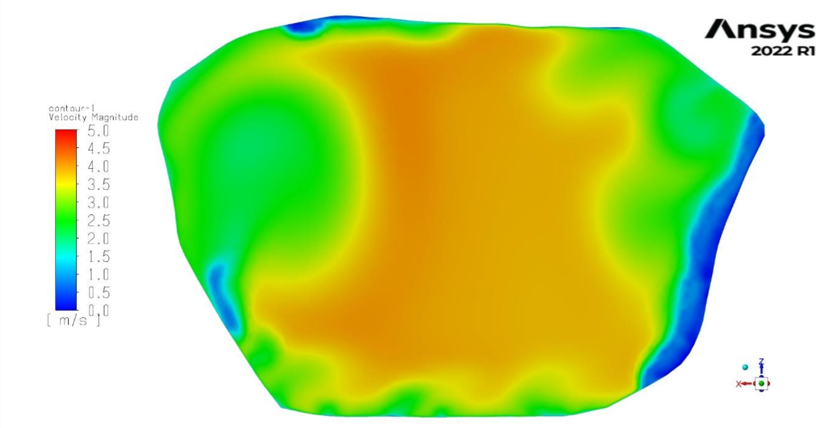

Figure 13. Hexcore mesh - velocity field at outlet

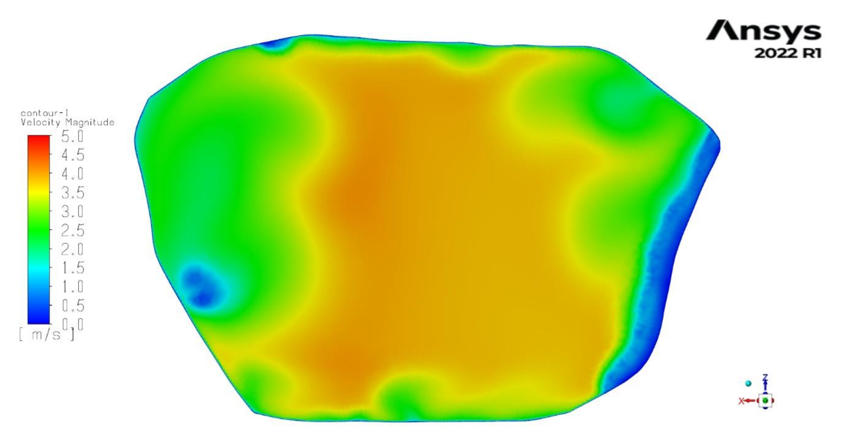

Figure 14. Poly-Hexcore mesh - velocity field at outlet

Table 2. Simulation results for Hexcore and Poly-Hexcore mesh type.

Type of mesh	Hexcore	Poly-Hexcore
Average velocity in the computational domain	3.03 [m/s]	3.02 [m/s]
Average velocity in 15 [m]	2.80	2.79
Average velocity in 20 [m]	3.03	3.02
Average velocity in outlet	3.23	3.23
Computation time	5h (on 32 core processor)	4h (on 32 core processor)

A k-omega SST turbulence model was applied for a simulation with an air velocity of 3 m/s set. The results are presented in Table 2 and Figures 9-13. Very similar results were obtained by utilization of Hexcore and Poly-Hexcore meshes. The difference in average air velocity values in the domain is very small and can be treated as a measurement error. Similar results of the velocity field were also obtained in cross-sections at each of the considered stages of the excavation length. The simulation results show that these meshes allow simulations to be performed with similar accuracy. However, the Poly-Hexcore type mesh allows the results to be obtained in a shorter computation time. Utilization of a more modern type of mesh makes work more dynamic, which is of particular importance when conducting numerical simulations of air distribution in large and complex computational domains.

Acknowledgements

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Digital Mining Center

VOT3D Ventilation Optimizing Technology based on 3D-scanning

Supported by eit RawMaterials Connecting matters

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References

[1] Zawślak, M. Method of Fluid-Flow Machinery and Systems Design and Modernisation by Computational Fluid Dynamics Application; Publishing house of the Poznan University of Technology **2017**

[2] Wróblewski, A.; Macek, A.; Banasiewicz, A.; Gola, S.; Zawiślak, M.; Janicka, A. CFD Analysis of the Forced Airflow and Temperature Distribution in the Air-Conditioned Operator's Cabin of the Stationary Rock Breaker in Underground Mine under Increasing Heat Flux. Energies **2023**, 16, 3814.

[3] Zore, K.; Sasanapuri, B.; Parkhi, G.; Varghese, A. Ansys mosaic poly-hexcore mesh for high-lift aircraft configuration. In Proceedings of the 21st AeSI Annual CFD Symposium, Bangalore, India, 8–9 August **2019**