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Optimal Sizing of the Evaporation Chamber in the Low-Flow Aerothermopressor for a Combustion Engine

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Abstract

The efficiency of gas turbine plants will be improved by cooling the cyclic air with an aerothermopressor. Constructive and technological factors affecting the aerothermopressor work were considered in this paper. CFD simulation and calculation of the water evaporation process in the evaporation chamber (working chamber) of the aerothermopressor was carried out. The Eulerian–Lagrangian approach was used to simulate the interaction of water droplets injected and airflow. The developed software was used in order to determine the characteristics of the aerothermopressor workflow. It is based on the methods of calculating thermogasdynamic compression and pressure losses due to the aerodynamic resistance of the two-phase flow in the aerothermopressor flow part. An empirical equation has been determined for calculating the optimal relative length of the aerothermopressor evaporation chamber depending on the initial droplet diameter at the inlet and the mass water concentration in the airflow. Analytical determination of the optimal relative length of the aerothermopressor evaporation chamber allows determining the length section of the evaporation chamber in order to obtain the maximum value of pressure increase, as a result of thermogasdynamic compression.

Keywords

CFD simulation Pressure increase Two-phase flow

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References

1. Chaker, M.: Key Parameters for the performance of impaction-pin nozzles used in inlet fogging of gas turbine engines. In: Proceedings of GT2005 ASME Turbo Expo: Power for Land, Sea and Air, pp. 1–7. Reno-Tahoe, Nevada, USA (2005)
Google Scholar (https://scholar.google.com/scholar?q=Chaker%2C%20M.%3A%20Key%20Parameters%20for%20the%20performance%20of%20impaction-pin%20nozzles%20used%20in%20inlet%20fogging%20of%20gas%20turbine%20engines.%20In%3A%20Proceedings%20of%20GT2005%20ASME%20Turbo%20Expo%3A%20Power%20for%20Land%2C%20Sea%20and%20Air%2C%20pp.%201%E2%80%937.%20Reno-Tahoe%2C%20Nevada%2C%20USA%20%282005%29)

2. Radchenko, A., Bohdal, L., Zongming, Y., Portnoi, B., Tkachenko, V.: Rational designing of gas turbine inlet air cooling system. In: Tonkonogyi, V., et al. (eds.) Advanced Manufacturing Processes. InterPartner-2019. Lecture Notes in Mechanical Engineering, pp. 591–599. Springer, Cham (2020)
Google Scholar (https://scholar.google.com/scholar?q=Radchenko%2C%20A.%2C%20Bohdal%2C%20L.%2C%20Zongming%2C%20Y.%2C%20Portnoi%2C%20B.%2C%20Tkachenko%2C%20V.%3A%20Rational%20designing%20of%20gas%20turbine%20inlet%20air%20cooling%20system.%20In%3A%20Tonkonogyi%2C%20V.%2C%20et%20al.%20%28eds.%29%20Advanced%20Manufacturing%20Processes.%20InterPartner-2019.%20Lecture%20Notes%20in%20Mechanical%20Engineering%2C%20pp.%20591%E2%80%93599.%20Springer%2C%20Cham%20%282020%29)

3. Lin, A., et al.: Evaluation of mass injection cooling on flow and heat transfer characteristics for high-temperature inlet air in a MIPCC engine. Int. J. Heat Mass Transf. **135**, 620–630 (2019)
CrossRef (https://doi.org/10.1016/j.ijheatmasstransfer.2019.02.025)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Evaluation%20of%20mass%20injection%20cooling%20on%20flow%20and%20heat%20transfer%20characteristics%20for%20high-temperature%20inlet%20air%20in%20a%20MIPCC%20engine&author=A.%20Lin&journal=Int.%20J.%20Heat%20Mass%20Transf.&volume=135&pages=620-630&publication_year=2019)

4. Konovalov, D., Trushliakov, E., Radchenko, M., Kobalava, H., Maksymov, V.: Research of the aerothermopressor cooling system of charge air of a marine internal combustion engine under variable climatic conditions of operation. In: Tonkonogyi, V. et al. (eds.) Advanced Manufacturing Processes. InterPartner 2019. Lecture Notes in Mechanical Engineering, pp. 520–529. Springer, Cham (2020)
Google Scholar (https://scholar.google.com/scholar?q=Konovalov%2C%20D.%2C%20Trushliakov%2C%20E.%2C%20Radchenko%2C%20M.%2C%20Kobalava%2C%20H.%2C%20Maksymov%2C%20V.%3A%20Research%20of%20the%20aerothermopressor%20cooling%20system%20of%20charge%20air%20of%20a%20marine%20internal%20combustion%20engine%20under%20variable%20climatic%20conditions%20of%20operation.%20In%3A%20Tonkonogyi%2C%20V.%20et%20al.%20%28eds.%29%20Advanced

%20Manufacturing%20Processes.%20InterPartner%202019.%20Lecture%20Notes%20in%20Mechanical%20Engineering%2C%20pp.%C2%A0520%E2%80%92529.%20Springer%2C%20Cham%20%282020%29)

5. Bohdal, T., Sikora, M., Widomska, K., Radchenko, A.M.: Investigation of flow structures during HFE-7100 refrigerant condensation. Arch. Thermodyn. **36**(4), 25–34 (2015)
Google Scholar (https://scholar.google.com/scholar?q=Bohdal%2C%20T.%2C%20Sikora%2C%20M.%2C%20Widomska%2C%20K.%2C%20Radchenko%2C%20A.M.%3A%20Investigation%20of%20flow%20structures%20during%20HFE-7100%20refrigerant%20condensation.%20Arch.%20Thermodyn.%2036%284%29%2C%2025%E2%80%9334%20%282015%29)

6. Jonsson, M., Yan, J.: Humidified gas turbines – a review of proposed and implemented cycles. Energy **30**, 1013–1078 (2005)
CrossRef (https://doi.org/10.1016/j.energy.2004.08.005)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Humidified%20gas%20turbines%20%E2%80%93%20a%20review%20of%20proposed%20and%20implemented%20cycles&author=M.%20Jonsson&author=J.%20Yan&journal=Energy&volume=30&pages=1013-1078&publication_year=2005)

7. Stepanov, I.R., Chudinov, V.I.: Some Problems of Gas and Liquid Motion in the Channels and Pipelines of Power Plants. The Science Publ., Leningrad (1977)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Some%20Problems%20of%20Gas%20and%20Liquid%20Motion%20in%20the%20Channels%20and%20Pipelines%20of%20Power%20Plants&author=IR.%20Stepanov&author=VI.%20Chudinov&publication_year=1977)

8. Fowle, A.: An experimental investigation of an aerothermopressor having a gas flow capacity of 25 pounds per second. Massachusetts Institute of Technology, USA (1972)
Google Scholar (http://scholar.google.com/scholar_lookup?title=An%20experimental%20investigation%20of%20an%20aerothermopressor%20having%20a%20gas%20flow%20capacity%20of%2025%20pounds%20per%20second&author=A.%20Fowle&publication_year=1972)

9. Bergman, T.L., et al.: Fundamentals of Heat and Mass Transfer, 7th edn. Wiley, New Jersey (2011)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Fundamentals%20of%20Heat%20and%20Mass%20Transfer&author=TL.%20Bergman&publication_year=2011)

10. Sirignano, W.A.: Fluid Dynamics and Transport of Droplets and Sprays, 2nd edn. Cambridge University Press, New York (2010)
CrossRef (https://doi.org/10.1017/CBO9780511806728)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Fluid%20Dynamics%20and%20Transport%20of%20Droplets%20and%20Sprays&author=WA.%20Sirignano&publication_year=2010)

11. ANSYS Fluent Tutorial Theory Guide Release 17.0.: ANSYS. Inc. Canonsburg (2016)
Google Scholar (https://scholar.google.com/scholar?q=ANSYS%20Fluent%20Tutorial%20Theory%20Guide%20Release%2017.0.%3A%20ANSYS.%20Inc.%20Canonsburg%20%282016%29)

12. Chen, Z., Xie, Q., Chen, G., Yu, Y., Zhao, Z.: Numerical simulation of single-nozzle large scale spray cooling on drum wall. Thermal Sci. **22**(1A), 359–370

(2018)
CrossRef (https://doi.org/10.2298/TSCI170920243C)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Numerical%20simulation%20of%20single-nozzle%20large%20scale%20spray%20cooling%20on%20drum%20wall&author=Z.%20Chen&author=Q.%20Xie&author=G.%20Chen&author=Y.%20Yu&author=Z.%20Zhao&journal=Thermal%20Sci.&volume=22&issue=1A&pages=359-370&publication_year=2018)

13. Korkodinov, Y.A.: An overview of the k-ε family of models for modeling turbulence. Mech. Eng. Mater. Sci. **5**(2), 5–16 (2013)
Google Scholar (http://scholar.google.com/scholar_lookup?title=An%20overview%20of%20the%20k-%CE%B5%20family%20of%20models%20for%20modeling%20turbulence&author=YA.%20Korkodinov&journal=Mech.%20Eng.%20Mater.%20Sci.&volume=5&issue=2&pages=5-16&publication_year=2013)

14. Nijdam, J.J., et al.: Lagrangian and Eulerian models for simulating turbulent dispersion and coalescence of droplets within a spray. Appl. Math. Modeling **30**, 1196–1211 (2006)
CrossRef (https://doi.org/10.1016/j.apm.2006.02.001)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Lagrangian%20and%20Eulerian%20models%20for%20simulating%20turbulent%20dispersion%20and%20coalescence%20of%20droplets%20within%20a%20spray&author=JJ.%20Nijdam&journal=Appl.%20Math.%20Modeling&volume=30&pages=1196-1211&publication_year=2006)

15. Jafarmadar, S., Jahangiramini, A.: Numerical simulation of flash boiling effect in a 3-dimensional chamber using computational fluid dynamic techniques. Int. J. Eng. **29**(5), 87–95 (2016)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Numerical%20simulation%20of%20flash%20boiling%20effect%20in%20a%203-dimensional%20chamber%20using%20computational%20fluid%20dynamic%20techniques&author=S.%20Jafarmadar&author=A.%20Jahangiramini&journal=Int.%20J.%20Eng.&volume=29&issue=5&pages=87-95&publication_year=2016)

16. Montazeri, H., Blocken, B., Hensen, J.: Evaporative cooling by water spray systems: CFD simulation, experimental validation and sensitivity analysis. Build. Environ. **83**, 129–141 (2015)
CrossRef (https://doi.org/10.1016/j.buildenv.2014.03.022)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Evaporative%20cooling%20by%20water%20spray%20systems%3A%20CFD%20simulation%2C%20experimental%20validation%20and%20sensitivity%20analysis&author=H.%20Montazeri&author=B.%20Blocken&author=J.%20Hensen&journal=Build.%20Environ.&volume=83&pages=129-141&publication_year=2015)

17. Konovalov, D., Kobalava, H., Radchenko, M., Scurtu, I.C., Radchenko, R.: Determination of hydraulic resistance of the aerothermopressor for gas turbine cyclic air cooling. In: 9th International Conference on Thermal Equipments, Renewable Energy and Rural Development (TE-RE-RD 2020), Constanta, Romania. E3S Web Conference, vol. 180, article no. 01012 (2020)
Google Scholar (https://scholar.google.com/scholar?q=Konovalov%2C%20D.%2C%20Kobalava%2C%20H.%2C%20Radchenko%2C%20M.%2C%20Scurtu%2C%20I.C.%2C%20Radchenko%2C%20R.%3A%20Det

ermination%20of%0Ahydraulic%20resistance%20of%20the%20aerothermopressor%20for%20gas%20turbine%20cyclic%20air%20cooling.%20In%3A%209th%20International%0AConference%20on%20Thermal%20Equipments%2C%20Renewable%20Energy%20and%20Rural%20Development%20%28TE-RE-RD%202020%29%2C%0AConstanta%2C%20Romania.%20E3S%20Web%20Conference%2C%20vol.%20180%2C%20article%20no.%2001012%20%282020%29)

18. Vulis, L.A.: Gas Flow Thermodynamics. Gosenergoizdat, Moscow (1950). [in Russian]
Google Scholar (http://scholar.google.com/scholar_lookup?title=Gas%20Flow%20Thermodynamics&author=LA.%20Vulis&publication_year=1950)

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