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KARYA ILMIAH : JURNAL ILMIAH

Judul Artikel Ilmiah : Turbulent Flow Analysis in Auxiliary Cross-Flow Runner of a Proto X-3 Bioenergy Micro Gas Turbine using RNG k-ε Turbulence Model
 Nama Penulis : Steven D., Ahmad I. S., Budiarsa, Asyari D., AgusT. G., Achmad B. W. and **HartoTanujaya**
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Jakarta, 10.12. 2019
 Penilai I



(Prof. Dr. Ir. Agustinus Purna Irawan)
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 Jabatan/Pangkat/Bidang Ilmu: Professor/IVC/Teknik Mesin
 Unit Kerja: Fakultas Teknik – Universitas Tarumanagara

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Jakarta, 18.12. 2019
Penilai I



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Unit Kerja: Fakultas Teknik – Universitas Tarumanagara

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Jakarta, 14-11-2019

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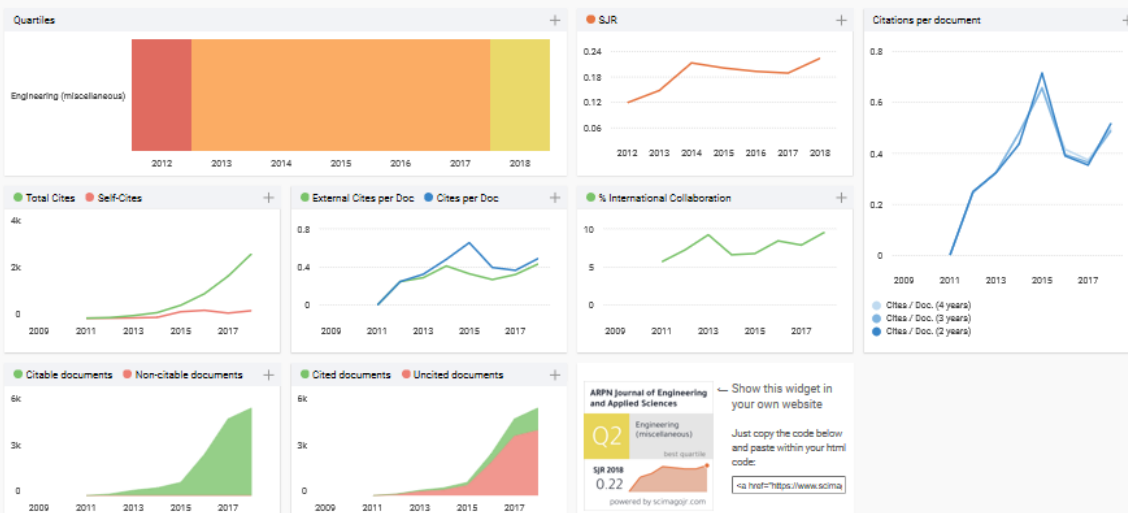
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TURBULENT FLOW ANALYSIS IN AUXILIARY CROSS-FLOW RUNNER OF A PROTO X-3 BIOENERGY MICRO GAS TURBINE USING RNG k-ε TURBULENCE MODEL

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¹Department of Mechanical Engineering, Universitas Indonesia, Depok, Jawa Barat, Indonesia
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ABSTRACT
 Simple and wide range application of cross-flow runner has had its application in a Proto X-3 Bioenergy Micro Gas Turbine (MGT) that has been developed. The MGT is a dual-stage radial compressor-turbine type. Furthermore, highly turbulent flow inside the cross-flow fan need accurate analysis. CFD method with RNG k-ε chosen based on model characteristics. This paper analyzed the flow inside the fan based on the experimental data of the MGT and the result represented by several parameters of turbulent flow. The simulation condition were assumed to be isothermal due to the small temperature difference with the inlet (Prandtl number $Pr_t = 1$). The result shows several specific vortex inside the runner. Recirculation flow often caused the eccentric vortex occurs at the inner side while the throughflow occurs at the outside of the fan. The mass flow rate calculated by CFD simulation shows a good agreement with the actual mass flow rate of the cross-flow runner. The results that presented by velocity magnitude, absolute pressure, static dissipation, and turbulent kinetic energy shows a realistic on each turbulent parameter based on they trends. This results shows that the method used is prospective to be applied both on analysis or design of the cross-flow runner.

Keywords: cross-flow runner, MGT, turbulent flow, RNG k-ε turbulence model, recirculation vortex

INTRODUCTION

Cross-flow runner (CFR, hereafter) is a atmospheric radial turbine that generates power by converting kinetic energy to mechanical energy which based on turbo machine (cross-flow turbine) [1]. CFR system consist of two main components: the runner itself and the matrix with square cross-section. CFR design based on three main characteristics: simple construction, low-work, and maximum efficiency and has been proposed as Renewable Energy Sources (RES) for under 3MW hydroelectric generation system [2], [3]. This characteristics has led the application of CFR as power extractor of a Proto X-3 Bioenergy Micro Gas Turbine (MGT) prototype that has been developed which is a challenge compressor-turbine [4]. The CFR was driven by the inlet air of the first stage compressor. The high flow air to first stage made it possible to drive the cross-flow fan. Basically, MGT is developed for small power generation up to 700 kW [4], [6]. Some of the advantages of this MGT are high power to weight ratio, high tolerance to many kind of liquid and gaseous fuels and low-cost has made this price more suitable to be used in zero energy turbine-based [7-10].

During the operation, in a turbomachine, the suction and discharge of CFR occurs radially, generated highly turbulent flow for recirculating and reserve flow [1]. Many experimental and numerical analysis shows the flow complexity of CFR. Experimental study by numbers of researchers has lead to development of two main vortex inside the CFR, throughflow at the outside region and recirculation flow at the inside region [11]-[17].

Modeling and costly experiment as well as the simulation has made numerical method also conducted on fan design with many turbulence model. Karimci use RNG k-ε found the throughflow as well as the recirculation flow [18]. Chang use CFD for numerical analysis the flow of CFR [19]. RNG k-ε also used by Tullio [2005] [16], Hiron et al in 2008 use S11 k-ε [20]. The current numerical analysis by Sun et al also RNG k-ε turbulence model for cross-sectional flow [17]. These numerical results show there are two main vortices occur in CFR: the eccentric vortex at recirculation region and vortex in the throughflow region. Since the flow inside the CFR is unsteady turbulent, flow analysis of turbulent flow with suitable turbulence model is needed to analysis and can be used for future development of the CFR system. Despite the S11 k-ε is the most widely used turbulence model, this model also reported since that model is overpredicts the dissipation rate [21-24]. RNG k-ε turbulence model developed by Yakhot & Orszag [25] for recirculating flow has become alternatives in predict such flows [26], [27].

The aim of this paper is to analyze numerically the flow inside the cross-flow runner with RNG k-ε turbulence model since this model is developed to such flow. The turbulent momentum diffusivity and turbulent thermal diffusivity is also assumed to be equal ($Pr_t = 1$) and the default constant to the Yakhot & Orszag model was used. Optimal flow characteristics of cross-flow runner on Proto X-3 can be used to optimized the system to be a compact power source system.