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Design and Development of A Vertical Wind Turbine Using Slow Wind Speed for Mini Power Generation

By

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Wind energy can be changed into other forms of energy, either mechanical or electrical energy. To convert the kinetic energy into electricity, the wind turbines, which consists rotor blades, shaft and electricity generator is needed. Rotor blade is the most important part because when the wind forces the blades to move, it will transfer most of its energy to the rotor. Then the rotor transfers its mechanical, rotational energy to the shaft, whereby it is connected to the center of the rotor before enters an electrical generator on the other end. The aim of this study is to investigate the possibility of improving wind energy capture, under low wind speed conditions using various blade configurations. This paper deals with the results of the first part of the study which is the development of the methodology using physical test rig and computer modeling using commercial computational fluid dynamics (CFD) code. This study focuses mainly on analyzing the efficiency of the energy conversion and torque coefficients in relation to the tip speed ratio of wind turbine. For the overall performance, the results show that the output power produced by the wind turbine has great potential to be used in the slow wind region in the range of 5 to 10 km/hr.

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Problem Statements:

- Most South East Asian Countries located under low wind speed zone
- In Malaysia, average wind speed is 2.8 m/s
- The total energy of this slow speed energy is quite significant to be neglected although it is very much lower than those in temperate countries
- Quantity and quality of wind turbine could compesate this wind speed defficiency

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Research Methodology:

- Concept Design Generation
  - Analytical Method
  - Graphical Method

- Engineering Analysis

  CFD and Ansys

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ANALYTICAL METHOD

Kinetic energy formula:

$P_w = ½\ \rho\vartheta^3 A = P_w = ½\ mV^2$

Power Coefficient formula:

$P_{ex} = C_p ½\ \rho AV^3$ for practical wind turbine,

the usual range of C_p is in the range of $0 \leq C_p \leq 0.4$

Torque Formula:

$T_t = \{ P_{ex}[2] \}/ w_t$

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GRAPHICAL METHOD

This method is mainly illustration based. As for this project, the graphical representation of the wind turbine is by using computer aided design drawing. The 3 D or solid modeling done by SOLIDWORK cad software for superior part and assembly modeling, drafting, transparent data management and built in finite element analysis.

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ENGINEERING METHOD

Computational Fluid Dynamic (CFD) is one of the branches of fluid mechanics that uses numerical methods and algorithms to solve and analyze problems that involved fluid flows. Computer are used to performed calculation required to simulate interaction of liquid and gas with surfaces defined by boundary conditions. The software used to perform this task is ANSYS FLUENT Flow Modeling Software.

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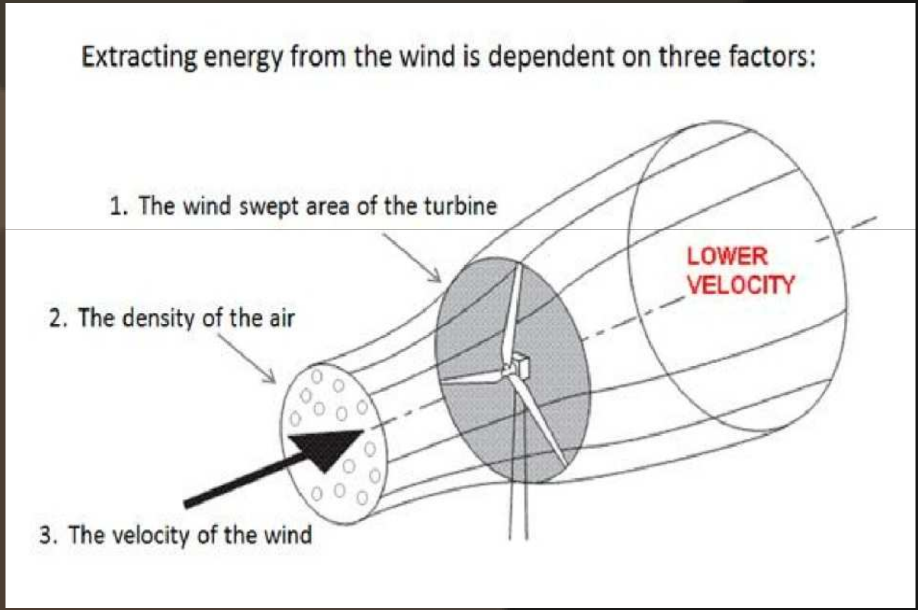

Literature Review

The energy that is contained in the wind is dependent on Three factors:

- The density of the air,
- The cross-sectional area the wind blows through,
- Speed/velocity of the wind.

Energy increases in cube of wind speed. Therefore, doubling wind speed increases energy generation by factor 8. The latest technology can capture up to maximum 59% of wind energy

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To capture the wind energy we need:

- Device to touch and trap the wind
- Using lifting based on bernoullie principal
- Using air drag principal
- Gear train to convert linier kinetic energy of the wind to torsional energy at the turbine blade axis and then to electrical generator
- Tribological device to increase efficiency

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RESULTS OF ANALYTICAL ANALYSIS

Referring to the analysis Table

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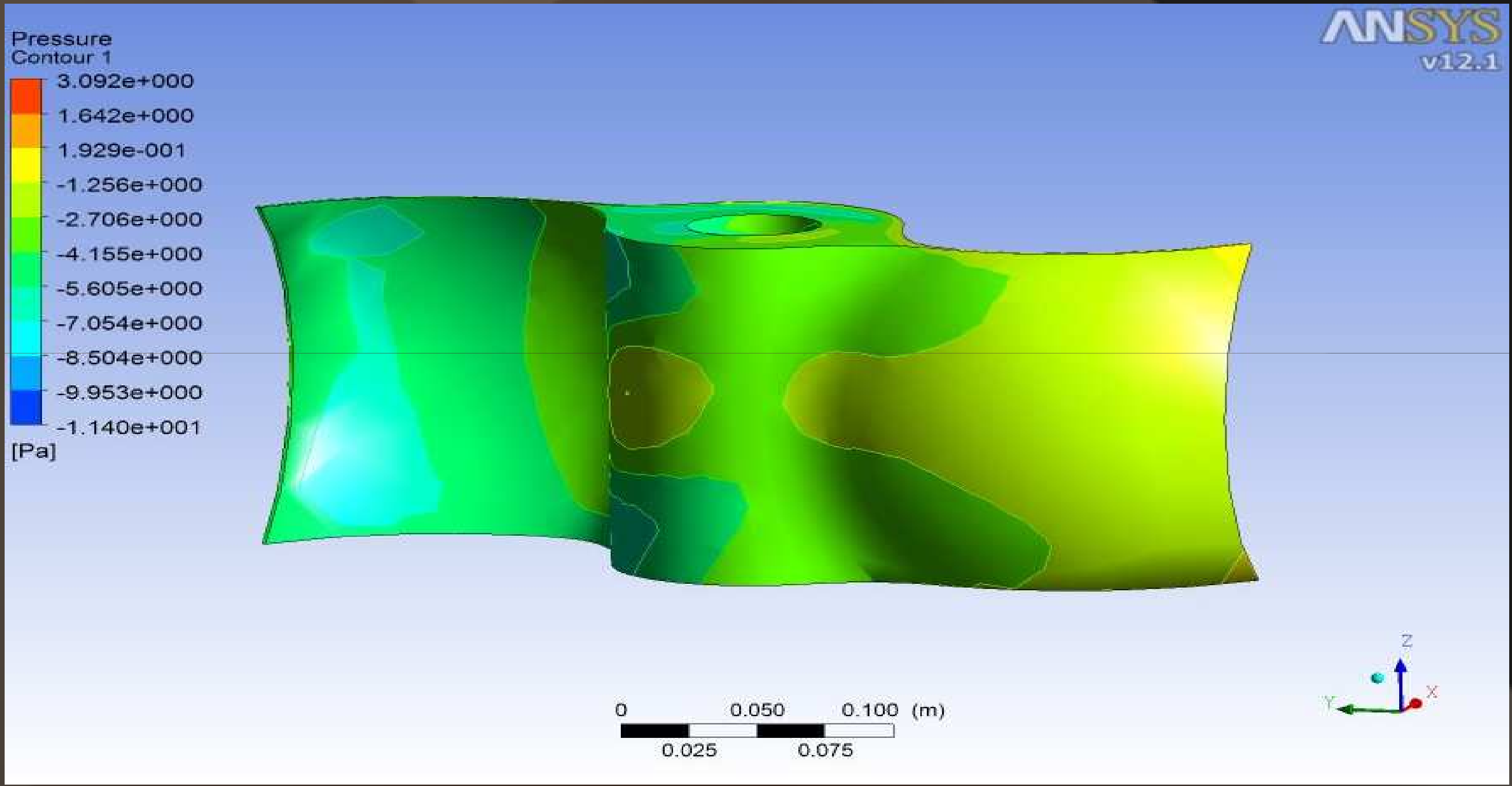
RESULTS OF ENGINEERING GRAPHICAL SIMULATION USING ANSYS



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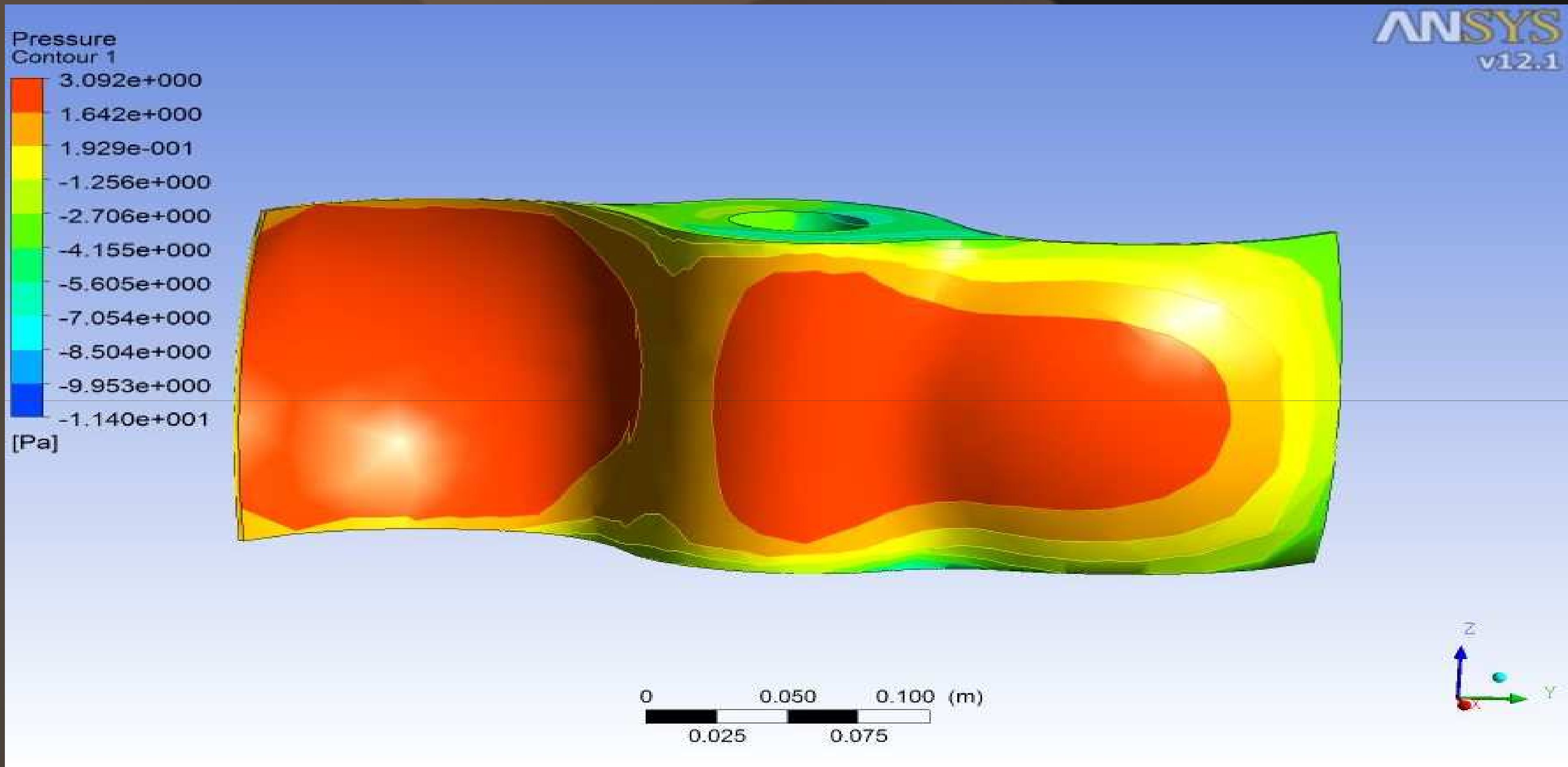

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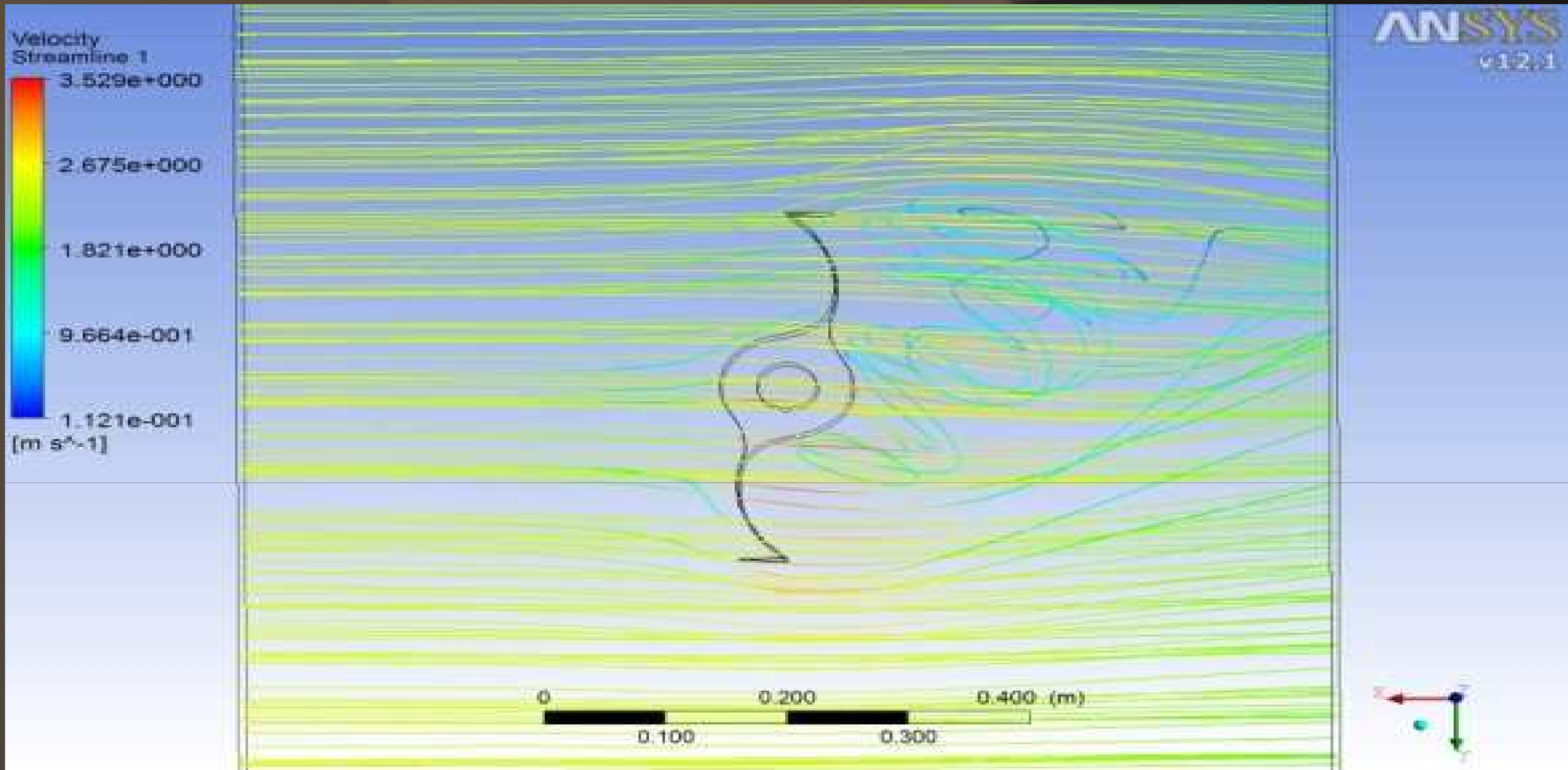
RESULTS OF VELOCITY SIMULATION



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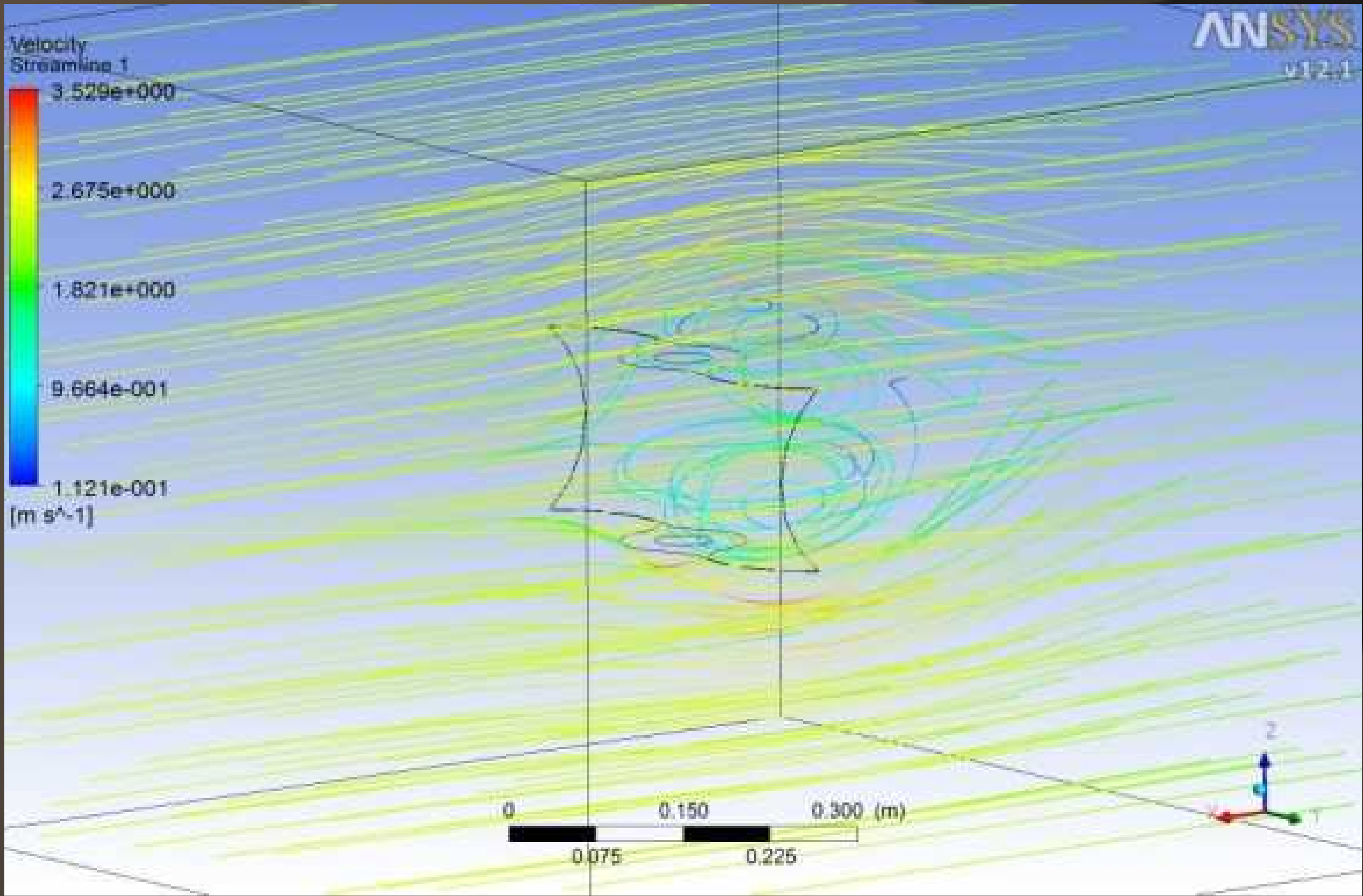

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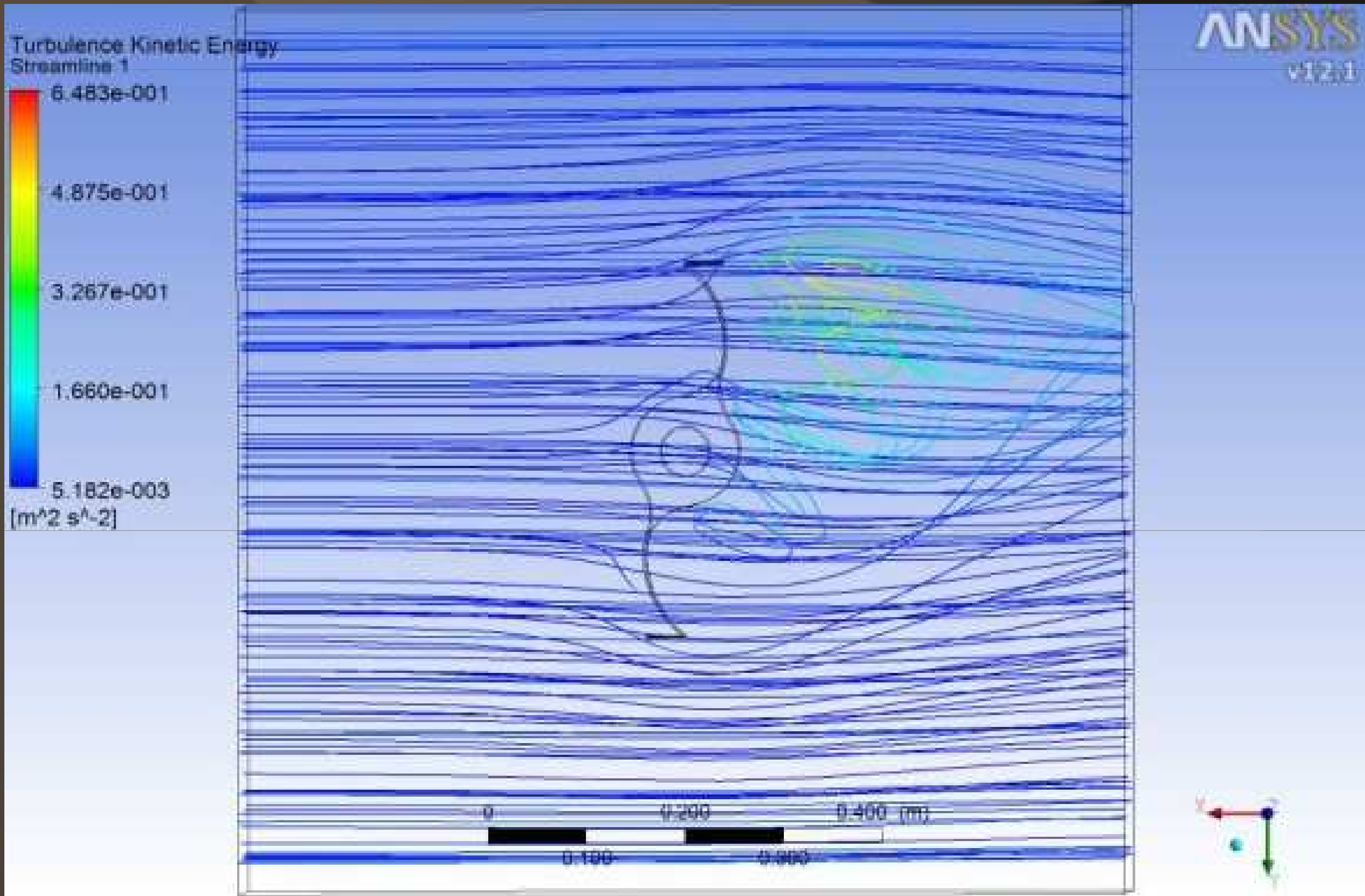
RESULTS OF TURBULENCE SIMULATION



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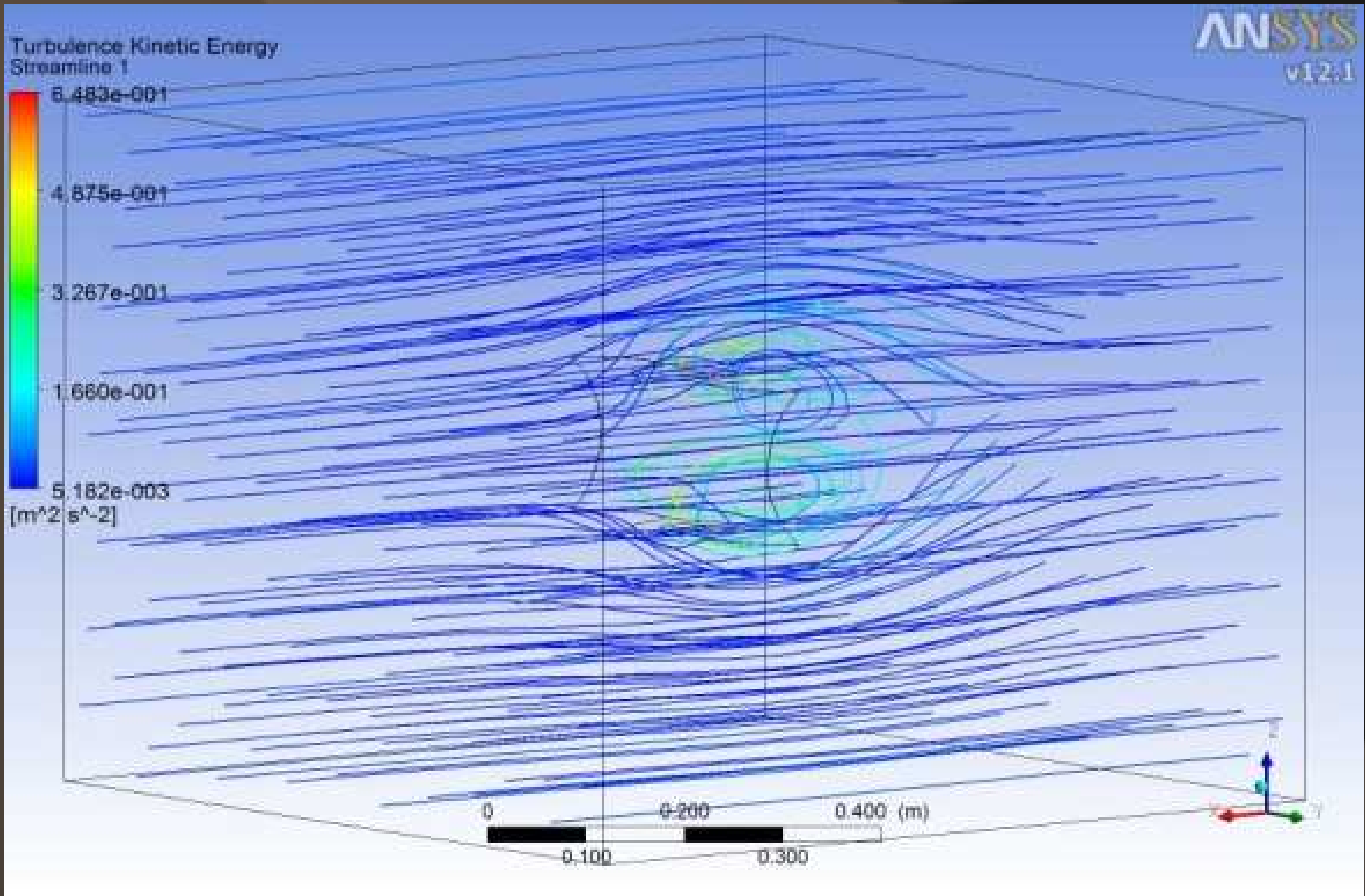
RESULTS OF VELOCITY SIMULATION



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CONCLUSION

From the results obtained it is found the the design can work for the slow speed range of wind of about 2.5 to 2.9 m/s. This mean that the research has achieved its importance objectives to design a wind turbine that can work in the slow wind speed zone like Malaysia. It is found that wind turbine of 2 blade design with 2,461.54 diameter is more acceptable as it has the optimum performance. This design has the performance Coefficient C_p of 0.324 which is in the best range of 0 to 0.4. The design is further endorsed by it tip speed ratio of 0.9967. The selected wind turbine is calculated to harness 8.8824 watt of power from the wind at 2.5 m/s speed with the maximum power of 24.4148 watts at 2.9 m/s wind speed.