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# Does Number Changes of Open Manometers Filled with Pure Water Impact Wind Speeds in Venturi Tube Systems?

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**KEYWORDS**

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**ABSTRACT**

Fluid flow in a venturi tube (VT) is a dynamic fluid phenomenon that plays an important role in human life. Flow safety control is necessary by installing several manometers of open (MoO) containing static fluid. The study's purpose was to know the change impacts of the number of installed MoOs against flow speed characters within VTs from conditions of 1 to 2 MoOs. The research uses experimental methods. The main research equipment includes 1 blower-rheostat system, 1 VT with 8 different diameters, and 2 MoOs containing pure water. Data analysis was done using SPSS. Within measurement intervals of $4\ \Omega \le R \le 281\ \Omega$ and $4.58\text{ cm} \le d \le 9.45\text{ cm}$, the study showed the comparison of the mean of wind speed, wind speed gradient to R (d fixed), convergent wind speed gradient to d (R fixed), and divergent wind speed gradient to d (R fixed) between 1-MoO and 2-MoO type, respectively, were1.21E+01 $ms^{-1}$ vs 1.55E+01 $ms^{-1}$, -2.73E-02 $ms^{-1}\Omega^{-1}$ vs -4.11E-02 $ms^{-1}\Omega^{-1}$, -3.13E+02 $s^{-1}$ vs -4.25E+02 $s^{-1}$, and -4.31E+02 $s^{-1}$ vs -4.84E+02 $s^{-1}$. While its impact differences are insignificant, insignificant, significant, and insignificant, respectively.

## 1. INTRODUCTION

VT is a tubular dynamic fluid channel, starting with a narrowed cross section and ending with an expanded cross section, so there are narrowed, throat, and expanded cross section types [1]. VT principle is very widely applied in various applications related to improving the quality of human life. This application does not only occur at the household level but also at the industrial level is very massive. There are utilizations of VT vacuum pumps at small and medium industrial levels for the processing of food products [2]. There are applications of venturi scrubbers to reduce soot emissions on direct injection diesel engines [3]. There is also utilization of the VT principle for moving clean water to a planned site [4] and controlling pond water in fishery cultivation [5].

MoO is a U-shaped glass tube containing a static-liquid fluid where end tubes connected to open or closed spaces containing static fluid and, or dynamic fluid of different types [6]-[8]. MoO's fundamental principle is pressure can measure if the liquid surface height difference between columns of MoO arms has occurred. It refers to concepts where when liquids in MoOs are in static equilibrium, each liquid particle has the same pressures if the position vertically of each particle is the same [9]-[11]. Height differences seen as causing its pressure difference or vice versa. MoO has implemented in various fields, including industries, laboratories, and others. As a measuring instrument, MoOs used for measuring fluid pressure in closed systems. In machining, MoOs are used to monitor pressure in pipes and tanks, both analog and digital [12].

Pressure drops in a VT are always balanced by an increase in flow speed or vice versa. This concept is according to energy conservation laws or Bernoulli equations [13]-[14]. In each MoO, the static fluid surface height differences result from the pressure difference between the upper parts of static fluid surfaces at its two columns. The chamber at the top of static fluid surfaces can conditioned to connect with VTs for fluid flow channels. Correlations of dynamic fluid pressures and static fluid surface height differences from column arms of MoO can formulated, immediately.

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Function MoO basics on VT is for converting dynamic fluid kinetic energy to static fluid Earth's gravitational potential energy. MoO is a U-shaped pipe containing with certain types of liquids where a one end can be conditionedis closed and open another. Closed means connected to dynamic fluids within VT so that dynamic fluids can interact directly with static fluids within MoO s. Changes in installed MoO numbers mean changes in energy conversion site numbers. The more MoO installed, the more produced to Earth's Gravity potential energy for each filler from MoO. On the other hand, dynamic fluid kinetic energy comes from one source and only flows through one channel VTs. Kinetic energy also represents dynamic fluid flow speeds in VT, where the flow speed squared is directly proportional to the kinetic energy [13]-[14].

This study aims to know the impacts of changes in the number of MoOs installed on dynamic fluid speed characters on the VT system. Impacts of change will be verified at each reference point or position where one end of the MoO is attached. Walls of area VT in which MoO tips are attached vary in diameter (d). Dynamics fluid kinetic energy per unit time or dynamics fluid mechanic power is too conditioned changes and sources from an electric power with varying electric resistance (R). Research on several values of d and R is expected to verify the impact changes in the number of installed MoOs on the character of the dynamic fluid flow speed comprehensively. However, for mathematical analysis, research scopes are still limited to ideal fluids.

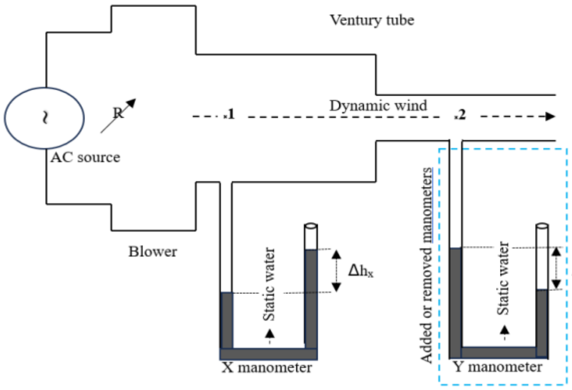


**Fig. 1.** Equipment Design

Wind flow phenomenons within a VT-MoO system where d varies, and pure waters fill each MoO are shown in Figure 1. Theoretically, it is stated that if d increases, pressure winds increase too, but speed winds decrease [15-18]. Relations between pressure and speed winds within VT satisfy Bernoulli's equation, for ideal fluids is:

$$p_1 + \tfrac{1}{2}\rho_{wi}v_1^2 = p_2 + \tfrac{1}{2}\rho_{wi}v_2^2 \qquad (1)$$

where $p_1$ and $p_2$ are pressure winds at reference sections 1 and 2; $v_1$ and $v_2$ are speed winds at reference sections 1 and 2; and $\rho_{wi}$ is density winds.

Relations of speed winds and cross-sectional d satisfy continuity equations, for an ideal fluid is:

$$v_1{d_1}^2 = v_2{d_2}^2 \qquad (2)$$

where $d_1$ and $d_2$ are cross-sectional d of references 1 and 2. Static waters in column MoO-Xs satisfy Bernoulli's equation with formulations:

$$p_1 = p_0 + \rho_{wa}g\Delta h_x \qquad (3).$$

where po is pressures of outside air; p1 in addition to meaning pressure winds at reference cross-section 1, also means pressure on surface waters along column MoO-Xs closed; g is Earth's gravitational acceleration; and Δhx is differences in water surface height between column MoO-Xs. Δhx is positive if surface waters in the closed pipe column are higher than open. It means air outside presses surface waters more strongly than winds. Phenomenons experienced by water in the closed MoO-Y column and the open MoO-Y column fulfill Bernoulli's equation with formulations:

$$p_2 = p_0 + \rho_{wa}g\Delta h_y \qquad (4)$$

where $p_2$ is pressure winds at reference cross-section 2 or pressures on the water surface along column MoO-Ys closed; and $\Delta h_y$ is differences of height between surface waters in column MoO-Ys closed and opens. $\Delta h_y$ is positive if air outside presses the water surface more strongly than wind.

Speed winds at each reference cross-section are formulated through application mathematics based on the equations above. Based on differences in water surface height at the 1st MoO columns and 2nd, speed winds at reference cross-section 1, fulfill formulations:

$$v_1 = \sqrt{\frac{2\rho_{wa}g(\Delta h_y - \Delta h_x)}{\rho_{wi}\left(1-\left(\frac{d_1}{d_2}\right)^4\right)}} \qquad (5)$$

Based on differences in water surface height at the 1st MoO columns and 2nd, speed winds at reference cross-section 2 fulfills formulation:

$$v_2 = \sqrt{\frac{2\rho_{wa}g(\Delta h_x - \Delta h_y)}{\rho_{wi}\left(\left(\frac{d_2}{d_1}\right)^4-1\right)}} \qquad (6)$$

When functions from MoO-Ys at reference cross-section 2 are eliminated, the consequences are equations (3) still apply but equations (2) and (4) do not apply. The formula of equation (1) becomes $p_1 + \tfrac{1}{2}\rho_{wi}v_1^2 = p_0$ and it appears that reference term 2 in equation (1) is replaced by the outside air pressure. These equation-based manipulations lead to a wind speed equation that applies to each reference cross-section where tips MoOs are attached with formulations:

$$v_1 = \sqrt{\frac{2\rho_{wa}g\Delta h_x}{\rho_{wi}}} \qquad (7)$$

Conceptual frameworks based on changing the number of MoOs from 2 to 1 are simplifying. In contrast to otherwise conditions, phenomenon winds within VT become more complicated. Conceptually, the characters of these two frameworks are not much different but require an experimental test to verify their impact on the wind speed characters at each reference cross-section, along wall VTs.

Based on equations (5) and (6), speed winds appear explicitly impacted by several factors involve differences in water surface height in column MoOs, fractions of water density to wind, Earth's gravitational acceleration, and fractions d of the two reference cross-sections Based on equation (7), the wind speed seems to be impacted by factors with a simpler structure but the same functions. Through research, applications of these three equations can verify impact changes in the number of MoOs on character wind speeds, regarding the use of each data pair type (d, R) in equipment. Resistance electrics of wind generator circuits composed from rheostat resistance and other components in systems. The function indirect of rheostat is to control the speed of winds. In form questions, problems of research are described as follows:

- Do additions MoOs to VTs significantly increase or decrease, or have no impact on speed wind, for each data pair type (d, R) studied?
- What are the wind speed change tendencies for each type of number of MoOs on VTs when R is increased but d is fixed? Does the number addition of MoOs have a significant impact on this tendency?
- What are the wind speed change tendencies of each type of number of MoOs on VTs, both when d VT conditioned narrowed (convergent flow) and widened (divergent flow) but R equipment is fixed? Does each change in the number of MoOs have a significant impact on this tendency?

## 2. METHODS

Research utilizes the Applied Physics Laboratory equipment, Bandung State Polytechnic. Activity of verifications are carried out through experiments. Experiments are measurements based on the best equipment design to obtain data in the form of related physical quantities, as planned. Experiments play an important role in building new theories or maintaining existing theories [19].

### 2.1 *Equipments*

The main equipment of study involve: 1) a wind generation system (blower) of AC sourced equipped with a rheostat to control power electric or power mechanics of winds, 2) 1 VT passed by winds and equipped eight observation points (each point equipped with a small copper pipe for air-water interaction site) that have different d's; and 3) 2 MoOs containing pure water. Its support equipment involve: 1) 5 silicone elastic hoses to connect VTs with MoOs and cover the measurement point walls when not in use, 2) 1 digital multimeter, 3) 1 tube lamp, and 4) length measuring instruments of ruler and caliper. Equipment designs are shown in Figure 1.

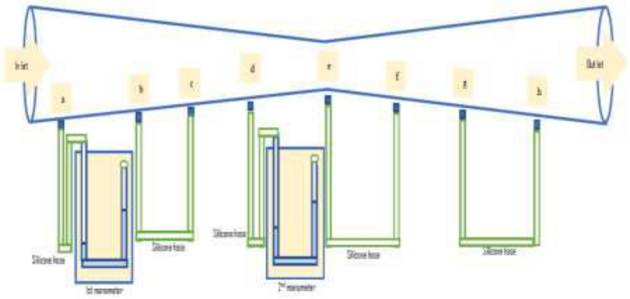
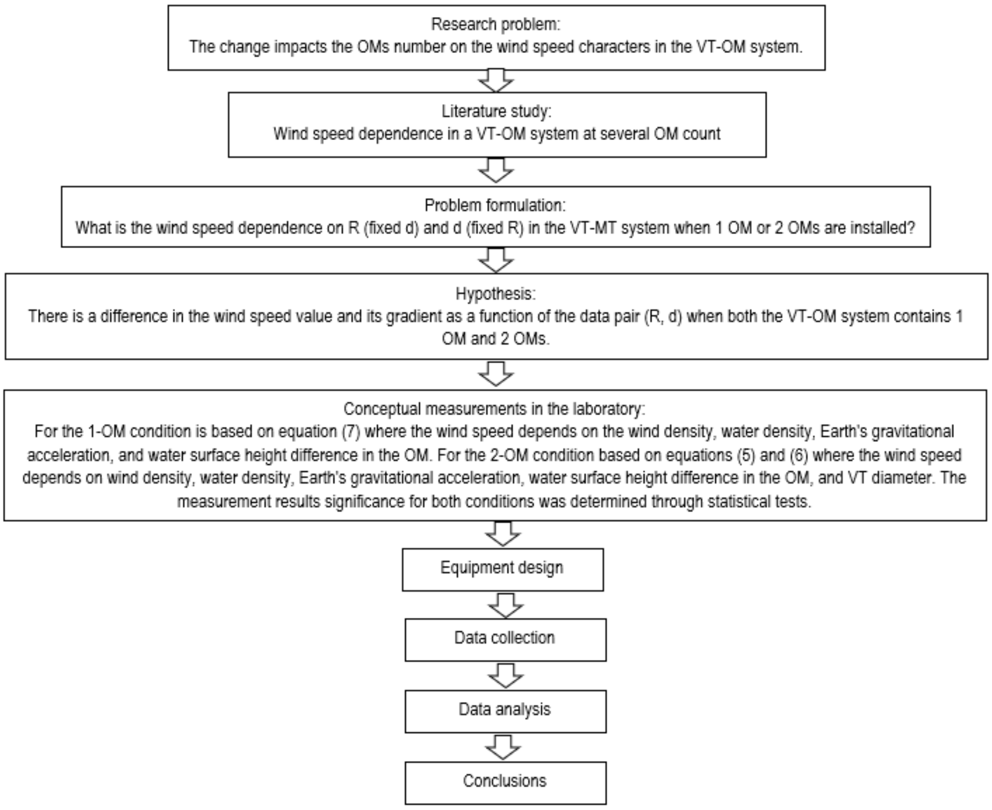


**Fig. 2.** Points within Convergent and Divergent Types



Research problem:
The change impacts the OMs number on the wind speed characters in the VT-OM system.

Literature study:
Wind speed dependence in a VT-OM system at several OM count

Problem formulation:
What is the wind speed dependence on R (fixed d) and d (fixed R) in the VT-MT system when 1 OM or 2 OMs are installed?

Hypothesis:
There is a difference in the wind speed value and its gradient as a function of the data pair (R, d) when both the VT-OM system contains 1 OM and 2 OMs.

Conceptual measurements in the laboratory:
For the 1-OM condition is based on equation (7) where the wind speed depends on the wind density, water density, Earth's gravitational acceleration, and water surface height difference in the OM. For the 2-OM condition based on equations (5) and (6) where the wind speed depends on wind density, water density, Earth's gravitational acceleration, water surface height difference in the OM, and VT diameter. The measurement results significance for both conditions was determined through statistical tests.

**Fig. 3.** Flow of Research

### *2.2 Procedure*

In stage 1, 9 different R types with wind speed standards measurable were set, and against each, it was applied both 1-MoOs and 2-MoOs systems. In stage 2, 8 reference points were set along VTs with different d for supporting each R type. Points a, b, c, d, and e are 5 reference points within converging flow types. Points e, f, g, and h are 4 reference points within diverging flow types, as shown in Figure 2. In stage 3, speed winds for the 1-MoO type were measured at each data pair type (R, d) based on one Δh type, which is the differences in water surface height between the columns of arm MoOs installed on wall-VTs. This includes the measurement of the wind speed gradient against conditions associated with data pair types (R, d). Wind speed measurements are only based on equation (7). In total, 72 different types of measurement results for wind speed were obtained. Measurement for each wind speed type does not the repetition. In stage 4, speed winds for 2-MoO type are measured for each data pair type (R, d) based on two Δh types, its difference in water surface height between the column of arm MoOs, each from MoO-X and MoO-Y, that installed to wall VTs. It includes measuring the wind speed gradient against conditions associated with the data pair type (R, d). This wind speed measurement is based on equations (5) and (6). For each type of R, 8 different wind speed types were produced. For each wind speed type that is measured, there are 7 repetitions. Each repetition involved 2 different d types so that are produced 33 pairments. In total, 9 x 33 pairs that involved, so it produced 297 measurement results of wind speeds different. In stage 5, Statistic tests do it, to see the significance of the wind speed difference in wind speed and differences in the wind speed change trends both against R (d fixed) and d (R fixed) between results of measurement 1-MoO and 2-MoO types. Its statistical test is in the form of a Normality test, Homogeneity test, and parametric test (T-test) or non-parametric test (Wil-Coxon test) depending on the applied results of requirement tests [20-22]. Data analysis was to determine characters of wind speed as a function of the data pair (R, d) at each type of number MoOs in TV system, so a conclusion was obtained. Research flow is shown in Figure 3.

## 3. FINDINGS AND DISCUSSION

The significance test of the change impact in the number of MoO on wind speed characters is determined from the requirements test results, namely normality test ($\chi^2$ test) and homogeneity test (F-test). Utilizing SPSS, results of normality test were obtained in form of ${\chi^2}_{count}$ as shown in Table 1. Through analysis that assisted SPSS application results, homogeneity test results were also obtained, namely $F_{count}$ as shown in Table 2.

**Table 1.** Normality Test Results

| N. | Data Types | 1-MoO type | | | 2-MoO type | | |
|---|---|---|---|---|---|---|---|
| | | ${\chi^2}_{count}$ | ${\chi^2}_{table}$ | Description | ${\chi^2}_{count}$ | ${\chi^2}_{table}$ | Description |
| 1 | Wind speed | 77.17 | 41.34 | Un normal | 5.64 | 82.52 | Normal |
| 2 | Wind speed gradient to R (d fixed) | 0.75 | 11.07 | Normal | 0.75 | 11.07 | Normal |
| 3 | Convergent wind speed gradient to d (R fixed) | 0 | 14.07 | Normal | 0 | 14.07 | Normal |
| 4 | Divergent wind speed gradient to d (R fixed) | 0 | 14.07 | Normal | 0 | 14.07 | Normal |

The ${\chi^2}_{\text{table}}$ and $F_{\text{table}}$ as shown in Tables 1 and 2, respectively were determined based on analysis utilizing freedom degrees, calculated by SPSS. Distribution from 8 data types, only 1-MoO wind speed type is not normal and other types are normal. Of the 4 types of data, only the wind speed type is inhomogeneous, and the other types are homogenous.

**Table 2.** Homogeneity Test Results

| N. | Type of Data Pair (1 MoO, 2 MoO) | $F_{count}$ | $F_{table}$ | Description |
|---|---|---|---|---|
| *1* | *Wind speed* | *1.08* | *0.69* | *Inhomogeneous* |
| *2* | *Wind speed gradient to R (d fixed)* | *1.11* | *4.28* | *homogenous* |
| *3* | *Convergent wind speed gradient to d (R fixed)* | *3.36* | *3.79* | *homogenous* |
| *4* | *Divergent wind speed gradient to d (R fixed)* | *1.01* | *3.79* | *homogenous* |

Regarding results of the significant test between impacts of the number of MoOs on wind speed characters, it appears in Table 3. From Tables 1 and 2 so only in the type of data pair number 1, a non-parametric test (*Wil-Coxon test*) can be applied, and yet in others, the parametric test (*T-test*) is applied enough [20]-[22]. Based on circumstances from results of the requirement test i.e. asymptotic significance 2-tailed > significance level (α), only types of data pair number 3 have a significant impact. Other types of data pairs have an insignificant impact.

**Table 3.** Results of Two-Means Difference Test

| N. | Type of Data Pair | $\alpha$ (%) | Asymp. Sig. (%) | Description |
|---|---|---|---|---|
| 1 | Wind speed of 1-MoO vs 2-MoO type | 5 | 0 | Insignificant |
| 2 | Wind speed gradient of 1-MoO vs 2-MoO type, to R (d fixed) | 5 | 0 | Insignificant |
| 3 | Convergent wind speed gradient of 1-MoO vs 2-MoO type, to d (R fixed) | 5 | 8 | Significant |
| 4 | Divergent wind speed gradient of 1-MoO vs 2-MoO type, to d (R fixed) | 5 | 0 | Insignificant |

The MoOs number changing impact measuring results on wind speed, wind speed gradient to R (d fixed), and wind speed gradient to d (R fixed) at intervals of 4 Ω ≤ R ≤ 281 Ω and 4.58 cm ≤ d ≤ 9.45 cm from 1 to 2 MoO are shown in Table 4. Mean wind speeds of 2 types of MoO amounts at intervals of R and d appear to be different. When the number of MoO is added, the mean wind speed is larger with a deviation of ± 3.4 $\mathrm{ms}^{-1}$. This means that the MoO number added has an impact on the mean wind speed, although not significant, as shown in Table 3.

Theoretically, an increase in the number of MoOs along the VT wall means an addition in the number of water Earth gravity potential energy generation phenomena, according to the number of MoOs installed [13]-[14]. On the other hand, an increase in wind speed means an increase in wind kinetic energy. According to energy conservation law, the number of gravity potential energy generated should ideally be equal to wind kinetic energy. This is because water Earth's gravitational potential energy only comes from the conversion of wind kinetic energy and negative of mechanical work by cohesion-adhesion friction force in this phenomenon is small and assumed zero so negligible. In other words, the mean wind speed at intervals R and d when used 1 MoO should ideally be greater than that of 2 MoO. This analysis seems to contradict experimental fact i.e. increasing the number of MoO even increases the mean of wind speed.

**Table 4.** Impact of The Number of MoOs on Wind Speed Characters

| N. | Wind Speed Characters | 1 MoO | 2 MoO (Mean) |
|---|---|---|---|
| 1 | Wind speed ($\mathrm{ms}^{-1}$) | 1.21E+01 | 1.55E+01 |
| 2 | Wind speed gradient to R, d fixed ($\mathrm{ms}^{-1}\Omega^{-1}$) | -2.73E-02 | -4.11E-02 |
| 3 | Convergent wind speed gradient to d, R fixed ($\mathrm{s}^{-1}$) | -3.13E+02 | -4.25E+02 |
| 4 | Divergent wind speed gradient to d, R fixed ($\mathrm{s}^{-1}$) | -4.31E+02 | -4.84E+02 |

Referring to characters of equation (7) as the basis for calculating 1-MoO wind speed, looks composed of two groups of physics quantities, namely $\left[\frac{2\rho_{wa}g}{\rho_{wi}}\right]^{0.5}$ behaving as a constant and $[\Delta h_x]^{0.5}$ behaving as a dependent variable. Physics quantities group $\left[\frac{2\rho_{wa}g}{\rho_{wi}}\right]^{0.5}$ is also used in Equations (5) and (6) as a basis for calculating 2-MoO wind speed. Physics quantities groups $[\Delta h_x]^{0.5}$ is not used in Equations (5) and (6). This group appears to change its structure by including the d factor of VT and takes the form $\left[\frac{(\Delta h_y-\Delta h_x)}{\left(1-\left(\frac{d_1}{d_2}\right)^4\right)}\right]^{0.5}$ for Equation (5) and $\left[\frac{(\Delta h_x-\Delta h_y)}{\left(\left(\frac{d_2}{d_1}\right)^4-1\right)}\right]^{0.5}$ for Equation (6). Comparing the structure of group number 2, between Equations (7) with (5), and between Equations (7) with (6) shows a completely different situation even though they have dimensions of same. Group number 2 in Equation (7) is very simple, just a function of differences in water surface hight between the installed MoO columns. But in formulations of equations (5) and (6), group number 2 besides depending on differences in water surface height between the installed MoO columns, also appears to depend on d VTs, where the wind speed is measured. Mathematically, the value of group number 2 in Equation (7) appears to be smaller than in Equation (5), as well as in Equation (6). This causes the mean wind speed of VT-2MoO systems to be greater than that of VT-1MoO systems within the R and d intervals of the study.

Under the condition of R increasing (d fixed), the wind speed change tendency when the number of MoOs is added appears to show similar symptoms as before, which tend to decrease with different decrease speeds. As shown in Table 5, at each the d value, much of the average wind speed of 2-MoO types decreases faster than 1-MoO. In theory, R is the electrical resistance of the wind kinetic energy generation circuit through the electrical energy conversion as the equipment system energy source. R larger, the electrical energy converted from the source or wind kinetic energy generated by the system is smaller, so the wind speed decreases [23]-[26]. At each value of d, it appears that the wind speed change characters against R are negative both for the 1-MoO and 2-MoO types. This fact is supported by physics concepts such as the energy conservation law, electrical energy, and kinetic energy.

**Table 5.** Wind Speed Gradient against R, d Fixed.

| N. | Σ MoO | $\Delta v/\Delta R$ ($\mathrm{ms}^{-1}/\Omega$) at d (cm) = ..... | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | *4.58* | *5.31* | *5.63* | *6.87* | *7.09* | *8.14* | *9.03* | *9.45* |
| 1 | 1 | -3.30E-03 | -2.91E-02 | -1.81E-02 | -2.54E-02 | -7.20E-02 | -4.51E-02 | -2.21E-02 | -3.30E-03 |
| 2 | 2 | -2.53E-02 | -2.53E-02 | -3.40E-02 | -3.96E-02 | -8.66E-02 | -5.21E-02 | -3.59E-02 | -3.02E-02 |

Overall, the decrease of mean wind speed against R in 1-MoO types is smaller than in 2-MoO type, as shown in Table 4. This means that there is a difference in the mean wind speed between 1-MoO and 2-MoO types, although it is not significant, as shown in Table 3. This condition reason is the different characters of the equation as a basis for calculating wind speeds for 1-MoO and 2-MoO types, as stated earlier. Formulations for 2-MoO types are more comprehensive in considering factors that impacted. This equation, in addition to considering water density, wind density, Earth's gravity acceleration, and differences in the water surface height, also considers d-VTs. On the other hand, for 1-MoO type formulation only considers water density, wind density, Earth's gravitational acceleration, and differences in water surface height of the installed MoO columns, without considering d-factors.

In this research, based on TV constructions, wind flow types are differentiated into two categories, namely convergent and divergent. Convergent flow is a flow type where flow directions through cross-sectional areas or d are getting smaller. Divergent flow is a flow type where flow directions through the cross-sectional area or d are getting larger [27]-[29]. In the convergent type for each data pair (R, d), appears that the wind speed gradient against d (R fixed) is negative, both for 1-MoO and 2-MoO types, as shown in Table 6. Implicitly, the continuity equation states that the flow speed is inversely proportional to the d square. As the d gets larger or the cross-section area gets larger, the flow speed gets smaller, and vice versa [15]-[18]. This concept is a strong reason about there is an experimental fact i.e. the wind speed gradient value to d is negative.

In convergent flow types, the chances of accompanying fluid dynamics phenomena by fluid particles motions are very potential to happen [27]-[29]. Phenomena such as turbulence, circular motion due to torque, collision with VT walls, and reversed motion of wind particles are inevitable. This has the wind speed decreasing impact. In this flow type, it seems there to be two-time weakening taking place sequentially. First, an increase in d weakens the wind speed, according to theories in continuity equation i.e. d is inversely proportional to wind speed root [15]-[18]. Secondly, the accompanying fluid dynamics phenomenon because structure VT conditions also weakens speed winds. Thus, the flow speed quantities weakening phenomenon of 2 times is real conditions or a fact that cause the wind speed gradient to d are negative, in both 1-MoO and 2-MoO types.

**Table 6.** Convergent Wind Speed Gradient vs d when R is Fixed.

| **N.** | **Σ MoO** | **Δv/Δd_convergent ($s^{-1}$) at R (Ω) = ......** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ***4*** | ***32*** | ***68*** | ***104*** | ***139*** | ***175*** | ***212*** | ***247*** | ***281*** |
| 1 | 1 | -4.26E+02 | -3.47E+02 | -3.55E+02 | -3.38E+02 | -3.06E+02 | -2.79E+02 | -2.84E+02 | -2.25E+02 | -2.53E+02 |
| 2 | 2 | -6.54E+02 | -5.16E+02 | -4.93E+02 | -4.79E+02 | -3.83E+02 | -3.58E+02 | -3.44E+02 | -3.36E+02 | -3.16E+02 |

Based on statistical test results, overall, it appears that the mean of convergent wind speed gradients to d (R fixed) in each type of the number of MoO is significantly different, as shown in Table 3 where the value for 2-MoO type being greater than 1-MoO, as shown in Table 4. This significance is also supported by calculation results, as shown in Table 6 where for each value of R, the mean of convergent wind speed gradient against d, in 2-MoO type is always greater than 1-MoO. This means that the decreased speed of the mean of convergent type wind speed against d, in 2-MoO type is faster than in 1-MoO. There is an impact caused by increasing the number of MoO on the convergent wind speed change rate.

The appearance of d-factors in the equation formulation of the 2-MoO type and the absence of d-factors in the equation formulation of the 1-MoO type is one factor causing this condition. On the other hand, additions of kinetic energy converting phenomenon into Earth's gravitational potential energy in 2-MoO type can reduce the wind kinetic energy, thus accelerating the wind speed decrease. It is different for 1-MoO types, where there is only one-times energy conversion, from the wind kinetic energy to the Earth gravity potential energy of pure water. This difference can also be seen as a factor causing the mean of wind speed gradient against d in 2-MoO types to be greater than in 1-MoO types.

**Table 7**. Divergent Wind Speed Gradient to d (R fixed).

| **N.** | **Σ MoO** | **Δv/Δd_divergent ($s^{-1}$) at R (Ω) = .......** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ***4*** | ***32*** | ***68*** | ***104*** | ***139*** | ***175*** | ***212*** | ***247*** | ***281*** |
| 1 | 1 | -7.04E+02 | -6.02E+02 | -5.72E+02 | -4.97E+02 | -2.44E+00 | -4.14E+02 | -3.77E+02 | -3.45E+02 | -3.14E+02 |
| 2 | 2 | -6.96E+02 | -5.99E+02 | -5.29E+02 | -5.02E+02 | -4.59E+02 | -4.38E+02 | -3.84E+02 | -3.93E+02 | -3.52E+02 |

For divergent flow types, the wind speed gradient value against d (R fixed) for each data pair (R, d) appears negative both for 1-MoO and 2-MoO types, as shown in Table 7. The wind speed gradient tendency in this flow type is like convergents. Of the 9 R-types, 100% of the wind speed gradient value against d for each type of numbe MoO are negative. Explanations for this fact are no different from those presented earlier. The factor that strongly impacts both for 1-MoO and 2-MoO types is the d VTs of location MoOs. The d is getting larger, wind speeds are smaller. This follows the concept implicit in continuity equation, which states that the d square is inversely proportional to flow speeds so that when the d is doubled, flow speeds become 25% previous flow speed [15]-[18].

Another fact shows that when d gets bigger, there is a condition where wind flow directions through the transverse plane-VT with cross-sectional area or d-VT get bigger. It's a harmonious state between wind flow directions and directions of d changes getting bigger. Chances of accompanying fluid dynamics phenomena such as turbulence, rotary motion due to torque, collisions, and reverse motion of wind particles in divergent flow types are much lower than in convergent flow types [27]-[29]. This means that there is a contradiction where d's weakens wind speeds but on the other hand, structure VTs does not weaken wind speeds. It can be considered that structure VTs of divergent are in favor of enhanced wind speeds. However, experimental facts show that structure VTs do not have a strong impact on wind speed. This is the reason, the divergent type of wind speed gradient against d is negative both for 1-MoO and 2-MoO types.

Within R intervals, the mean of divergent type wind speed gradient against d for 2-MoO types shows that there are 6 R types larger, but 3 R types smaller, than in 1-MoO, as shown in Table 7. Overall, the mean of divergent type wind speed gradient against d for 2-MoO types is more negative than in 1-MoO, as shown in Table 4. As d increases, 2-MoO types have a stronger impact than 1-MoO type so the mean of divergent type wind speed of 2-MoO types of changes faster within reaching mean of wind speed smaller or slower. The MoO number additions in these flow types decrease the wind speed faster and when the MoO number additions in these flow types are done massively, a wind speed with the value of zero is likely to be obtained or very possible.

As mentioned earlier, d factors theoretically impacted weakened wind speeds. The attached MoO location is a site where wind and water interact, and windstheansfer some of its kinetic energy. Waters receive it and then convert it to Earth's gravitational potential energy resulting in a difference in water surface heights of attached MoO columns [13]-[14]. The kinetic energy of wind is an entity of wind speed. The added MoOs result in the distribution addition of wind kinetic energy to each MoO attached. The value of kinetic energy received, or Earth's gravitational potential energy generated at each MoO is getting smaller. Then differences of water surface height in the installed MoOs columns are getting lower. It's a manifestation of the wind speed of getting lower through the places where MoOs are installed. Divergence flow types within VTs do not appear to increase the wind speed. VT d conditions of getting larger, and more kinetic energy distribution are reasons the mean of divergent type wind speed gradient in 2-MoO conditions is more negative than 1-MoO.

Comparing the convergent flow type and divergent about it is the mean of a gradient of wind speed to d (R fixed) from the condition of 1-MoO to 2-MoO, divergences type is smaller than convergent. As shown in Table 4, for convergent flow types, there is a deviation of ± 112 $s^{-1}$, and when divergent flow types, there is a deviation of ± 53 $s^{-1}$. As d increases, the means of divergent wind speed decreases more slowly but the means of convergent wind speed decreases faster. Changes in the negativity of means of the divergent type wind speed are lower than the convergent type. This experimental fact is strongly correlated with differences in effect strengths of the fluid dynamics phenomenon that accompanies, that sources from VT-walls, in each wind flow type. In convergent flow types, VT-wall massively generates reverse motions of wind particles, which accelerates decreases in wind speed within VT. In divergent flow types, the transverse plane formed by the cross-sectional area of the VT wall along the flow direction gets larger. This condition causes the wind mass flow to experience no significant resistance. Winds freely flow within and along VT without any reverse motion in the incident wind direction. Transverse plane structures in convergent flow types are narrowed while in divergent flow types, it is widened. This geometrical fact is the reason why the wind speed against d decreases faster in convergent flow types than in divergent flow types [27]-[29].

## 4. CONCLUSIONS

In VT-MoO systems, MoO number differences impact different against the wind speeds but are insignificant, where 2-MoO types are higher than 1-MoO type. Change rates of wind speeds are always faster in 2-MoO types than in 1-MoO type, in both conditions of the R increasing with d fixed; the convergent flow type, d increasing with R fixed; and the divergent flow type, d increasing with R fixed. Differences in the change rate of wind speed between the 2-MoO and 1-MoO types are insignificant for conditions of the R increasing with d fixed; significant for the convergent flow type, d increasing with R fixed; insignificant for the divergent flow type, d increasing with R fixed. Decreases in wind speed when d increases but R fixed is faster for the convergent flow type than divergent flow type.

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