

Blo-Wiper: From Conceptual Design to Computer Simulation Analysis for New National Car Development Project (A Case Study for Malaysia Small Medium Enterprise-SME)

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Abstract. Blo-Wiper is a project proposed by Techno Brozek Enterprise to Malaysian government in 3rd National Car Project (NNCP). According to a feasibility study conducted by them, conventional windshield wiper is less effective during heavy rains especially for countries located at equatorial. They came out with Blo-Wiper idea which is a novel system that combined two mechanisms; wiping and blowing. Their first white paper is covered on feasibility study and concept development. Then, they continue their Research and Development (R&D) from conceptual design to computer simulation analysis by using Proof of Concept (PoC) process. Interaction of rain droplets with blowing air is simulated by using Computational Fluid Dynamics(CFD). CFD result for windshield wiper with blowing air proven that rain droplets are shattered and repelled towards left and right of boundary layer. Meanwhile, without air blowing, the rains droplets falling down on floor boundary layer. Rain Droplets Removing Width (RDRW) for a system with wiping and blowing is 76mm while conventional system is zero. That means, Blo-Wiper mechanisms; wiping and blowing is better than conventional mechanism; wiping only. The objective of this white paper is to publish R&D progress which is development from conceptual phase to numerical simulation phase.

Keywords: Blo-Wiper, Windshield Wiper, 3rd National Car Project, Computational Fluid Dynamics, Proof of Concept, Small Medium Enterprise, Rain Droplet Removing Width

1. Introduction

On 26-November-2018, Techno Brozek Enterprise has submitted Blo-Wiper proposal to Ministry of International Trade and Industry (MITI), Malaysia. At same time, they also published a white paper in engrXiv [1]. The main purpose of the white paper is to introduce a new conceptual design of windshield wiper called Blo-Wiper. It's also suggested a novel method how to develop Small Medium Enterprise (SME) in 3rd National Car Project (NNCP). Besides, the readers of the white paper can get info about Malaysian SMEs capabilities in automotive manufacturing sector. The NNCP main function is to create an ecosystem that will produce thousand new high skilled jobs for local talents and boost Malaysia economy.

The previous two national car projects; *Perusahaan Otomobil Nasional* (PROTON) and *Perusahaan Otomobil Kedua* (PERODUA) are using public funds for paid-up capitals and declared as Government Linked Company (GLC) [2][3]. This time the approach is different from previous. The car conceptual and project paid-up capitals are come from private sectors [4]. Thus, government has encouraged any parties from local and international to submit their proposals to MITI. Based on an official media statement, more than 20 proposals have been received and the government has approved RM20 millions for Research & Development (R&D) grants to stimulate the NNCP [5].

In this paper, the authors' intentions are to publish current R&D progress for Blo-Wiper project by using Proof of Concept (PoC) process. A Turtle Diagram shows simplified details of PoC process as can be seen in Figure 1.0.

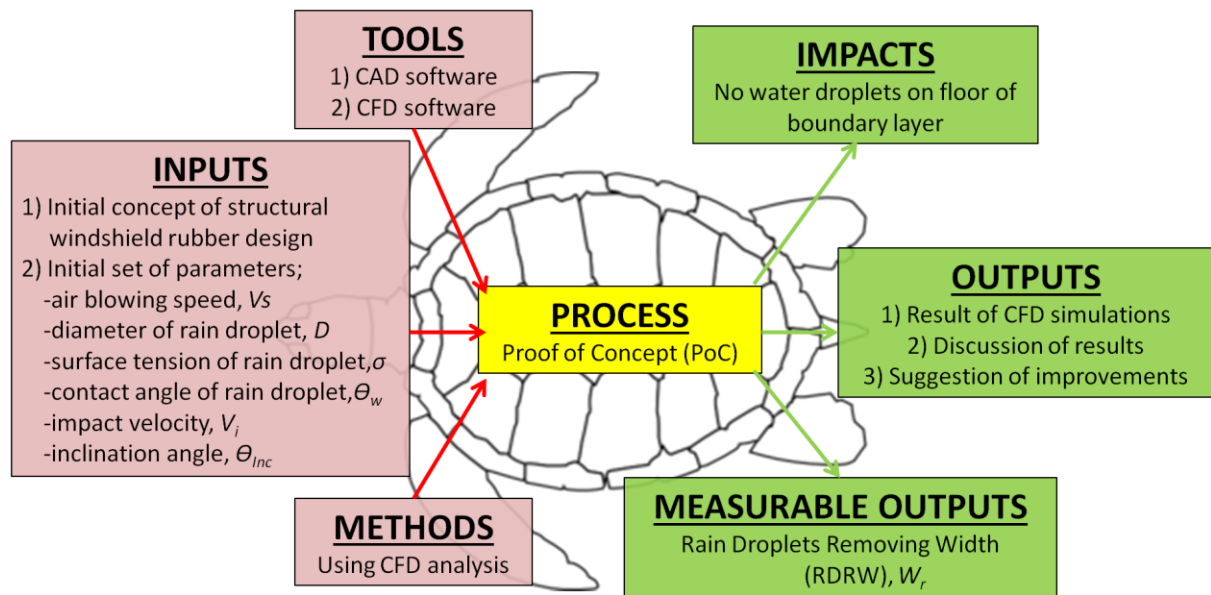


Figure 1.0 Turtle Diagram - PoC for Blo-Wiper

2.0 Methodology

The initial concept of structural windshield rubber is design based on modification of conventional structure. Figure 2.0 below shows the conventional windshield rubber shape. Blowing structure is added and wiping structure is maintained. Therefore, Blo-Wiper have two rain droplet removing methods; wiping and blowing while conventional only has one method; wiping.

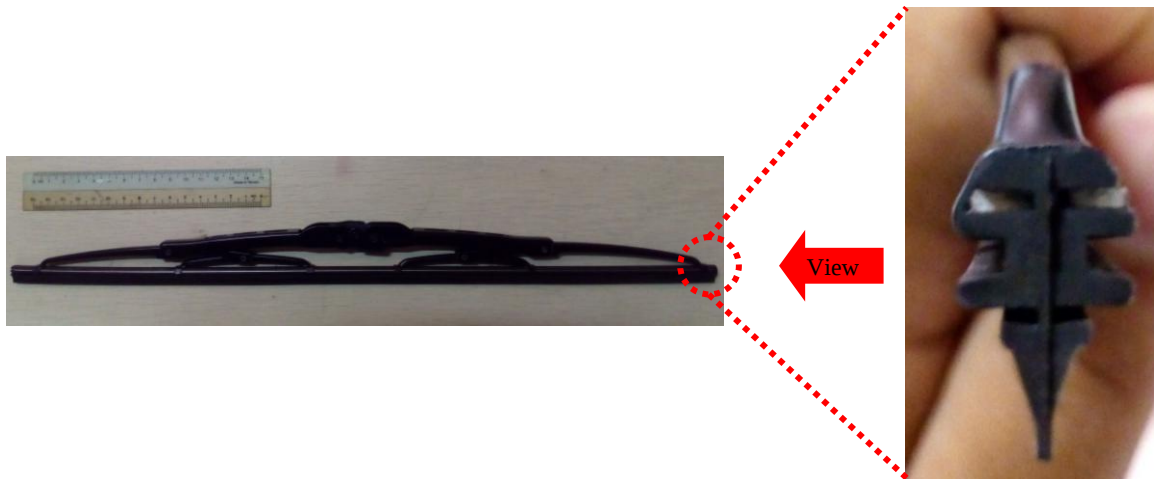


Figure 2.0 Conventional Windshield Rubber Shape

Comparison effectiveness on removing of rain droplets between WITH and WITHOUT blowing method is simulated by using Computational Fluid Dynamic (CFD) analysis. The process of evaluation must begin from a simple Blo-Wiper structure. It's a proven method to understand interaction between rain droplets and air blowing. From results of the first analysis, series of improvements are compulsory until get optimum parameters and optimum design structure. Lastly, overall Blo-Wiper structure needs to be analysed and confirm its final performance. Figure 3.0 shows an initial concept of structural windshield rubber for Blo-Wiper.

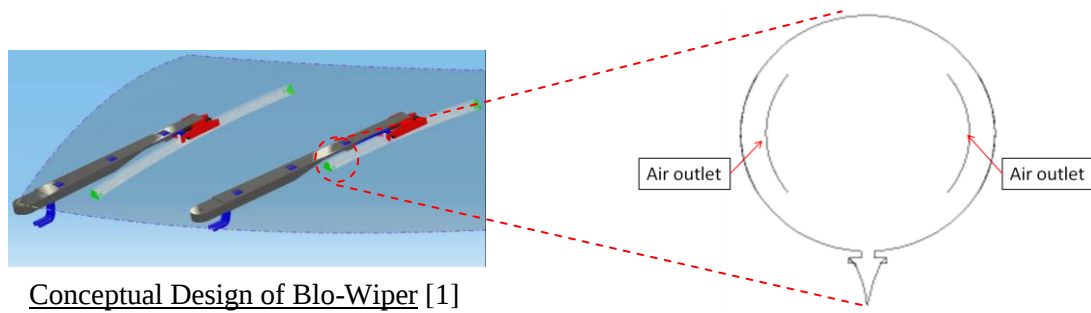


Figure 3.0 Initial Concept of Structural Windshield Rubber for Blo-Wiper

The structure in Figure 3.0 is put inside a fixed volume. Then, five (5) rain droplets are set on top of the volume with certain distance and height. Figure 4.0 below shows the CFD geometry setup that use for evaluate the effectiveness of removing rain droplets WITH and WITHOUT air blowing. CFD simulation is simulate based on one hypothesis and one assumption; air droplets WITH blowing air will not falling down on floor of boundary layer and effectiveness of wiping method for WITH and WITHOUT blower is same.

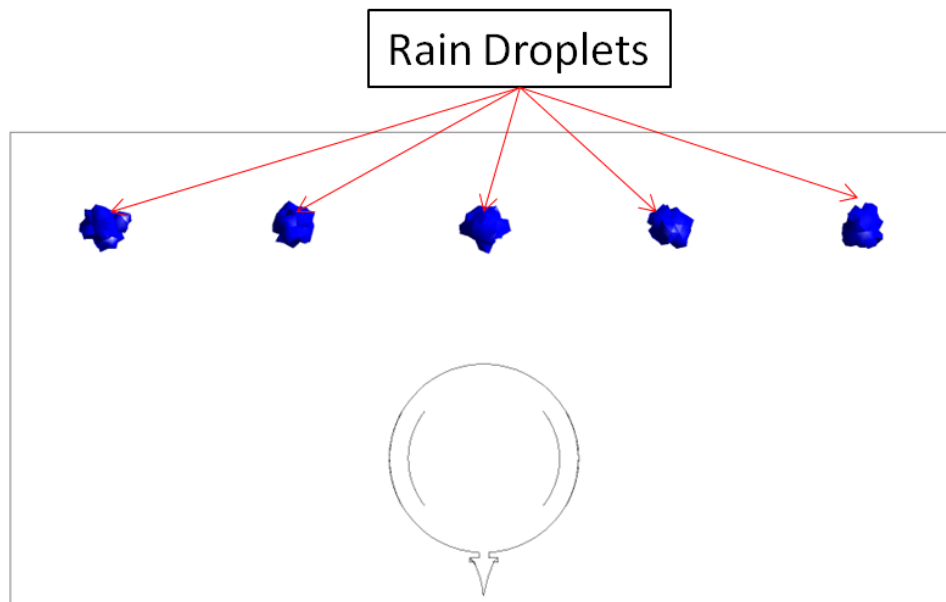
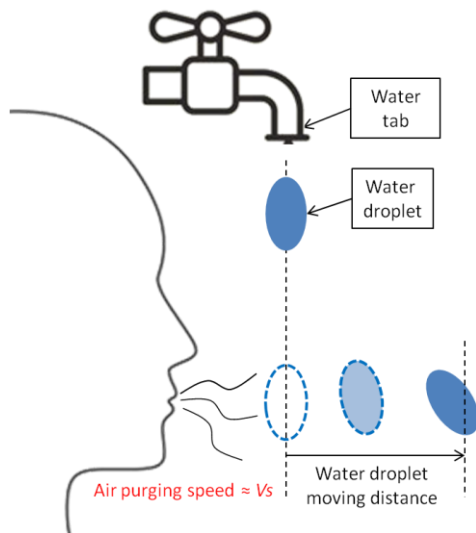
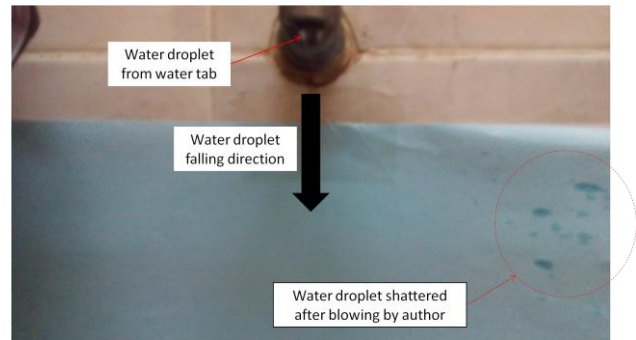


Figure 4.0 CFD Geometry Setup

There are 6 initial set of parameters; air blowing speed, V_s , diameter of rain droplet, D , surface tension of rain droplet, σ , contact angle of rain droplet, θ_w , impact velocity, V_i , and inclination angle, θ_{inc} . Air blowing speed, V_s is how much air speed at outlet of blowing structure. The V_s value is determine by using Analogy method. If air purging out from human mouth is almost same value as air blowing speed, thus water droplets can be blown at same circumstance. A simple Design of Experiment (DOE) is made to prove the Analogy. Figure 5.0 shows side by side comparison between DOE and actual experiment. Air blown from mouth was able to blow a water droplet to a certain distance. According to a research, the average air speed of human blowing is 12m/s [6]. It is successful proven that the air speed value is sufficient enough to be set as an initial benchmark value. It will be tuned later according to numerical and experimental analysis.



DOE



ACTUAL

Figure 5.0 DOE vs ACTUAL of Air Blowing Speed

Then, diameter of rain droplet, D , surface tension of rain droplet, σ , contact angle of rain droplet, θ_w , impact velocity, V_i , and inclination angle, θ_{Inc} are constant values that decided from literature review. All parameters values are tabulated in Table 1.0 and Figure 6.0 shows a structure of rain droplet.

Table 1.0 Initial Set of Parameters Values

Parameter	Value
Air blowing speed, V_s	12m/s [6]
Diameter of rain droplet, D	2mm [7]
Surface tension of rain droplet, σ	0.073 N/mm at 293K [8]
Contact angle of rain droplet, θ_w	100° [9]
Impact velocity, V_i	1m/s [7]
Inclination angle, θ_{Inc}	0° [7]

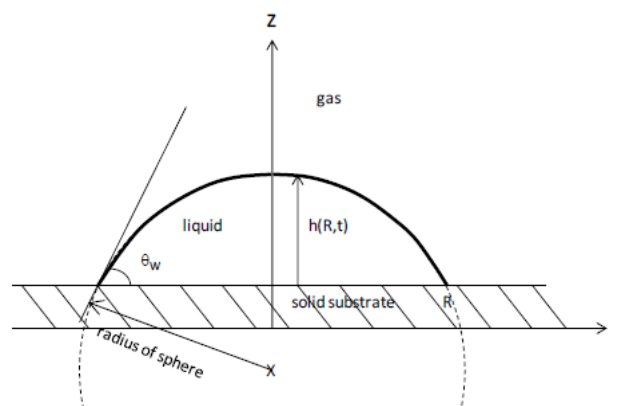
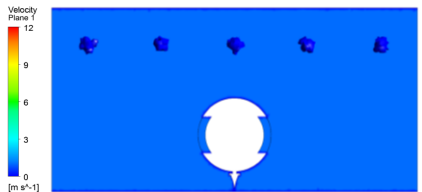
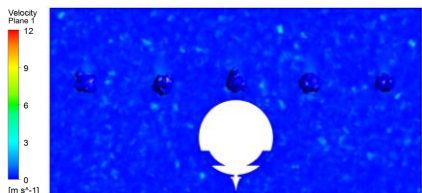
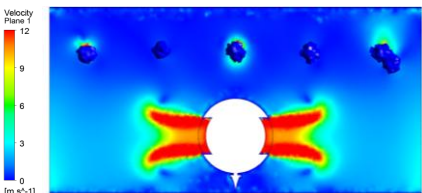
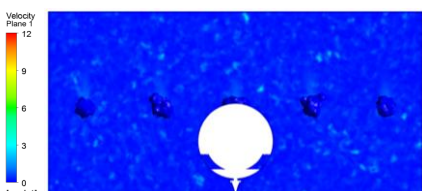
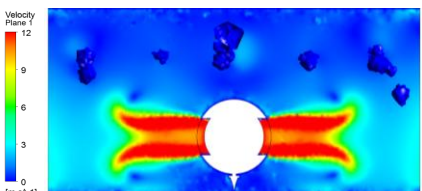
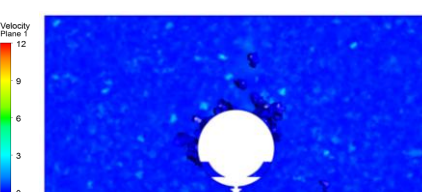
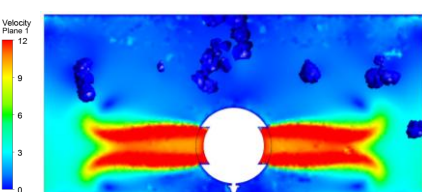


Figure 6.0 Rain Droplet Structure [10]

3.0 Results

Table 2.0 below shows the CFD simulation results for WITHOUT and WITH blowing method. Phase One (1) shows the initial state for rain droplets. Both WITHOUT and WITH blowing method have a same conditions. There are no rain droplets falling down. For Phase Two (2), rains droplets start moving and WITHOUT blowing method is moving down faster compared to WITH blowing method. Significant different size of rain droplets can be seen in Phase Two (2). Rains droplets exposed to air blowing start to shattered. The shattered of rains droplets is increasing on Phase Three (3). At same time, rains droplets WITHOUT blowing method has maintained its size and keep moving downward. At Phase Four (4), rains droplets spreading on floor of boundary layer and windshield rubber except rain droplets WITH blowing method. The rains droplets are shattered above air blowing and flying towards left dan right of boundary layer.

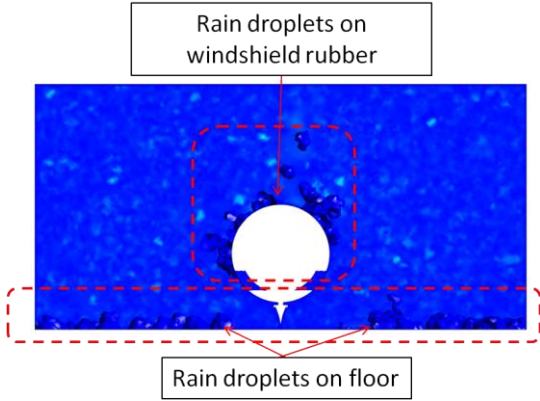
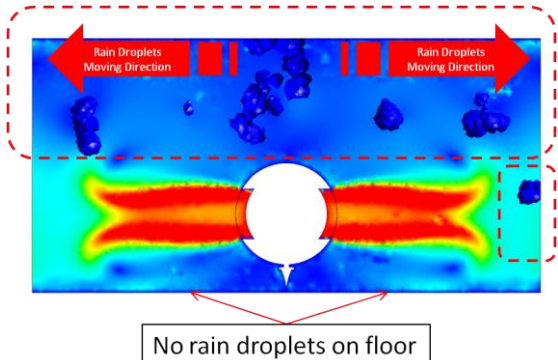
Table 2.0 CFD Simulation Result for WITHOUT and WITH Blowing Method

Phase	WITHOUT Blowing Method	WITH Blowing Method
1		
2		
3		
4		

4.0 Discussions

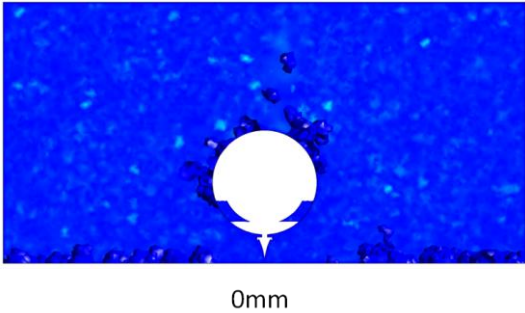
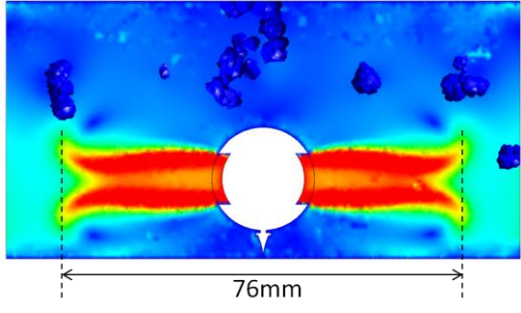
From simulation results inform that rain droplets WITHOUT blowing air (Wiping Only) are falling down and then spreading on floor of boundary layer floor. It's because of gravitational force and no external forces exert to stop the rain droplets. Meanwhile, high speed blowing air as colored by red is blocking rain droplets from keep falling down as shown in Table 3.0. High kinetic force generated from blowing air pushing rain droplets towards left and right of boundary layer (Wiping and Blowing).

Table 3.0 Rain Droplets Movement

Wiping Only	Wiping and Blowing
	

Rain Droplets Removing Width (RDRW) is a parameter to measure a distance of rain droplets blocked from touching boundary floor. RDRW for Wiping Only is zero. The wiper rubber only has one thin line for wiping based on width of wiper rubber touched on windshield [1]. Combination of wiping and blowing method has better RDRW which is 76mm. Refer to Table 4.0 below for details.

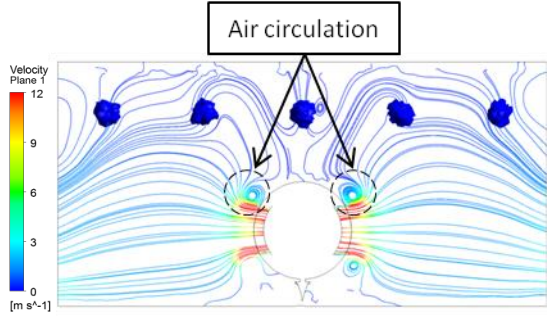
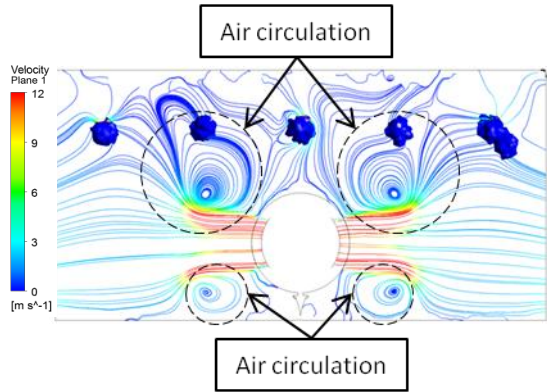
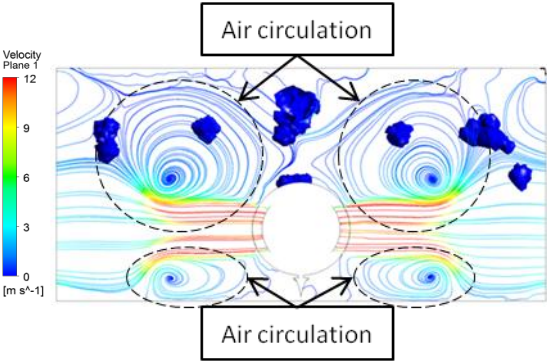
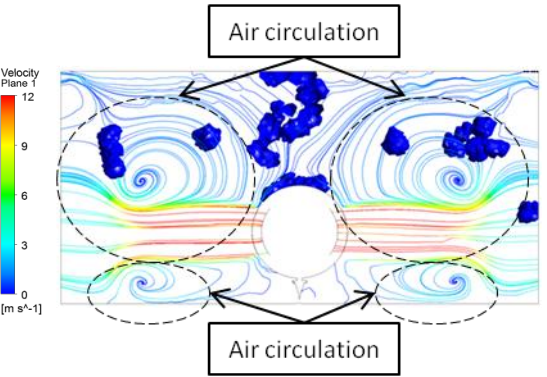
Table 4.0 Rain Droplets Removing Width (RDRW)

Wiping Only	Wiping and Blowing
	

On the other hand, air vortexes start generated when air purging out from air outlet. The air vortexes size becomes greater and moving towards left and right. From perspective of aerodynamic, air vortexes are not good for a system. The reason is it's creating pressure different and chaos. The system is considered imbalance and uncontrollable with existence of strong air vortexes.

It does can be considered as input of improvement for next phase. For initial phase is focus on understanding of air flow behaviour and improvements must be implemented on next phase. Table 5.0 shows air streamlines and vortexes generated from Phase one (1) until Phase four (4).

Table 5.0 Air Streamlines for Wiping and Blowing

Phase	Air Streamlines for Wiping and Blowing	Descriptions
1	 The diagram shows a central white circular obstacle. Air streamlines flow from the left and right towards the obstacle. Two small, nascent vortices are visible just behind the obstacle, one on each side. A color scale on the left indicates velocity from 0 to 12 m/s. Labels 'Air circulation' with arrows point to the developing vortices.	Small air vortexes generated near the air outlet
2	 The vortices behind the obstacle have grown significantly in size. Two new vortices have formed at the bottom of the obstacle. The top vortices are now larger and more defined. Labels 'Air circulation' with arrows point to the top and bottom vortex pairs.	Air vortexes size become bigger and two additional generated at bottom
3	 All four vortices (top-left, top-right, bottom-left, bottom-right) have continued to grow in size and intensity. The streamlines are more turbulent. Labels 'Air circulation' with arrows point to the top and bottom vortex pairs.	All air vortexes size keep on increasing
4	 The vortices are now moving away from the central obstacle towards the left and right edges of the frame. The top vortices are moving left and right, while the bottom vortices are also moving outwards. Labels 'Air circulation' with arrows point to the top and bottom vortex pairs.	All air vortexes moving towards left and right

5.0 Conclusion

This research is successful meets the target objective. CFD simulation results have proven that windshield rubber WITH blowing air can repel rain droplets from falling down on floor of boundary layer. RDRW for wiper structure WITH blowing air is 76mm while RDRW for wiper structure WITHOUT blowing air is zero (0). It's shows that Proof of Concept (PoC) process is an reliable process that used by authors to conduct development from conceptual design to numerical simulation analysis. Initial structure of Blo-Wiper and set of initial parameters have been determined through this analysis. Improvements will be implemented in next research publication.

Acknowledgments

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