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CFD SIMULATIONS AND OPTIMIZATION OF BOX VAN AERODYNAMICS: IMPACT OF COMPUTATIONAL PARAMETERS

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ABSTRACT

The key purpose of this thesis is to explore ways to reduce the aerodynamic drag coefficient and to improve the stability of full-size road vehicles using three dimensional Computational Fluid Dynamics (CFD) simulations. The baseline model of the spacecraft used in the simulation is the Land Rover Discovery. There are several new aerodynamic add-on devices which are investigated in this study. Many of these instruments are used separately or in combination. These add-on devices do not impact the vehicle capability and comfort. In this analysis three velocities of the air were used: 28 m/s (100.8 km/hr), 34 m/s (122.4 km/hr) and 40 m/s (144 km/hr). The measured drag coefficient for the baseline model of Land Rover Discovery agrees quite well with the experimental results. It is evident that the usage of a ventilation duct has an important role in minimizing the aerodynamic drag coefficient.

Keywords: Aerodynamics; Turbulence; Computational methods

OBJECTIVE

Investigate the effect of domain size on your numerical results for lift and drag by varying the domain dimensions in a systematic way.

Provide a clear statement of the results of your investigations into the effect of flow domain size and select suitable flow domain dimensions.

Modify the given solid model to incorporate the features you have selected and re-do the CFD simulations and analysis of your modified model use flow domain dimension

I. INTRODUCTION

1.1. Background

Box vans are one of the more popular vehicles in use today yet it has received very little attention in car aerodynamics literature. The aerodynamics of pickup vans is more complex than any other open bed trucks, because the short length of the bed can result in interaction of the bed walls and tailgate with the separated shear layer formed at the edge of the cab. The present study is to gain a better understanding of the flow structure near the wake region, since the theories on the aerodynamics are yet to mature and wind tunnel experiments cost long periods and great expenses, the numerical simulation based on computational fluid dynamics (CFD) is a good approach to adopt. The complexity of the flow makes drag prediction tools, including CFD based methods, unreliable. The main goal of the present research is to gain a better understanding of pickup truck aerodynamics using detailed flow field measurements

Computational Fluid Dynamics (CFD) has gained popularity as a tool for many airflow situations including road vehicle aerodynamics. This trend, to bring CFD to bear on vehicle aerodynamic design issues, is appropriate and timely in view of the increasing competitive and regulative pressures being faced by the automotive industry. Three-dimensional transient aerodynamic flow model development occurs in an environment influenced by numerical and turbulence modeling uncertainties, among others. In order to assess the accuracy of the aerodynamic CFD flow computations, a comprehensive comparison between the CFD results and measurements of the aerodynamic flow structures over generic pickup truck geometry is undertaken. Detailed flow field comparison includes surface pressures and velocity fields in the near-wake region.

Modifying vehicle geometry for aerodynamic performance improvement is the most important task of an automotive aerodynamics engineer. For computational analysis, modifying the geometry may entail creation of a new CAD model, meshing it in a pre-processor and setting up case file for the computational solver. This may require several engineer hours and computational resources. On the other hand, if the mesh itself is deformed keeping the mesh quality intact, to achieve the desired geometry change, then a large amount of time and resources could be saved. The converged solution of the baseline geometry can be used to quickly arrive at a converged solution for the deformed geometry.

Furthermore, this process could be automated. Several components can be morphed (deformed) in this manner and their degree of deformation can be controlled. This is known as parameterized morphing. The parameterized morphing can then be used to investigate which deformations need to be undertaken and to what extent (by quantifying the deformation) so as to meet one or more design objectives (reduce drag coefficient, increase cooling airflow rate to the radiator, reduce wind noise, increase cooling airflow to brake components etc.). This can be done through multi-objective optimization scheme. Multi-objective optimization is the process of simultaneously optimizing two or more conflicting objectives subject to certain constraints. The authors have developed an automated multi-objective optimization for this purpose. In the past, this methodology has been applied to airfoils, heat exchangers, chemical processes etc. The implementation of this approach on a full-sized production tractor-trailer configuration, however, involves several computational challenges due to the size and complexity of the model.

1.2. Computational fluid dynamics (CFD)

Computational fluid dynamics (CFD) is a branch of fluid mechanics that uses numerical analysis and data structures to analyze and solve problems that involve fluid flows. Computers are used to perform the calculations required to simulate the free-stream flow of the fluid, and the interaction of the fluid (liquids and gases) with surfaces defined by boundary conditions. With high-speed supercomputers, better solutions can be achieved, and are often required to solve the largest and most complex problems. Ongoing research yields software that improves the accuracy and speed of complex simulation scenarios such as transonic or turbulent flows. Initial validation of such software is typically performed using experimental apparatus such as wind tunnels. In addition, previously performed analytical or empirical analysis of a particular problem can be used for comparison. A final validation is often performed using full-scale testing, such as flight tests.

CFD is applied to a wide range of research and engineering problems in many fields of study and industries, including aerodynamics and aerospace analysis, weather simulation, natural science and environmental engineering, industrial system design and analysis, biological engineering, fluid flows and heat transfer, and engine and combustion analysis.

1.3. ANSYS CFX

Simulation tool plays an important role is predicting product performance, optimizing the designs and validating the product behavior before manufacturing. ANSYS CFX is an advanced solver technology, which provides reliable and accurate solutions, quickly and robustly. It provides fast, accurate and flexible fluid flow and thermal simulations. ANSYS CFX is a high-performance, general purpose fluid dynamics program, with extensive capabilities for customization and automation using session files, scripting and a powerful expression language.

This course explicitly focuses on solver and post-processing part of typical CFD process using simulation tool ANSYS CFX. This course is a perfect blend of theoretical foundation and software exposure. This course starts with the CFD fundamentals. It provides an introduction to the governing equations of fluid flows and heat transfer, and the numerical methods developed for solving flow problems on computers, the computational aspects of fluid dynamics. The most common numerical methods for solving PDEs using FDM, FVM and FEM will be discussed in detail. Once you are comfortable with the basics of CFD, you will learn the solver ANSYS CFX software. Primarily you will get acquainted with the GUI of software. The typical workflow into the solver will get introduced. You will be learning in detail the solver basics such as domain conditions, boundary conditions, solver settings, residuals etc. The special attention is given onto the solver mathematics. You will learn using solve manager. As you get accustomed to solver GUI and typical workflow, then course takes you to the post processing aspects which are the most important part of the simulation. You will be learning how to extract simulation results, visualization techniques and understanding and interpreting those results. You will learn usage of CFX expression language (CEL) and CFX Command language in CFX. The most importantly you will learn how to carry out CFD simulation of transient phenomenon in CFX.

1.4. Simulation And Optimization Overview In ANSYS

In the project setup, design optimization requires identification of input and output parameters. The input parameters are typically geometric parameters that are to be optimized. Output parameters are typically expression values evaluated post simulation.Based on the identified input and output parameters, parameter correlations can be determined which identifies strong and weak correlations between sets of input and output parameters. ANSYS design exploration also offers response surface generation and response surface optimization which is particularly suitable for cases with larger DoE sets. In this case, a direct optimization component (shown in project setup image above) is used for optimizing the pipe section length.

In the optimization properties, one or more objectives with or without constraints can be set. The direct optimization component in ANSYS workbench offers several methods for single and multi objective optimization such as:

Screening, a simple approach based on sampling and sorting Multi objective genetic algorithm, based on NSGA-II

Non linear programming by quadratic Lagrange, which is a gradient based algorithm suitable for local refinement of single objective with continuous parameters

Mixed integer sequential quadratic programming

Adaptive multi-objective method which is based on NSGA-II, but limited to continuous input parameters

A gradient based adaptive single-objective method limited to continuous parameters. In this current exercise, the adaptive single objective method is used with three initial samples and maximum number of evaluations limited to 20. The trade-off chart shown above shows the relation between the expansion length and the component pressure drop. The top candidates (design points) are also listed.

ANSYS design exploration seamlessly integrates multi-objective optimization, parameter correlations and response surfaces in the standard CFD workflow and offers several options for design point management.

1.5. API Concept

The fundamental idea driving the development of this API is the concept that, in a truly extensible multidisciplinary framework, all of the components must be modular. It is unrealistic to expect that all disciplines in a multidisciplinary analysis to be coded in a monolithic framework. This would limit the ability of the code to be extended to accommodate future needs. Therefore, we define the boundaries of atypical CFD analysis to establish a general method for modularizing CFD codes. The key concept for enabling this is to define the geometric surface of the CFD problem as the point of interaction for the flow solver. In most CFD problems, this geometric surface defines the boundary of the flow domain. This is true, regardless of the flow solver fidelity level. Both analyses with a volumetric analysis domain, such as RANS and Euler CFD codes, and analyses with a surface domain, such as a panel code, can be handled using this approach. Furthermore, having the interface defined at the surface allows for straightforward use in both multidisciplinary analysis and design optimization applications. It is on this surface that physical quantities are integrated. For example, the transfers of the heat flux in an are thermodynamic analysis or the displacements and forces in aero structural analyses are done through this surface. A second important concept for the API is the separation between the flow conditions definition for a given analysis and the geometric definition of the problem. Several tasks, from parameter sweeps to multipoint optimization problems, require the analysis of a single geometry at multiple flow conditions. By separating the definition of the flow conditions from the solver itself, it is possible to analyse any number of flow conditions without reinitializing the flow solver and incurring the associated start-up penalty.

1.6. Computational Performance

While the performance of a multidisciplinary analysis and optimization setup depends on many factors, we focus on the impact of treating the flow solver as a library using three problems. These problems also serve as additional example problems that demonstrate the flexibility of the API. The first problem is a simple aerodynamic optimization with two design variables, which gives an idea of the relative importance of different phases of the solutions process in an aerodynamic optimization. The second problem is a simple aero structural analysis, which highlights the additional areas of a multidisciplinary analysis that become performance critical: more specifically, the reduced cost of the flow solution process relative to other portions of the analysis. Finally, in the third problem, we solve an aero structural optimization problem with the same two design variables. This case extends the multidisciplinary analysis comparison to a full optimization and further demonstrates how the API developed in this work addresses those challenges.

2. METHODOLOGTY

Mode-FRONTIER is used in conjunction with other CAE tools in driving the design optimization. The major phase of the design optimization process is integrating the entire workflow. Details of each step are discussed in the following sections. Mode-FRONTIER is a parametric design optimization tool that allows for multiple CAE programs to be coupled together, thus enabling streamlined process automation and a complete design feedback loop that allows for design optimization of very complex systems.

2.1. Model Parameterization

Mesh morphing techniques in ANSA are used to reshape shell and solid mesh, without having to return to the CAD level for modifications which would involve re-meshing the model. This technique makes CFD based shape optimization task much easy. ANSA mesh morphing can be applied by two methods: using Morphing Boxes, or using Direct Morphing. The current approach uses morphing boxes. The size and shape of the morphing boxes are directly related to the design parameters used for optimization. In general, a morphing box is created around the area of interest. Subsequently, the edges of the box may or may not be fitted to the curves in the mesh. The box edges are then manipulated to control the deformation of the mesh. The design input parameters are defined based on the morphing boxes movement and direction needed to construct the desirable morphing shape. Parameter constraints are added to maintain good quality mesh in the model. Design space exploration flexibility simply increases with increasing number of parameters implemented to the model. However, increase in the size of the design space also increases the computational cost. The drawback of the current approach can be overcome by alternative adjoint optimization, which is not demonstrated in this paper.

2.2. CFD Solver

Steady-state Navier-Stokes's solver in Fluent is used to simulate fluid dynamics behaviour. Non-equilibrium k-ε turbulence modelling in conjunction with algebraic 'law of the wall' has been employed to model the turbulence characteristics. A good converged airflow result requires 6thorder of magnitude residual level and the total drag forces history to reach a stable value.

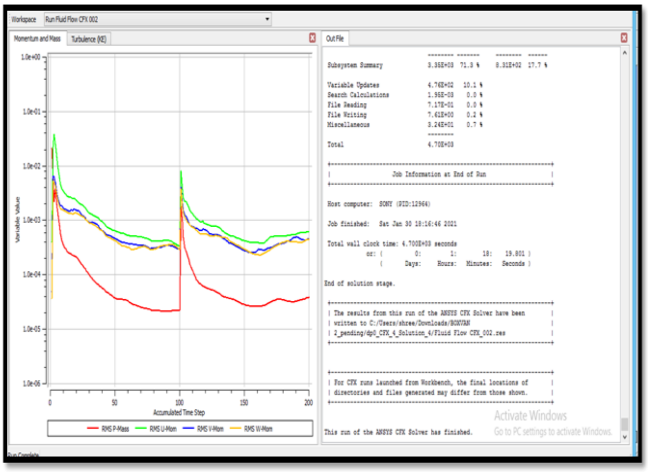

Fig.3.1. CFD Solver Results

2.3. Geometry and Meshing

A production BOX-VAN (full vehicle) external aerodynamics analysis is simulated using commercial code Fluent. The model consists of all vehicle body components including powertrain and chassis components. All CAD geometries are imported in IGES format, cleaned-up and meshed in ANSA. The intermediate surface mesh is imported into Tgrid to create volume mesh. The final volumetric mesh size in computational domain contains a total of 22 million of cells. The mesh consists of predominantly hexahedral cells covering most of the air region. Prism meshes are used to accurately capture the boundary layer growth present on the external surfaces.

2.4. Optimization methodology

Having developed a procedure for obtaining accurate and consistent CFD results, these are combined with optimization methods in search of an improved design. The strategy used is summarized as:

(1) Problem formulation: determine constraints and objective functions.

(2) Parameterization: describe the shape to be optimized in terms of D design variables.

(3) Design of experiments (DoE): generate a specified number of designs in D-dimensional space.

(4) CFD solutions: obtain CFD responses (objective functions) for each high-fidelity design. (5) Metamodel: build a surrogate response hyper-surface based upon the CFD responses and investigate the sensitivity of the metamodel.

(6) Optimization: use a combination of global and local methods to locate potential optimum design on the metamodel.

(7) Validation: obtain further CFD responses to validate the proposed design.

(8) Rebuild: update the metamodel using any additional solutions and reoptimize.

(9) Cycle: Repeat steps 7 and 8 as necessary until an optimum design is converged upon

2.5. Problem formulation

The success of any optimization methodology depends critically on the problem formulation stage, when it is vital to select design variables that influence the objective functions within the constraints of the problem. As discussed earlier, the box van is designed purely with space considerations in mind and is poor aerodynamically. While such a van is largely shielded from the approaching free-stream by the towing vehicle, the extremities of the headboard are often exposed. The study depends upon the CFD simulation and optimization. The statement is to study of CFD simulation and optimization of box van aerodynamic: impact of computational parameters.

2.6 Optimization

The optimization method is not widely used in vehicle aerodynamics simulations until recently due to the high computational cost and the limitation of the computational resources. With the increase in computation speed, more researches were carried out in the field of the aerodynamic performance optimization. However, few publications can be found in optimization of the flow field of a pickup truck. Simulation and Aerodynamic Optimization of Flow Over a Pickup van Model. The objective of this paper is to study how the flow field changes with the variation of the geometry of the pickup van, so that the drag coefficient can be minimized. The optimization need to be performed on a large number of simulations. The unsteady state simulations would take a large amount of time due to the limit of the computational resources.

Details of the CFD analysis are presented, and the results are compared with the existing experimental and numerical results. A response surface model is created through a DOE (Design of Experiment) matrix, and multiple CFD simulations were performed. The minimum coefficient of drag (Cd) is found through the multi-island generic algorithm and Non-Linear Programming by Quadratic Lagrangian optimization (NLPQL) method. The result is compared with the CFD simulation result, and the difference is shown to be small. The whole methodology of minimizing drag based on CFD and optimization method is found to be effective.

Optimization Strategy

The objective of current research is to find a best aerodynamic configuration for the pickup van model through geometry variation. To achieve this target, the design variables are first defined. Then the variations of these design variables are performed on the surface meshes using a DoE matrix. And CFD simulations of all the sampling points are performed to construct the response surface model. At last, the minimal Cd is found through combinations of several optimization techniques.

Optimization Algorithms

Optimization algorithms are applied on the response surface model to find the minimum drag coefficient using iSIGHT software. Although the problem in this study is single object, the relations of the four design variables are complex. More than one local minimum or maximum may exist on the response surface. A gradient based optimizing algorithm, though very fast in reaching an optimum, is prone to fall in a local extremum. A multi-island genetic algorithm can avoid this problem however the searching efficiency is low especially when approaching to the optimum. In this study, a combined optimization method is used. First use the multi-island genetic algorithm to find the points near the optimum, then the Non-Linear Programming by Quadratic Lagrangian (NLPQL) method, which is a gradient based optimizing algorithm, is used to find the minimum drag coefficient. The searching time is evidently reduced.

2.7. Aerodynamics

Automotive engineers know the challenges of aerodynamic shape optimization. Some parts of the car body design are notoriously difficult to aerodynamically optimize, like a side mirror, because they have complex shapes that need to enclose mechanical components of a fixed size.

The aerodynamic performance is an important part of the vehicle performances. For example, the aerodynamic lift has strong effect on the control stability at high speed, and the drag force contributes a lot to the fuel consumption. Today, the velocity of the automobile is increasing, especially in the developing countries like China where highways are spreading all around due to the fast growing economy. Massive cars are produced and driven to the road every day. Enhancing the aerodynamic performance in car design is especially important to safety and fuel economy. Comparing to sedans, the aerodynamics of the pickup vans are less concerned because they take only small fraction of the total car sales. However, the aerodynamic performance of the pickup vans should not be neglected due to the large amount produced, especially in some specific areas like the North America. Also the existence of the bed of the pickup truck causes large flow separation and makes its drag resistance larger than ordinary sedans. Reducing the drag force is very important to the fuel economy of the pickup vans.

The aerodynamics characteristics of a vehicle directly affect the vehicle driving characteristics, stability, fuel consumption and safety features of the automobiles. The analysis of vehicles aerodynamics using computational method have been widely utilised by automobile manufacturer as the reference to their bodywork design in order to reduce drag and increase the down force for stability during manoeuvre. The drag force acting on the vehicle is the consequence of vehicle surface in motion with stationary air in the surrounding. The sum of pressure differences mostly at the front and at the rear of the vehicle will result in the production of drag force. As the vehicle move forward, it will push the air to the side. This will increase the static pressure at the front of the vehicle. Meanwhile at the rear section of the vehicle, the air flow is unstable due to wake thus resulting in pressure drop. According to research by Juhala, the airflow surrounding a vehicle in motion is asymmetric with respect to its longitudinal axis. This is due to wind condition while driving and approaching traffic. The relative flow speed is the combination of driving speed and speed of wind.

In order to improve vehicle aerodynamics features, numbers consideration have been taken into account such as increasing the angle between the hood and the front windshield to get a better airflow around the car. the size of separation at the windshield base is determined by the inclination angle between the bonnet and the windshield. When the inclination angle is larger, the air flowing outward to the A-pillar is smaller thus reducing the vortices produced. Another method proposed by to reduce the value of coefficient of drag is by arching the roof in the longitudinal direction. This method somehow will change the frontal area thus increasing the drag force. good performance of a vehicle,ithasto be aerodynamically efficient by reducing the drag force and increasing the down force for better handling. describe a favourable vehicle aerodynamics geometry as a vehicle which satisfy dynamics road behaviour by minimizing airflow resistance and optimised aerodynamics lift. A previous study has found that installation of a rear wing with an appropriate angle can reduce the aerodynamics lift coefficient. It was found on the same study that the installation of an endplate can reduce the noise behind the car. It is clear that the vertical stability of a passenger car and its noise elimination can be improved.

There are two types of separation described by which is quasi-two-dimensional and three-dimensional. For quasi-two-dimensional separation, the governing equation is known as boat tailing. This parameter determined by the roof, side and undercarriage angles. The formation of three dimensional separations is determined by rear end angle. The objectives of boar tailing are to keep the area as small as possible. The designs of the undercarriage also have been an attention recently. The car manufacturer aim is to keep the undercarriage to be as smooth as possible in order to eliminate the local vortices. Suggested that application of small spoilers can be used in front of the component that produces local vortices. For example, tyre rotation will result in flow turbulence. The flow will spreads outwards and influencing yaw angle for flow contact with tyre.

How to Automate Shape Optimization of Box Van Body Designs?

Engineers can use the Ansys Fluent adjoint solver to automate shape optimizations especially those hard to optimize components.

In this case, engineers need to set up a computational fluid dynamics (CFD) simulation and state that the optimization goal is to reduce the drag of the car body design. The adjoint solver then automatically morphs the geometry and mesh of the design, based on previous iterations, to improve the aerodynamic performance.

To demonstrate the capabilities of the adjoint solver, engineers used it to optimize the shape of one of the most complex, and challenging, parts of the car to aerodynamically designthe side mirror.

Small features, mechanisms and mirrors need to fit into the side mirror enclosure without negatively affecting the rest of the car's aerodynamics.

The position of side mirrors is rather set. They tend to fit on the car's A-pillar to improve aerodynamics and a driver's ability to adjust the view. To improve the aerodynamics, engineers need to conduct a shape optimization of the side mirror's enclosure. After only two iterations, the adjoint solver automatically morphed the geometry of the side mirror's enclosure to improve the drag coefficient from 0.299 to 0.286. That represents an improvement of 13 automotive drag counts.

2.8 Impact of Computational Parameters

Starting from these theoretical and practical considerations, it becomes imperative to focus the research on the development of conceptual and experimental models whose versatility is guaranteed by a whole series of scientific solutions characterized by validated results through numerical modeling and simulations. The methods used to determine the ballistic and security parameters analyzed by classical and computer means are relevant to the interpretation of the nature of the explosive matter in terms of its framing in terms of its effect on the environment of use in the event of an explosion according to the legislation in force, being an important indicator of classification, handling, storage and transport in the assessment and management of the risks related to these operations.

Impact Sensitivity: is the explosive tendency to detonate by impact and is a parameter that characterizes the safety of explosives in handling and transport. It is expressed in joules (J), ie the minimum impact energy at which the explosion of the explosive sample occurs.

Friction sensitivity: is a parameter that characterizes safety during the manual / mechanized loading of the explosive in mine / well holes, when explosive friction forces can occur between the explosive and the walls of the holes. It is expressed in newton (N) and is the minimum frictional force at which detonations, ignitions or traces of chemical reactions occur.

2.9. Computerized modelling of the safety parameters of explosives for civil use at the sensitivity to friction and impact

1. Computerized simulation of the security parameter concerning the sensitivity to friction

Determination of friction sensitivity at the high explosives and the core of the detonating fuses in order to satisfy the requirements of the Directive 2014/28 / EU, transposed at national level by GD 197/2016 and the Technical Norms to Law no.126 / 1995 with subsequent amendments and normative documents of the products, this test is required.The method consists in determining a minimum friction force for which it is produced a reaction in eight tests on the fixed sample on a porcelain plate on which it is applied a horizontal translation motion.Friction force is made with a special device for this purpose, through a porcelain pin fixed in the apparatus above the test sample.For the determination of friction sensitivity, the test was carried out with a granular explosive consisting of a mixture of porous ammonium nitrate and diesel fuel type AUSTINITE manufactured by Austin Powder.

2.Computerized simulation of the security parameter regarding the impact sensitivity

Thus, by using the Geometry module within the ANSYSMultiphysics package, the geometry of the impact device and the explosive load placed within it.Through the ANSYS Workbench platform, the connection was made between the Geometry module and the Explicit Dynamics application, in which the geometry of the ensemble was realized, the discretization network for the entire virtual model in order to perform the numerical simulation of the impact sensitivity of the explosive consisting of a mixture of porous ammonium nitrate and diesel fuel type AUSTINITE. As can be seen from the figure, the discretization is highly refined in the area of interest, respectively the inside of the impact device where the explosive sample is located, in order to obtain qualitative and quantitative results with increased accuracy.At the same time, the contact surfaces between the interacting elements were defined: explosive, intermediate anvil as well as the defining characteristics of these elements: explosive type AUSTINITE and intermediate anvil.

2.10. CFX

Ansys CFX is a high-performance computational fluid dynamics (CFD) software recognized for its outstanding accuracy, robustness and speed with turbomachinery such as pumps, fans, compressors, and gas and hydraulic turbines.

ANSYS CFX is a high-performance computational fluid dynamics (CFD) software tool that delivers reliable and accurate solutions quickly and robustly across a wide range of CFD and Multiphysics applications. CFX is recognized for its outstanding accuracy, robustness and speed when simulating turbomachinery, such as pumps, fans, compressors and gas and hydraulic turbines.

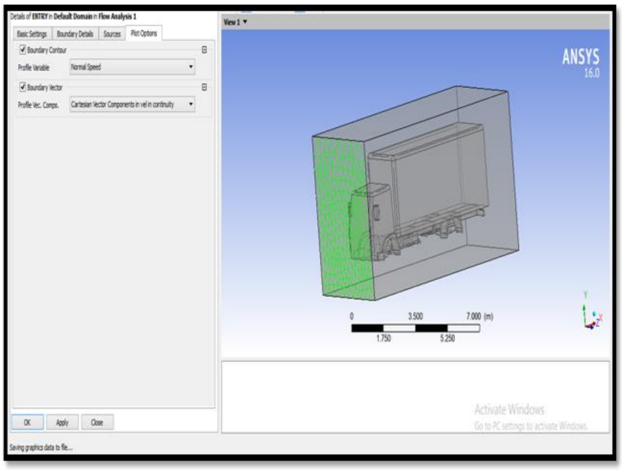

Fig.3.2. CFX in Box Van (Boundary)

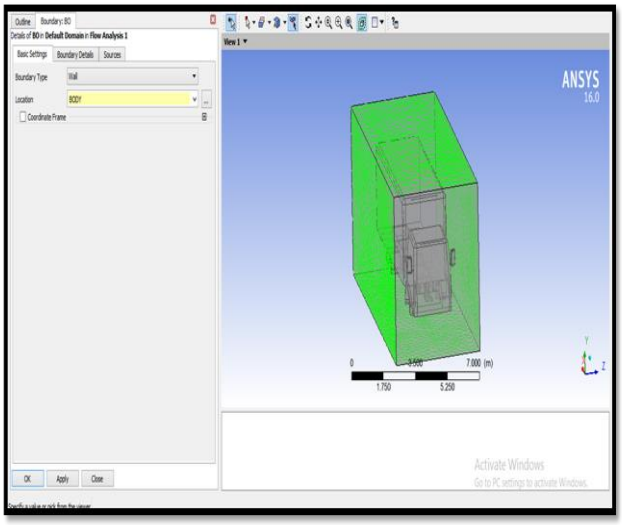

Fig.3.3. CFX in Box Van (Body wall)

New: Harmonic analysis is 2X faster and expanded to multi frequency. Harmonic analysis speeds solutions to multistage, transient blade row problems, by calculating as few as one blade per row and reducing computational time by a factor of 100 (versus a full wheel solution) and a factor of 25

3. CONCLUSIONS

In certain systems, the absence of drag correlated with fluid movement is of continuous concern. The body flowing through the fluid will feel a drag correlated with the distribution of pressure, i.e., foam drag, as well as viscous friction (shear) drag, for unqualified movement. The study of viscous drag and the approaches that can be used to minimize it are the subject of this work. In the sense of laminar, pressure-drive (poisil) as well as kinetically guided (coyote) currents in a tube, research is carried out. By adding multiple types of surface corridors, the flow is changed. Via a rise in wet surface area and shifts in the distribution of shear pressures, these corridors impact viscous pulling. Two forms of pressure pulling can have identical corridors. The drag of the shape occurs because the corridors have a flow barrier. Due to the phase difference between the pressure field and the geometry, the pressure interaction drag is generated. This study takes into account corridors of a certain class, i.e. longitudinal longitudinal grooves parallel to the path of flow where there is no position for the pressure effect. Due to their capacity to decrease pushing, longitudinal grooves / ribs, generally known as rebates, have drawn interest in turbulent flow breaches. These long grooves have viscous scale order wavelengths which pull short cuts through interacting with turbulence manufacturing. The full compilation of the tests indicates a 10 percent series maximum drag reduction. In studies, the viscous regime of the depleted rebate distance is well known and confirmed. The minimal pull is connected to the collapse of the viscous regime for greater rebates, but the initial image of this mechanism is important to several experiments, even if it has only lately been established.

It received fewer support from the Laminar Rebels. These rebates have often been known to raise drag by 10%, but recent studies have shown that long-wavelength long grooves can minimize stress-driven current losses. The decrease in drag is attributed to the redistribution of the bulk movement, which results in an improvement in the rate of mass flow in the areas corresponding to the full opening of the channel. Longer grooves with wavelengths shorter than a certain essential value tend to a rise rather than a reduction in drag. Their drag reducing capability reduces steadily as the angle of inclination between the long grooves and the flow directions rises.

REFERENCES

[1]. F. Malizia, H. Montazeri, B. Blocken, et.al. “CFD simulations of spoked wheel aerodynamics in cycling: Impact of computational parameters” Journal of Wind Engineering & Industrial Aerodynamics, 2019

[2]. Yuichi Kuya, Kenji Takeda, Xin Zhang, and Alexander I. J. Forrester, et.al. “Multifidelity Surrogate Modeling of Experimental and Computational Aerodynamic Data Sets” Aiaa Journal, vo. 4, 2011

[3]. Robin B. Langtry, et.al. “Correlation Based Transition Modeling for Unstructured Parallelized Computational Fluid Dynamics Codes”Aiaa Journal, vo. 47, 2009

[4]. Mehrdadkhosravi, FarshidMosaddeghi, MajidOveisi, Ali khodayari, et.al. “Aerodynamic drag reduction of heavy vehicles using append devices by CFD analysis” J. Cent. South Univ. 2015

[5]. Jameson, et.al. “Computational Fluid Dynamics for Aerodynamic Design: Its Current and Future Impact” American Institute of Aeronautics & Astronautics

[6]. Charles A. Mader, Gaetan K. W. Kenway, Anil Yildirim, and Joaquim R. R. A. Martins, et.al. “A D flow: An Open-Source Computational Fluid Dynamics Solver for Aerodynamic and Multidisciplinary Optimization” Journal Of Aerospace Information Systems, 2020

[7]. Eric J. Nielsen and W. Kyle Anderson, et.al. “Aerodynamic Design Optimization on Unstructured Meshes Using the Navier-Stokes Equations” Aiaa Journal, vol.37

[8]. J. Laurenceau, et.al. “Building Efficient Response Surfaces of Aerodynamic Functions with Kriging and Cokriging” Aiaa Journal, vol.46

[9]. James C. Newman, et.al. “Overview of Sensitivity Analysis and Shape Optimization for Complex Aerodynamic Configurations” Journal Of Aircraft Vol. 36

[10]. Dipl.Ing. Christian Kar, et.al. "CFD Simulation for the Cooling Circuit of a Truck Diesel Engine" Development, 2008

[11]. Haoting Wang, Tieping Lin, Xiayi Yuan, and Qi Zhang, et.al. "Simulation and Aerodynamic Optimization of Flow Over a Pickup Truck Model" Downloaded from SAE International by Imperial College London, 2018

[12]. Jean Moureh, et.al. "CFD Optimization of Airflow in Refrigerated Truck Configuration Loaded with Pallets" Computational Fluid Dynamics in Food Processing, 2007

[13]. Mohammed RuhailMasood, et.al. "CFD Design optimization of plenum box" International Journal of Science, Engineering and Technology, vol. 8, 2019

[14]. VladNicolaeArsenoaia, et.al. "CFD Simulation Of The Hot Air Flow Used For Cereal Seed Drying" International Conference on Hydraulics and Pneumatics, 2016

[15]. C.P. Om AriaraGuhan , G. Arthanareeswaran, et.al. "Exhaust System Muffler Volume Optimization of Light Commercial Vehicle Using CFD Simulation" Materials Today: Proceedings, 2018

[16]. Ting Gao, Yaxing Wang, Yongjie Pang &Jian Cao, et.al. "Hull shape optimization for autonomous underwater vehicles using CFD" Engineering Applications of Computational Fluid Mechanics, 2016

[17]. L. Salati, P. Schito, F. Cheli, et.al. "Wind tunnel experiment on a heavy truck equipped with front-rear trailer device" Journal of Wind Engineering & Industrial Aerodynamics, 2017

[18]. C. A. Gilkeson, V. V. Toropov, et.al. "Aerodynamic Shape Optimization of a Low Drag Fairing for Small Livestock Trailers" Multidisciplinary Analysis and Optimization Conference, 2008

[19]. H.M. Thompson, M.C.T. Wilson, et.al. "Multi-objective aerodynamic shape optimization of small livestock trailers" Engineering Optimization, vol.45, 2013