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The use of the Computational Fluid Dynamics - CFD tool for decision support in CBRN Defense by IDQBRN

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Abstract: Computational simulations are tools with a range of applicability to many areas of knowledge. Based on Computational Fluid Dynamics (CFD), associated to the CBRN Defense, constitute a powerful tool to support the defense actions for the decision makers by Chemical, Biological, Radiological and Nuclear Defense Institute.

Keywords: CBRN Defense, Computational Fluid Dynamics, CFD, Fluent, Metrology.

1. INTRODUCTION

In September 2001, with the attack on the twin towers in the USA, a Chemical, Biological, Radiological and Nuclear Defense (CBRN) stood out in Brazil and in the world. From this moment, the USA began the War on Terror. Although terrorist acts have always taken place in different places and at different times, it was from 2001 that there was a clear intensification of this type of attack, according to the Global Terrorism Database [1,2]. And a variable that adds even more terror to these attacks of extreme violence is the use of CBRN agents.

It is, therefore, extremely important to that the Defense Organisation should be prepared to respond efficiently and effectively to such attacks, detecting and identifying the types of agents employed and deciding what actions to take to minimize the consequences of the use CBRN Agents.

In this context, Computational Fluid Dynamics (CFD) techniques can be used to predict different scenarios involving the use of CBRN agents.

These CFD techniques have been widely used, where simulation has been useful to develop quality products, measure the efficiency of high performance equipment, adapt and improve the conditions and operational plans of equipment and processes [3], which are essential aspects control of measurements.

In this way and in the scope of metrology we can cite as applications of CFD:

- Design and optimization of measurement configurations [3];
- Simulation and prediction of experiences [3];
- Determination of the influence of different parameters on the measurement uncertainty;

- Support in Particle Metrology; [4,5]
- Application in the measurement of dust and mists; [6] and
- Metrology in flowmetering: reactor cooling system (RCS) flow measurement [7].

Then the use of this type of simulation therefore appears as an alternative to experimental means that demand an extremely high and costly level of complexity, generating savings in terms of human and financial resources, as well as positive gains in terms of personnel safety and environmental Protection.

The techniques of computational fluid dynamics are becoming increasingly important, which can be corroborated by their inclusion in the list of projects of strategic interest of the National Defense, prepared jointly by the Ministries of Defense and Science, Technology, Innovation and Communications.

In addition, the presentation of a proposal to Ministry of Defense for the technical-scientific development of CFD for in the area of CBRN Defense [8]. Also collaborated for the relevance of the technique and consequently, to the Brazilian Army, adoption of the CFD simulation in its projects, with training in human resources and survey of specific knowledge needs in this area.

Within this scenario, the Laboratory of Consequence Modeling and Risk Analysis (LAMCAR) has been created by the Institute of Chemical Biological Radiological and Nuclear Defense (IDQBRN) [9].

2. DEVELOPMENT

2.1. Objectives

LAMCAR, through the use of simulation tools, has the following objectives:

- Planing and execution the Research and Development of Defense Products (PRODE) in the area of CBRN Defense.
- Providing scientific advice and technical support to the Army Chemical, Biological, Radiological and Nuclear Defense System (SisDQBRNEx) [10].
- Providing technical and scientific services in the area of CBRN Defense measurement and detection.
- Providing service for determination of parameters and constants, in projects with uncertainty in measurements.
- Optimizing laboratory measurement services in the area of CBRN Defense.
- Optimizing the positioning of CBRN detectors in risk situations, strategic, sports and collective facilities, such as nuclear power plants, public transportation stations and others.
- Participation in training of human resources for CBRN Defense activities.
- Simulation of gas dispersion of toxic industrial materials, in open or closed populated spaces, in order to estimate the levels of toxic concentration, lethal dose, residence time and gas flow profile;
- Simulation of the diffusion of toxic industrial materials in basins, rivers, water distribution systems, estimating contamination concentration, diffusive behavior in the environment, velocity profile, temperature range, and variation of the level of oxygen concentration in water .
- Calculate the saturation time (ts) of the equipment and protective suit used by the responders compared to that reported by the manufacturer when subjected to a contaminated environment.

- Measure the concentration of toxicity and dose lethality inside and outside the CBRN decontamination tents.

Contribute to improve safety, health and environmental conservation procedures.

2.2. Laboratory Structure

In 2016, funding from the Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro - FAPERJ and other sources, IDQBRN has refurbished a room to accommodate LAMCAR, which has an auditorium and classroom setup with professional sound system, full HD LCD TV, state-of-the-art computers and notebooks, and a non-comprehensive library with CFD reference books.

2.2.1. Hardware

LAMCAR today has the following structure:

• 02 (two) notebook computers;

• 01 (one) computer for license management;

• 04 (four) high performance computers;

• 01 (one) Full HD 48 "LCD TV

• 01 (one) surround sound system;

• 01 (one) LAMCAR internal network switch.

2.2.2. Simulation Software

The laboratory uses the Ansys Academic Research CFD License which includes ANSYS Fluent and ANSYS CFX, and provides fast results for virtually any fluid or multiphysics application in its most varied variations, with precision and robustness.
These software enable LAMCAR to perform analysis of fluid flow, heat transfer and associated phenomena, such as chemical reactions, through numerical simulations based on computational processing, using the Finite Volume Method to solve the equations in the fluid domain.

2.2.3. Human Resources

Currently at LAMCAR, it has in its technical staff

01 (one) Chemical Engineer, Ph. D in CFD;

01 (one) Mechanical Engineer, Ph; D Student in CFD; and

01 (one) Chemical Engineer, M. Sc. in CFD.

2.2.4. Partnerships

The existence of partnerships with other institutions are strategic alliances for research and development.

In this way LAMCAR is currently developing a project on Green Chemistry for Organisation for the Prohibition of Chemical Weapons (OPCW), in collaboration with researchers from Federal University of Rio de Janeiro (UFRJ) and Federal University of Esprito Santo (UFES).

3. CONCLUSION

The creation of LAMCAR has provided to IDQBRN resources and tools that contribute to the generation of opportunities for improvement in measurement procedures in CBRN Defense activities, such as assessment of concentrations of toxic gases in the atmosphere, lethality levels and speed profiles, Temperature and pressure. And even in the institute itself, for example:

- Synthesis simulation in micro tubular reactors of the Laboratory of Organic Synthesis (LSO); and
- Simulation of adsorption separation in high performance liquid chromatography for the Laboratory of Chemical Analysis (LAQ);

The CFD techniques combined with the knowledge of the Institute's technical staff allow to IDQBRN providing reliable information to decision makers the emergency and CBRN Defense area.

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