ON FIRST IGNITION IN METALLIC PLATE COVERED GEOMETRY

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ABSTRACT

In this work, metallic covered boundary geometry is considered. Bottom half estimates equally spaced liquid and gas. Control volume is constructed, meshed, and refined at interests. Jet of air is allowed to enter from the top at a side; and run for a case of jet flow in empty. Unsteady turbulence multiphase modeling simulations are performed. The continuum is set with the fluids: single and couple. Single as well as the coupled fluids are at rest initially. The jet strikes the constituent and strips each other. Volume fraction contours draws the first ignition. Accident, jet and container space fuzzified to build relationships among the information gained.

KEYWORDS

Multiphase Modeling, Air jet, Ignition, Safety, Fuzzy interfacing, Low temperature

INTRODUCTION

Accidents happen due to mishandling the fluid to be injected to refill or refuel. Accident may occur during management of such situations. Replacement of fluids with other fluids is practiced. Air jetting is used in drying processes. Control is essential for such kind of applications.

At atmospheric pressure and temperature, fuels have flammable limits. Ignition of a fuel is a function of several variables such as turbulence, friction, hot surfaces, shock waves or other many factors. Ranges are required for each to fuel ignition; to avoid accidents; such limits must be carefully pointed out. Without any ignition source, burning of a mixture indefinitely defines the flammable mixture. To ignite a fuel, when the favorable condition exists, an ignition time lag between introduction of igniter and first ignition is present. It varies for fuel to fuel and situation to situation. Increase in temperature and pressure decreases this lag. Turbulent dispersion processes [1] were calculated. The reactive mixing of gases [2] was reported. Heat transfer in a heated jet pipe flow [3] was measured. The dimensions of the reaction zone [4] and influence of diffusion with reaction zone on selectivity [5] for mixing and fast chemical reaction were reported. Diffusive mixing in a tubular reactor [6] was studied. Confined jet mixing [7] was experimentally studied.

Turbulent fluctuations in NO formations was [8] studied. Influence of geometry and flow variation on jet mixing and NO formation [9] was reported. Splashing and nonlinear instability of water were experimentally investigated [10]. The inlet of the jet-geometry has many effects on inside fluids. Such effects about inlet conditions during mixing operation were presented [11]. Pipe line mixing operation by single side injection heat transfer measurements [12] was investigated. Computational fluid dynamics of gas injection [13] was reported. Oscillations in impinging jets in an enclosure were investigated [14]. Laminar boundary layer response [15] was discussed. Finite-element two-dimensional simulation flow mixing [16] was performed. Modelling of a two phase jet aerator [17] was published. Many situations of accident may be listed. During refilling case, incoming jet liquid may contain air due to inadequate storage or inadequate pumping. In case of cleaning or drying any container, the presence of unexpected gas may generate danger.

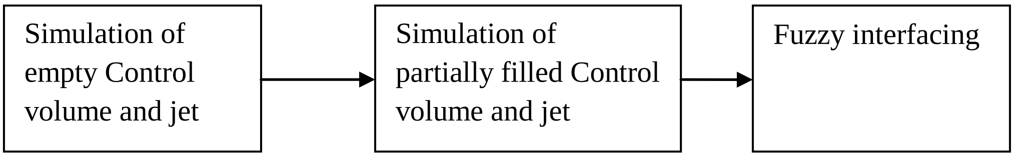


Figure 1: The plan ketch

In present work, Figure 1, the geometry is firstly empty then it contains bottom half space filled with equal amount of a gas and a liquid. Liquid is liquid-water. The fluids move and slither. Interface disturbance happened and turbulence appeared. Computational package code was used to model the system after constructing and meshing the considered geometry. Empty geometry and partially empty geometry was simulated with air jet to obtain the impacts on both fluids. Continuum, the space of control volume, was adjusted with materials. Contours produced resemblance the first ignition within geometry. The waterfall process of simulation work is shown in figure 2. Fuzzy logic is used to frame random observations for inputs to display relationships with outputs. Without using complex analytical equations, fuzzy inference system is a simple to build systems. Fuzzy sets [18] were introduced. Knowledge representation [19] was published. Information gained of accident chances are related with jet and container space. Ready surface plot are generated.

MATERIALS AND METHODS

Many computational code and packages are available. PHOENICS fluid flow package was used [20]. TEACH-T code was used to simulate mixing characteristics in the absence and presence of a reaction [21]. Computational data using FLUENT was used to establish support vector machine model and fuzzy model for pipe injection side flow mixing [22].

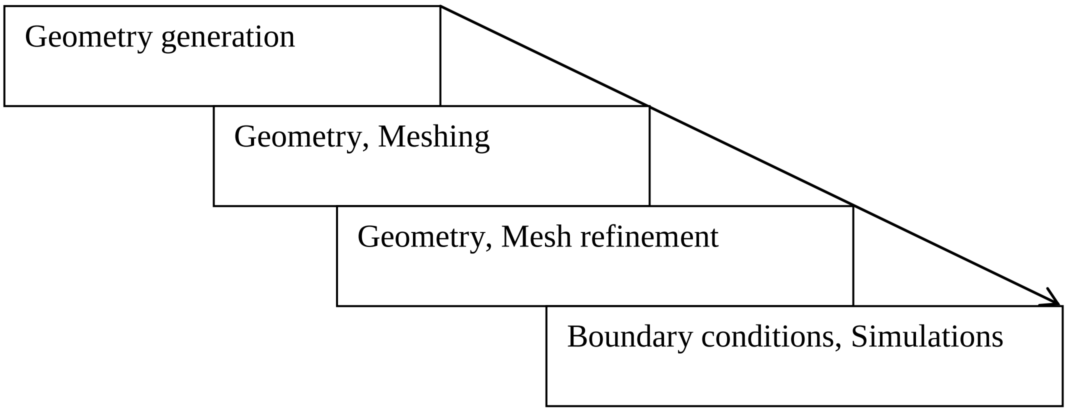


Figure 2: Waterfall process Pre-processing of geometry generation to simulation

A pre processor GAMBIT, for geometry generation was available. Geometry, 2D rectangular, was created. It was meshed and refined at area of interests. Geometry was spaced axi-symmetric with steady time with viscous model. Turbulence models were standard k-epsilon and Reynolds stress model each at a time. At the top air jet was introduced. Simulations were performed by solving the mass, momentum energy conservation equations. Figure 2 outlines the waterfall process of simulation work.

The flow computations were carried out by computational code by the finite volume method for the discretization of the equations. Boundary conditions were applied at inflow and at quantum fluids. It was considered that fluids do not do slipping at walls. Bottom and wall boundaries were metallic. Temperature was low. Pressure was atmospheric.

Figure shows the geometry diagram in [23]. Horizontal is length L and vertical is depth D. The ratio of horizontal L to vertical D Depth is L/D~2.5. Control volume was constructed, meshed, and refined at area of interests. Mesh was used of type structured quad. Computational code was axi symmetric, segregated with standard k-epsilon turbulence, and Mixture multiphase model. Unsteady turbulence multiphase modeling simulations were performed. Equation of continuity and equations of motions were resolved. Equation of continuity is given bellow.

$$\frac{\partial \rho}{\partial t}+\frac{\partial}{\partial x}\left(\rho\, v_x\right)+\frac{\partial}{\partial y}\left(\rho v_y\right)+\frac{\partial}{\partial z}\left(\rho v_z\right)=0 \qquad \text{E-1}$$

Equation of motion for x component is as.

$$\rho\left(\frac{\partial v_x}{\partial t}+v_x\frac{\partial v_x}{\partial x}+v_y\frac{\partial v_x}{\partial y}+v_z\frac{\partial v_x}{\partial z}\right)=-\frac{\partial p}{\partial x}+\mu\left(\frac{\partial^2 v_x}{\partial x^2}+\frac{\partial^2 v_x}{\partial y^2}+\frac{\partial^2 v_x}{\partial z^2}\right)+\rho g_x \qquad \text{E-2}$$

Equation of motion for y component is as.

$$\rho\left(\frac{\partial v_y}{\partial t}+v_x\frac{\partial v_y}{\partial x}+v_y\frac{\partial v_y}{\partial y}+v_z\frac{\partial v_y}{\partial z}\right)=-\frac{\partial p}{\partial y}+\mu\left(\frac{\partial^2 v_y}{\partial x^2}+\frac{\partial^2 v_y}{\partial y^2}+\frac{\partial^2 v_y}{\partial z^2}\right)+\rho g_y \qquad \text{E-3}$$

Simplified forms of equations E-1 to E-3 are E-4 to E6.

Equation of continuity in simplified form is given bellow.

$$\frac{\partial \rho}{\partial t}+\frac{\partial}{\partial x}\left(\rho\, v_x\right)+\frac{\partial}{\partial y}\left(\rho v_y\right)=0 \qquad \text{E-4}$$

Equation of motion for x component is simplified as.

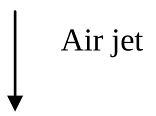
$$\rho\left(\frac{\partial v_x}{\partial t}+v_x\frac{\partial v_x}{\partial x}+v_y\frac{\partial v_x}{\partial y}\right)=-\frac{\partial p}{\partial x}+\mu\left(\frac{\partial^2 v_x}{\partial x^2}+\frac{\partial^2 v_x}{\partial y^2}\right)+\rho g_x \qquad \text{E-5}$$

Equation of motion for y component is simplified as.

$$\rho\left(\frac{\partial v_y}{\partial \mathrm{t}}+v_x\frac{\partial v_y}{\partial \mathrm{x}}+v_y\frac{\partial v_y}{\partial \mathrm{y}}\right)=-\frac{\partial p}{\partial \mathrm{y}}+\mu\left(\frac{\partial^2 v_y}{\partial \mathrm{x}^2}+\frac{\partial^2 v_y}{\partial \mathrm{y}^2}\right)+\rho g_y \qquad \text{E-6}$$

Jet was on left side parallel to small side towards the bottom. Air jet was introduced; air space remained no more motionless then it approached towards bottom. For a second case, geometry was set with fifty percent water at bottom that is the fifty percent of lower space in figure was water. Jet was on left side parallel to small side towards the bottom. Air jet was introduced; air space remained no more motionless then it approached towards water surface.

Further, in Figure 3, top and bottom were introduced as top: 0.5, Bottom: 0.5. 50% of bottom was interlined with gas forming a system as air: gas: liquid-water ~ 0.5: 0.25: 0.25. There were no impurities on top of the both fluids; instead, the clean air filled the upper half space. At fifty percent estimated depth of the vessel, the interface of top air and lighter gas than water was. The estimated rest amount of bottom space was equally occupied by gas and water. Computational code was axi-symmetric, segregated with standard k-epsilon turbulence, and Mixture multiphase model.



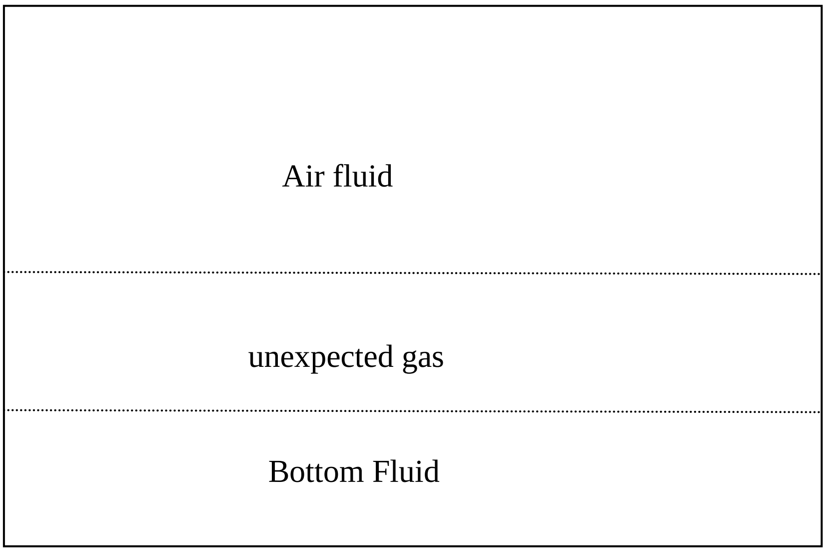


Figure 3: Air, unexpected gas and liquid water after downing of jet into control volume

Table 1: Continuum ingredient recipe; jet is of Air

Continuum	Air	Gas,	Water
Upper half	x		
Lower third quarter		x	
Lower quarter			x

Unsteady turbulence multiphase modeling simulations were performed. Air jet was introduced; air space adjacent interface gas surface remained no more motionless then it approached towards the surface of motionless gas. Air jet displaced and changed the volume fractions. Table 1 shows the initial continuum ingredient. Simulations were performed. Information gained was recognized as inputs and output. Figure 4 shows the model of setting up fuzzy interface system of the information which will be learned from simulation work. Preparation will be followed the learning and fuzzy interface system will be built. Relationship results will be shown.

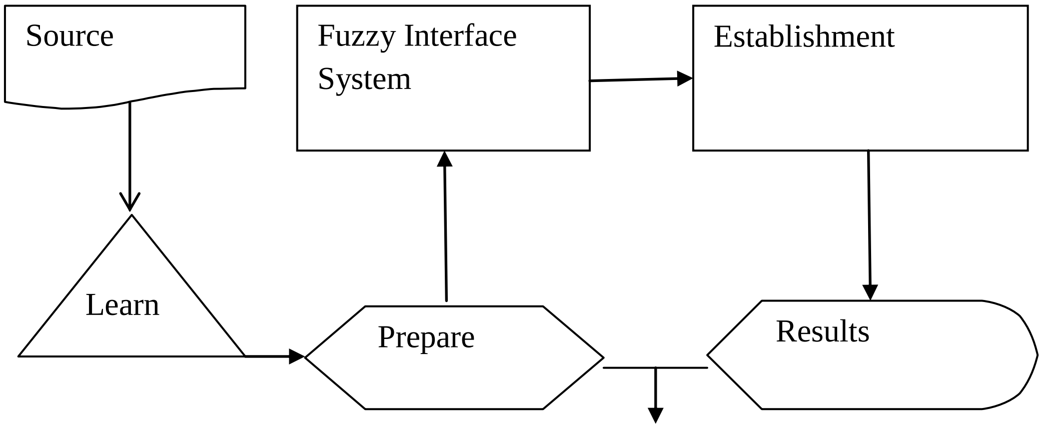


Figure 4: The fuzzy interface system modeling titivate model

RESULTS

Empty geometry with air jet, air-water with jet and multiple phase system of air-gas-liquid in the close geometry box with a vertical air injection from orifice on top of the bottom, the surface of water and the surface of gas above water were considered. The fluids move together after start of operation. The present concern focuses at upper interface where the first meeting of jet happened. Along with turbulence model, multiphase models Mixture for the multi phase flow system were applied during simulations each at a time.

Multiphase models, Mixture, responded well. Figure 5 shows top side air injection into an empty close geometry. Velocity vectors show the current inside along metallic walls of box. Jet current flows into defined geometry and circulates. It flows down towards the bottom. At bottom it is sliding on the surface and spins.

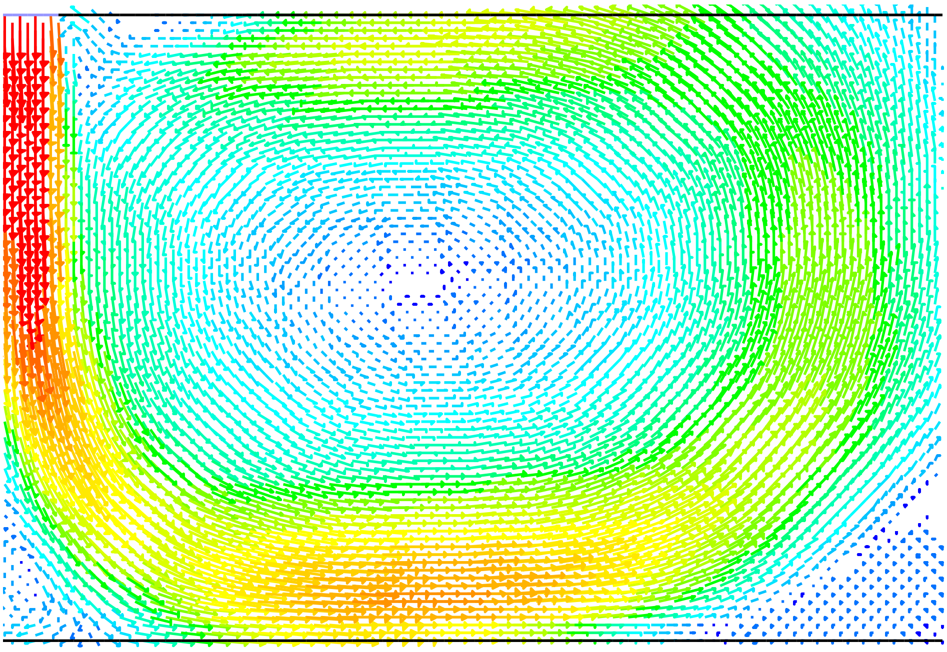


Figure 5: Vector contours of system. Geometry is structured grid, top side air injection.

Figure 6: Contours of air-water mixture.

In case when the continuum was set with half spaced water at bottom, the jet stroke the water surface and absorbed into the water. Figure 6 shows the contours of air-water mixture. Abreast waves can be seen of the mixture moving from jet side to other side. Further, the continuum was set with equally spaced unexpected gas and liquid water at lower half. Table 1 shows the distribution. Figure 7 shows the first ignition. Contours are of volume fraction of gas. The effect can be described as a region generation of gas and liquid at their interface. On the side of the incoming air jet, this disturbance is initiated. Direct jet strikes and produces turbulence. The pressure impacts are transferred till the other end at the gas-liquid interface. The jet from top was not stopped to into the system. The disturbance has to be balanced. The air at upper space tried to way out from corners of inlet. Volume fraction of contents inside vessel was changing with respect to point location.

Temperature and pressure are standard atmospheric. The unexpected gas in the box which was going to be refilled or cleaned prior to reuse presented the dangerous situation which may cause an accident. The disturbance at the interface showed the initiation of the phenomenon.

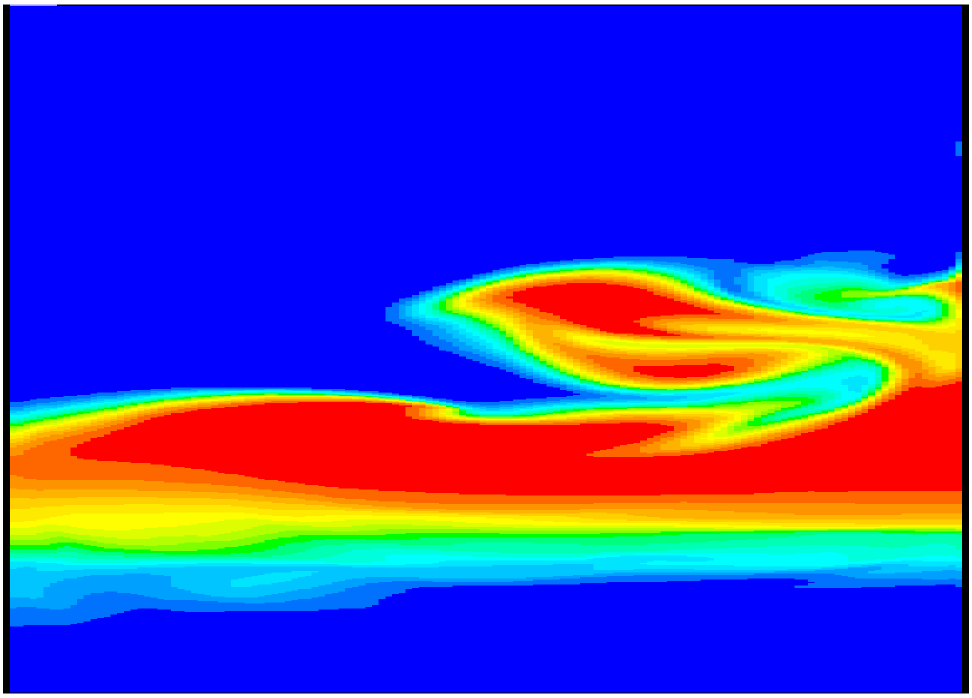


Figure 7: First ignition look of incoming air jet contours Volume fraction gas

The upper interface and the lower interface were widely mixed at the side of jet strike. The effect prevailed till other side. Many layers of gas distinguished. The strike of air on layers of gas created turbulence of such level that the gas burned. The information of chance of such accident with air jet and continuum space was learned. Fuzzy interface system was summed with the information gain. Figure 8 shows the model. Information gained of jet, continuum space was fuzzified with accident chances. Ready surface plots of relationships were drawn.

Mamdani fuzzy interface model [24] was used to build interface between inputs: jet, continuum and output: accident chance. Membership functions were assigned to each variable with ranges from 0 to 1. Information gain was added with full weight. The ready surface plot among jet, continuum and chance of accidents is shown in Figure 9. At low jet and empty continuum, the chances of accident are less. When jet is variable into dangerous continuum constituents chances of accident are more.

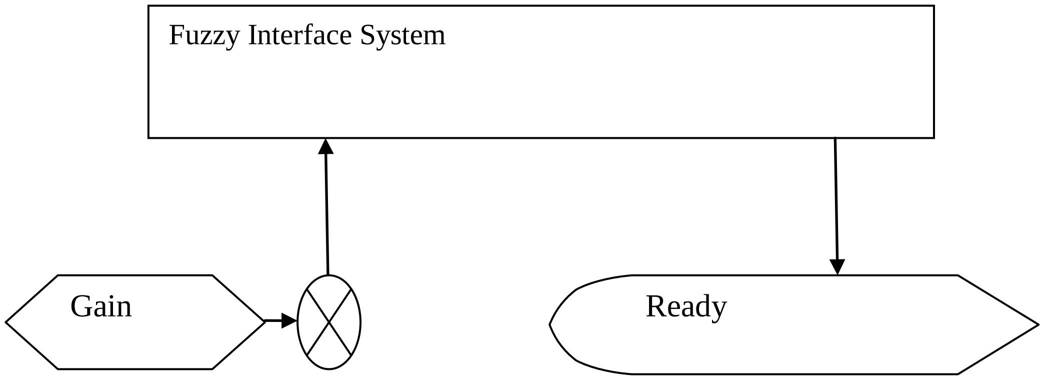


Figure 8: Summation of the fuzzy interface system model

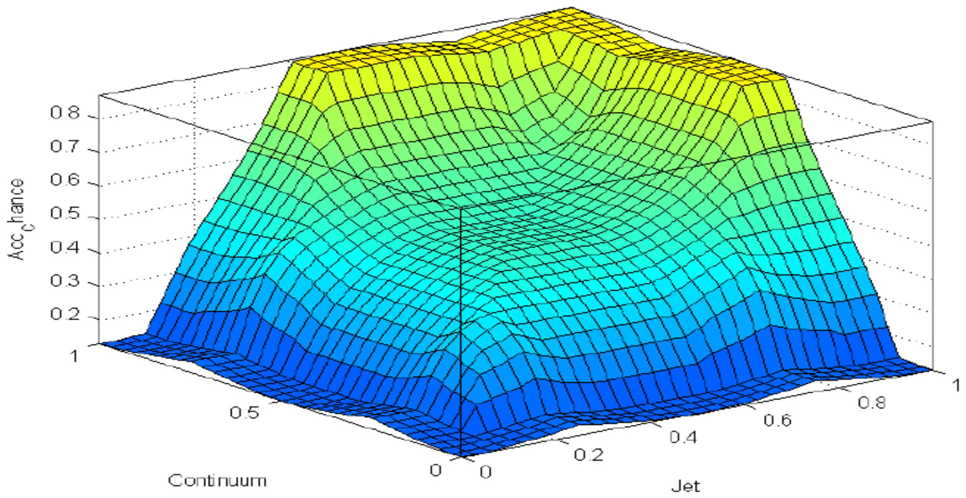


Figure 9: Ready surface plot of jet, continuum and chance of accident with into dangerous continuum constituents

SUMMARY

The incoming jet which in refilling case was liquid contains air due to inadequate storage or inadequate pumping. In case of cleaning or drying the container, the presence of any gas was not expected which may generate danger.

Gas inside the container was flammable. Jet flew deep till bottom in empty situation. The speed of air jet was high. Air jet may have produced scratches on the metallic walls. The backflow at inlet may be a reason. It is assumed that at this time reaction may take place when attains condition of speed such that to reach the opposite wall [25].

Gas cannot be burnt unless otherwise there are some kinds of igniters are. A safety valve may reduce the chances of such ignition if provided at suitable location of containers to be refilled or used for such operations. Grounding is necessary during such kind of situations. Air jet split has occurred and earlier reaction due to many jets has taken place. The relationship may be drawn among initial meeting dip and fist ignition [23]. Experienced practice is needed prior to avoid such situations. For the gas identification with known liquid or vice versa experimental apparatus may be fabricated and the above procedures may be followed.

Particle pollution disturbances may be investigated. Explosion technology may be benefited with fuzzy interfacing.

The gas was flammable. Reaction may have occurred due to some driving force. Moving air was a source. Fuzzy modelling may lighten the mile stones ahead. Variable injections and continuum ingredients show more impacts. Additional input may be added prior to simulations.

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