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PROCESSES OF SPREADING GAS POLLUTION ON HILLY FIELDS

PROCESY ROZPRZESTRZENIANIA SIĘ ZANIECZYSZCZEŃ GAZOWYCH NA OBSZARACH PAGÓRKOWATYCH

Abstract: A conditioning rank exists for the emission of a harmful substance, which overlaps in vicinity of varied ground-based objects. Consequently, part of the process of spreading pollution is determined by the flowing conditions and is shaped by their presence and distribution. However, under real conditions, complexes systems of terrain obstacles exist. A subject of interest among many authors is the flow and dispersion of pollutants surrounding single elements such as a hill or a building. This type of research enables a better understanding of the flow and propagation of pollutants on terrain with complex topography. The aim of the present work is the investigation of the influence of the complex character of a velocity field, particularly its periodic composition (non-stationary blowing) as well as rotating structures generated by obstacles such as hills on the propagation of various types of gaseous pollutants. The base of analysis represents the evolution of the carbon dioxide concentration in profiles surrounding hills or different locations in relation as well to the height of the source emission. By propagating a gaseous tracer in a rolling medium from a source located in a flush zone, a source's location relative to circulation zones of increased level turbulent fluctuations of flow velocity can be determined.

Keywords: experimental and numerical modeling, pollutants dispersion, gaseous pollutions, hilly field

Introduction

In many cases, the emission of harmful substances takes place in a neighborhood with various ground-based objects. As a consequence, a part of the dispersion process of pollution takes place in flow conditions formed by their presence and position. However, in complex systems and exist due to terrain conditions, a subject discussed by many authors is flow and pollution dispersion of small elements in a surrounding (hill, building) [1]. Such researchers are the first step to better understanding the flow and dispersion on terrain consisting of complex topographies. The tests of structured wind flow in mundane zones, which are comprised complex topographies, contribute series of information relevant for the most recent aerodynamics problems. Among other things, they relate to the dispersion of pollution, fire propagation, wind erosion and local condition researches which favor wind energetic. The last herein mentioned aspect forms the particular motive for wind flow analysis in the rolling medium. Flow features around single hills have both an influence conditions as inlet conditions and medium geometry. The collection of the mentioned factors can cause big differences in the kinematics within the jet stream which in general case sets detachment phenomenon, recirculation and adherence. The problem of wind flow over rolling media was taken in a series of work which involved both researches led in natural all-terrain condition, experimental modeling, and also numerical simulations. Most quoted work belong to Jackson and Hunt [2], presents analytical solutions for the genial hill shape, numerical Peterson models [3], Lenelin and

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others [2] and experimental results of Ferreira et al [4] and Kim et al [5, 6]. The focus of this research was mainly focused on deformation profiles of wind velocity flow according to apparition of symmetrical hills a low inclination [7, 8]. Geometry of media which was taken in most analyses does not appear to lead to strong detachment and recirculation zone. This constrains compliance of offered calculation methods [4] and experimental model consistency with a real wind field along the hill. Practical value of results of research denigrates the lack of information about general currents in nature, unfavorable aerodynamic modeled flow features. Detachment and recirculation cause strong fluctuations in velocity zones and change flow wind directions. Demodulation of these zones has an important meaning in wind engineering.

The testing bench

Scheme of measuring instrument is shown in Figure 1. The role of tap gas source, from the scoring source (pipe) from pointing source was played by carbon dioxide with a flow outlet velocity equal in approximation of undisturbed flow velocity, above layer zone.

To measure the concentration of CO_2 analyser Guardian plus was used. Analysed model of the hill was installed on a medium aerodynamic tunnel in the Aerodynamic Laboratory of Czestochowa University of Technology upon which the layer zone of thickness $\delta = 0.1$ m was generated, and profile velocity shape typical for an open ground with poor vegetation.

The velocity of the boundary of the layer zone amounted to $U_o = 13$ m/s. The shape of tested hill model is described by the relationship:

$$z_s = \frac{H}{2}\left\{1+\cos\left[\left(\frac{\pi}{2}\right)\left(\frac{x}{0.5W}\right)\right]\right\} \tag{1}$$

where: $H = 60$ mm, $W = 100$ mm (Fig. 1). Measurements were conducted for three different locations ($x = x_s$, $z = h_s$) and their emissions (Fig. 1), namely: (p1) $x_s = -W$, $h_s = 1H$; (p2) $x_s = 0$, $h_s = 1H$; (p3) $x_s = -W$, $h_s = 0$.

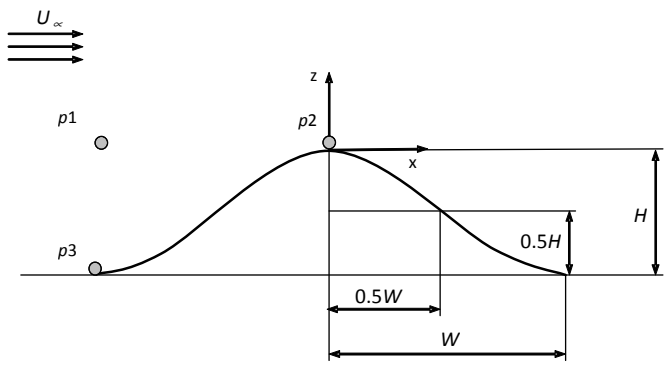

Fig. 1. Scheme of measuring testing bench with mounted researched object with marked location of emission CO_2 source

The measuring probe was mounted on a moveable support, which enables establishment of vertical concentration CO_2 profiles for chosen stream x = const set in localizations: $x = 0$; $0.6W$; W; $2W$; $3W$; $4W$. All measurements were done in a tunnel axis.

Work results

The aerodynamic outline of the researched object which enabled the detection of surrounding characteristic zones with strong diversified features, namely the area of increased velocity flow above the top of the hill and recirculation region of flow behind the hill (Fig. 2).

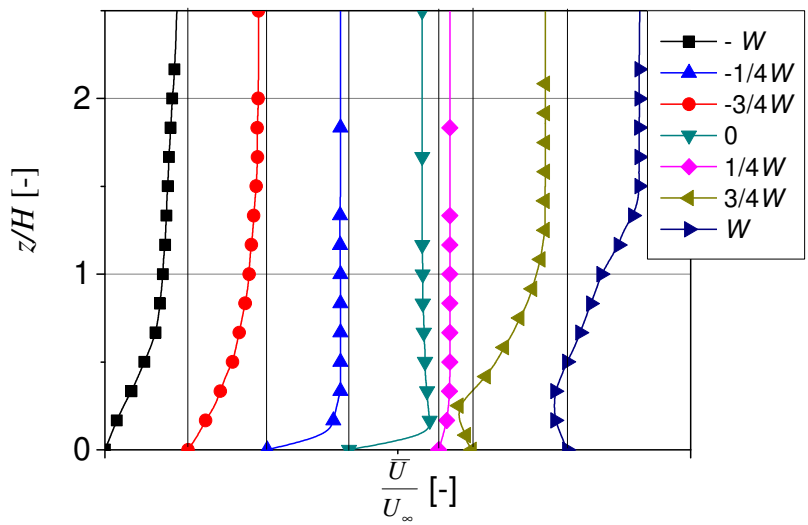

Fig. 2. View of evolution the average velocity profile component in flow around hill (scale: 0-1 for each profile)

The evolution of the concentration profile of carbon dioxide in a hilly environment for different locations and height source emissions is shown on Figure 3. As shown in the aforementioned diagram, courses differ on a particular drawing both qualitatively and quantitatively, but generally speaking, the presence of the terrain obstacle, which modifies the shape of emitted in environment trail of pollution in a relevant way could be ascertained.

This abides to features of velocity fields connected to an aerodynamic object in a fluid stream, but in a particularly closed environment in which recirculation zones arise from the zone of increased turbulence zone behind the hill. For the dispersion process of substances emitted from the source responsible are both mass diffusion mechanism, caused by concentration gradients and advection, transported pollution in a flow direction with help of average air flow and a turbulent transport process in which their own part has own turbulent velocity fluctuations. The maximum concentration values of carbon dioxide on the plume axis in every considered case varies.

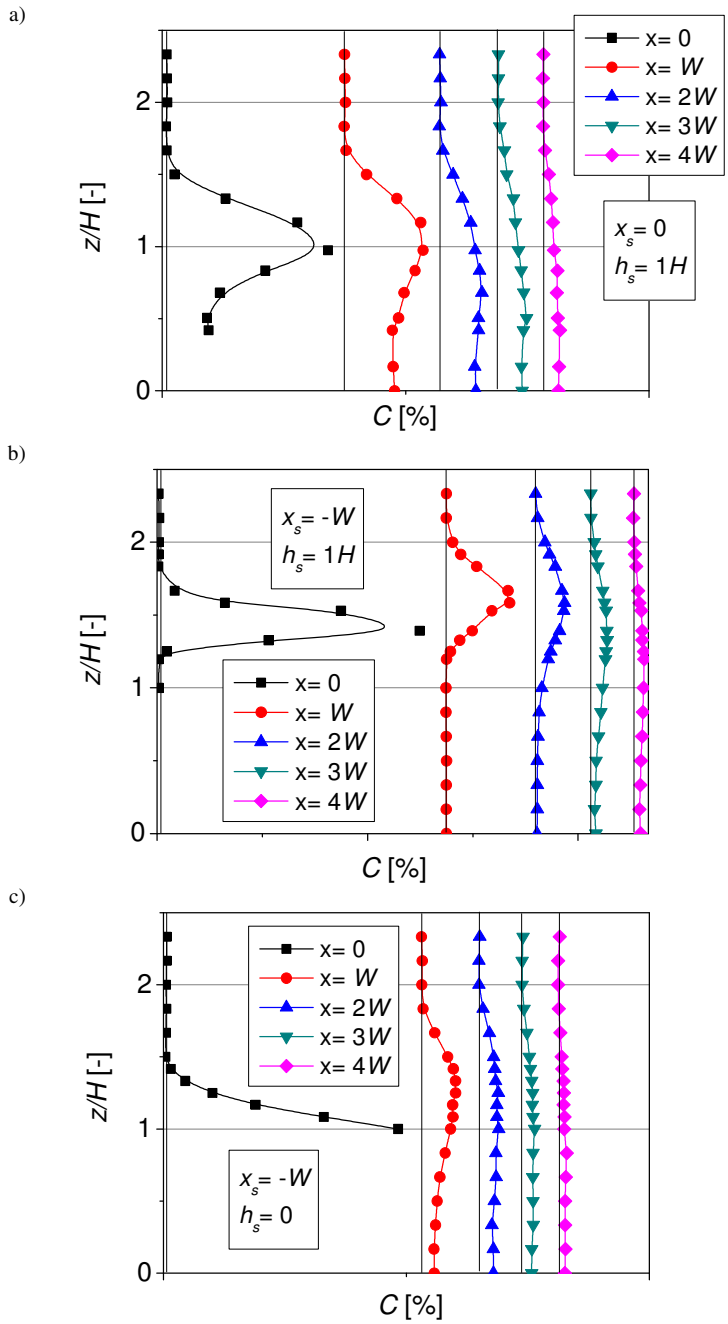

Fig. 3. View of concentration profiles of carbon dioxide in surroundings of a hill for a source emission in a locations: a) p1; b) p2; c) p3 (scale: 0-1 for each profile)

As the maximal values of distributions show qualitative similarity, they decreased with the distance from the source emission in every case, as long as the plume axis locations depend on a location at a predetermined distance from source location. As an effect of deflection of the stream which is emitted from a source in a location, (p2) ($x_s = 0$, $h_s = 1H$) an increased value of CO_2 concentration at ground level is obtained. In that case of the location of source the stream of carbon dioxide is provided almost directly into a recirculation zone behind the hill, where dilution and dispersion appears. The effect of that is mainly movement at ground level. In the case where the source was located on a height $h_s = 1H$ it was found in a distance W in front of the hill, then the dominant transport mechanism of emitted gas is advection, which causes the maxima of concentration to rise above the recirculation zone. At the same time the concentration of CO_2 is measured at ground level is practically equal to normal atmospheric values at close distances behind the hill. At long distances the influence of the situated source in terms of tab gas concentration at ground level disappears.

Summary and conclusions

To sum up obtained results, it can ascertained, that the dispersion of the CO_2 tab emitted from sources located in a flow flush on element of rolling medium and on its top performs in the different flow conditions, which are responsible for dissimilar character of course concentration of CO_2 in modeled wind field. Firstly, the source location in relation to the recirculation zone and the area of increased fluctuated turbulence velocity flow level is essential.

In the article, the initial results of researchers which suggest the significant influence of oscillation component of the velocity on pollution dispersion is shown. It is also acknowledged here that this theme still requires further research.

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PROCESY ROZPRZESTRZENIANIA SIĘ ZANIECZYSZCZEŃ GAZOWYCH NA OBSZARACH PAGÓRKOWATYCH

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Abstrakt: Istnieje szereg uwarunkowań, w których emisja szkodliwych substancji zachodzi w sąsiedztwie różnorodnych obiektów naziemnych. W konsekwencji część procesu rozprzestrzeniania się zanieczyszczeń przebiega w warunkach przepływowych kształtowanych ich obecnością i rozmieszczeniem. Mimo że w warunkach rzeczywistych występują złożone układy przeszkód terenowych, przedmiotem zainteresowania wielu autorów jest przepływ i dyspersja zanieczyszczeń w otoczeniu pojedynczych elementów, jak wzgórze czy budynek. Badania tego typu służą lepszemu zrozumieniu przepływu i rozprzestrzeniania zanieczyszczeń w terenach o złożonej topografii. Celem niniejszej pracy jest zbadanie wpływu złożonego charakteru pola prędkości, a szczególnie jego składowej okresowej (niestacjonarnych podmuchów wiatru) oraz struktur wirowych generowanych obecnością wzgórza na rozprzestrzenianie się różnego typu zanieczyszczeń gazowych. Podstawę analizy stanowi ewolucja profili koncentracji ditlenku węgla w otoczeniu wzgórza dla różnego położenia i wysokości źródła emisji. Na rozprzestrzenianie się znacznika gazowego emitowanego ze źródła usytuowanego w strefie napływu na faliste podłoże ma wpływ przede wszystkim położenie źródła względem strefy recyrkulacji oraz obszaru o podwyższonym poziomie turbulentnych fluktuacji prędkości przepływu.

Słowa kluczowe: modelowanie rozprzestrzeniania zanieczyszczeń, zanieczyszczenia gazowe, teren pagórkowaty