Fog Collector Influence on the Wind Velocity Field

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Abstract: The experimental campaign aims at mapping the flow velocity field when approaching the fog collector, in Spanish called *atrapaniebla*, with the purpose of investigating the flow in the open area under the collecting pipe, around the post and in its downstream region. Field data of wind intensity and direction were collected in the fog season 1997 in the experimental station in the *Lomas de Mejia* in Peru, through fix cup anemometers connected to data loggers and a mobile revolving-vane anemometer. Qualitative maps of the ratio between the measured velocity value and the undisturbed one show the trend of the velocity field, where the flow is accelerated and decelerated. The fog collector presence is felt up to a downstream distance equal to the height of the obstacle. A reduction coefficient of velocity values due to the mesh presence is obtained for different velocity classes: low wind velocities (2÷3 m/s) are weakly influenced by the presence of the mesh, the reduction is equal to 16%, higher wind velocities (3÷5 m/s) are more influenced, the reduction is equal to 24%. The obtained results give a preliminary answer to the possibility of spatially characterizing the variations in the velocity field occurred by the presence of a fog collector through field experiments.

1. INTRODUCTION

When the wind encounters a barrier, as a fog collector, in Spanish *atrapaniebla*, placed on a ridge, the uniform current becomes disturbed and the turbulent motion exerts a brake on the forward velocity. Any obstacle which obstructs the flow of the wind creates zones of modified flow both upstream and downstream of the obstacle itself and their extension depends on the form, dimension and structure of the obstacle. Part of the hitherto horizontal air flow is deflected over the top, the remainder, in a much weakened form, passes through the voids of the mesh causing an abatement in the velocity values in the downstream region.

The present work deals with the first results come out from an experimental campaign aiming at mapping the velocity value variations due to the presence of a vertical mesh able to interrupt the incoming fog path and let the water particles flow down in a collecting pipe located beneath the mesh [Schemenauer *et al.*, 1991]. The experimentation was carried out in the framework of the project funded by the EU, "Fog as a new water resource for the sustainable development of the ecosystems of the Peruvian and Chilean coastal desert" (TS3-CT94-0324, DG12 HSMU) on the hills of the coast of Southern Peru, called the *Lomas de Mejia*, approximately 170 km South of Arequipa during the 1997 fog season [Bresci, 1999].

The analysis of the collected data allowed to generate contour maps representing the ratio of the measured velocity values and the corresponding undisturbed value occurred in the same time interval.

The experimentation went through the analysis of the field velocity in the open area under the collecting pipe, around the post and in the downstream region.

2. METHODS

Wind speed data was collected mainly on days without fog through two fix cup anemometers and a mobile revolving-vane anemometer. One fix cup instrument was mounted upstream of the collector at a distance of 7 m where the flux could be still considered undisturbed, the other one 2 m downstream, both giving data at 5 minute intervals. They were located at the same height from the ground to measure velocity values on the horizontal plane passing through the barycentre of the mesh. They were registering data continuously and they were synchronized in time to have the wind speed registration covering the same time interval. The revolving-vane anemometer was moved inside the field site to measure velocity values in given points of the flow field. Data coming from the two data loggers connected with the two cup anemometers was downloaded each evening and immediately processed. They had a double utilization: the former was to collect a sufficiently long data series in order to determine the reduction of wind velocity values induced by the passage through the porous mesh, the latter was to make use of the mobile anemometer data series once referred to the cup anemometer data covering the same time lag. The duration of 5 minute registration of the upstream cup anemometer used as reference for the undisturbed velocity value, was covered by enough measurements coming out every 22 seconds by the mobile anemometer. The mean value of data covering the 5 minute registrations (Vvane) was calculated and then divided by the corresponding value from the fix anemometer (Vcup). Qualitative maps of dimensionless flow velocity through the ratio of Vvane to Vcup were produced combining the two series of data for different areas of investigation; a ratio value bigger than one means that the current is accelerated and a ratio less than one means that it is decelerated.

Trials on the same investigation survey were carried out on different days in order to obtain enough data to describe the phenomenon with sufficient accuracy.

3. RESULTS

Measurements on a vertical line passing through the barycentre of the mesh, or equivalently 6 m far from the two posts, were made in order to map the modified velocity profile due to the open area under the collecting pipe where the air flow, mist or not, could freely pass and get accelerated.

Figure 1 shows the dimensionless vertical profile under the pipe starting from 0.6 up to 1.4 m distance from the ground.

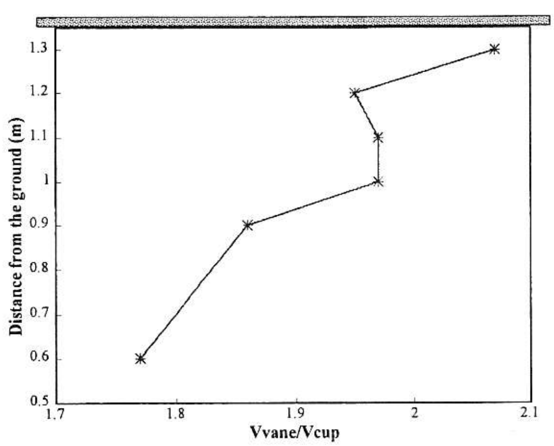

Figure 1. Dimensionless velocity vertical profile under the collecting pipe.

The acceleration induced by the presence of the open area clearly appears and it is stronger closer to the pipe, showing a velocity value about twice the undisturbed one. Moving down to the ground up to 0.6 m, the ratio is still 1.8, indicating that the viscous boundary layer is very small.

As regards the flow acceleration in the open area under the collecting pipe, measurements on a line parallel to the main dimension of the collector at 1.2 m distance from the ground were collected in order to map the modified velocity profile at increasing distance from the post. Tests were made 0.2 m above and below the collecting pipe sampling every meter and the dimensionless velocity profiles are shown in figure 2.

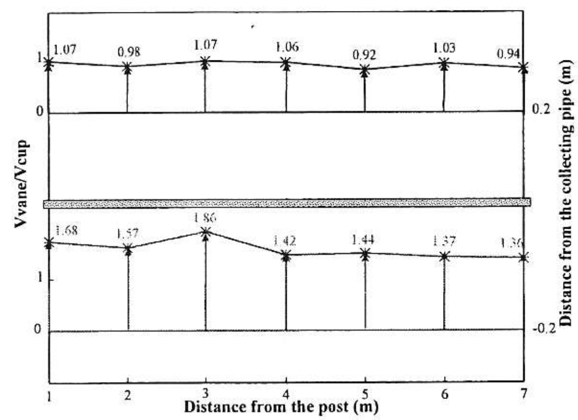

Figure 2. Dimensionless velocity horizontal profiles below and above the collecting pipe upstream of the collector.

The horizontal profile 0.2 m above the collecting pipe is practically undisturbed, showing values close to one. On the contrary, the profile in the open area under the collecting pipe, is strongly disturbed showing an increasing trend in the ratio values moving close to the post. At 1 m distance from it, the velocity value is increased of 50%.

In order to map the flow velocity around the post of the collector, wind velocity data was collected through the mobile anemometer on a spatial grid whose cells were 1 m wide placed around the post on an horizontal plane 1.25 m above the ground. The contour map representing the disturbance offered by the post is shown in figure 3.

The flow field is characterized by symmetric structures, in fact the contour lines 1 m upstream and downstream seems to be very similar, at a lateral external side the flow field is strongly effected by the presence of the post originating a symmetric structure.

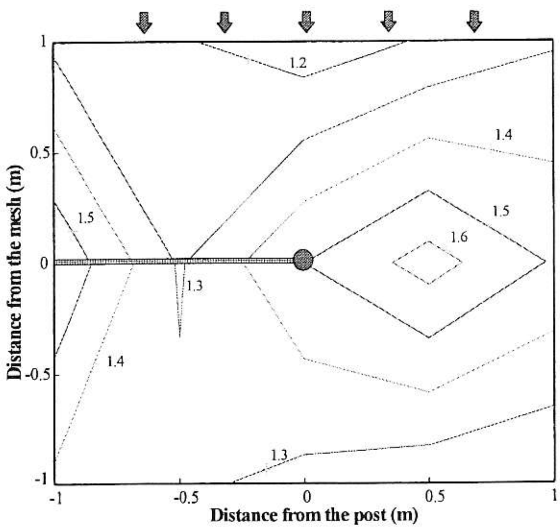

Figure 3. Dimensionless velocity ratio iso-lines close to the fog collector post.

As regards the downstream flow, measurements were taken on an horizontal spatial grid of 1 m width located at 1.25 m from the ground downstream of the collector.

The dimensionless velocity values are shown in figure 4.

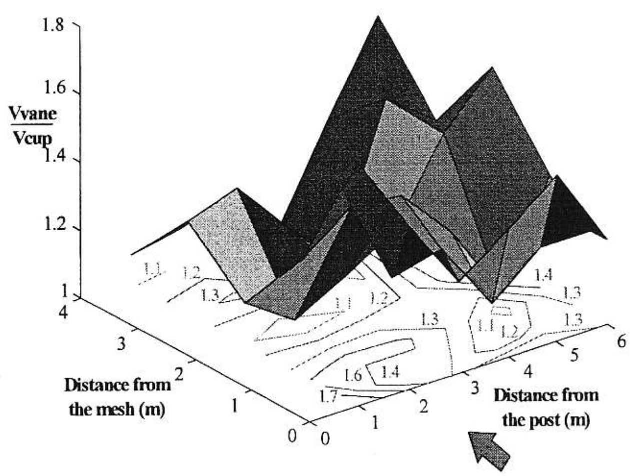

Figure 4. Dimensionless velocity ratio iso-lines in the downstream region.

The downstream area is characterized by values greater than one, testifying an acceleration of the flow due to the effect of the open area under the collecting pipe and the effect of the flow around the post. The two regions characterized by peaks of values up to 1.6 are close to the post and in the middle of the collector at a downstream distance of 4 m. Going further from the mesh, the profiles seem to be re-established, even if the disturbance still remains in the middle of the collector up to a distance equal to the height of the collector.

The time interval for data recording was chosen equal to 5 minutes, small enough to register also wind gusts. The analysis is referred to a period of 13 days: the collection period was longer but some data has been excluded from the analysis due to problems occurring in the anemometer located downstream of the collector. Three different vectors were created containing the wind speed values downstream and upstream of the collector, and the ratio between them (*r*). The complementary to one to that ratio (*rc*) is the reduction in wind speed given by the passage through the mesh. In table 1 some statistical parameters of *r* are presented dividing the velocity range into three different intervals and the corresponding *rc* values.

Table 1. Statistical parameters of the wind speed ratio

Wind speed (m/s)	sample size	*r* min	*r* max	*r* mean	std	*rc* (%)
2-3	344	0.74	0.99	0.84	0.047	16
3-3.5	782	0.65	0.97	0.78	0.044	22
3.5-5	417	0.61	0.85	0.76	0.035	24
2-5	1543	0.61	0.99	0.79	0.052	21

The mean values of the ratio for each interval and for the whole velocity variation range (2÷5 m/s) can be considered representative considering the low values of the standard deviation (*std*). The mean wind speed ratios and the reduction coefficients show how low wind velocities are weakly influenced by the presence of the mesh, in fact the reduction is equal to 16% for velocities ranging from 2 to 3 m/s. The stronger is the wind speed, the bigger is the reduction coefficient; for velocities in the interval 3÷3.5 m/s the reduction is 22%, for the 3.5÷5 m/s class the reduction is 24%.

4. CONCLUSIONS

The effect of the presence of a permeable obstacle represented by a fog collector is examined through field experiments with the aim of characterizing the modifications induced to the flow motion. Some new phenomena that have been observed and measured include the acceleration given by the presence of the open area below the mesh, the influence of the post presence on the motion side to the post itself and the modification in the flow field in the downstream region. The research survey shows that the presence of the open area under the collecting pipe induces a strong flow acceleration with values double with respect to the undisturbed flow; the disturbance downstream of the collector is the result of the combined effects due to the post and the open area under the collecting pipe. In particular, in the first meter both the effects are felt; moving downstream, the open area plays such a role that up to 4 m the flow is still disturbed to increase the velocity of 50%. As regards the results obtained for the reduction effect on wind speed values given by the presence of the collecting mesh which allow the wind to pass through it, a slight reduction effect is found for low wind speed values and a bigger reduction for stronger winds.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

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