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AIRBORNE DUST DISTRIBUTION IN TIED COWS HOUSE WITH DIFFERENT FANS OPERATION REGIME

Author(s):
G. Topisirovic

Affiliation:
Faculty of Agriculture, University of Belgrade, Nemanjina 6, 11080 Zemun – Belgrade, Serbia

Email address:
gogi@agrif.bg.ac.rs

Abstract

Dust concentration is significant microclimate parameter in livestock buildings. Increased dust concentration affects animal health. Paper presents results of experimental study focused to the influence of fans working regime on airborne dust concentration in the barn for tied cows. Different fans rotation rates gave air flows from 23750 m^3h^{-1} to 48000 m^3h^{-1}. Measurements were conducted at four height levels, three lateral and four longitudinal sections. Consequently, 48 measuring points were selected to cover the whole space. Analysis showed that this setup gave satisfactory results. Certain regimes were recommended and rate with 37300 m^3h^{-1} was found as the most suitable.

Keywords

fan regime, ventilation, airflow velocity, microclimate, airborne dust

1. Introduction

Expression dust is defined as solid particles with a diameter up to 100 μm that are suspended in the air. Within the total (inhalable), fraction of respirable dust should be distinguished, as it contains particles with less than 5 microns in diameter [1]. There are significant because they penetrate into the deepest parts of the lungs, as opposed to larger particles that are largely retained in the upper parts of the respiratory tract. Dust in livestock buildings is primarily organic. It comes from the animal body surface (dried skin particles), bedding, dried feces and concentrated feeds [2].

The presence of increased dust concentrations causes a number of health problems. Therefore, animals productivity decreases. Employees health problems arise as well, so recommendations for allowable concentrations of dust are given according to the humans sensitivity. The most commonly accepted is value of 10 mgm-3 for total and 5 mgm^{-3} for respirable dust. In order to prevent the occurrence of long-term health problems, much more stringent limit is only 2.5 mgm^{-3} for total and 0.2 mgm^{-3} for respirable dust [3].

Optimising the heating and ventilating procedures of livestock buildings and determining the economically reasonable usage of this mechanized systems is important from the relations of costs savings. [4, 5, 6]

This paper analyzes the influence of multi regime roof fans on the concentration of particular dust fractions in order to determine the relationship between fan operation regime and dust concentration [7]. Based on this, recommendations about fan usage and settings are given.

2. Material and Methods

We investigated the effect of De Laval ventilation system Multifan with control unit STD - Manual 8 A thermostatic controller T15 - WD and DF 1300 fans. This system has a six rotation speed regimes. The fans are located below the roof, above the feeding alley. Maximum fan capacity is 48000 m^3h^{-1} (at 0 Pa), at the maximum rotation speed of 400 rpm. Measurements in the experimental cows barn are carried out at 48 measurement points (Figure 1). The dots are arranged in three sections, with 4 vertical rows in each section, and the four height levels. Measuring sections were placed in 3 distinctive parts, to 3.30 m from the front door to the feeding alley on the north side, and another 2 at the distance of 14.90 m from each other, so that the fans influence zones are covered. Vertical arrays are placed symmetrically above the feeding places and manure channels [8]. Height levels are at 50, 100, 150 and 200 cm, with the same goal as in the previous case. Concentrations of dust fraction ≤ 3 μm and ≤ 5 μm were measured. The measurement was done for five different fan operating regimes.

3. Results and Discussion

During the first series of dust concentration measurements in the experimental cow barn, fans were switched off. In those conditions, concentrations of dust particles in different parts of the room depend on natural movement of air and air humidity. Consequently, concentrations of both dust fractions (up to 3 μm and up to 5 μm) were higher compared to corresponding concentrations when roof fans were in any operating regime (Figure 2a and 3a, respectively). Concentrations were fairly uniform over the object volume, which confirms stationary state of air speed fields in the stable without forced ventilation. Some deviations that were recorded may arise as a result of cows activity, different bedding composition, distribution of concentrated feeds etc.

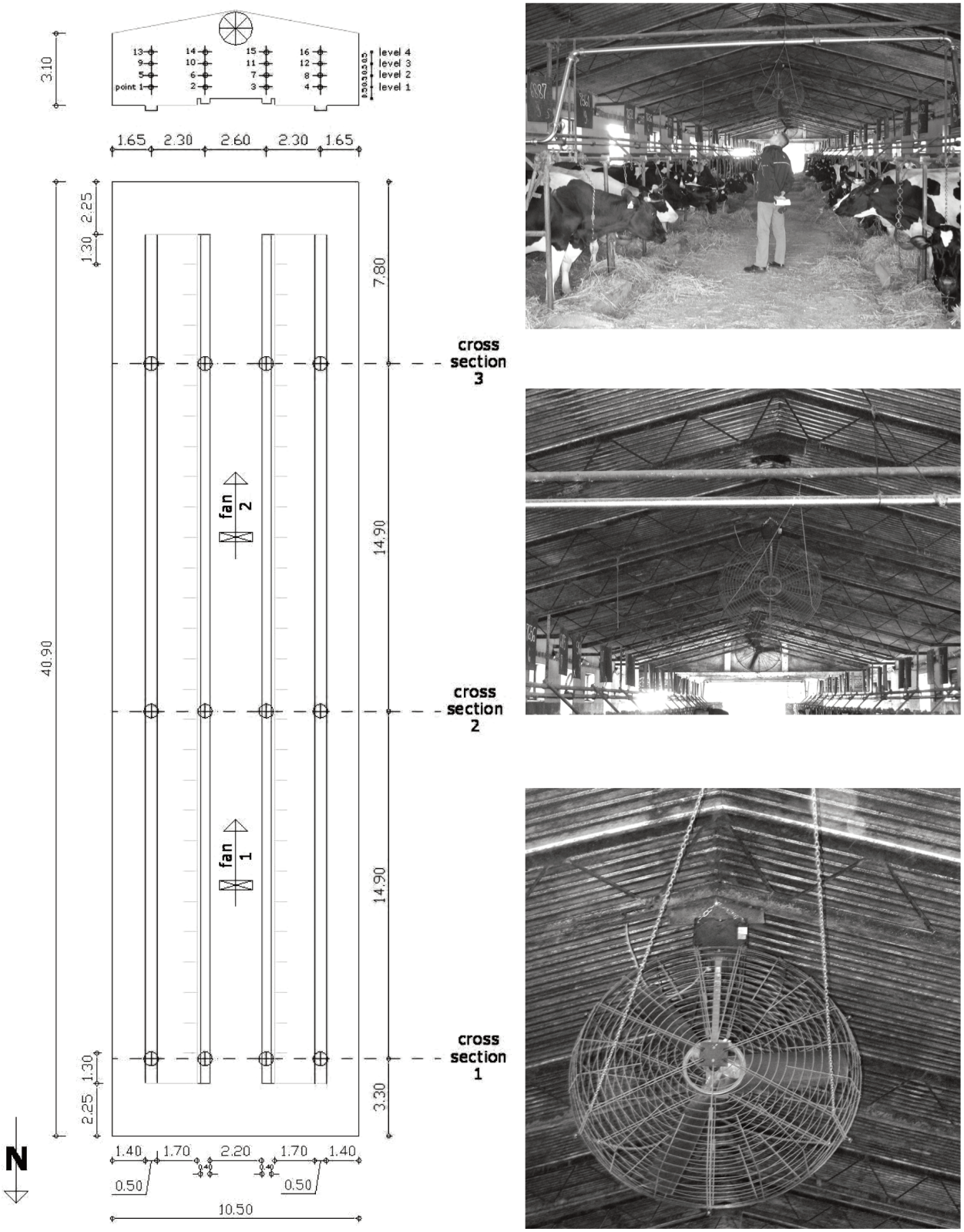

Figure 1. Building and measuring points setup (left) and inside ambient photos (right)

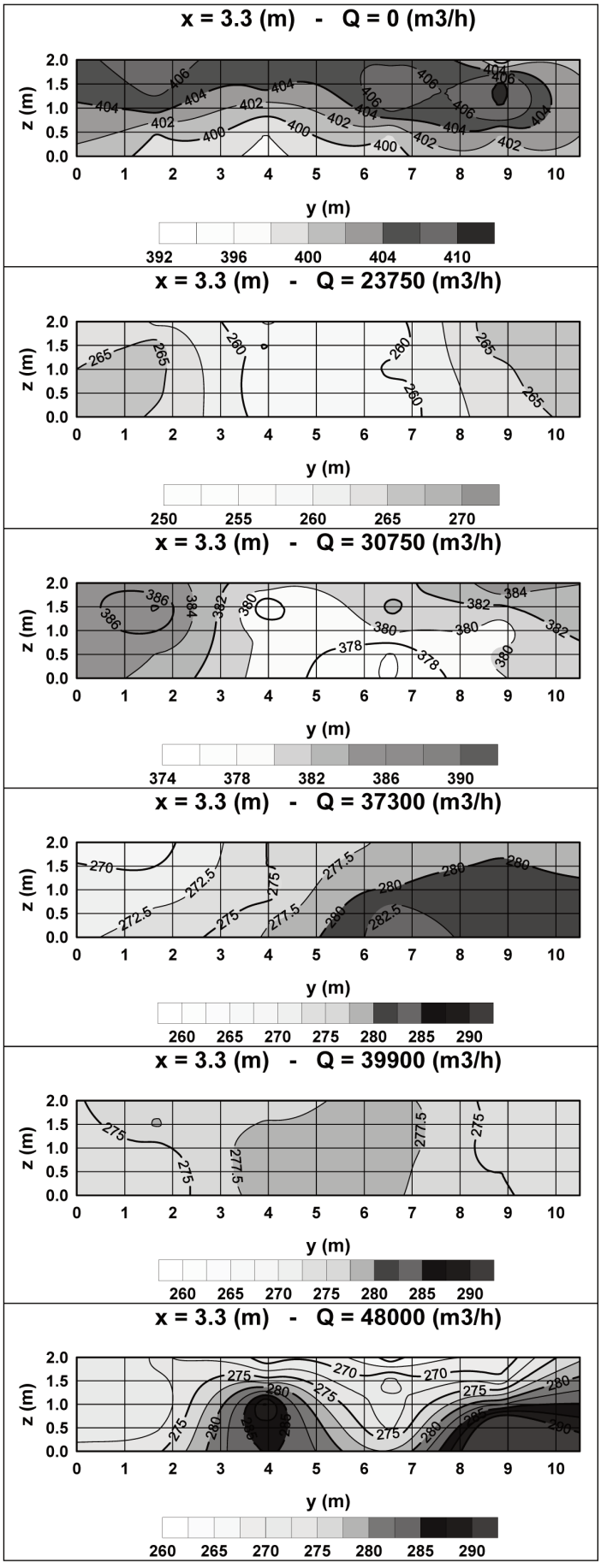

Figure 2. Distribution of 3 μm dust fraction concentrations in cross section at 3,3 m from the feeding alley entrance, under different operating regimes of roof fans

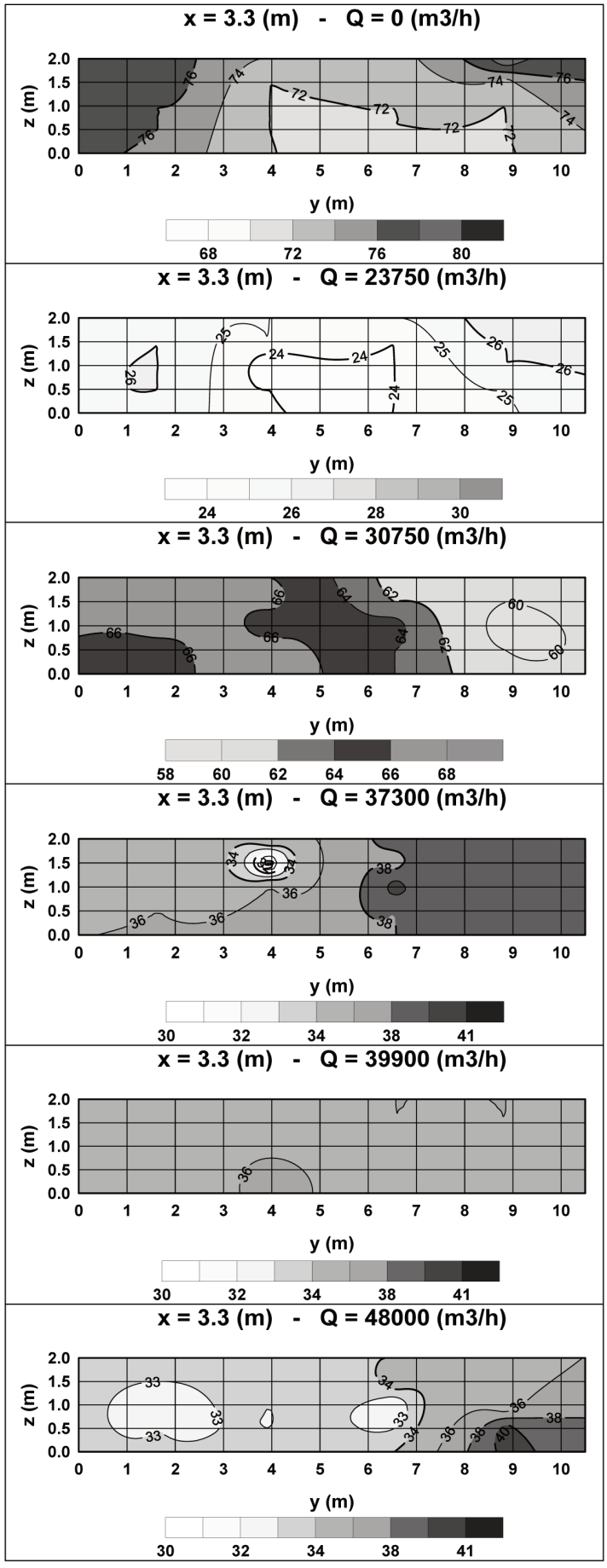

Figure 3. Distribution of 5 μm dust fraction concentrations in cross section at 3,3 m from the feeding alley entrance, under different operating regimes of roof fans

During the second series of measurements, when the fans provided nominal air flow of 23750 m^3h^{-1}, the lowest airborne dust concentration was observed, in relation to all the other operating regimes (Figure 2b and 3b). In this mode, fans provide adequate air exchange, and acceptable air flow velocity, that does not resuspend dust sediment from the floor and other surfaces. All those issues resulted in reduced airborne dust concentrations in the stable, compared to other fans operating regimes - the average concentration of dust fraction ≤ 3 μm was reduced from 403 particles·ml^{-1} (Figure 2a) to 260 particles·ml^{-1} (Figure 2b), ie. by 35%, and the concentration of dust fraction with ≤ 5 μm in diameter decreased from 72 particles·ml^{-1} (Figure 3a) to 26 particles·ml^{-1} (Figure 3b), ie. by 64%.

During the third series of measurements, that included 2nd fan operating regime with nominal flow rate of 30750 m^3h^{-1}, the highest concentrations of both dust particles fractions in the experimental facility were recorded (Figure 2c and 3c), compared to all the other regimes (excluding switched of fans). It can be expected that dust concentration would decrease after a longer fan operation and that later on reduction would continue and concentrations would stabilize at lower values.

During the fourth (Figure 2d and 3d) and fifth (Figure 2e and 3e) series of measurements, that included 3rd and 4th fan operating regime (respectively) with nominal flow rate of 37300 m^3h^{-1} and 39900 m^3h^{-1} (respectively), reduction of both dust fractions (up to 3 μm and up to 5 μm) was observed. In the facility was established a fairly uniform dust concentrations distribution. In this operating regimes, convective transport (exhaust) of dust particles exceeds its introduction into air flow as a result of sedimented particles raising from the floor and other surfaces within the facility.

During the sixth series of measurements, that includes 5th fan operating regime with maximum air flow of 48000 $m^3 \cdot h^{-1}$, the concentrations of sirborne dust particles began to rise again (Figure 2f and 3f), as a result of intensive dust resuspending from bedding, due to the increased airflow velocity in the house.

After a comparative analysis of airflow velocities and dust concentrations at different fan operating regimes, it can be concluded that, for air exchange in summer conditions, the optimal operating regimes are primarily 1st (23750 m^3h^{-1}), and then 3rd (37300 m^3h^{-1}) and 4th (39900 m^3h^{-1}). In these three cases, along with optimal limited airflow velocities, the best effects of subjective feeling were achieved by intensive body heat drawing, while achieving the lowest concentration of both dust fractions.

4. Conclusions

Based on the analysis of results of dust concentration measurements, with respect to the optimal airflow velocities requested in such buildings, it may be concluded that the best effects were achieved by the lower fan rotation speeds.

Considering reduction of airborn dust concentration, particularly favorable is 1st regime (23750 m^3h^{-1}), but also acceptable are 3rd (37300 m^3h^{-1}) and 4th (39900 m^3h^{-1}) regime. In those conditions very stable and effective dust concentration reduction was achieved, with airflow velocities that are within the optimal intervals for summer conditions (0.2 - 0.9 ms^{-1}).

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