Analysis of the Current Models of Aerosol Dry Deposition

V.N.Piskunov

Russian Federal Nuclear Center – VNIIEF; Sarov, Nizhni Novgorod region, 607190, Russia

Keywords: aerosol, dry deposition, rough surfaces, theoretical models, comparison with experimental data

Presenting author email: piskunov@vniief.ru

Lately, the models of dry deposition of aerosols on rough surfaces have been developed intensively. The following three models will be considered.

Z-W model (Zhao and Wu, 2006) is based on a rigorous treatment of walk and directed motion of particles in the boundary layer. The lower boundary is defined by the empirical interpretation of the experiments.

S-P model (Piskunov, 2009) is based on the empirical generalization of experimental results? obtained Sehmel in 1973-1980 and review of (Slinn, 1978). The model agrees with analytical solutions for smooth surfaces.

H-S model (Hussein et al, 2012) integrates the results of (Zhao and Wu, 2006) and considers not only the roughness height K, but also the distance in between L. The corrections are referred to the weakly inhomogeneous ones with $K/L < 0.082$!! At $K/L > 0.082$ it agrees with Z-W model.

Further, the three models will be compared, the conclusion will be drawn concerning their completeness and the ways of dry deposition model development will be suggested.

1. The direct comparison of H-S and S-P under experimental conditions of Hussein et al (2009)

In figures: across – the particle diameters, vertically – the deposition velocities.

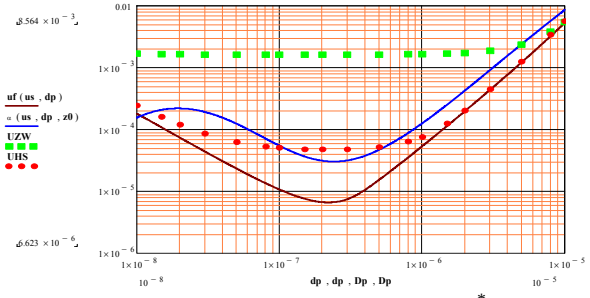

Figure 1 – Data for rough wall plaster (u^* = 0.1 m/s; K = 380-542 μm; K/L = 0.08169)

The difference between the blue curve (S-P model) and the red dots (H-S model) is less than two and ranges between the spread of the experimental data (they are not given here, since they are graphically given in Hussein et al (2009).

2. Data counting (Roupsard et al, 2013)

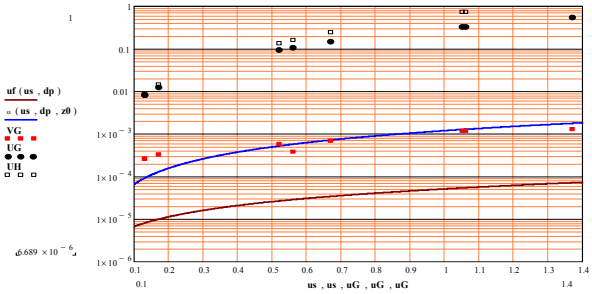

Figure 2 – Data for sinthetic grass ($0.1 \le u^* \le 1.5$ m/s; d_p = 0. 2 μm; K = 4 400 μm; $K/L \sim 1$)

The results speak for themselves.

3. Data counting (Slinn, 1978)

From the calculations it follows that for u^*>0.1m/s works well only model S-P. Apparently, H-S and Z-W models overestimate the deposition velocities due to the extremely large values of the form-factor $F = K - e$.

4. Discussion of results

It is obvious from the whole comparison of computations and three groups of experiments that the completely adequate model of dry deposition has not been developed at this time. S-P model is more general for all the environmental conditions, though its empirical character is more adapted to the atmospheric problems and surfaces of high roughness. H-S and Z-W are more adapted to the flows in ventilation pipes with low roughness and friction velocities. H-S model extends Z-W model for inhomogeneous surfaces with $K/L < 0.082$, and agrees with Z-W model for the ordinary surfaces. On the strength of all the evidence author would prefer S-P model.

Conclusions

1. Currently, the problem of theoretical prediction of aerosol deposition velocities on a rough surface can hardly be solved.

2. The statement of (Hussein et al, 2012), that S-P model overestimates the experimental data is not true. For weakly inhomogeneous surfaces, both models are equivalent. For ordinary surfaces with $K/L \sim 1$ S-P works much better.

3. At this stage author suggest using the semi-empirical S-P model for practical purposes in various cases.

4. For rigorous approaches author suggest analysis and application of the results of Macdonald (2000) for the form-factor F evaluation.

5. Apparently, the integration of theoreticians and experimentalists efforts is more effective to make a coordinated plan of experimental works.

References

Hussein, T., Kubincova, L., Dohanyosova, P., Hruska, A., Dzumbova, L., Hemerka, J., et al. (2009) *Build. Environ.*, **44**,:2056–2063.

Hussein, T., Smolik, J, Kerminen, V., and Kulmala, M. (2012) *Aerosol Science and Technology* **46**, 44–59.

Macdonald, R.W. (2000) *Boundary-Layer Meteorology* **97**, 25–45.

Piskunov, V. (2009) *Aerosol Science* **40**, 664—679.

Roupsard, P., Amielh, M., Maro, D., Coppalle, A., Branger, H., Connan, O., Laguionie, P., He´bert, D., and Talbaut, M.. (2013) *Journal of Aerosol Science* **55**, 12–24.

Slinn, W.G.N. (1978) *Nuclear Safety*, **19(2)**, 205–219.

Zhao, B., and Wu, J. (2006) *Atmospheric Environment* **40**, 6918–6927.