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Wind Tunel Testing of a New Solar Tracker

M. Libra [1], V. Poulek [2]

[1] Czech Technical University, Faculty of Mechanical Engineering,
Technicka 4, 166 07 Prague 6, Czech Republic
[2] Poulek Solar Co. Ltd., Kastanova 1481, 250 01 Brandys nad Labem, Czech Republic

Introduction

The solar tracker, a device that keeps collectors at an optimum right angle to the sun's radiation during daylight hours, can increase the collected energy by 30%. This increase is raised to 80% when solar panels are used to pump water. The functionality of the new model had been verified, but it was necessary to perform a durability test to establish its robustness. The tracker must work for a minimum of 20 years with minimal maintenance. Because we are dealing with a device which is mounted outside it has to meet international safety requirements, including wind speed. The forces acting upon the solar system were to this date either theoretically calculated, or were submitted to static or dynamic testing by simulated weights. We have not yet found mention in any literature about testing any stand with mounted solar panels in an wind tunnel.

Experimental arrangement

Our mobile stand for two photovoltaic panels TRAXLE™ type PST 301 (Poulek Solar, s.r.o.), was mounted by panels of Czech manufacture TETOM type T15 (TETOM, Prostredni Becva). Our stand is protected against wind by a self-locking transmission with a maximum torque of $M = 500\,\mathrm{N.m}$, and is designed in a way that lets is withstand wind of more then up to $v = 160\,\mathrm{km.h^{-1}}$. We performed a factual test of durability in June 1998 in a large wind tunnel with a diameter of 3 meters, which is located in the Aircraft Research and Testing Institute in Prague. This institute has the authorization to perform aerodynamic testing. The whole solar system was placed sucessively into four positions relative to the direction of wind. These directions were: perpendicular to the front, perpendicular to the back, perpendicular to the side, and sideways to the back with and angle of 45°. In each positions we slowly increased the speed of the wind up to $v = 160\,\mathrm{km.h^{-1}}$, and then let it affect the solar tracker for the time $t = 3\,\mathrm{min}$. Fig.1 shows the dimensional diagram of our tested device, and Fig.2 shows the solar system during the tests in the wind tunnel.

Results

The international norm CSN P ENV 1991-2-4 "The fundamentals of designing and loading of the constructions, part 2-4 Loading of the constructions by wind" speaks about resistance of constructions to wind. The whole territory of Europe is never subject to speeds exceeding $v = 160\,\mathrm{km.h^{-1}}$ near ground level. That is why our device was tested in a wind tunnel up to this particular wind speed.

The whole structure was very stable and had minimal vibrations during the tests that we described above. The air currents around the solar systems also behaved calmly. The system kept it's stability, even when we raised the wind speed to $v = 180\,\mathrm{km.h^{-1}}$ for a short time. The tests did not damage the solar tracker in any way. We judge this from the fact of it's working properly after the test.

Given limited money we have not been able to perform aerodynamic tests with different sizes of our solar trackers. Neither has it been possible to measure the real values of the forces that are at play and compare them to theoretically calculated ones.

According to /1/, a wind of speed v in air of density ρ and acting perpendicularly upon rectangular area S, produces a force F given by

$$F = c_x S \rho \frac{v^2}{2} \quad .$$

c_x is the coefficient for the resistance of air for a rectangular planar area S, which is oriented perpendicularly to the flow. You can look up the values c_x in table 1, where a/b is the ratio of the sides of the rectangle. These tests, and the comparison of the acquired values with the theoretical values, are already planned in the future.

Conclusion

Our solar tracker has withstood forces that are caused by winds of a speed of $v = 160\,\mathrm{km.h^{-1}}$ with reserve. It therefore meets the international norm CSN P ENV 1991-2-4 “The fundamentals of designing and loading of the constructions, part 2-4 Loading of the constructions by wind”. It also meets the safety criteria for mounting outdoors. We intend to measure and compare theoretically calculated wind forces with real values in our future work.

References

/1/ F. M. White : *Fluid Mechanics*, Mc. Graw-Hill, inc., (1994)

Tab.1 : The coefficient c_x for the resistance of air for a rectangular planar area which is oriented perpendicularly to the flow in dependence on the ratio *a/b* of the sides of the rectangle.

a/b	c_x
1	1,18
5	1,2
10	1,3
20	1,5
∞	2

Figure captions:

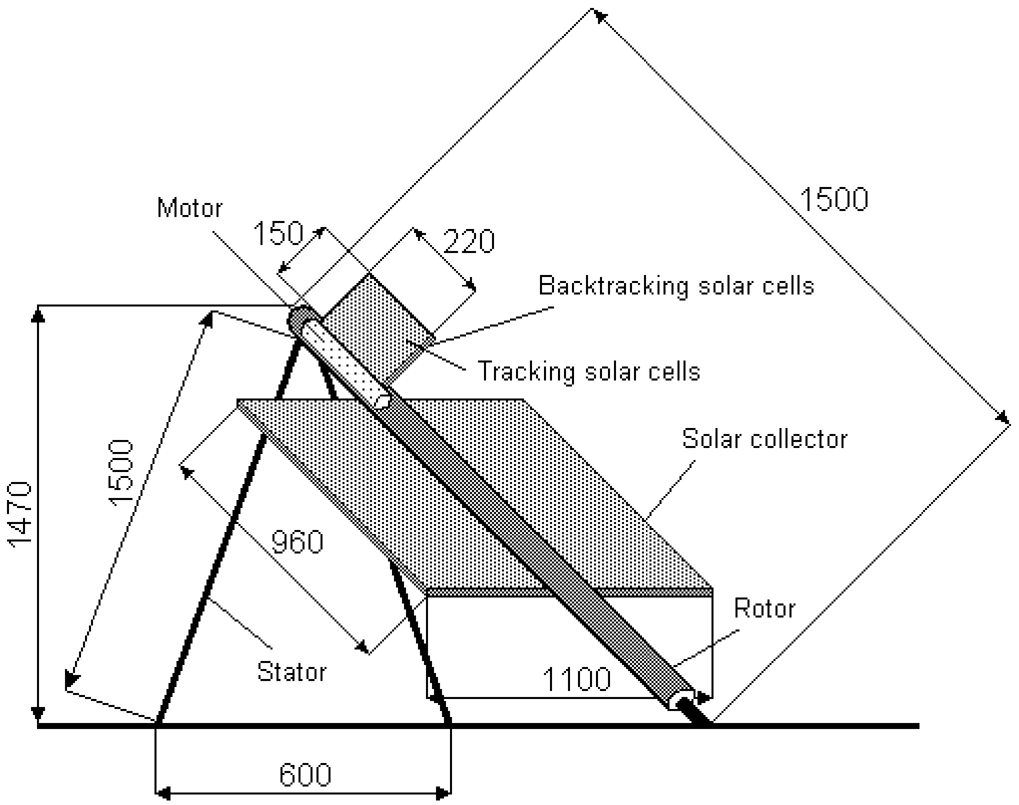

Fig.1 : The dimensional diagram of our tested device.

Fig.2 : The solar system during the tests in the wind tunnel.