NASA TM-77326

NASA-TM-77326 19840010146

A Reproduced Copy

OF

NASA TM-77326

Reproduced for NASA

by the

NASA Scientific and Technical Information Facility

NF00309

FFNo 672 Aug 65

NASA TECHNICAL MEMORANDUM NASA TM 77326

REMARKS ON THE LAYOUT OF THE SUBSONIC FREE JET WIND TUNNELS

Jorg-Dieter Vagt

Translation of "Bemerkungen zur Auslegung eines Unterschall-Freistrahl-windkanals", Zeitschrift fuer Flugewissenschaften, Volume 21, Number 5, 1973, pp. 159-162.

(NASA-TM-77326) REMARKS ON THE LAYOUT OF THE SUBSONIC FREE JET WIND TUNNELS (National Aeronautics and Space Administration) 12 p HC A02/MF A01 CSCL 14B
N84-18214
Unclas
G3/09 12463

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546 NOVEMBER 1983

N84-18214 #

ORIGINAL PAGE IS
OF POOR QUALITY

STANDARD TITLE PAGE

1. Report No. NASA TM-77326	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle REMARKS ON THE LAYOUT OF THE SUBSONIC FREE JET WIND TUNNELS		5. Report Date November 1983
		6. Performing Organization Code
7. Author(s) Jorg-Dieter Vagt, Herman Foettinger Institute of the Technical University of Berlin.		8. Performing Organization Report No.
		10. Work Unit No.
9. Performing Organization Name and Address Leo Kanner Associates Redwood City, California. 94063		11. Contract or Grant No. NASw-3541
		13. Type of Report and Period Covered Translation
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration, Washington, D.C. 20546		14. Sponsoring Agency Code

15. Supplementary Notes

Translation of "Bemerkungen zur Auslegung eines Unterschall-Freistrahlwindkanals", Zeitschrift fuer Flugewissenschaften, Volume 21, Number 5, 1973, pp. 159-162.

(A73-33266)

16. Abstract

By means of a recently installed wind tunnel with a circular free jet, it is shown that requirements concerning the flow parameters (e.g. uniform velocity profile and uniform and low tubulence level in the nozzle exit) can be easily and at moderate expenses fulfilled without changing the settling chamber and the nozzle itself. The installations in the settling chamber are adjustable. The structure is not limited to settling chambers with a circular cross-section.

17. Key Words (Selected by Author(s))	18. Distribution Statement Unlimited-Unclassified

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages	22.

REMARKS ON THE LAYOUT OF THE SUBSONIC FREE JET WIND TUNNELS

Jorg-Dieter Vagt

Hermann Foettinger Institute for Flow Technology
Technical University of Berlin

I. Introduction /15

Wind tunnels often constitute a prerequisite for conducting experiments on flow mechanics. Problems of the aircraft dynamics or also problems of the still young sector of building aerodynamics can only be worked out in the wind tunnel. In any case however the wind tunnel should not generate only a random flow, but exclusively a reproducible flow movement defined by the problem and which is characterized by the velocity profile, the turbulence profile, etc. Thus for example in one case we are interested in the flow around a body in a shear flow, whereas in another case investigations in a flow with equal velocity vector everywhere should be prefered.

Since experience in building wind tunnels can be transfered only rarely, especially when special requirements are imposed on the flow, particular importance is attributed to the optimizing of the channel. Therefore this article will report on how by means of a simple construction a wind tunnel may be optimized quickly and economically with regard to a uniform velocity profile and a uniform and low degree of turbulence. But for the sake of clarity a few preliminary remarks will first be made on the plant.

2. Free Jet Plant

The plant consists of the components blower if air filter collected before it, stabilization chamber with diffuser at the entrance, built-in units in the chamber and the nozzle. The decrease of cross-section of

*Numbers in the margin indicate pagination in the foreign text.

the nozzle over its length was calculated according to /1/. But the boundary conditions to achieve a shorter structural length were somewhat modified (compare Figure 1).

The following requirements were first imposed:

1. Extensive freedom from dust of the flow, to protect on one hand the probes, but on the other hand also to protect the built-in units in the stabilization chamber from dirt.
2. To prevent interferences the sieve should in accordance with a study by Bradshaw /2/ should not go below an opening ratio of

$$\beta = \left(1 - \frac{d}{l}\right)^2$$

   of 0.57. Here d is the wire diameter of the round wire sieve /16 and l is the mesh width.
3. The Reynolds number formed with the wire diameter in the chamber

$$Re_k = u_k d / \nu_k$$

   should according to Pankhurst and Holder /3/ have an upper limit of 40, to decrease the intensity of turbulent fluctuations.
4. The coefficient for the decrease of pressure on the sieve should have a value of approximately 2 according to /3/ to reduce the lack of uniformity in the flow profile in front of the sieve.

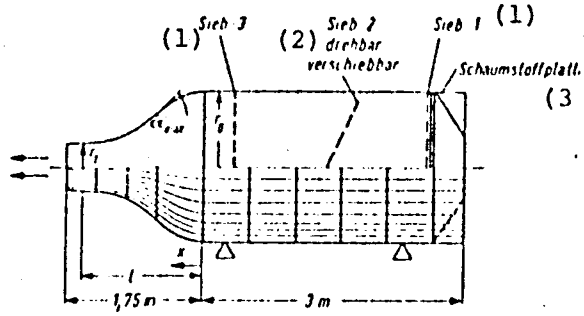

Figure 1: Stabilization chamber with built-in units and nozzle. Nozzle contour: $\frac{r_\xi - r_1}{r_0 - r_1} = \xi^2(2 - \xi^2)$, $\xi = \frac{x}{l}$, $\alpha_{max} = 43°$, $l \approx 2.15\,(r_0 - r_1)$

Key: (1) sieve; (2) rotating; (3) foam plate.

In the present case the following values were obtained:

For 1: The air filter used absorbs 99.9 percent of all the dust particles in the air with a grain diameter of 2.5 μm and 80 percent of all dust particles with a grain diameter of 0.5 μm.

For 2: β=0.59.

For 3: Rekmax=36.

For 4: For the pressure loss coefficient according to the power law of Wieghardt /4/ for the round wire sieve used with d=0.2 mm a value of about 1.9 to 2.4 was obtained according to the speed.

3. Optimization

The optimization studies refer according to what was stated above to the incorporated units in the stabilization chamber. In general the number of these units and the place of incorporation are established beforehand. The stabilization chamber is subdivided into several parts and the site of incorporation is therefore at the connection point of two parts of the chamber. A subsequent revision requires considerable structural outlay and is therefore costly.

The purpose was now to organize the structure of the incorporated units in such a simple way that a displacement, exchange or addition of a sieve is possible without having to intervene in the stabilization chamber itself. In this connection the sieves must be always stretched and free from bumps. Fluttering phenomena must be avoided unconditionally in the flow.

3.1 Construction of the Holders for the Sieve

The incorporated units extend in this case over a circular cross-section with a diameter of 2 m. The incorporation of the sieve is first discussed.

A steel ring of rectangular cross-section is halfed and a rigid screw shackle is applied on the two separating points (compare Fig. 2).

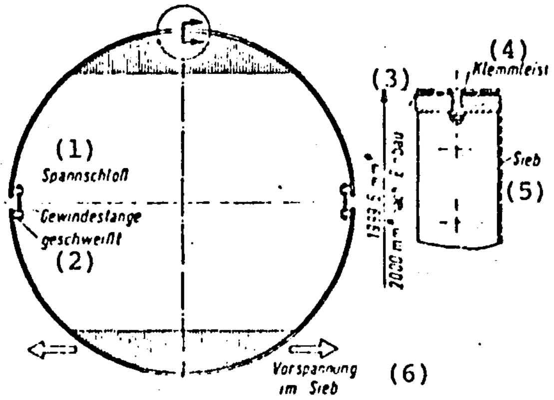

Figure 2: Sieve holder

Key: (1) spanner; (2) welded threaded rod; (3) after incorporation; (4) bonding strip; (5) sieve; (6) initial stress in the sieve.

After their introduction in the stabilization chamber the ring halves are drawn apart with the spanners to such an extent that they lie on the wall. At the same time the sieve is stretched. If the place of the sieve has to be altered, the spanners must be loosened to some extent. The diameter of the sieve or of the frame is reduced and the frame can be shifted. In this connection generally folds occur on the sieve, but they disappear again insofar as there was no overextension in the first stretching.

Figure 3 shows two sieves moved several times. The smooth state free from folds can be observed particularly in the rear sieve because of the illumination in the plane of the sieve.

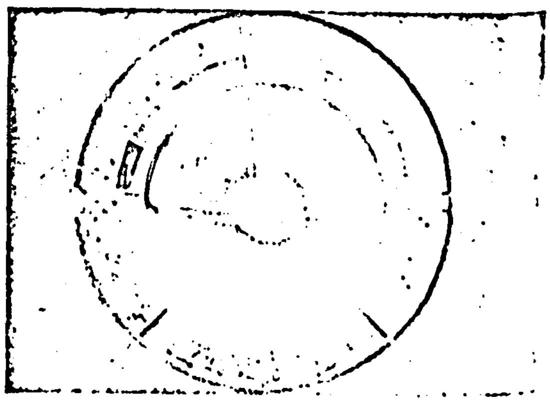

Figure 3: Sieves inside the stabilization chamber.

The principle of the holding structure is not limited to circular cross-sections. For example for a rectangular channel a structure is proposed according to Fig. 4. Here four corner frames are joined with /1 spanners. The angle between the arms of the frame should be more than 90 degrees before the connection, to assure sufficient tension in the sieve even in the area of the spanners. If necessary the assembly can also be carried out with spacing units, which bring the frames to their final form and can be removed after the introduction of the sieve.

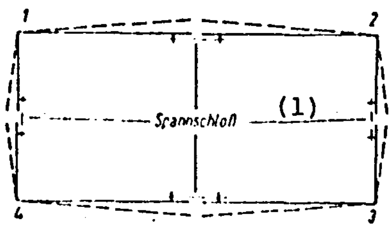

Figure 4: Construction of the holder for rectangular cross-section. Key: (1) spanner.

The actual optimization consisted in this case of establishing the type and number of incorporated units and their position in the stabilization chamber to achieve the required properties of the flow at the end of the nozzle. This requires thorough measurements at the nozzle outlet, which had to be carried out after each change of the incorporated units.

The measurements were carried out with a heating wire anemometer of the type HDA II of the DFVLR /5, 6/ (Federal German Aeronautics and Space Organization) combined with a gauge of the degree of turbulence of the type TGM of the DFVLR /7/. The measurement probe for the longitudinal intensity of the fluctuations of velocity for the average velocity was a so-called single wire probe. To obtain the transversal intensity which is not discussed in greater detail here, an X-wire probe was introduced according to /8/.

The following criteria were used for the quality of the flow:

1. Uniformity of the velocity profile over the nozzle cross-section at different levels of the nozzle.
2. Uniformity of the degree of turbulence or the intensity of the velocity fluctuations in the direction of flow in the frequency range of 5 Hz up to 10,000 Hz and the extent of the degree of turbulence itself.

3.2 Results of Optimization

For the arrangement I according to Fig. 5 with two sieves, of which one directly behind the diffuser to avoid detachment phenomena in the flow, a nonuniformity factor was obtained (Umax - Umin)/Umax of about 1 percent was obtained measured in the outlet plane of the nozzle. The measurement points are obtained from an automatically and continuously recorded curve variation.

The longitudinal intensity of the fluctuations of velocity assumes on the other hand high values (more than 2 percent) is not uniformly distributed over the cross-section of the nozzle and depends greatly on the speed.

The incorporation of a third round wire sieve at the end of the stabilization chamber, directly in front of the nozzle, caused a decrease of the longitudinal intensity by about a factor 4. The nonuniformity factor was here increased to 2 to 3 percent.

Since the origin of the fluctuations lies certainly in front of the first sieve, spin in the ventilator, detachments in the diffuser, after applying a 5 mm thick foam plate an attempt was made to reduce considerably the intensity of fluctuations and the spin practically at the site of their occurrence. The results are shown in Fig. 6. The intensity as improved decisively (less than 0.3 percent) and is distributed uniformly. The nonuniformity factor was now about 2 percent, naturally only in the measurement plane - 4.

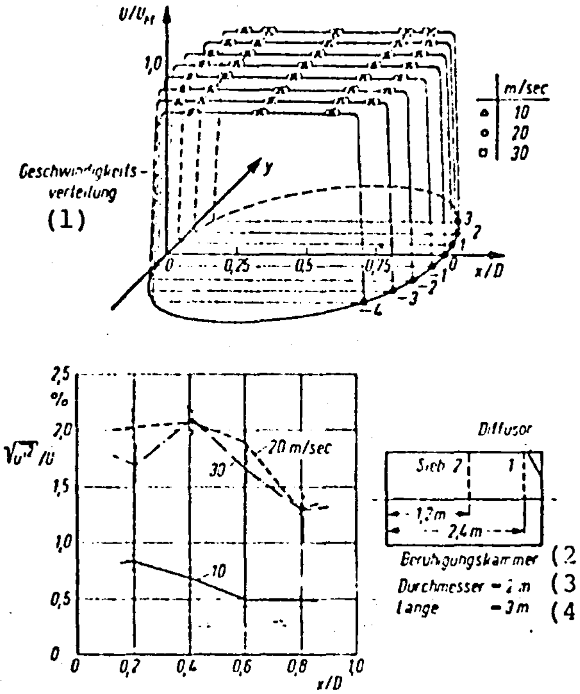

Figure 5: Arrangement I. Distribution of the average velocity and the intensity. Key: (1) velocity distribution; (2) stabilization chamber; (3) diameter; (4) length.

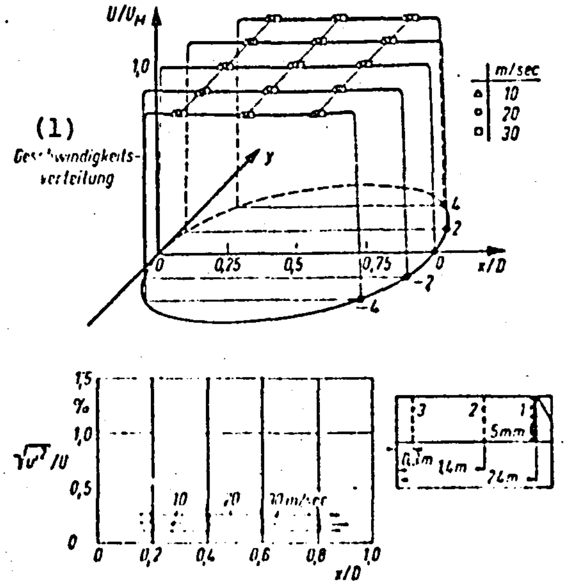

Fig. 6: Arrangement IV. Distribution of the average speed and intensity. Key: (1) distribution of velocity;

Only a displacement of the second and third sieve upstream caused an improvement of the nonuniformity factor by about 1.5 percent. The /11 distribution of intensity was not altered in this case (Fig. 7).

Here we have only a relative optimum, that is decisive improvements as was shown by further experiments cannot be achieved directly by altering the incorporated units. An analysis of the frequencies occurring showed that a large portion of the intensity comes from frequencies between 10 and 13 Hz. In the measurement with high pass filters connected in between (20 Hz) the intensity in the total speed range is about 0.09 percent.

The more detailed study showed that the wall of the stabilization chamber oscillates in operation with a frequency of 10 to 13 Hz in the present range of speeds and that thus the further reduction of the speeds of oscillation in the flow is possible only by increasing the wall mass because of the low frequencies of the wall oscillation.

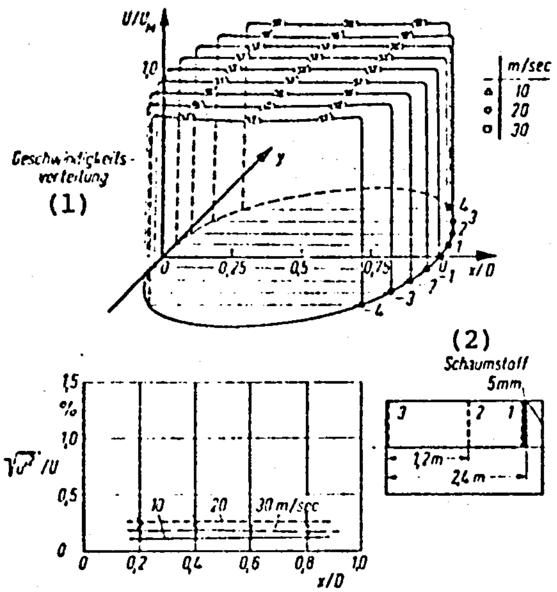

Fig. 7: Arrangement VI. Distribution of the average speed and of the intensity. Key: (1) distribution of speed; (2) foam.

4. Summary

Wind tunnels often represent the prerequisite for conducting experiments on flow mechanics. This means that a reproducible flow movement defined by the problem is needed. But so far the production of an exactly defined flow is possible only in the rarest of cases by transferring the values obtained by experience from one tunnel to the other. The tunnel must be optimized, that is the required flow movement must be produced by altering the individual components, especially the sieves.

By a flexible consturction of the above described type the optimization of the wind tunnel can be conducted quickly and cheaply, since costly interventions in the external structure of the tunnel are avoided. The optimization studies are discussed on the basis of an example of a new wind tunnel with round cross-section in the Hermann Foettinger Institute for Flow Technology of the Technical University of Berlin. The structure is basically available also for noncircular cross-sections.

5. Bibliography

/1/ R. Wille: Contributions to the Phenomenology of Free Jets. DVL Report number 292 (1963).

/2/ P. Bradshaw: The Effect of Wind Tunnel Screens on Nominally Two-Dimensional Boundary Layers. J. Fluid Mech. 22 (1965), pages 679-687.

/3/ R. C. Pankhurst and D. W. Holder: Wind Tunnel Technique. Pitman and Sons Ltd., London, 1948, page 78.

/4/ W. Wuest: Wire Sieves in Flow Technology. Draft II (1960), number 8, page 417.

/5/ E. Berger, P. Freymuth, E. Froebel: Application in Regular Technology for the Development of a Constant Temperature Heating Wire Anemometer. Part I. DVL Report number 282 (1963).

/6/ E. Berger, P. Freymuth, E. Froebel: Application of Regular Technology in the Development of a Constant Temperature Heating Wire Anemometer. Part II. DVL Report number 283 (1963).

/7/ E. Froebel: Gauge of the Degree of Turbulence TGM I. Internal Report of the DFVLR Institute for Turbulence Research, Berlin (patent applied for).

/8/ J. D. Vagt: Hot Wire Measurement Technique. Von Karman Institute for Fluid Dynamics, Brussels, Lecture Series 32 (April 26-30, 1971 Turbulent Jet Flows.

Received on 24 January 1972.

END

DATE

FILMED

APR 24 1984

End of Document