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EXPERIMENTAL STUDY OF BASE PRESSURE OF ROUND CYLINDERS OF GREAT ELONGATION

V. M. Kovalenko, et al

Foreign Technology Division
Wright-Patterson Air Force Base, Ohio

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by

V. M. Kovalenko, V. S. Kosorygin,
V. V. Shumskiy

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З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

EXPERIMENTAL STUDY OF BASE PRESSURE OF ROUND CYLINDERS OF GREAT ELONGATION

V. M. Kovalenko, V. S. Kosorygin
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A vacuum appears behind the blunt base of a body of revolution which is in a supersonic gas flow. The degree of the vacuum determines the magnitude of the base wake drag - one of the components of total drag of a body.

As is known, the base pressure depends, in the first place, on the state of the boundary layer at the separation point and in the region between it and the zero slip point, which is located on the axis behind the base section. Furthermore, it depends on the angle of attack, shape of the body as a whole, and, in particular, on the main parameters of the incident flow - the Mach and Reynolds numbers and the wall temperature. Experimental data on the effect of different factors on the wake drag of a body of revolution are available at present [1]. Nevertheless, these data do not always make it possible to calculate sufficiently reliably the magnitude of the wake drag, in particular, in those cases when the shape of the body considered is considerably different from the variants for which the experimental data are obtained. For example, the existing experimental results and empirical formulas, which estimate the effect of the elongation on the magnitude of the base pressure, are obtained only with moderate elongations ($\lambda \leq 18\text{-}20$). Used in practice are bodies of revolution, for example, meteorological rockets, with elongations which exceed two times the indicated range. The method of direct measurement of the base pressure remains the most reliable in such cases.

The experimental study of the base pressure is carried out on three models of bodies of revolution of moderate and very great elongation. The models are a combination of a cylinder and ogive with a spindle (Fig. 1). The cylindrical part has an elongation of $\lambda_{ц} = 10.3$ (model 1) and 32.8 (models 2 and 3). Model 3 is distinguished from model 2 by the presence of a reverse tail cone.

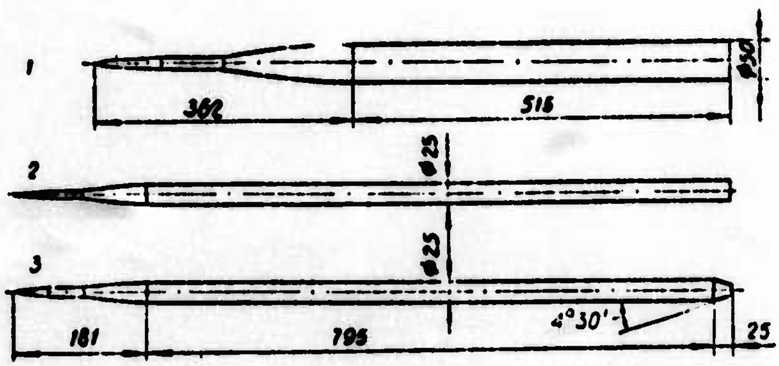

Fig. 1. Aerodynamic diagrams of models.

Experiments are conducted in a wind tunnel with dimensions of the working section of $0.6 \times 0.6\ m^2$ at Mach numbers of 3 and 4; the numbers Re_{1M} were $36 \cdot 10^6$ and $54 \cdot 10^6$, respectively.

Attachment of the models to the α-mechanism of the tunnel was accomplished by means of an arrow-shaped side sting (Fig. 2). The small diameter of the base section of the models (25 and 20.9 mm) excluded the possibility of using a tail holder. The end part of the side sting had a cylindrical shape, and its diameter was equal to the diameter of models 2 and 3. All the models were sectional. The tail parts of the models were attached to the end cylindrical part of the side sting by means of a pneumatic joint and tie bolt. This made it possible to test all the models on one sting.

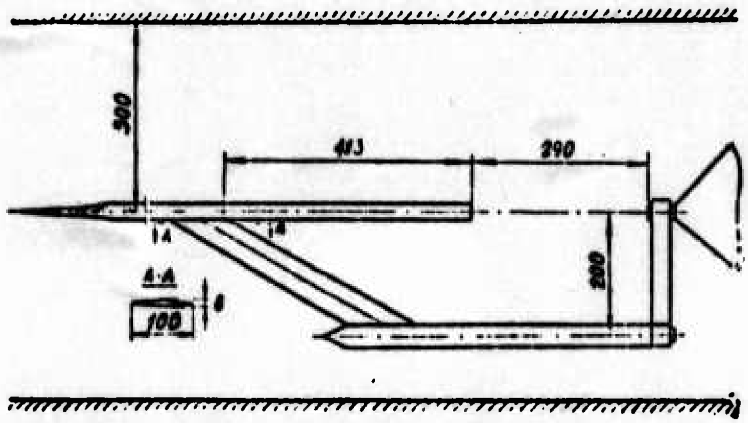

Fig. 2. Diagram of installation of the model in a wind tunnel.

To decrease the effect of the side sting on the base pressure, its thickness was selected as minimum as possible from conditions of strength. To increase the rigidity of the model-sting system relative to the Y axis, which has considerable importance at the starting moment of the wind tunnel, the model is additionally fastened by means of two bracing wires 0.8 mm in diameter going from the base of the reel to windows of the wind tunnel.

The base pressure was measured in two mutually perpendicular sections. The design of the base part of the model allowed turning rows of drainage holes around the axis of the model within ±45° with a step of 15°. To measure and record the pressure, group recording manometers [GRM] (ГРМ) with limits of measurement of ±1000 kg/m^2 (class of accuracy, 0.5) were used. Calculated then were the coefficients of pressure

$$\bar{p}_i = \frac{p_i - p_\infty}{q_\infty},$$

where p_i - pressure at the i-th point of the base section; p_∞ - static pressure of the undisturbed flow; q_∞ - dynamic pressure. The pressure distribution obtained in the experiments proved to be virtually constant along the diametric sections of the base section with measurement of the relative radius $\bar{r}$ from 0 to ±0.93 and not dependent on angle ϕ (angle of the plane of measurement with the xz plane, Fig. 3). These data confirm the results of measurements of the base pressure, given in source [2], with the presence of the turbulent boundary layer at the point of separation.

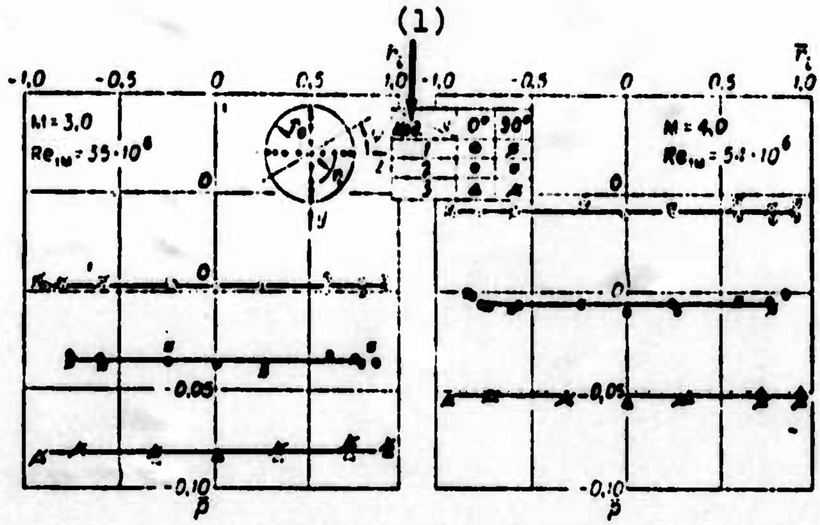

Fig. 3. Distribution of the coefficient of base pressure along the base of the model.
KEY: (1) Model.

When $|\bar{r}| > 0.93$ the pressure coefficient $\bar{p}_i$ in absolute value, apparently, is decreased. If we accept $\bar{p}_i$ as being constant along the section when $0 \leq |\bar{r}| \leq 1$ and equal to its mean value $\bar{p}_{cp}$ and $0 \leq |\bar{r}| \leq 0.93$, then the coefficient of the wake drag

$$C_{x\text{д}} = -\bar{p}_{cp}\bar{S},$$

where

$$\bar{S} = \frac{S_{\text{дн}}}{S_{\text{мид}}},$$

Figure 4 shows experimental values of $C_{x\text{д}}$ for three models. With moderate elongations they agree well with the data of other sources [2]. An increase in the elongation of the cylindrical part $\lambda_{ц}$ from 10.3 to $\lambda_{ц}$ = 32.8 leads to a decrease in the wake drag when M = 3 and 4, respectively, by 12 and 6%, i.e., with an increase in the M number of the incident flow, the effect of the elongation becomes less important. This result agrees qualitatively with the physical concepts about the nature of the base pressure and is confirmed by data of Fig. 5, shown on which is the effect of the dimensionless thickness of the boundary layer on the base pressure at different M numbers (according to source [1] and our experiments).

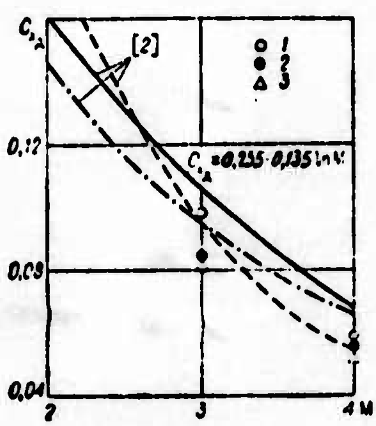

Fig. 4. Coefficient of base pressure. Comparison of the experiment (models 1-3) with data of source [2].

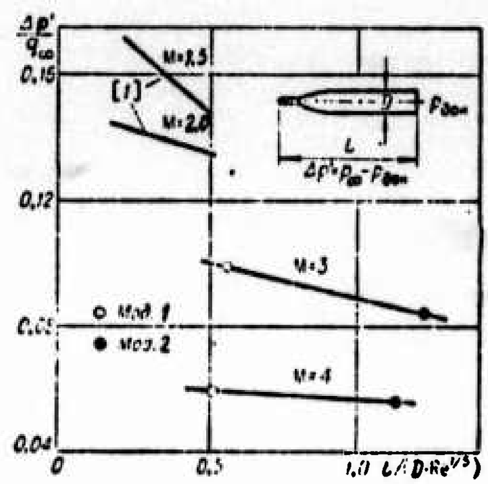

Fig. 5. Dependence between the value of the base pressure and dimensionless thickness of the boundary layer.

In conclusion, let us note that the presence of the tail cone (model 3) *decreases* the absolute value of the coefficient of base pressure by approximately 5%.

Institute of Theoretical and
Applied Mechanics of the Siberian
Branch of the Academy of
Sciences of the USSR,
Novosibirsk

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BIBLIOGRAPHY

1. К. Э. Браун. В сб. «Аэродинамика больших скоростей и реактивная техника», т. VII. М., Изд-во иностр. лит., 1959.
2. Handbook of supersonic aerodynamics Bodies of revolution. Navweps Report 1488, 3, 1961.