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FEATURES'ANALYSIS OF SMALL AND VERY SMALL SCALE WINGS EXPERIMENTED BYAERODYNAMICS TUNNELAND CONFRUNTED WITH THE TWO SCALES SIMILARITY THEORY

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***Abstract**: It compares the NACA 6412 profile and the NACA 0015 profile specific features experimentally with using the two scales similarity theory. The results confirm the fact the two scales similarity theory represents a simple and method establish the hydrodynamic special features of profiles.*

***Keywords**: similarity theory, span, model wing, distort ratio, elongation, aerodynamics coefficient*

Introduction

For raising the features of small and very small-scale wings, experimental tests have been conducted on the NACA 0015 and NACA 6412 profile in the aerodynamics tunnel.

Experimental tests have been carried out at consistent flow within the measurement section 1600 x 1200mm of the naval aerodynamics tunnel for a range of angles of attack α comprised between 0^0 and 32^0 for NACA 0015 and between -10^0 and 15^0 for NACA 6412 (elongation $\lambda \leq$ 6).

Determining the aerodynamic torque, overall qualitative type forces and moments have been achieved by using a strain gauge balance with six components of Kempf Remmers type. Experimental data storage for each angle has been made on the computer. By means of a software package such data has been processed thus obtaining the variation curves of the aerodynamic coefficients c_y and c_x. The results are shown in tables 2 and 3 for NACA 0015 profile and in tables 7 and 8 for NACA 6412 profile.

Analysis by comparison of NACA 0015 profile andNACA 6412 profile features, experimentally obtained by aerodynamics tunnel with their features achieved through the two sales similarity theory

$R_y = F_N \cos\alpha - F_T \sin\alpha$ -carrying capacity(1)

$R_N = F_N \sin\alpha - F_T \cos\alpha$ - resistance to progress (2)

$c_y = \dfrac{R_y}{\dfrac{\rho v^2}{2} \cdot S}$ - bearing capacity coefficient

(3) $c_x = \dfrac{R_x}{\dfrac{\rho v^2}{2} \cdot S}$ - resistance to progresscoefficient(4)

$S = c \cdot l$ -wing surface (5)

The geometric parameters of NACA 0015 profile are provided in Table 1.

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Table 1

% c	Thickness of sect % l
0	0
5	8,8
10	11,7
20	14,3
30	15
40	14,5
50	13,2
60	11,4
70	9,1
80	6,5
90	3,62
100	0

and aerodynamic parameters experimented by aerodynamics tunnel are provided in tables (2) and (3).

$c_y = f(\alpha, \lambda)$ Table 2

λ / α^0	0,25	0,50	0,75	1,0	1,5	2,0	3,0	5,0
0	0	0	0	0	0	0	0	0
4	0,04	0,07	0,09	0,10	0,14	0,16	0,22	0,25
8	0,1	0,15	0,19	0,23	0,29	0,35	0,45	0,50
12	0,15	0,26	0,31	0,36	0,44	0,54	0,69	0,75
16	0,22	0,36	0,43	0,50	0,61	0,73	0,88	0,95
20	0,32	0,48	0,56	0,64	0,80	0,90	0,89	0,70
24	0,41	0,60	0,72	0,80	0,93	0,53	0,56	0,72
28	0,51	0,75	0,86	0,94	0,47	0,49	0,56	0,73
30	0,60	0,88	1,00	1,05	0,49	0,50	0,56	0,74

$c_x = f(\alpha, \lambda)$ Table 3

λ / α^0	0,25	0,50	0,75	1,0	1,5	2,0	3,0	5,0
0	0,03	0,01	0,02	0,01	0,02	0,01	0,01	0,01
4	0,05	0,02	0,02	0,02	0,02	0,02	0,01	0,01
8	0,05	0,03	0,03	0,03	0,04	0,03	0,04	0,03
12	0,07	0,05	0,06	0,06	0,06	0,06	0,07	0,07
16	0,10	0,09	0,10	0,10	0,11	0,11	0,11	0,19
20	0,12	0,14	0,14	0,15	0,16	0,16	0,27	0,25
24	0,19	0,21	0,23	0,22	0,23	0,22	0,31	0,28
28	0,26	0,30	0,30	0,30	0,28	0,35	0,36	0,37
30	0,34	0,37	0,42	0,38	0,47	0,40	0,39	0,40

The variation of the c_y aerodynamic coefficient depending on the angle of incidence α of NACA-0015 profile is appropriate for the elongations that it has been experienced.

Applying the two scales similarity theory of NACA-0015 profile with λ =5 obtained for elongations λ = 0,25; 0,50; 0,75; 1,0; 1,5; 2,0; and 3,0 the following

λ / α^0	2	3	6	λ / α^0	2	3	6
-10	-0,35	-0,38	-0,34	-10	0,13	-0,15	0,17
-8	-0,25	-0,34	-0,33	-8	0,10	0,12	0,14
-6	-0,01	-0,22	-0,31	-6	0,08	0,09	0,12
-4	-0,05	-0,01	-0,20	-4	0,08	0,08	0,09
-2	0,26	0,21	-0,06	-2	0,06	0,07	0,08
0	0,45	0,52	0,40	0	0,07	0,08	0,09
3	0,76	0,92	1,10	3	0,12	0,13	0,12
6	1,01	1,23	1,55	6	0,17	0,20	0,17
9	1,26	1,50	1,90	9	0,25	0,29	0,28
12	1,51	1,78	2,14	12	0,36	0,39	0,36
15	1,74	1,96	1,61	15	0,49	0,53	0,44

values of the bearing capacity c_y coefficient and the resistance to progress c_x the coefficient are shown in Tables 4 and 5.

$c_y = f(\alpha, \lambda)$ Table 4

λ / α^0	0,25	0,50	0,75	1,0	1,5	2,0	3,0	5,0
0	0	0	0	0	0	0	0	0
4	0,01	0,02	0,04	0,05	0,07	0,10	0,15	0,25
8	0,02	0,05	0,07	0,10	0,15	0,20	0,30	0,50
12	0,04	0,07	0,11	0,15	0,22	0,30	0,45	0,75
16	0,05	0,09	0,14	0,19	0,28	0,38	0,57	0,95
20	0,03	0,07	0,11	0,14	0,21	0,28	0,42	0,70
24	0,04	0,07	0,11	0,14	0,22	0,29	0,43	0,72
28	0,04	0,07	0,11	0,15	0,22	0,29	0,44	0,73
30	0,05	0,07	0,11	0,15	0,22	0,30	0,44	0,74

$c_x = f(\alpha, \lambda)$ Table 5

λ / α^0	0,25	0,50	0,75	1,0	1,5	2,0	3,0	5,0
0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01
4	0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,01
8	0,00	0,00	0,00	0,00	0,01	0,01	0,02	0,03
12	0,00	0,01	0,01	0,01	0,02	0,03	0,04	0,07
16	0,01	0,02	0,03	0,04	0,06	0,08	0,12	0,19
20	0,01	0,03	0,04	0,05	0,07	0,10	0,15	0,25
24	0,01	0,03	0,04	0,06	0,08	0,11	0,17	0,28
28	0,02	0,04	0,06	0,07	0,11	0,15	0,22	0,37
30	0,02	0,04	0,06	0,08	0,12	0,16	0,24	0,40

For NACA 6412 profile, the geometric parameters are provided in Table 6.

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Table 6

% c	extrados % c	intrados % c
0,0	0,0	0,0
5,0	5,36	-1,99
10	7,58	-1,99
20	10,3	-1,25
30	11,6	-0,38
40	11,8	0,2
50	11,1	0,55
60	9,9	0,8
70	8,2	0,8
80	6,0	0,7
90	3,3	0,39
100	0,0	0,0

and the aerodynamic parameters experimented by aerodynamics tunnel on Re = 85.000, are provided in
Table 7.

$c_y = f(\lambda, \alpha, \mathrm{Re})$; $c_x = f(\lambda, \alpha, \mathrm{Re})$ Table 7

The polarities of NACA 6412 profile corresponding to the elongation λ = 2, 3 and 6 and number Re = 85.000 are shown in figure 3, below.

λ α⁰	2	3	6	λ α⁰	2	3	6
-0	-0,11	-0,17	-0,34	-10	0,06	0,08	0,17
-8	-0,11	-0,17	-0,33	-8	0,04	0,07	0,14
-6	-0,10	-0,16	-0,31	-6	0,04	0,06	0,12
-4	-0,07	-0,10	-0,20	-4	0,03	0,05	0,09
-2	-0,02	-0,03	-0,06	-2	0,06	0,04	0,08
0	0,13	0,2	0,39	0	0,03	0,04	0,09
3	0,36	0,55	1,10	3	0,04	0,06	0,12
6	0,51	0,78	1,54	6	0,06	0,08	0,17
9	0,63	0,95	1,90	9	0,09	0,14	0,28
12	0,71	1,07	2,14	12	0,12	0,18	0,36
15	0,54	0,80	1,61	15	0,15	0,22	0,44

Applying the two scales similarity method to NAC 6412 profile too with λ= 6, we obtain for elongations λ = 2 and λ = 3 the following values of the bearing capacity c_y coefficient and the one of the resistance to progress c_x coefficient in table 8, valid for a number Re. $\mathrm{Re} = 85000 \cdot \frac{K_c^2}{\sqrt{K_l}}$

$c_y = f(\lambda, \alpha, \mathrm{Re}))$; $c_x = f(\lambda, \alpha, \mathrm{Re})$ Table 8

CONCLUSIONS

By comparing the values obtained for the two profiles with those experimentally obtained by wind tunnel, a dispersion of the experimental values is observed related to the values of those calculated by the two scales similarity method since the experiments were conducted at Reynolds numbers that differ from those obtained by applying the theory of similarity between the two scales or otherwise similarity values obtained by applying the two scales similarity method being valid for another Reynolds number which differs from that of the model. This aspect related to the Reynolds number on the model and on the prototype model, it results even from the law of this phenomenon.

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