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Engineering Report: **XFOIL Software Validation**

Applicable paragraphs of airworthiness requirements: N/A

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SCOPE

The purpose of this report is to validate results generated by XFOIL software for further use in subsonic airfoil design and analysis.

General

NASA TM 81927 Two-Dimensional Aerodynamic Characteristics of The NACA0012 Airfoil report has been selected as a reference for validation.

Conditions selected for analysis are as follows:

1. Re=3e6 and 9e6
2. M=0.3, 05 and 0.7
3. Transition point for the upper and lower surface has been fixed at 5% of the chord.

NACA0012 has been used from the XFOIL internal data with standard XFOIL airfoil setup with 160 panels.

INIT – boundary layer initiation for viscous mode analysis.

Results

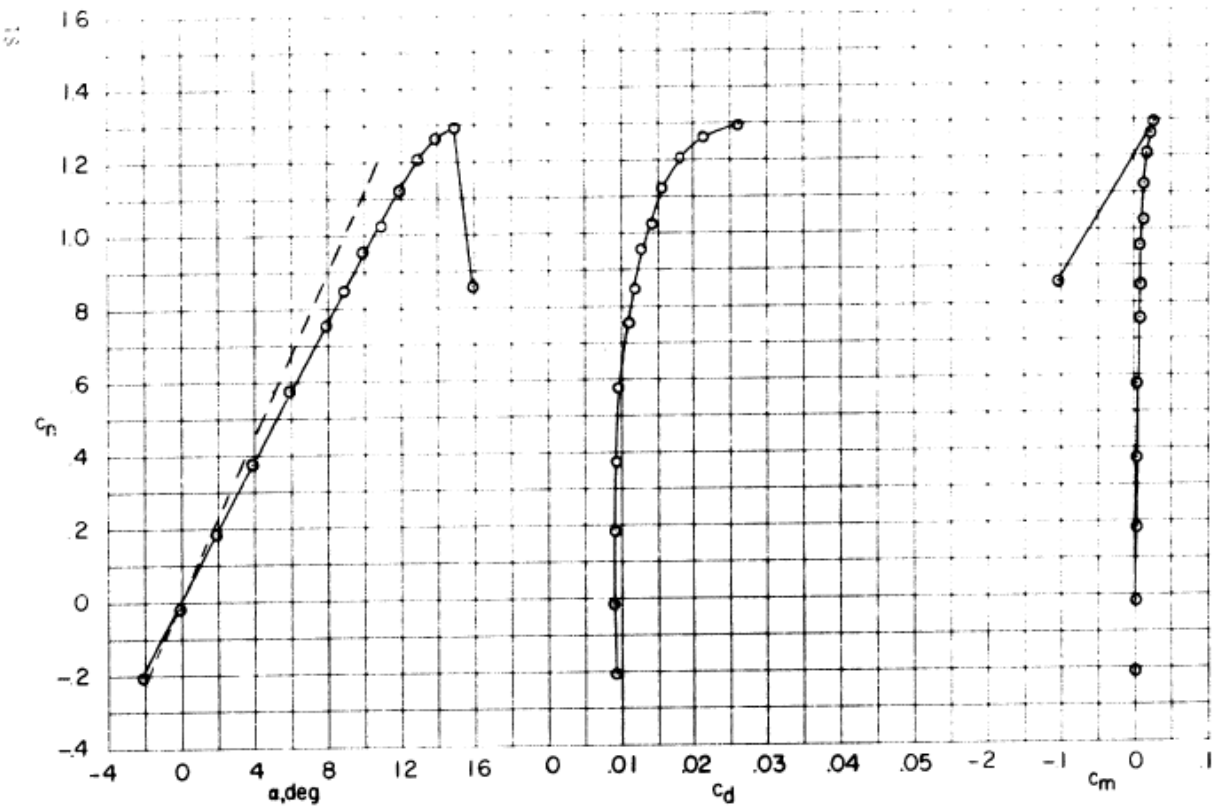
The tables below summarize Cl, Cd and Cm values within AOA range 0 up to 10 degrees (depending on mode) for both XFOIL and NASA report as well as percentage of difference between each of the two corresponding values.

	Re=3e6 M=0.3		Fig. 1&2						
	XFOIL	NASA		XFOIL	NASA		XFOIL	NASA	
AOA	**Cl**	**Cl**		**Cd**	**Cd**		**Cm**	**Cm**	
0	0.000	0.000	-	0.009	0.009	0.0%	0.000	0.000	-
2	0.240	0.230	4.2%	0.009	0.009	0.0%	0.000	0.000	-
4	0.481	0.460	4.4%	0.009	0.009	0.0%	0.000	0.000	-
6	0.720	0.680	5.6%	0.010	0.010	0.0%	0.002	0.002	0.0%
8	0.953	0.900	5.6%	0.012	0.012	0.0%	0.006	0.006	0.0%
10	1.176	1.130	3.9%	0.014	0.013	7.1%	0.012	0.010	16.7%

	Re=3e6 M=0.7		Fig.3&4						
	XFOIL	NASA		XFOIL	NASA		XFOIL	NASA	
AOA	**Cl**	**Cl**		**Cd**	**Cd**		**Cm**	**Cm**	
0	0.000	0.000	-	0.010	0.010	0.0%	0.000	0.000	-
2	0.337	0.300	11.0%	0.010	0.010	0.0%	0.005	0.005	0.0%
4	0.687	0.620	9.8%	0.011	0.013	-18.2%	0.016	0.015	6.3%

	Re=9e6		Fig. 5&6						
	M=0.5								
	XFOIL	NASA		XFOIL	NASA		XFOIL	NASA	
AOA	**Cl**	**Cl**		**Cd**	**Cd**		**Cm**	**Cm**	
0	0.000	0.000	-	0.008	0.008	6.3%	0.000	0.000	-
2	0.273	0.240	12.1%	0.008	0.008	6.3%	0.000	0.000	-
4	0.550	0.530	3.6%	0.008	0.008	0.0%	0.002	0.002	0.0%
6	0.830	0.800	3.6%	0.009	0.009	5.6%	0.007	0.007	0.0%
8	1.117	1.050	6.0%	0.011	0.011	0.0%	0.018	0.020	-11.1%

	Re=9e6		Fig. 7&8						
	M=0.7								
	XFOIL	NASA		XFOIL	NASA		XFOIL	NASA	
AOA	**Cl**	**Cl**		**Cd**	**Cd**		**Cm**	**Cm**	
0	0.000	0.000	-	0.008	0.008	6.3%	0.000	0.000	-
2	0.346	0.340	1.7%	0.008	0.008	6.3%	0.004	0.004	0.0%
4	0.707	0.690	2.4%	0.009	0.012	-33.3%	0.013	0.010	23.1%



(a) M = 0.30

Figure 5.- Force and moment characteristics of NACA 0012 airfoil. Rn = 3.0 × 10^6, transition fixed. (dashed line indicates angle of attack correction for wall interference).

Fig. 1

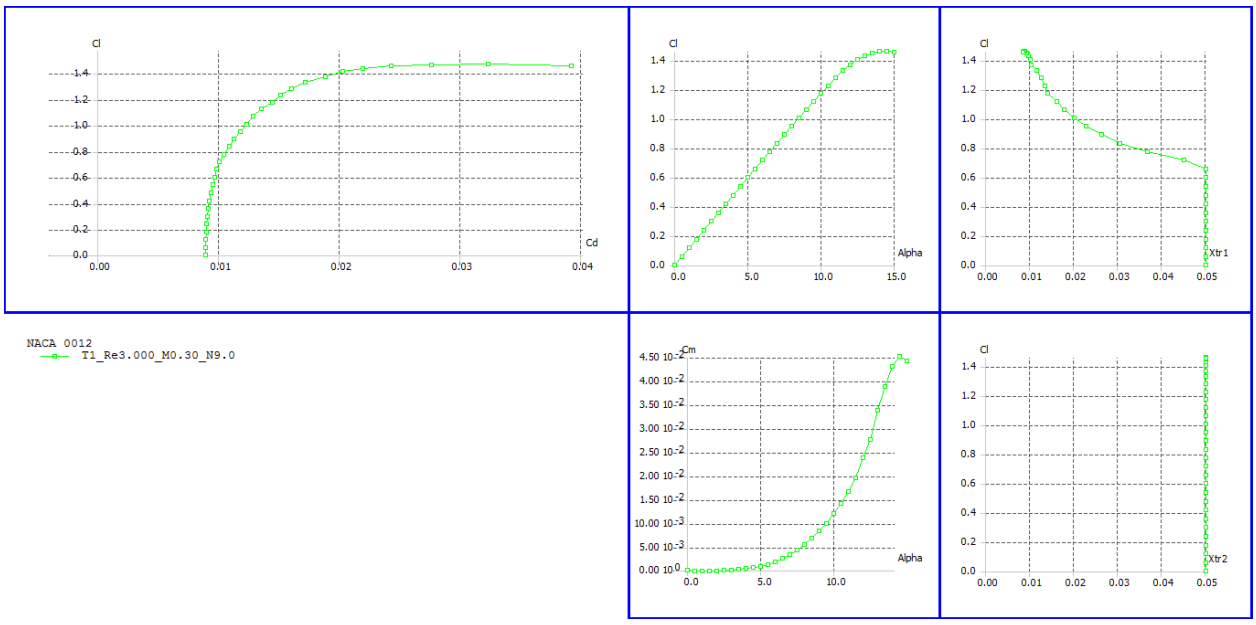
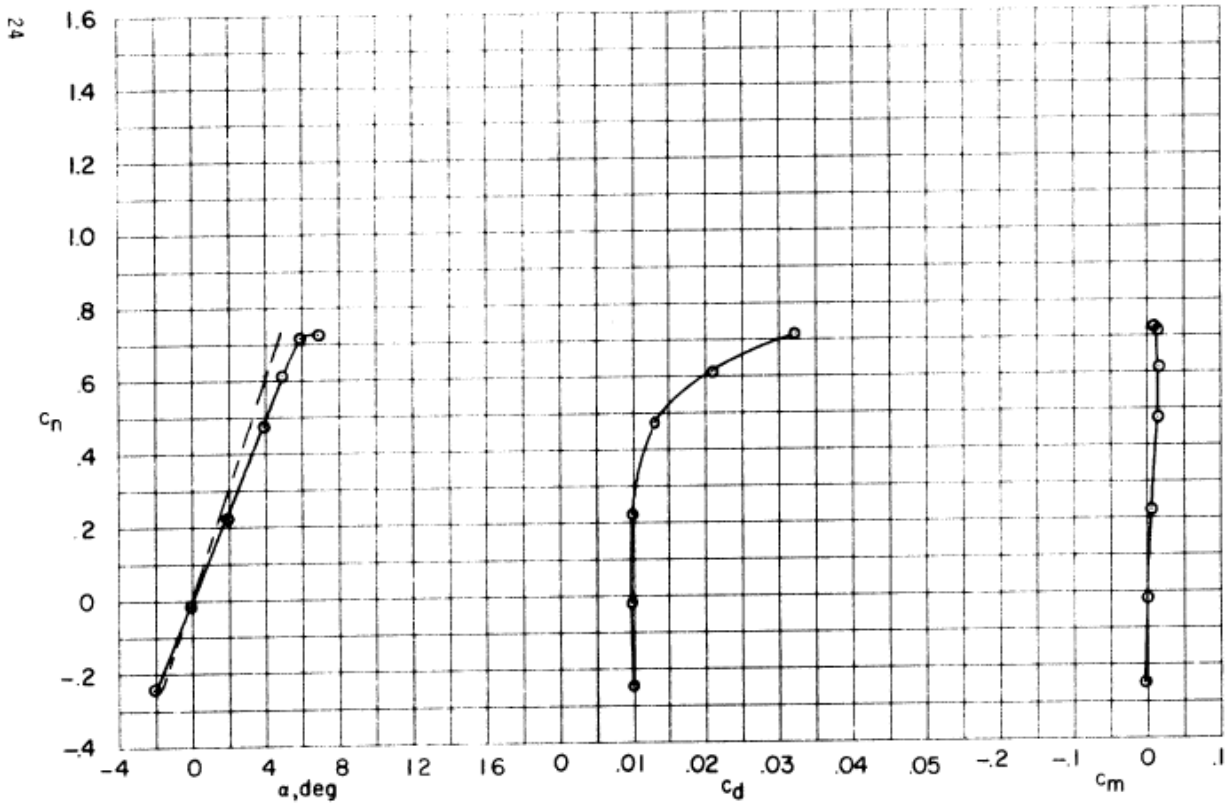


Fig. 2



(g) M = 0.70

Figure 5.- Continued.

Fig. 3

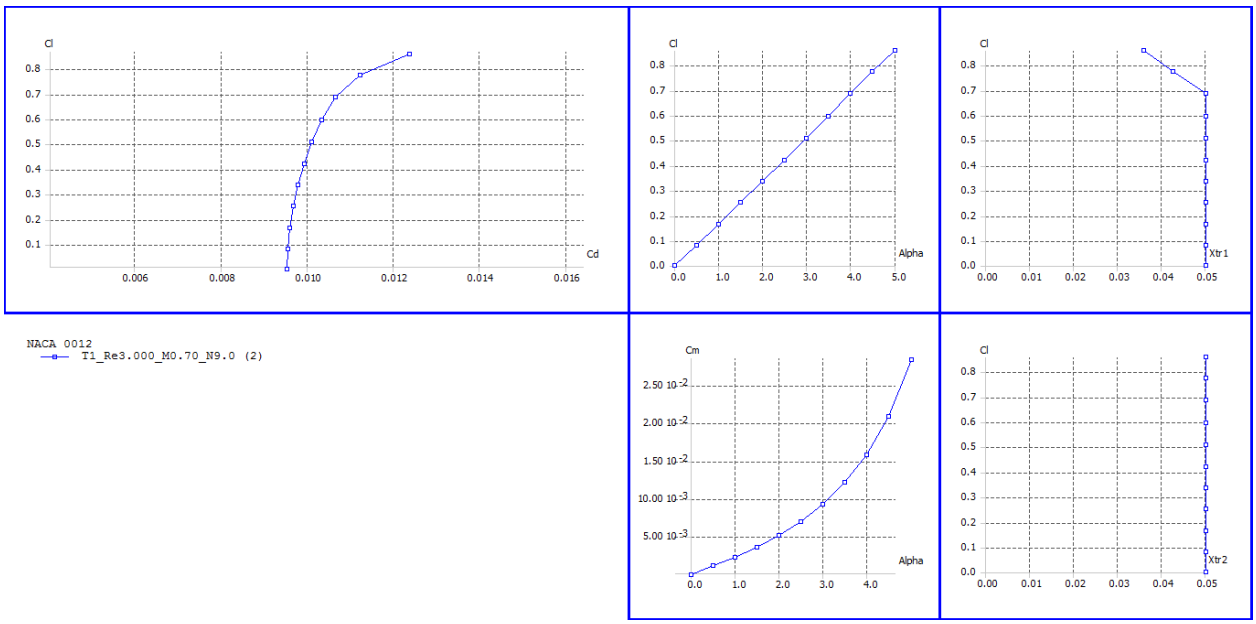
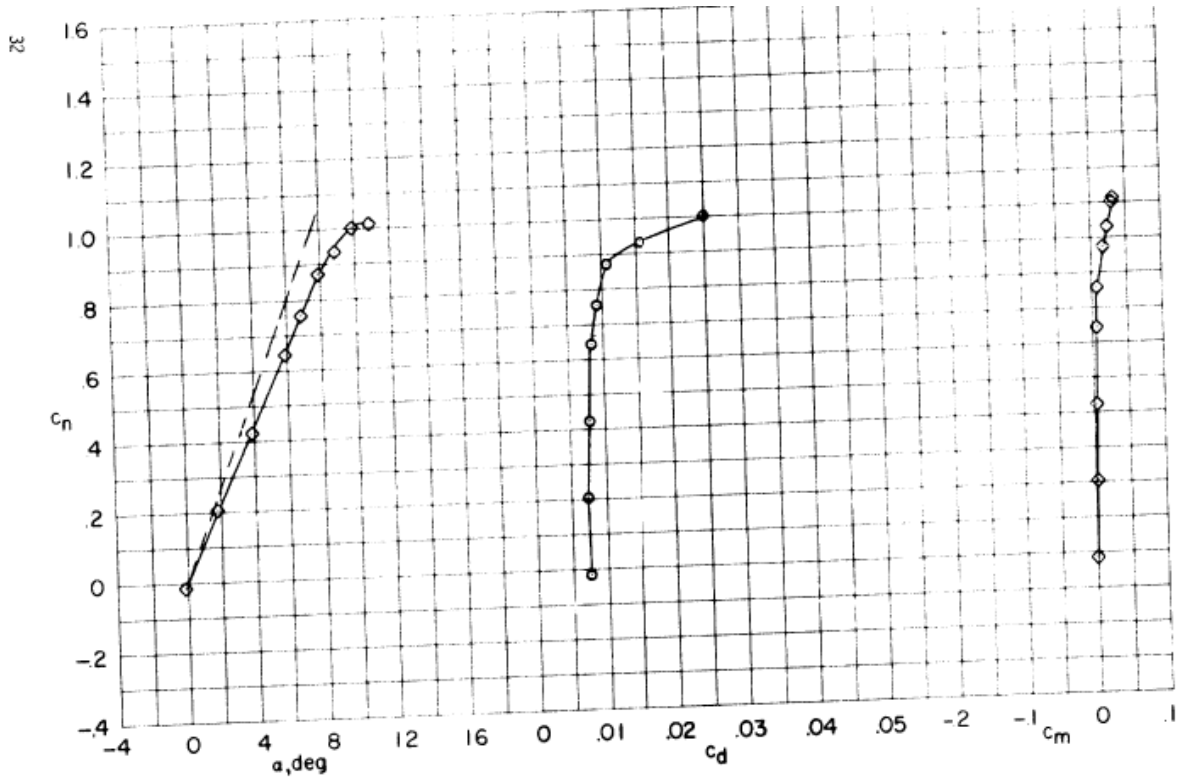


Fig. 4



(a) M = 0.50

Figure 6.- Force and moment characteristics of NACA 0012 airfoil. Rn = 9.0 × 10^6, transition fixed. (dashed line indicates angle of attack correction for wall interference).

Fig. 5

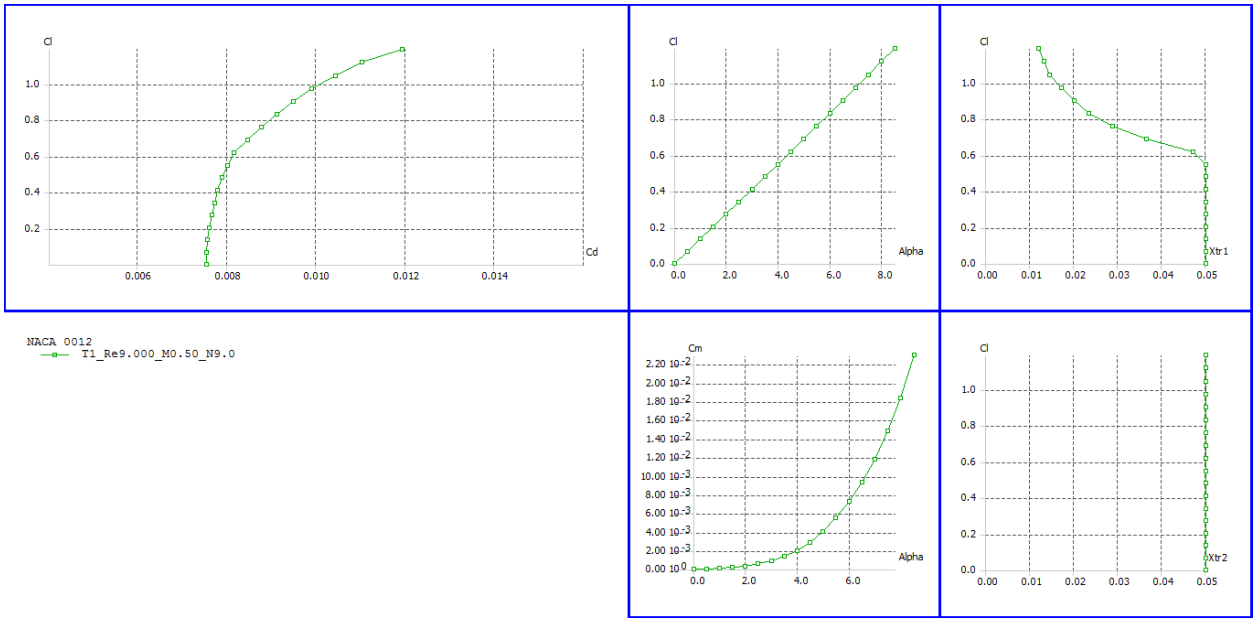
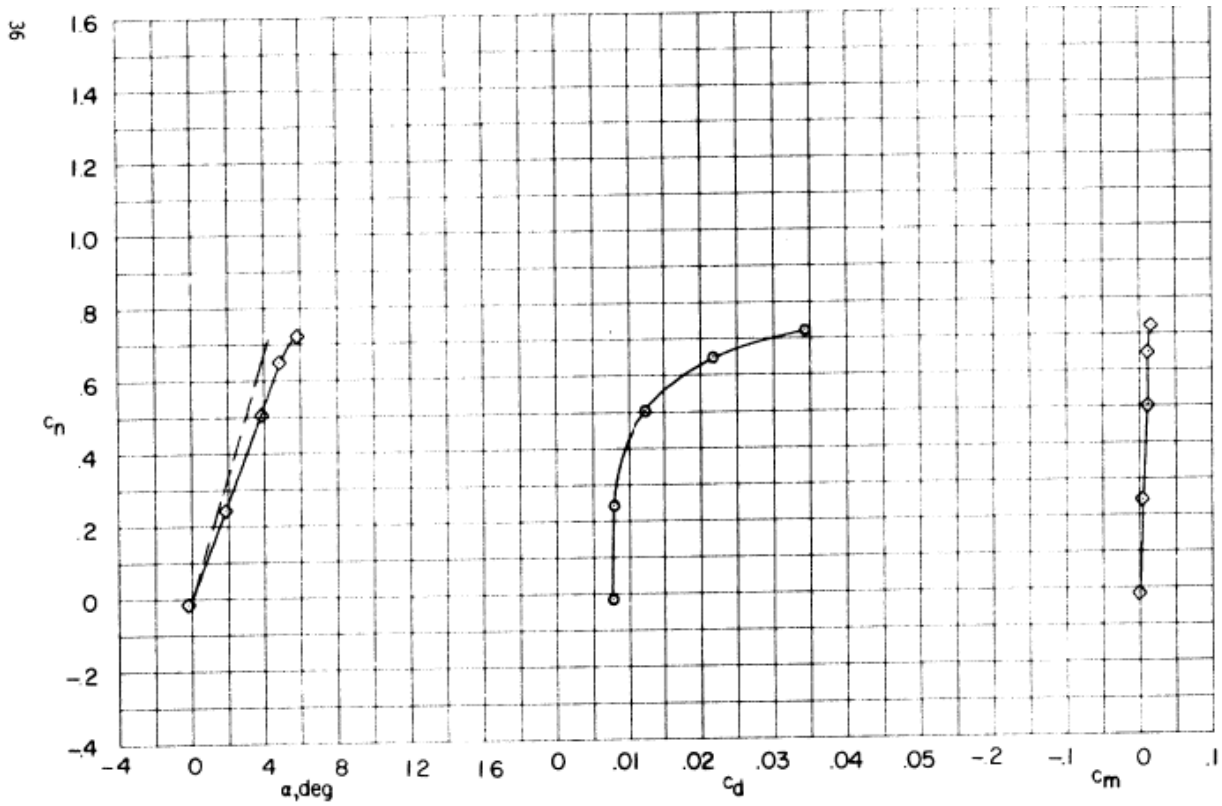


Fig. 6



(e) M = 0.70

Figure 6.- Continued.

Fig. 7

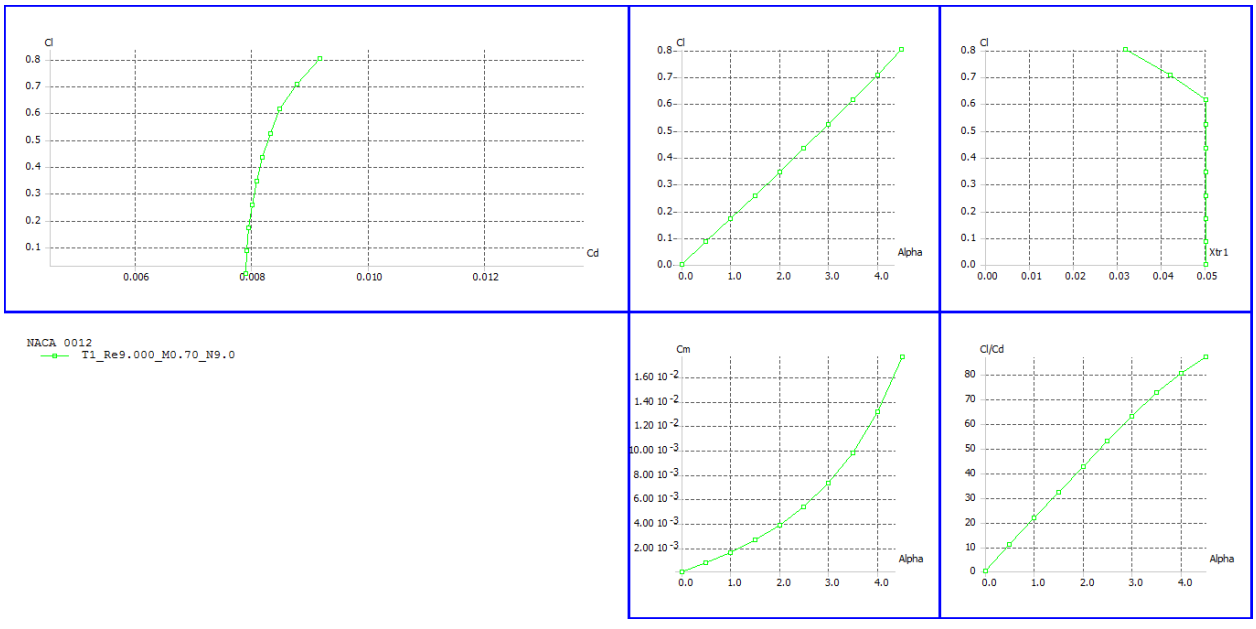


Fig. 8

Conclusion

1. XFOIL can be used only for subsonic applications. It fails as soon as air velocity locally reaches speed of sound.
2. XFOIL generates reasonably accurate results taking into account usual engineering practice. Bigger errors/deviations can be explained by no grid at NASA's report charts, big scale for Cm, and apparently inaccurate Cl curves corrected for wind tunnel walls effect.

References

1. NASA TM 81927 "Two-Dimensional Aerodynamic Characteristics of The NACA0012 Airfoil".
2. XFOIL 6.96 User Guide.