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Shock control bump optimization on a transonic laminar flow airfoil

A Test Case for
Database Workshop for Multiphysics Software Validation
16 March 2009, Agora, Jyvaskyla, Finland

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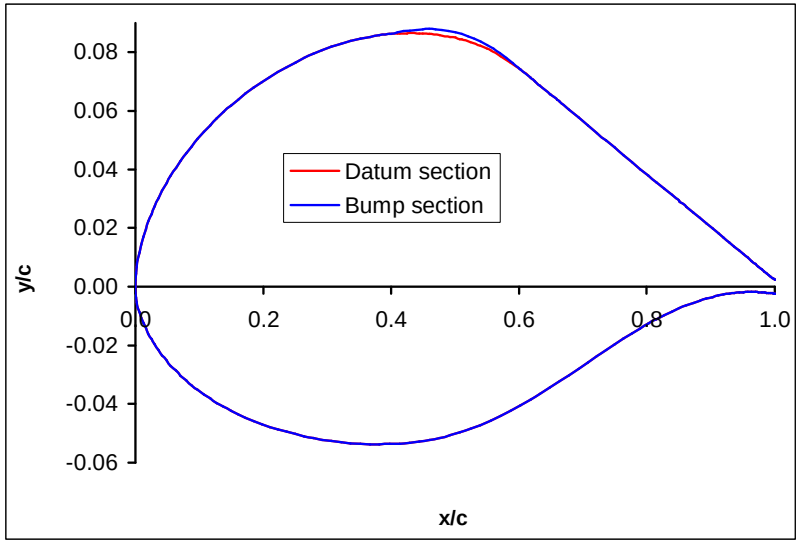
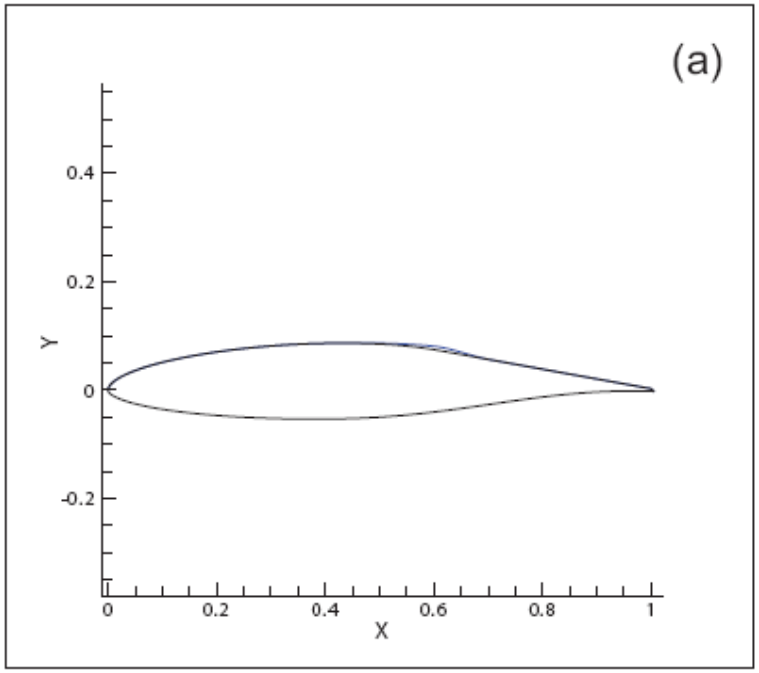
The Airfoil – RAE5243

- Natural laminar flow airfoil at transonic condition
- Shock wave at M = 0.68 and C_L = 0.82





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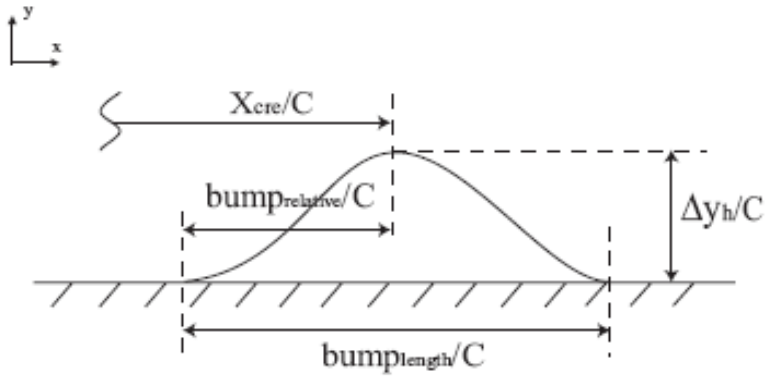
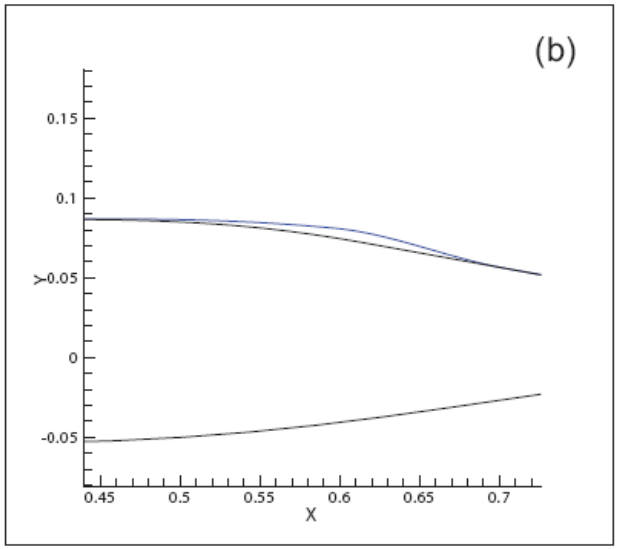
The bump design

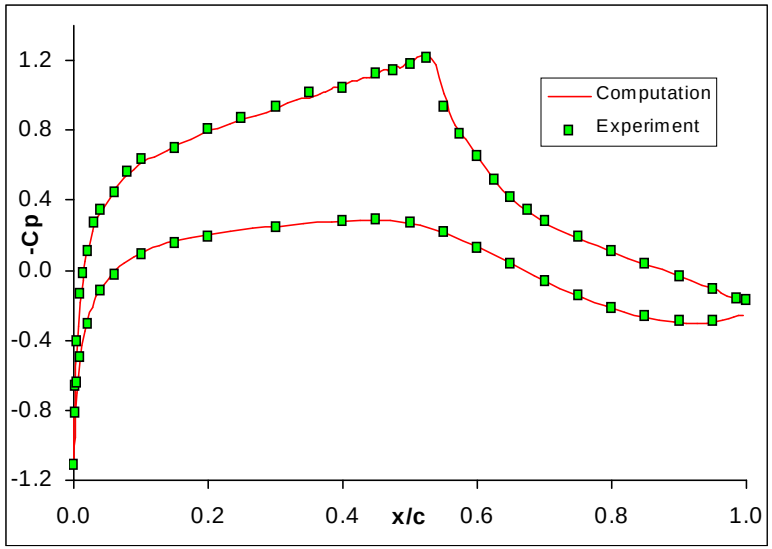
- 4 design variables: bump height, position, length and crest position
- Bump added to the airfoil shape
- Tangent at connection points and at the crest





The Test Cases

- Experiments were tripped for full turbulent flow
- Both full turbulent flow and fixed transition cases



Aerofoil	M_∞	$Re_{c,\infty}$	C_l	Flow condition	
RAE5243	0.68	1.9×10^7	0.82	Fully turbulent	
RAE5243	0.68	1.9×10^7	0.82	45%c transition	

The optimization problem

- Optimization problem

Minimize the total drag of the airfoil $\min C_d = C_{d,pressure} + C_{d,friction}$

Under the constraint: $C_l = 0.82$

- Design variable bounds

Bump crest position	$0 < X_{cre}/C < 1,$
Bump starting point to crest	$0 < X_{bumprelative}/C < X_{bumplength}/C$
Bump total length	$0 < X_{bumplength}/C < 0.4$
Bump height	$0 < \Delta Y_h/C < 0.05$