전산유체해석실습 과제 (5차)

과목명 : 전산유체해석실습
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학번 : 2021010530
이름 : 박진우
제출일 : 25-10-23

RAE6-9CK AIRFOIL

- gmsh_airfoil.geo

```
ymax = 4;
xmax = 10;
n_inlet = 60;
n_vertical = 90;
r_vertical = 1/0.95;
n_airfoil = 50;
n_wake = 100;
r_wake = 1/0.95;
```

```
//+
Point(129) = {-1, ymax, 0, 1.0};
//+
Point(130) = {-1, -ymax, 0, 1.0};
//+
Point(131) = {1, ymax, 0, 1.0};
//+
Point(132) = {1, -ymax, 0, 1.0};
//+
Point(133) = {xmax,-ymax, 0, 1.0};
//+
Point(134) = {xmax, -ymax, 0, 1.0};
//+
Point(134) = {xmax, 0, 0, 1.0};
//+
Point(135) = {xmax, 0, 0, 0};
//+
Point(136) = {xmax, ymax, 0, 1.0};
```

```
//+
Circle(2) = {130, 64, 129};
//+
Line(3) = {129, 131};
//+
Line(4) = {131, 136};
//+
Line(5) = {130, 132};
//+
Line(6) = {132, 133};
//+
Line(7) = {135, 136};
//+
Line(8) = {135, 133};
//+
Line(9) = {128, 135};
//+
Line(10) = {57, 129};
//+
Line(11) = {71, 130};
//+
Line(12) = {128, 131};
//+
Line(13) = {128, 132};
```

```
//+
Split Curve {1} Point {57, 71};
//+
Split Curve {15} Point {128};
```

```
//+
Transfinite Curve {2, 14} = n_inlet Using Progression 1;
//+
Transfinite Curve {10, 12, 7} = n_vertical Using Progression r_vertical;
//+
Transfinite Curve {11, 13, 8} = n_vertical Using Progression r_vertical;
//+
Transfinite Curve {4, 9, 6} = n_wake Using Progression r_wake;
//+
Transfinite Curve {3, 5} = n_airfoil Using Bump 2;
//+
Transfinite Curve {17, 16} = n_airfoil Using Bump 0.2;
```

```
//+
Curve Loop(1) = {2, -10, 14, 11};
//+
Plane Surface(1) = {1};
//+
Curve Loop(2) = {10, 3, -12, 17};
//+
Plane Surface(2) = {2};
//+
Curve Loop(3) = {12, 4, -7, -9};
//+
Plane Surface(3) = {3};
//+
Curve Loop(4) = {11, 5, -13, -16};
//+
Plane Surface(4) = {4};
//+
Curve Loop(5) = {13, 6, -8, -9};
//+
Plane Surface(5) = {5};
```

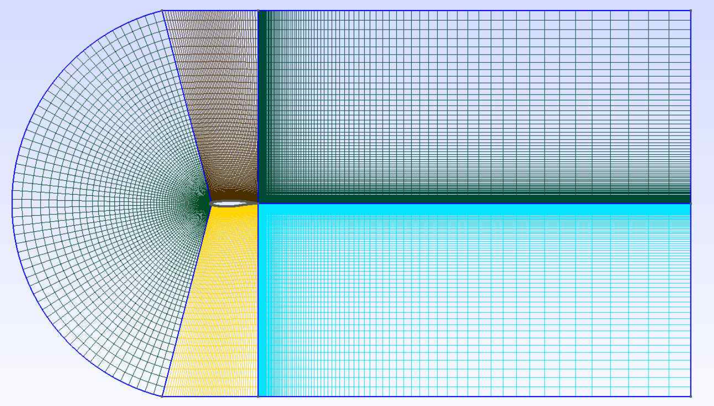
```
//+
Transfinite Surface {1};
//+
Transfinite Surface {2};
//+
Transfinite Surface {3};
//+
Transfinite Surface {5};
//+
Transfinite Surface {4};
```

```
//+
Recombine Surface {1, 2, 3, 5, 4};
```

```
//+
Physical Curve("farfield", 18) = {2, 3, 4, 7, 8, 6, 5};
//+
Physical Curve("airfoil", 19) = {17, 14, 16};
```

RAE6-9CK AIRFOIL

- mesh



RAE6-9CK AIRFOIL

- condition

.su2

```
NDIME= 2
NELEM= 31595
NMARK= 2
MARKER_TAG= farfield
MARKER_ELEMS= 533
MARKER_TAG= airfoil
MARKER_ELEMS= 157
```

airfoil.geo

```
//+
Physical Curve("farfield", 18) = {2, 3, 4, 7, 8, 6, 5};
//+
Physical Curve("airfoil", 19) = {17, 14, 16};
```

.cfg

```
% -------------------- BOUNDARY CONDITION DEFINITION -------------------------%
%
% Navier-Stokes wall boundary marker(s) (NONE = no marker)
MARKER_HEATFLUX= ( airfoil, 0.0 )
%
% Far-field boundary marker(s) (NONE = no marker)
MARKER_FAR= ( farfield )
%
% Symmetry boundary marker(s) (NONE = no marker)
%MARKER_SYM= ( SYMMETRY )
%
% Marker(s) of the surface to be plotted or designed
MARKER_PLOTTING= ( airfoil )
%
% Marker(s) of the surface where the functional (Cd, Cl, etc.) will be evaluated
MARKER_MONITORING= ( airfoil )
```

mach=0.8395

```
% ------------------- COMPRESSIBLE FREE-STREAM DEFINITION -------------------%
%
% Mach number (non-dimensional, based on the free-stream values)
MACH_NUMBER= 0.8395
%
% Angle of attack (degrees, only for compressible flows)
AOA= 3.06
%
% Side-slip angle (degrees, only for compressible flows)
SIDESLIP_ANGLE= 0.0
%
% Init option to choose between Reynolds (default) or thermodynamics quantities
% for initializing the solution (REYNOLDS, TD_CONDITIONS)
INIT_OPTION= REYNOLDS
%
% Free-stream option to choose between density and temperature (default) for
% initializing the solution (TEMPERATURE_FS, DENSITY_FS)
FREESTREAM_OPTION= TEMPERATURE_FS
%
% Free-stream temperature (288.15 K by default)
FREESTREAM_TEMPERATURE= 288.15
%
% Reynolds number (non-dimensional, based on the free-stream values)
REYNOLDS_NUMBER= 11.72E6
%
% Reynolds length (1 m by default)
REYNOLDS_LENGTH= 0.64607
```

```
% --------------------- REFERENCE VALUE DEFINITION --------------------------%
%
% Reference origin for moment computation
REF_ORIGIN_MOMENT_X = 0.25
REF_ORIGIN_MOMENT_Y = 0.00
REF_ORIGIN_MOMENT_Z = 0.00
%
% Reference length for pitching, rolling, and yawing non-dimensional moment
REF_LENGTH= 1.0
%
% Reference area for force coefficients (0 implies automatic calculation)
REF_AREA= 1
%
% Compressible flow non-dimensionalization (DIMENSIONAL, FREESTREAM_PRESS_EQ_ONE,
%                              FREESTREAM_VEL_EQ_MACH, FREESTREAM_VEL_EQ_ONE)
REF_DIMENSIONALIZATION= FREESTREAM_VEL_EQ_ONE
```

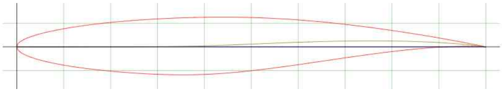
RAE6-9CK AIRFOIL

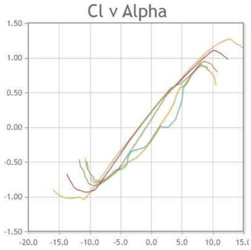
- CL,CD

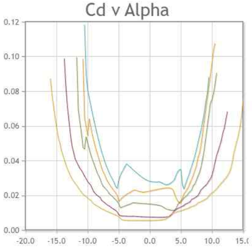
CL	CD
0.103291	0.044287
0.103291	0.044287
0.103290	0.044287
0.103289	0.044287
0.103287	0.044287
0.103286	0.044287
0.103285	0.044286
0.103283	0.044286
0.103282	0.044286
0.103280	0.044285
0.103279	0.044285
0.103277	0.044285
0.103276	0.044284
0.103274	0.044284
0.103273	0.044284
0.103272	0.044284
0.103271	0.044283
0.103271	0.044283
0.103270	0.044283
0.103269	0.044283
0.103269	0.044283
0.103269	0.044283
0.103269	0.044283
0.103269	0.044283
0.103269	0.044283
0.103269	0.044283
0.103269	0.044283
0.103269	0.044283
0.103270	0.044283
0.103270	0.044283
0.103271	0.044283
0.103271	0.044284
0.103272	0.044284
0.103273	0.044284
0.103273	0.044284
0.103274	0.044284
0.103275	0.044285
0.103275	0.044285
0.103276	0.044285
0.103277	0.044285
0.103277	0.044285
0.103278	0.044285
0.103279	0.044285
0.103279	0.044285
0.103280	0.044286
0.103280	0.044286
0.103281	0.044286
0.103281	0.044286

CL : 0.103281에 수렴
CD : 0.044286에 수렴

RAE6-9CK AIRFOIL

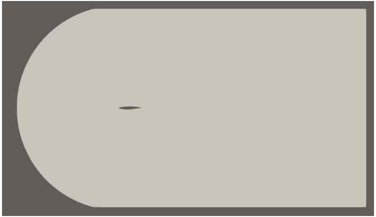


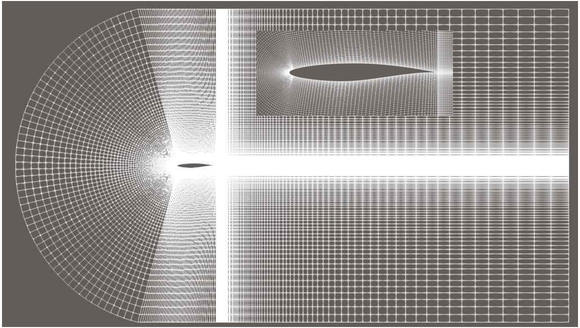




RAE6-9CK AIRFOIL

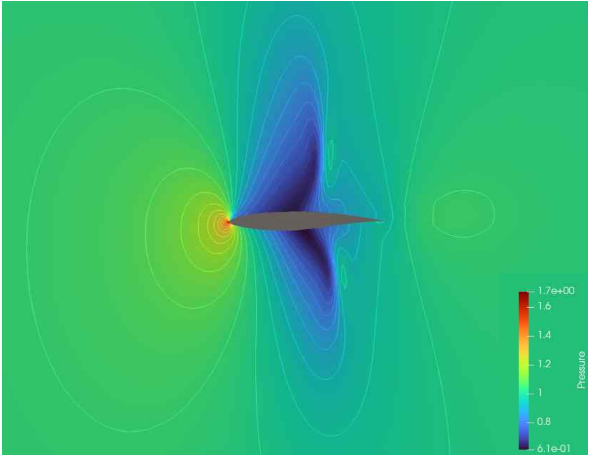
- mesh





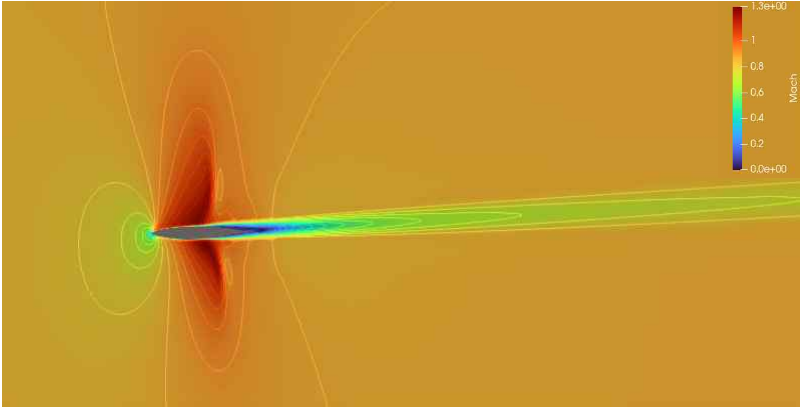
RAE6-9CK AIRFOIL

- pressure



RAE6-9CK AIRFOIL

- mach



RAE 2822 AIRFOIL

- gmsh_airfoil.geo

```
//+

ymax = 4;
xmax = 10;
n_inlet = 60;
n_vertical = 90;
r_vertical = 1/0.95;
n_airfoil = 50;
n_wake = 100;
r_wake = 1/0.95;
```

```
//+
Point(129) = {-1, ymax, 0, 1.0};
//+
Point(130) = {-1, -ymax, 0, 1.0};
//+
Point(131) = {1, ymax, 0, 1.0};
//+
Point(132) = {1, -ymax, 0, 1.0};
//+
Point(133) = {xmax, ymax, 0, 1.0};
//+
Point(134) = {xmax, -ymax, 0, 1.0};
//+
Point(135) = {xmax, 0, 0, 1.0};
```

```
//+
Circle(2) = {130, 64, 129};
//+
Line(3) = {129, 131};
//+
Line(4) = {131, 133};
//+
Line(5) = {130, 132};
//+
Line(6) = {132, 134};
//+
Line(7) = {135, 133};
//+
Line(8) = {135, 134};
//+
Line(9) = {128, 135};
//+
Line(10) = {57, 129};
//+
Line(11) = {71, 130};
//+
Line(12) = {128, 131};
//+
Line(13) = {128, 132};
```

```
//+
Split Curve {1} Point {57, 71};
//+
Split Curve {15} Point {128};
```

```
//+
Transfinite Curve {2, 14} = n_inlet Using Progression 1;
//+
Transfinite Curve {10, 12, 7} = n_vertical Using Progression r_vertical;
//+
Transfinite Curve {11, 13, 8} = n_vertical Using Progression r_vertical;
//+
Transfinite Curve {4, 9, 6} = n_wake Using Progression r_wake;
//+
Transfinite Curve {3, 5} = n_airfoil Using Bump 2;
//+
Transfinite Curve {17, 16} = n_airfoil Using Bump 0.2;
```

```
//+
Curve Loop(1) = {2, -10, 14, 11};
//+
Plane Surface(1) = {1};
//+
Curve Loop(2) = {10, 3, -12, 17};
//+
Plane Surface(2) = {2};
//+
Curve Loop(3) = {12, 4, -7, -9};
//+
Plane Surface(3) = {3};
//+
Curve Loop(4) = {13, 6, -8, -9};
//+
Plane Surface(4) = {4};
//+
Curve Loop(5) = {11, 5, -13, -16};
//+
Plane Surface(5) = {5};
```

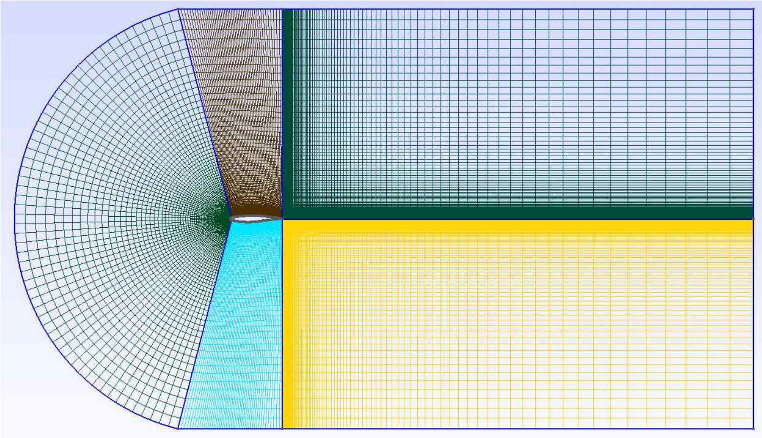
```
//+
Transfinite Surface {1};
//+
Transfinite Surface {2};
//+
Transfinite Surface {3};
//+
Transfinite Surface {4};
//+
Transfinite Surface {5};
```

```
//+
Recombine Surface {1, 2, 3, 4, 5};
```

```
//+
Physical Curve("farfield", 18) = {2, 3, 4, 7, 8, 6, 5};
//+
Physical Curve("airfoil", 19) = {14, 17, 16};
```

RAE 2822 AIRFOIL

- mesh



RAE 2822 AIRFOIL

- condition

.su2

```
NDIME= 2
NELEM= 31595
NMARK= 2
MARKER_TAG= farfield
MARKER_ELEMS= 533
MARKER_TAG= airfoil
MARKER_ELEMS= 157
```

airfoil.geo

```
//+
Physical Curve("farfield", 18) = {2, 3, 4, 7, 8, 6, 5};
//+
Physical Curve("airfoil", 19) = {14, 17, 16};
```

.cfg

```
% -------------------- BOUNDARY CONDITION DEFINITION -------------------------%
%
% Navier-Stokes wall boundary marker(s) (NONE = no marker)
MARKER_HEATFLUX= ( airfoil, 0.0 )
%
% Far-field boundary marker(s) (NONE = no marker)
MARKER_FAR= ( farfield )
%
% Symmetry boundary marker(s) (NONE = no marker)
%
% Marker(s) of the surface to be plotted or designed
MARKER_PLOTTING= ( airfoil)
%
% Marker(s) of the surface where the functional (Cd, Cl, etc.) will be evaluated
MARKER_MONITORING= ( airfoil )
```

mach=0.3

```
% -------------------- COMPRESSIBLE FREE-STREAM DEFINITION --------------------%
%
% Mach number (non-dimensional, based on the free-stream values)
MACH_NUMBER= 0.3
%
% Angle of attack (degrees, only for compressible flows)
AOA= 3.06
%
% Side-slip angle (degrees, only for compressible flows)
SIDESLIP_ANGLE= 0.0
%
% Init option to choose between Reynolds (default) or thermodynamics quantities
% for initializing the solution (REYNOLDS, TD_CONDITIONS)
INIT_OPTION= REYNOLDS
%
% Free-stream option to choose between density and temperature (default) for
% initializing the solution (TEMPERATURE_FS, DENSITY_FS)
FREESTREAM_OPTION= TEMPERATURE_FS
%
% Free-stream temperature (288.15 K by default)
FREESTREAM_TEMPERATURE= 288.15
%
% Reynolds number (non-dimensional, based on the free-stream values)
REYNOLDS_NUMBER= 11.72E6
%
% Reynolds length (1 m by default)
REYNOLDS_LENGTH= 1.0
```

```
% --------------------- REFERENCE VALUE DEFINITION ---------------------------%
%
% Reference origin for moment computation
REF_ORIGIN_MOMENT_X = 0.25
REF_ORIGIN_MOMENT_Y = 0.00
REF_ORIGIN_MOMENT_Z = 0.00
%
% Reference length for pitching, rolling, and yawing non-dimensional moment
REF_LENGTH= 1.0
%
% Reference area for force coefficients (0 implies automatic calculation)
REF_AREA= 1
%
% Compressible flow non-dimensionalization (DIMENSIONAL, FREESTREAM_PRESS_EQ_ONE,
%                              FREESTREAM_VEL_EQ_MACH, FREESTREAM_VEL_EQ_ONE)
REF_DIMENSIONALIZATION= FREESTREAM_VEL_EQ_ONE
```

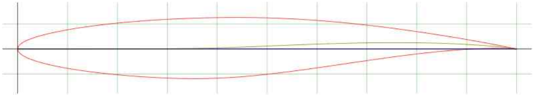
RAE 2822 AIRFOIL

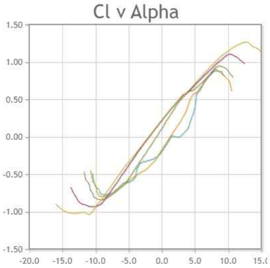
- CL,CD

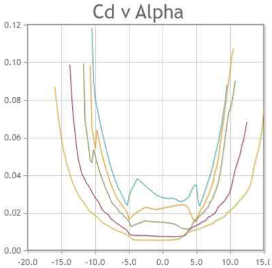
CL	CD
0.376404	0.015165
0.376363	0.015165
0.376323	0.015166
0.376285	0.015166
0.376246	0.015167
0.376209	0.015167
0.376173	0.015168
0.376137	0.015168
0.376103	0.015169
0.376069	0.015169
0.376036	0.015170
0.376003	0.015170
0.375972	0.015171
0.375941	0.015171
0.375910	0.015171
0.375881	0.015172
0.375852	0.015172
0.375824	0.015173
0.375796	0.015173
0.375769	0.015173
0.375743	0.015174
0.375717	0.015174
0.375692	0.015175
0.375667	0.015175
0.375643	0.015175
0.375619	0.015176
0.375596	0.015176
0.375574	0.015176
0.375552	0.015177
0.375530	0.015177
0.375509	0.015177
0.375489	0.015177
0.375468	0.015178
0.375449	0.015178
0.375430	0.015178
0.375411	0.015179
0.375393	0.015179
0.375375	0.015179
0.375357	0.015179
0.375340	0.015180
0.375324	0.015180
0.375307	0.015180
0.375291	0.015180
0.375276	0.015181
0.375261	0.015181
0.375246	0.015181
0.375232	0.015181
0.375218	0.015181

CL : 0.375218에 수렴
CD : 0.015181에 수렴

RAE 2822 AIRFOIL

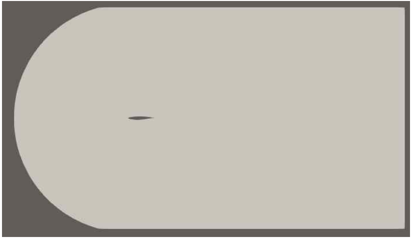


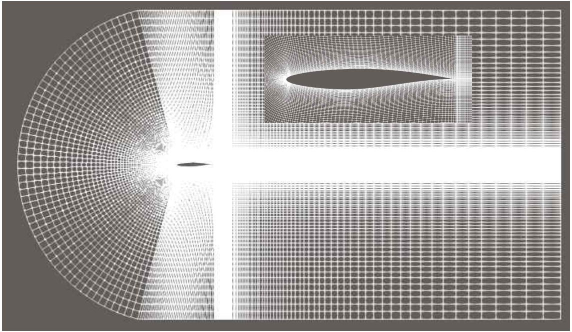




RAE 2822 AIRFOIL

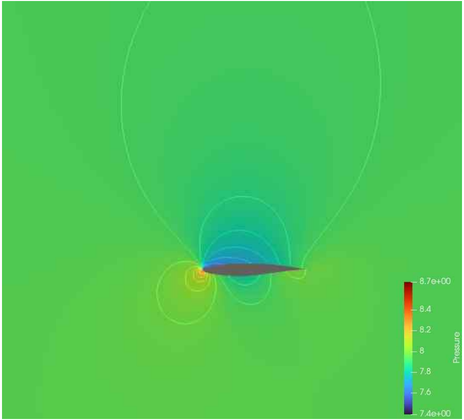
- mesh





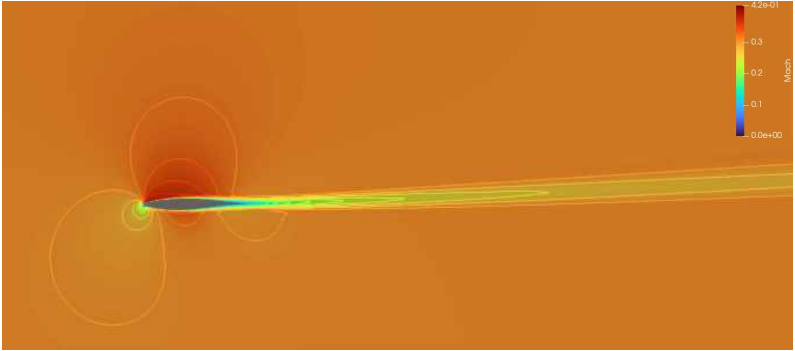
RAE 2822 AIRFOIL

- pressure



RAE 2822 AIRFOIL

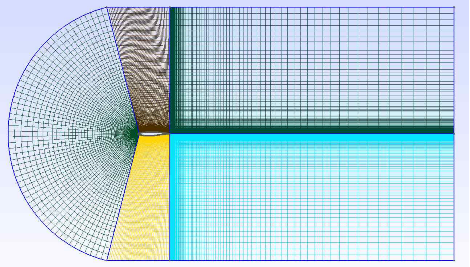
- mach



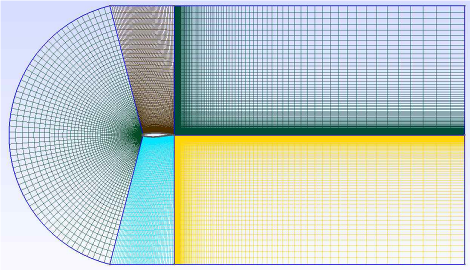
RAE6-9CK AIRFOIL VS RAE 2822 AIRFOIL

- mesh

RAE6-9CK AIRFOIL



RAE 2822 AIRFOIL



조건을 동일하게 설정하였기 때문에, 격자의 모양이 유의미한 차이는 나타나지 않았다

RAE6-9CK AIRFOIL VS RAE 2822 AIRFOIL

- condition

RAE6-9CK AIRFOIL : mach=0.8395

```
% ------------------- COMPRESSIBLE FREE-STREAM DEFINITION -------------------%
%
% Mach number (non-dimensional, based on the free-stream values)
MACH_NUMBER= 0.8395
%
% Angle of attack (degrees, only for compressible flows)
AOA= 3.06
%
% Side-slip angle (degrees, only for compressible flows)
SIDESLIP_ANGLE= 0.0
%
% Init option to choose between Reynolds (default) or thermodynamics quantities
% for initializing the solution (REYNOLDS, TD_CONDITIONS)
INIT_OPTION= REYNOLDS
%
% Free-stream option to choose between density and temperature (default) for
% initializing the solution (TEMPERATURE_FS, DENSITY_FS)
FREESTREAM_OPTION= TEMPERATURE_FS
%
% Free-stream temperature (288.15 K by default)
FREESTREAM_TEMPERATURE= 288.15
%
% Reynolds number (non-dimensional, based on the free-stream values)
REYNOLDS_NUMBER= 11.72E6
%
% Reynolds length (1 m by default)
REYNOLDS_LENGTH= 0.64607
```

RAE 2822 AIRFOIL : mach=0.3

```
% ------------------- COMPRESSIBLE FREE-STREAM DEFINITION -------------------%
%
% Mach number (non-dimensional, based on the free-stream values)
MACH_NUMBER= 0.3
%
% Angle of attack (degrees, only for compressible flows)
AOA= 3.06
%
% Side-slip angle (degrees, only for compressible flows)
SIDESLIP_ANGLE= 0.0
%
% Init option to choose between Reynolds (default) or thermodynamics quantities
% for initializing the solution (REYNOLDS, TD_CONDITIONS)
INIT_OPTION= REYNOLDS
%
% Free-stream option to choose between density and temperature (default) for
% initializing the solution (TEMPERATURE_FS, DENSITY_FS)
FREESTREAM_OPTION= TEMPERATURE_FS
%
% Free-stream temperature (288.15 K by default)
FREESTREAM_TEMPERATURE= 288.15
%
% Reynolds number (non-dimensional, based on the free-stream values)
REYNOLDS_NUMBER= 11.72E6
%
% Reynolds length (1 m by default)
REYNOLDS_LENGTH= 1.0
```

RAE6-9CK AIRFOIL은 mach를 0.8395로 설정하였고, RAE 2822 AIRFOIL는 mach를 0.3으로 설정했다.
마하수를 제외한 모든 조건은 동일하다.

RAE6-9CK AIRFOIL VS RAE 2822 AIRFOIL

- CL,CD

CL	CD
0.376404	0.015165
0.376363	0.015165
0.376323	0.015166
0.376285	0.015166
0.376246	0.015167
0.376209	0.015167
0.376173	0.015168
0.376137	0.015168
0.376103	0.015169
0.376069	0.015169
0.376036	0.015170
0.376003	0.015170
0.375972	0.015171
0.375941	0.015171
0.375910	0.015171
0.375881	0.015172
0.375852	0.015172
0.375824	0.015173
0.375796	0.015173
0.375769	0.015173
0.375743	0.015174
0.375717	0.015174
0.375692	0.015175
0.375667	0.015175
0.375643	0.015175
0.375619	0.015176
0.375596	0.015176
0.375574	0.015176
0.375552	0.015177
0.375530	0.015177
0.375509	0.015177
0.375489	0.015177
0.375468	0.015178
0.375449	0.015178
0.375430	0.015178
0.375411	0.015179
0.375393	0.015179
0.375375	0.015179
0.375357	0.015179
0.375340	0.015180
0.375324	0.015180
0.375307	0.015180
0.375291	0.015180
0.375276	0.015181
0.375261	0.015181
0.375246	0.015181
0.375232	0.015181
0.375218	0.015181

RAE6-9CK AIRFOIL
CL : 0.103281에 수렴
CD : 0.044286에 수렴

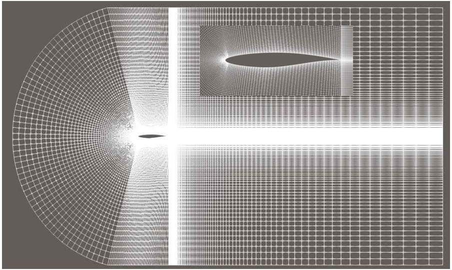
CL	CD
0.376404	0.015165
0.376363	0.015165
0.376323	0.015166
0.376285	0.015166
0.376246	0.015167
0.376209	0.015167
0.376173	0.015168
0.376137	0.015168
0.376103	0.015169
0.376069	0.015169
0.376036	0.015170
0.376003	0.015170
0.375972	0.015171
0.375941	0.015171
0.375910	0.015171
0.375881	0.015172
0.375852	0.015172
0.375824	0.015173
0.375796	0.015173
0.375769	0.015173
0.375743	0.015174
0.375717	0.015174
0.375692	0.015175
0.375667	0.015175
0.375643	0.015175
0.375619	0.015176
0.375596	0.015176
0.375574	0.015176
0.375552	0.015177
0.375530	0.015177
0.375509	0.015177
0.375489	0.015177
0.375468	0.015178
0.375449	0.015178
0.375430	0.015178
0.375411	0.015179
0.375393	0.015179
0.375375	0.015179
0.375357	0.015179
0.375340	0.015180
0.375324	0.015180
0.375307	0.015180
0.375291	0.015180
0.375276	0.015181
0.375261	0.015181
0.375246	0.015181
0.375232	0.015181
0.375218	0.015181

RAE 2822 AIRFOIL
CL : 0.375218에 수렴
CD : 0.015181에 수렴

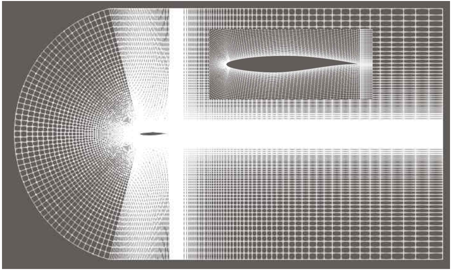
RAE6-9CK AIRFOIL VS RAE 2822 AIRFOIL

- mesh

RAE6-9CK AIRFOIL



RAE 2822 AIRFOIL

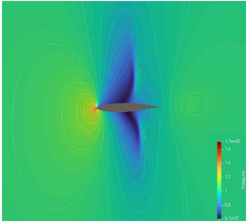


조건을 동일하게 설정하였기 때문에 격자의 형태에서 유의미한 차이가 나타나지 않았으나, RAE 2822 AIRFOIL의 격자가 상대적으로 더 세밀한 것으로 확인되었다.

RAE6-9CK AIRFOIL VS RAE 2822 AIRFOIL

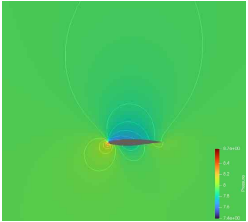
- pressure

RAE6-9CK AIRFOIL (M=0.8395)



RAE6-9CK AIRFOIL (M=0.8395): 에어포일 중간 영역에 충격파가 형성되어, 충격파 직후 정압이 급증하고 동시에 비가역 손실로 인해 전체압이 감소한다.

RAE 2822 AIRFOIL (M=0.3)



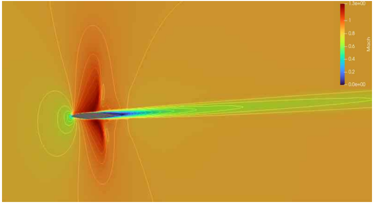
RAE 2822 AIRFOIL (M=0.30): 아음속 조건에서는 충격파가 형성되지 않아 압력 분포가 전반적으로 완만하며, RAE6-9CK AIRFOIL(M=0.8395)보다 상대적으로 높은 정압이 유지되는 경향을 보인다.

RAE6-9CK AIRFOIL VS RAE 2822 AIRFOIL

- mach

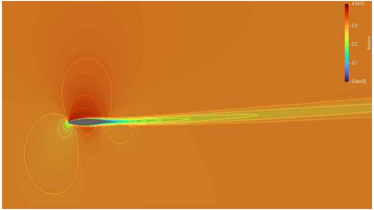
RAE6-9CK AIRFOIL (M=0.8395): 에어포일 중간 영역에서 충격파가 형성된 모습을 확인할 수 있다.

RAE6-9CK AIRFOIL (M=0.8395)



RAE 2822 AIRFOIL (M=0.30): 아음속 조건에서는 충격파가 형성되지 않아 압력 분포가 전반적으로 완만하게 나타난다.

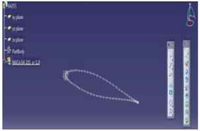
RAE 2822 AIRFOIL (M=0.3)



NACA 64-215 AIRFOIL

- 선정이유
- 벨루가 항공기의 에어포일 형상을 조사하던 중, 해당 항공기에 적용된 정확한 에어포일 정보를 찾기 어려웠다. 이에 따라 벨루가 항공기의 기반이 되는 Airbus A300-600의 에어포일을 조사하였고, 그 결과 NACA 64-215 Airfoil이 사용된다는 자료를 확인하였다. 따라서 NACA 64-215 Airfoil을 선택하였다.

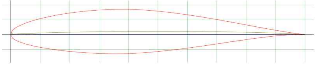
Figure 3: NACA64-215 Airfoil Generation



The Figure 3 shows the NACA64-215 Airfoil generation. For wing Skelton structure we use NACA64-215 co-ordinates. Import the co-ordinates to catia v5 R20 through Microsoft excel then the airfoil shape is generated in catia v5 R20.

https://www.ijmerr.com/uploadfile/2015/0421/20150421100859233.pdf?utm_source=chatgpt.com

Naca64-215 Airfoil



에어버스 벨루가

에어버스 벨루가

종류	화물기
첫 비행	1994년 9월 13일
현황	생산 중단
주요 사용자	에어버스
생산 대수	5대
개발 원형	에어버스 A300-600
비고	엔진: 제너럴 일렉트릭 CF6

NACA 64-215 AIRFOIL

- gmsh_airfoil.geo

```
ymax = 4;
xmax = 10;
n_inlet = 60;
n_vertical = 90;
r_vertical = 1/0.95;
n_airfoil = 50;
n_wake = 100;
r_wake = 1/0.95;
```

```
//+
Point(51) = {-1, ymax, 0, 1.0};
//+
Point(52) = {-1, -ymax, 0, 1.0};
//+
Point(53) = {1, ymax, 0, 1.0};
//+
Point(54) = {1, -ymax, 0, 1.0};
//+
Point(55) = {xmax, ymax, 0, 1.0};
//+
Point(56) = {xmax, -ymax, 0, 1.0};
//+
Point(57) = {xmax, 0, 0, 1.0};
```

```
//+
Circle(2) = {52, 25, 51};
//+
Line(3) = {51, 53};
//+
Line(4) = {53, 55};
//+
Line(5) = {52, 54};
//+
Line(6) = {54, 56};
//+
Line(7) = {57, 55};
//+
Line(8) = {57, 56};
//+
Line(9) = {50, 57};
//+
Line(10) = {20, 51};
//+
Line(11) = {30, 52};
//+
Line(12) = {50, 53};
//+
Line(13) = {50, 54};
```

```
//+
Split Curve {1} Point {20, 30};
//+
Split Curve {15} Point {50};
```

```
//+
Transfinite Curve {2, 14} = n_inlet Using Progression 1;
//+
Transfinite Curve {10, 12, 7} = n_vertical Using Progression r_vertical;
//+
Transfinite Curve {11, 13, 8} = n_vertical Using Progression r_vertical;
//+
Transfinite Curve {4, 9, 6} = n_wake Using Progression r_wake;
//+
Transfinite Curve {3, 5} = n_airfoil Using Bump 2;
//+
Transfinite Curve {17, 16} = n_airfoil Using Bump 0.2;
```

```
//+
Curve Loop(1) = {2, -10, 14, 11};
//+
Plane Surface(1) = {1};
//+
Curve Loop(2) = {10, 3, -12, 17};
//+
Plane Surface(2) = {2};
//+
Curve Loop(3) = {12, 4, -7, -9};
//+
Plane Surface(3) = {3};
//+
Curve Loop(4) = {13, 6, -8, -9};
//+
Plane Surface(4) = {4};
//+
Curve Loop(5) = {13, -5, -11, 16};
//+
Plane Surface(5) = {5};
```

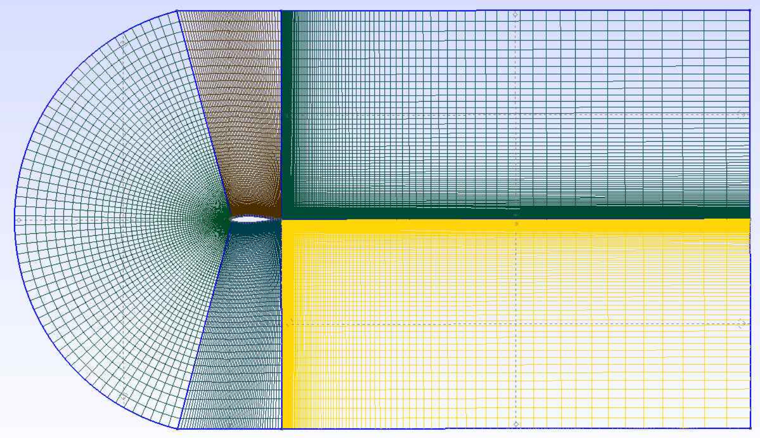
```
//+
Transfinite Surface {1};
//+
Transfinite Surface {2};
//+
Transfinite Surface {3};
//+
Transfinite Surface {4};
//+
Transfinite Surface {5};
```

```
//+
Recombine Surface {1, 2, 3, 4, 5};
```

```
//+
Physical Curve("farfield", 18) = {2, 3, 4, 7, 8, 6, 5};
//+
Physical Curve("airfoil", 19) = {17, 16, 14};
```

NACA 64-215 AIRFOIL

- mesh



NACA 64-215 AIRFOIL

- condition

.su2

```
NDIME= 2
NELEM= 31595
NMARK= 2
MARKER_TAG= farfield
MARKER_ELEMS= 533
MARKER_TAG= airfoil
MARKER_ELEMS= 157
```

airfoil.geo

```
//+
Physical Curve("farfield", 18) = {2, 3, 4, 7, 8, 6, 5};
//+
Physical Curve("airfoil", 19) = {17, 16, 14};
```

.cfg

```
% -------------------- BOUNDARY CONDITION DEFINITION -------------------------%
%
% Navier-Stokes wall boundary marker(s) (NONE = no marker)
MARKER_HEATFLUX= ( airfoil, 0.0 )
%
% Far-field boundary marker(s) (NONE = no marker)
MARKER_FAR= ( farfield )
%
% Symmetry boundary marker(s) (NONE = no marker)
%
% Marker(s) of the surface to be plotted or designed
MARKER_PLOTTING= ( airfoil )
%
% Marker(s) of the surface where the functional (Cd, Cl, etc.) will be evaluated
MARKER_MONITORING= ( airfoil )
```

mach=0.3

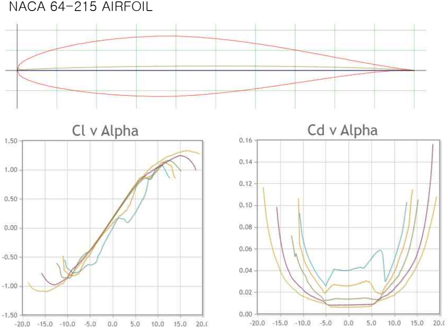
```
% ------------------- COMPRESSIBLE FREE-STREAM DEFINITION -------------------%
%
% Mach number (non-dimensional, based on the free-stream values)
MACH_NUMBER= 0.3
%
% Angle of attack (degrees, only for compressible flows)
AOA= 3.06
%
% Side-slip angle (degrees, only for compressible flows)
SIDESLIP_ANGLE= 0.0
%
% Init option to choose between Reynolds (default) or thermodynamics quantities
% for initializing the solution (REYNOLDS, TD_CONDITIONS)
INIT_OPTION= REYNOLDS
%
% Free-stream option to choose between density and temperature (default) for
% initializing the solution (TEMPERATURE_FS, DENSITY_FS)
FREESTREAM_OPTION= TEMPERATURE_FS
%
% Free-stream temperature (288.15 K by default)
FREESTREAM_TEMPERATURE= 288.15
%
% Reynolds number (non-dimensional, based on the free-stream values)
REYNOLDS_NUMBER= 11.72E6
%
% Reynolds length (1 m by default)
REYNOLDS_LENGTH= 1.0
```

```
% --------------------- REFERENCE VALUE DEFINITION -------------------------%
%
% Reference origin for moment computation
REF_ORIGIN_MOMENT_X = 0.25
REF_ORIGIN_MOMENT_Y = 0.00
REF_ORIGIN_MOMENT_Z = 0.00
%
% Reference length for pitching, rolling, and yawing non-dimensional moment
REF_LENGTH= 1.0
%
% Reference area for force coefficients (0 implies automatic calculation)
REF_AREA= 1
%
% Compressible flow non-dimensionalization (DIMENSIONAL, FREESTREAM_PRESS_EQ_ONE,
%                              FREESTREAM_VEL_EQ_MACH, FREESTREAM_VEL_EQ_ONE)
REF_DIMENSIONALIZATION= FREESTREAM_VEL_EQ_ONE
```

NACA 64-215 AIRFOIL

- CL,CD

CL : 0.359738에 수렴
CD : 0.018593에 수렴

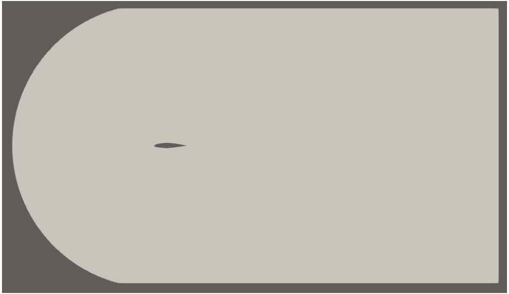


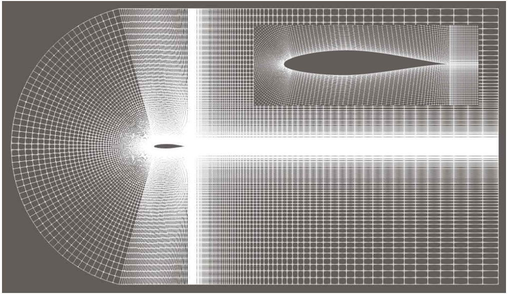
비슷하게 나오는 것을 확인할 수 있다.

Inner_Iter	Time(sec)	rms[Rho]	rms[nu]	CL	CD
392	6.8884e-02	-9.065798	-9.820296	0.359923	0.018590
393	6.8851e-02	-9.074719	-9.830768	0.359917	0.018590
394	6.8823e-02	-9.083644	-9.841231	0.359912	0.018590
395	6.8791e-02	-9.092576	-9.851687	0.359906	0.018590
396	6.8779e-02	-9.101517	-9.862135	0.359901	0.018590
397	6.8746e-02	-9.110468	-9.872576	0.359896	0.018590
398	6.8716e-02	-9.119433	-9.883011	0.359891	0.018590
399	6.8681e-02	-9.128413	-9.893439	0.359885	0.018590
400	6.8648e-02	-9.137410	-9.903860	0.359880	0.018591
401	6.8633e-02	-9.146424	-9.914275	0.359876	0.018591
402	6.8599e-02	-9.155459	-9.924684	0.359871	0.018591
403	6.8568e-02	-9.164515	-9.935087	0.359866	0.018591
404	6.8537e-02	-9.173592	-9.945483	0.359861	0.018591
405	6.8506e-02	-9.182691	-9.955873	0.359857	0.018591
406	6.8474e-02	-9.191813	-9.966255	0.359852	0.018591
407	6.8442e-02	-9.200958	-9.976631	0.359848	0.018591
408	6.8416e-02	-9.210125	-9.986999	0.359844	0.018591
409	6.8387e-02	-9.219313	-9.997359	0.359840	0.018591
410	6.8357e-02	-9.228522	-10.007710	0.359835	0.018591
411	6.8327e-02	-9.237750	-10.018052	0.359831	0.018591
412	6.8296e-02	-9.246997	-10.028384	0.359827	0.018591
413	6.8277e-02	-9.256260	-10.038705	0.359824	0.018591
414	6.8248e-02	-9.265537	-10.049015	0.359820	0.018591
415	6.8224e-02	-9.274826	-10.059314	0.359816	0.018592
416	6.8194e-02	-9.284125	-10.069600	0.359812	0.018592
417	6.8166e-02	-9.293432	-10.079872	0.359809	0.018592
418	6.8139e-02	-9.302744	-10.090131	0.359805	0.018592
419	6.8109e-02	-9.312059	-10.100376	0.359802	0.018592
420	6.8159e-02	-9.321373	-10.110603	0.359798	0.018592
421	6.8140e-02	-9.330685	-10.120815	0.359795	0.018592
422	6.8109e-02	-9.339992	-10.131011	0.359792	0.018592
423	6.8081e-02	-9.349292	-10.141190	0.359788	0.018592
424	6.8052e-02	-9.358579	-10.151352	0.359785	0.018592
425	6.8024e-02	-9.367844	-10.161498	0.359782	0.018592
426	6.7997e-02	-9.377075	-10.171625	0.359779	0.018592
427	6.7968e-02	-9.386281	-10.181735	0.359776	0.018592
428	6.7942e-02	-9.395481	-10.191827	0.359773	0.018592
429	6.7916e-02	-9.404671	-10.201901	0.359770	0.018592
430	6.7889e-02	-9.413846	-10.211958	0.359768	0.018592
431	6.7877e-02	-9.422998	-10.221997	0.359765	0.018592
432	6.7850e-02	-9.432127	-10.232018	0.359762	0.018592
433	6.7824e-02	-9.441235	-10.242022	0.359760	0.018592
434	6.7796e-02	-9.450324	-10.252010	0.359757	0.018592
435	6.7767e-02	-9.459395	-10.261981	0.359754	0.018592
436	6.7743e-02	-9.468451	-10.271937	0.359752	0.018592
437	6.7713e-02	-9.477495	-10.281878	0.359750	0.018592
438	6.7686e-02	-9.486529	-10.291804	0.359747	0.018593
439	6.7660e-02	-9.495554	-10.301717	0.359745	0.018593
440	6.7633e-02	-9.504574	-10.311616	0.359742	0.018593
441	6.7603e-02	-9.513589	-10.321504	0.359740	0.018593
442	6.7574e-02	-9.522603	-10.331382	0.359738	0.018593

NACA 64-215 AIRFOIL

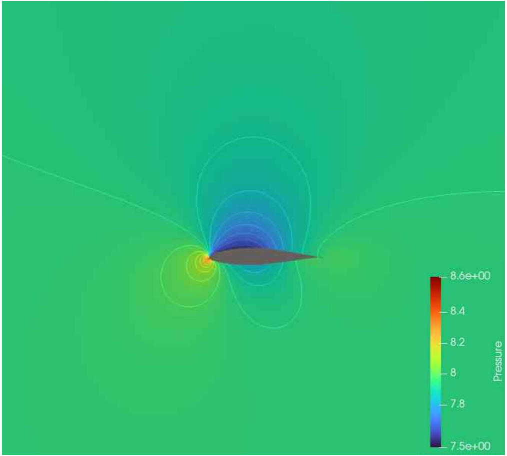
- Mesh





NACA 64-215 AIRFOIL

- pressure



NACA 64-215 AIRFOIL

- mach