



REPORT

학과: 항공기계공학과
과목: 전산유체해석실습
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제출날짜: 11/27 (목)



CHEONGJU UNIVERSITY

공력형상최적설계 프로젝트

공력형상최적설계 프로젝트

[프로그램]

SU2_CFD.exe
SU2_DEF.exe
SU2_DOT.exe
SU2_GEO.exe

- **SU2_CFD** - 직접 및 동반 유동 시뮬레이션을 수행합니다
- **SU2_DOT** - 수반 표면 감도를 설계 공간에 투영하여 기울기를 얻습니다
- **SU2_DEF** - 형태 최적화 과정에서 설계 변수의 변화에 따라 기하학과 메쉬를 변형시킵니다
- **shape_optimization.py** - SU2 도구와 최적화 도구를 실행하여 전체 형태 설계 과정을 자동화합니다

inv_NACA0012_basic.cfg

```
% ----- DIRECT, ADJOINT, AND LINEARIZED PROBLEM DEFINITION -----%
%
% Physical governing equations (EULER, NAVIER_STOKES,
%                               WAVE_EQUATION, HEAT_EQUATION, FEM_ELASTICITY,
%                               POISSON_EQUATION)
SOLVER= EULER
%
% Mathematical problem (DIRECT, CONTINUOUS_ADJOINT)
MATH_PROBLEM= DIRECT
%
% Restart solution (NO, YES)
RESTART_SOL= YES
```

```
% ----- ADJOINT-FLOW NUMERICAL METHOD DEFINITION -----
% Adjoint problem boundary condition (DRAG, LIFT, SIDEFORCE, MOMENT_X,
%                                     MOMENT_Y, MOMENT_Z, EFFICIENCY,
%                                     EQUIVALENT_AREA, NEARFIELD_PRESSURE,
%                                     FORCE_X, FORCE_Y, FORCE_Z, THRUST,
%                                     TORQUE)
OBJECTIVE_FUNCTION= DRAG
%
% Convective numerical method (JST, LAX-FRIEDRICH, ROE-1ST_ORDER,
%                             ROE-2ND_ORDER)
CONV_NUM_METHOD_ADJFLOW= JST
%
% 2nd, and 4th order artificial dissipation coefficients
ADJ_JST_SENSOR_COEFF= ( 0.0, 0.02 )
%
% Time discretization (RUNGE-KUTTA_EXPLICIT, EULER_IMPLICIT)
TIME_DISCRE_ADJFLOW= EULER_IMPLICIT
%
% Reduction factor of the CFL coefficient in the adjoint problem
CFL_REDUCTION_ADJFLOW= 0.8
%
% Limit value for the adjoint variable
LIMIT_ADJFLOW= 1E6
```

```
% ----- COMPRESSIBLE FREE-STREAM DEFINITION -----
%
% Mach number (non-dimensional, based on the free-stream values)
MACH_NUMBER= 0.8
%
% Angle of attack (degrees)
AOA= 1.25
%
% Free-stream pressure (101325.0 N/m^2 by default, only Euler flows)
FREESTREAM_PRESSURE= 101325.0
%
% Free-stream temperature (288.15 K by default)
FREESTREAM_TEMPERATURE= 273.15
```

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[추가 내용 : CL]

```
% ----- CL DRIVER DEFINITION -----%
%
% Activate fixed lift mode (specify a CL instead of AoA, NO/YES)
FIXED_CL_MODE= YES
%
% Target coefficient of lift for fixed lift mode (0.80 by default)
TARGET_CL= 0.326
%
% Estimation of dCL/dAlpha (0.2 per degree by default)
DCL_DALPHA= 0.2
%
% Maximum number of iterations between AoA updates
UPDATE_AOA_ITER_LIMIT= 50
%
% Number of iterations to evaluate dCL_dAlpha by using finite differences (500 by default)
ITER_DCL_DALPHA= 250
```

[유동 조건]

- Pressure = 101325 Pa
- Temperature = 273.15 K
- Mach number = 0.8

[Python 실행]

```
$ python shape_optimization.py -g CONTINUOUS_ADJOINT -o SLSQP -f inv_NA
CA0012_basic.cfg
```

NIT	FC	OBJFUN	GNORM
1	2	9.396069E-09	3.579135E-06
2	3	1.854566E-08	2.648894E-06
3	5	1.615308E-08	2.332950E-06
4	7	1.524233E-08	2.064152E-06
5	9	1.271440E-08	1.802789E-06
6	11	1.026987E-08	1.561805E-06
7	13	8.695519E-09	1.347786E-06
8	15	9.199283E-09	1.164774E-06
9	17	7.682627E-09	9.703512E-07
10	19	8.418900E-09	8.246650E-07
11	21	9.653563E-09	7.274988E-07

Optimization terminated successfully (Exit mode 0)

Current function value: 1.599597398e-09

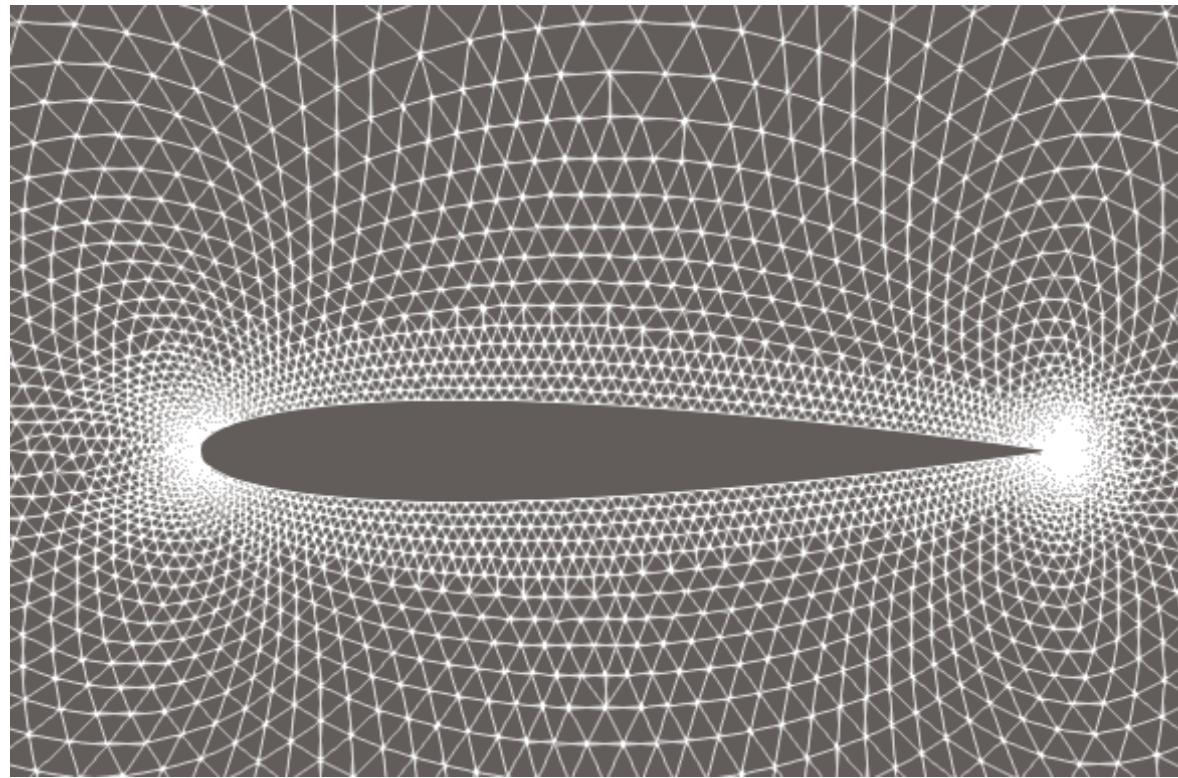
Iterations: 11

Function evaluations: 30

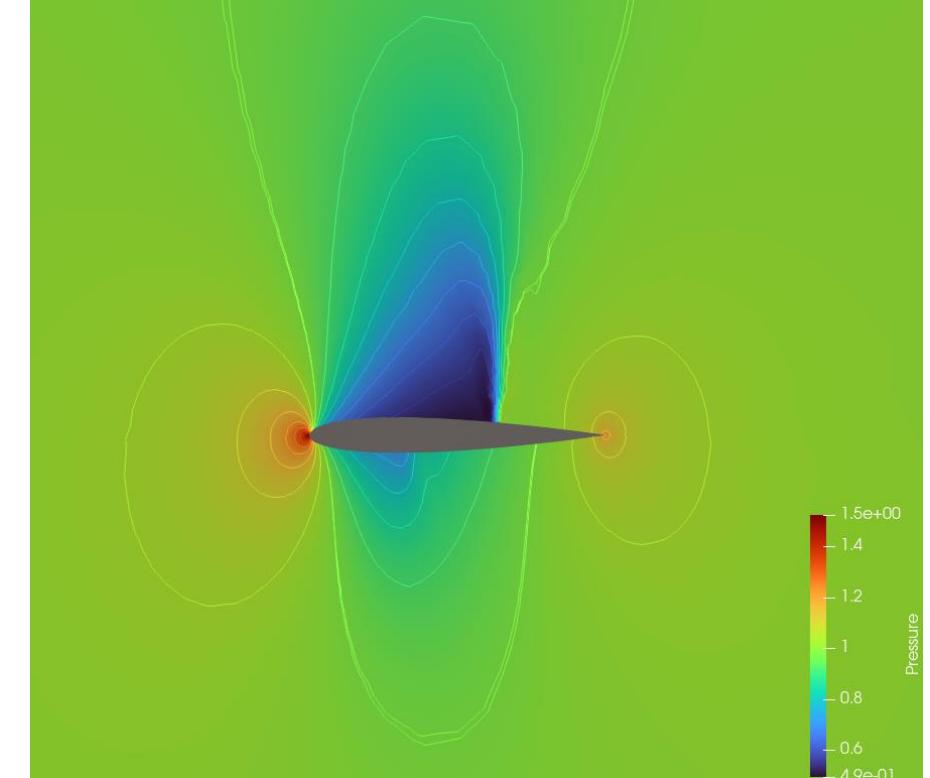
Gradient evaluations: 11

공력형상최적설계 프로젝트

■ DSN_001



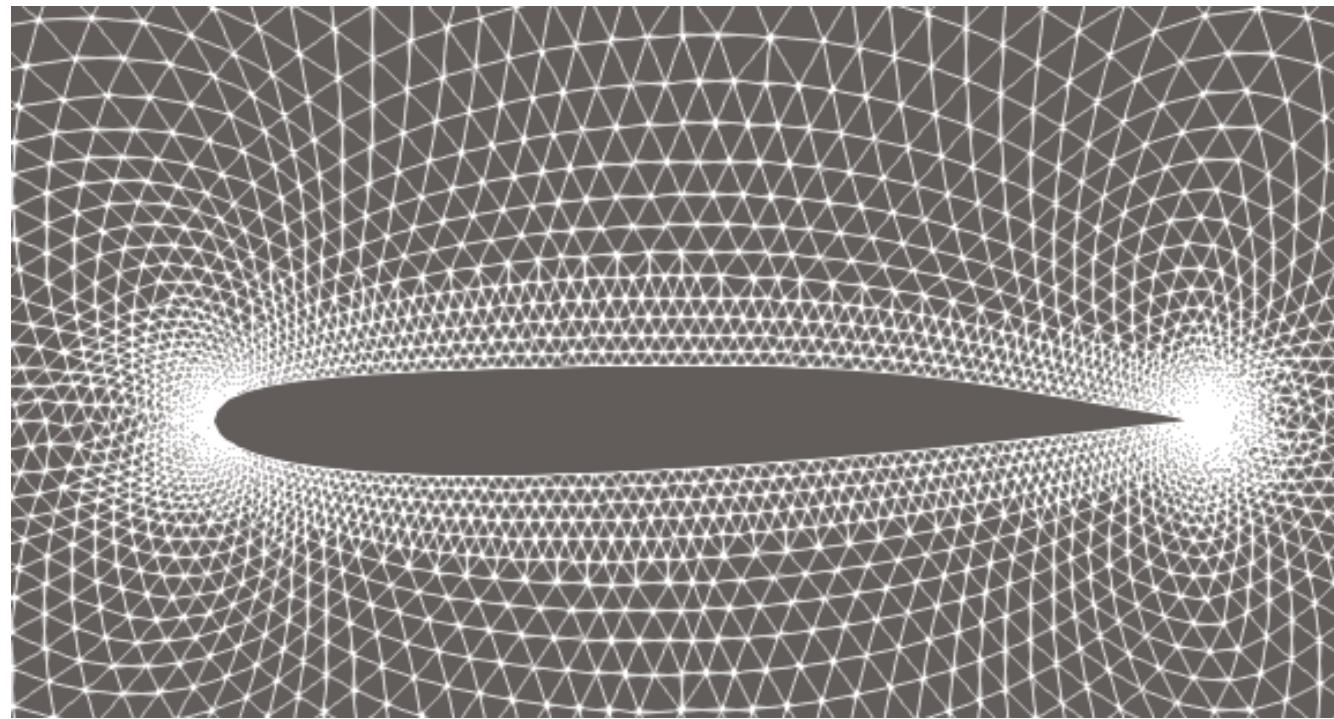
[mesh]



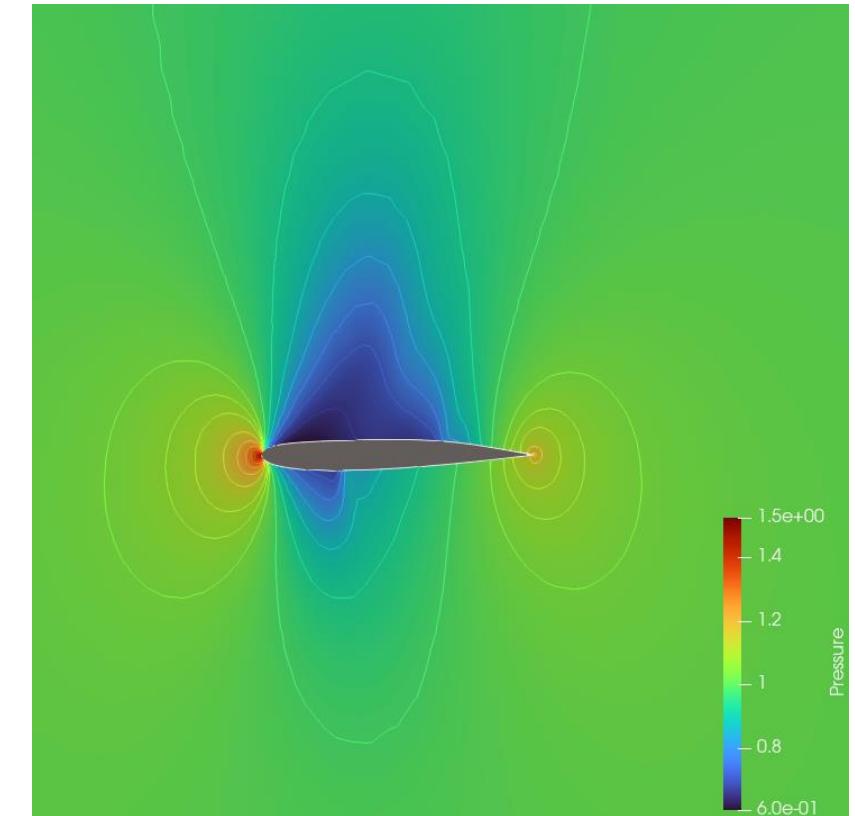
[Pressure]

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DSN_030



[mesh]



[Pressure]

공력형상최적설계 프로젝트

```
[설계 시작... (총 30개 풀기)]  
[성공] DSN_001: 0.02129104152 (컬럼명: "CD")  
[성공] DSN_002: 0.009396069424 (컬럼명: "CD")  
[성공] DSN_003: 0.0185456602 (컬럼명: "CD")  
[성공] DSN_004: 0.006668468852 (컬럼명: "CD")  
[성공] DSN_005: 0.01615308206 (컬럼명: "CD")  
[성공] DSN_006: 0.004840381409 (컬럼명: "CD")  
[성공] DSN_007: 0.01524232984 (컬럼명: "CD")  
[성공] DSN_008: 0.003551788708 (컬럼명: "CD")  
[성공] DSN_009: 0.01271440081 (컬럼명: "CD")  
[성공] DSN_010: 0.002730060708 (컬럼명: "CD")  
[성공] DSN_011: 0.01026987337 (컬럼명: "CD")  
[성공] DSN_012: 0.00222570639 (컬럼명: "CD")  
[성공] DSN_013: 0.008695519267 (컬럼명: "CD")  
[성공] DSN_014: 0.001914698725 (컬럼명: "CD")  
[성공] DSN_015: 0.009199283042 (컬럼명: "CD")  
[성공] DSN_016: 0.001707045317 (컬럼명: "CD")  
[성공] DSN_017: 0.007682627034 (컬럼명: "CD")  
[성공] DSN_018: 0.00161564364 (컬럼명: "CD")  
[성공] DSN_019: 0.008418900109 (컬럼명: "CD")  
[성공] DSN_020: 0.001599597409 (컬럼명: "CD")  
[성공] DSN_021: 0.009653562516 (컬럼명: "CD")  
[성공] DSN_022: 0.001686822514 (컬럼명: "CD")  
[성공] DSN_023: 0.001604584117 (컬럼명: "CD")  
[성공] DSN_024: 0.0016000626 (컬럼명: "CD")  
[성공] DSN_025: 0.001599649332 (컬럼명: "CD")  
[성공] DSN_026: 0.001599611334 (컬럼명: "CD")  
[성공] DSN_027: 0.001599599978 (컬럼명: "CD")  
[성공] DSN_028: 0.001599597653 (컬럼명: "CD")  
[성공] DSN_029: 0.00159959742 (컬럼명: "CD")  
[성공] DSN_030: 0.001599597398 (컬럼명: "CD")
```

완료! 엑셀 파일이 생성되었습니다.

[Python 실행]



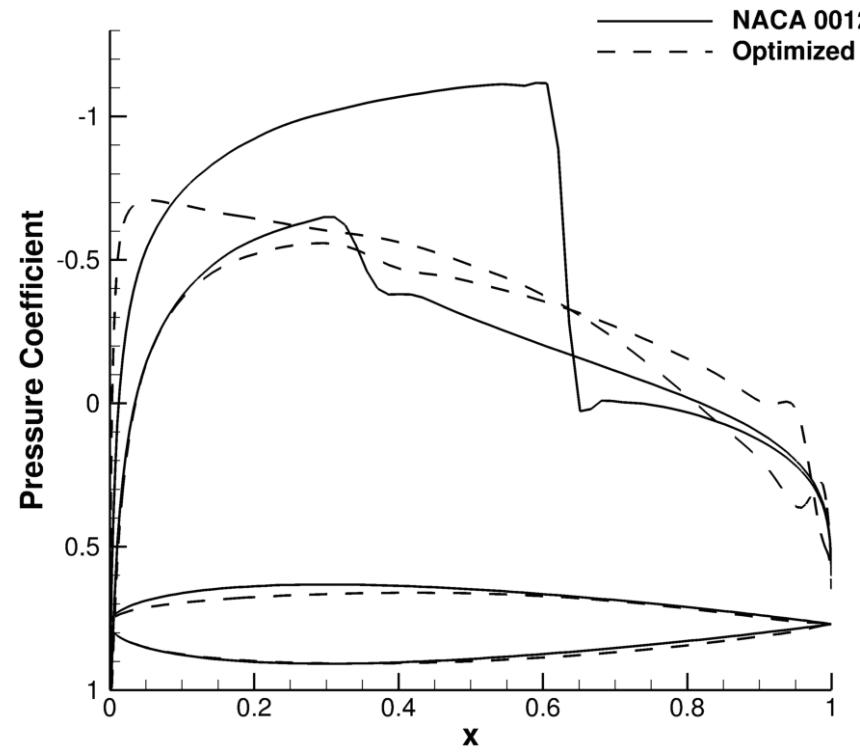
I	J	K	L	M	N
Points_0	Points_1	Points_2	Points_Ma	Pressure	Pressure_C
0.99975	-3.63E-05	0	0.99975	1.43213	0.964579
0.999	-0.00015	0	0.999	1.2707	0.604252
0.99776	-0.00032	0	0.99776	1.24106	0.538084
0.99602	-0.00057	0	0.99602	1.20897	0.466461
0.99378	-0.00088	0	0.99378	1.18439	0.411594
0.99105	-0.00124	0	0.991051	1.16526	0.368886
0.98784	-0.00164	0	0.987841	1.15003	0.334878
0.98413	-0.00206	0	0.984132	1.13974	0.311931
0.97995	-0.00249	0	0.979953	1.1344	0.300008

Points_0	Pressure_Coefficient	Points_0	Pressure_Coefficient
0.99975	0.964579	0.99975	0.936902
0.999	0.604252	0.999	0.573555
0.99776	0.538084	0.99776	0.517313
0.99602	0.466461	0.99602	0.457569
0.99378	0.411594	0.99378	0.414327
0.99105	0.368886	0.99105	0.381799
0.98784	0.334878	0.98784	0.352798
0.98413	0.311931	0.98413	0.32706
0.97995	0.300008	0.97995	0.303436
0.97528	0.29694	0.97528	0.281478
0.97015	0.298414	0.97015	0.260838
0.96454	0.299422	0.96454	0.241255
0.95847	0.295915	0.95847	0.22257
0.95194	0.285933	0.95194	0.204645
0.94496	0.269689	0.94496	0.187385

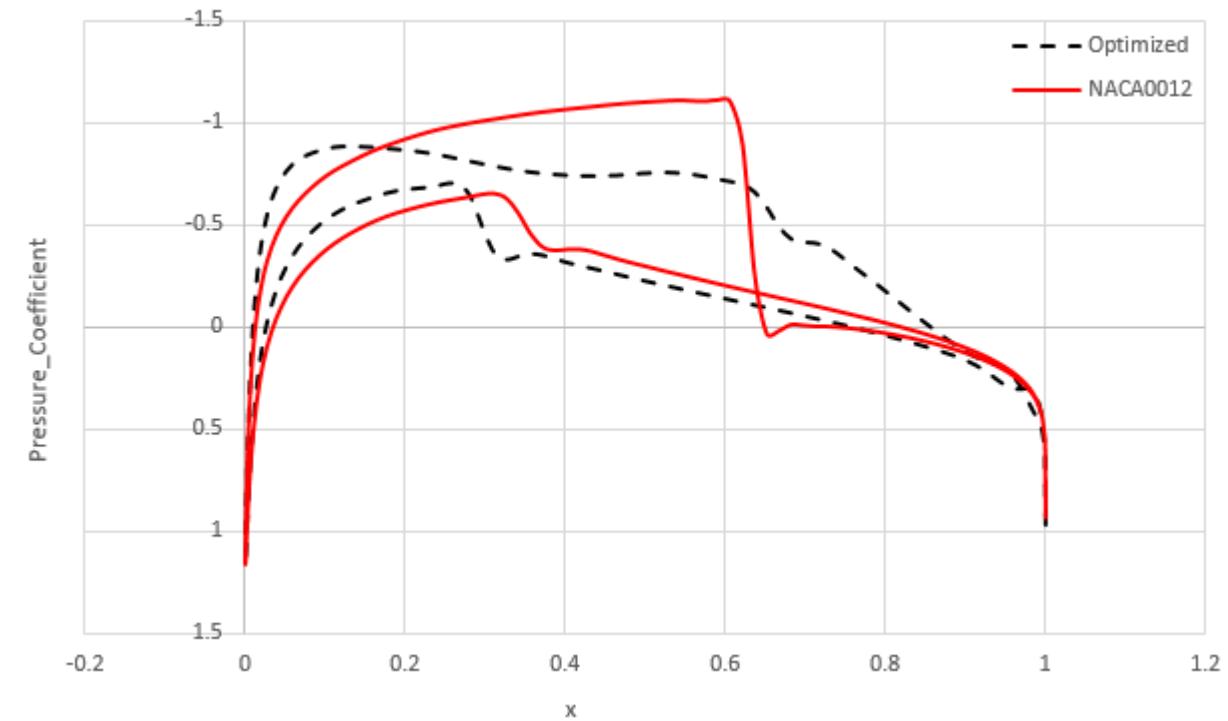
[Data 생성]

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[압력계수 비교]



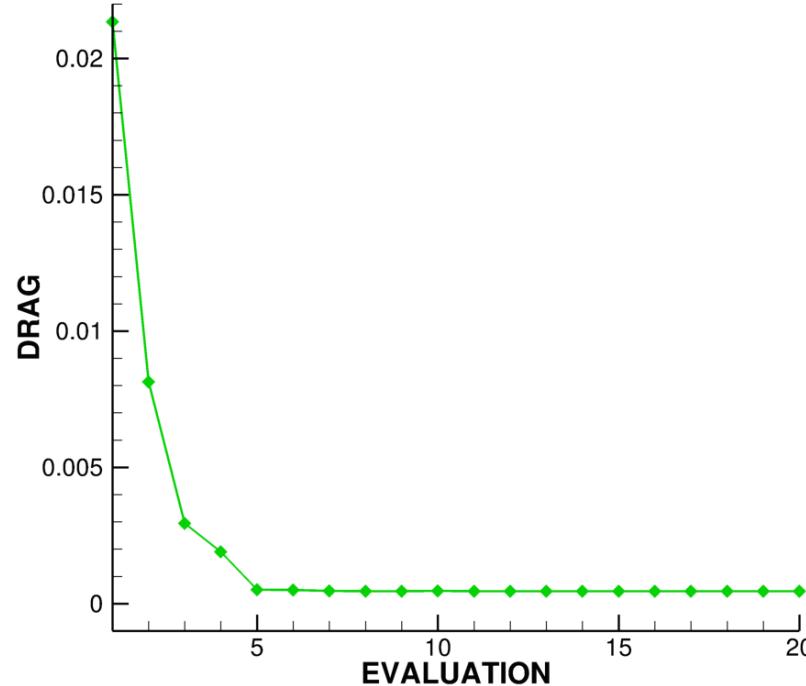
[SU2 Data]



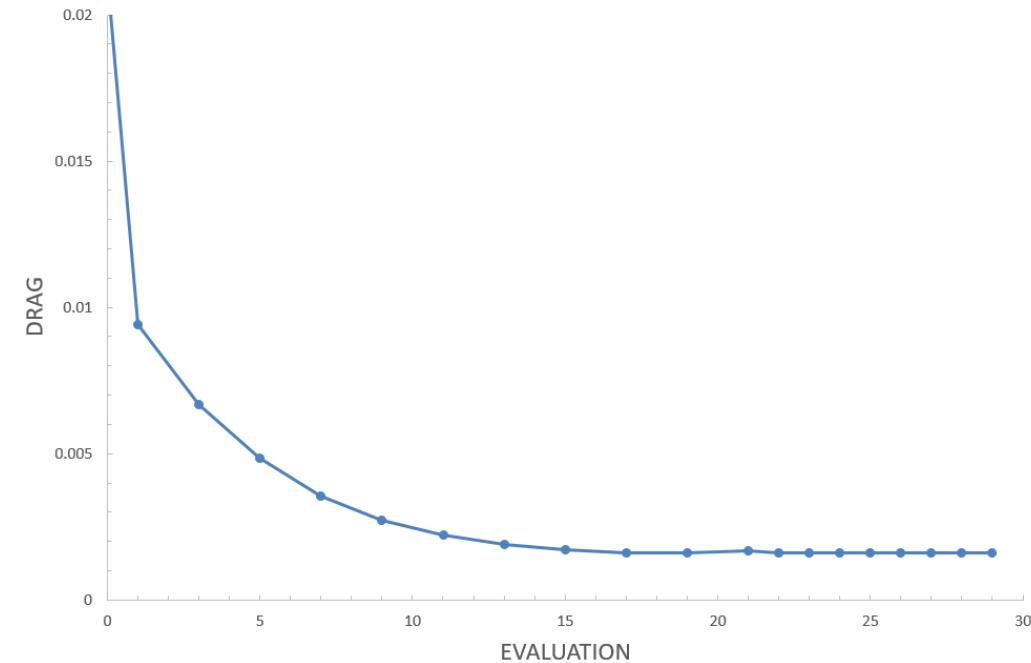
[실행 Data]

공력형상최적설계 프로젝트

[항력계수 추이]



[SU2 Data]



[실행 Data]