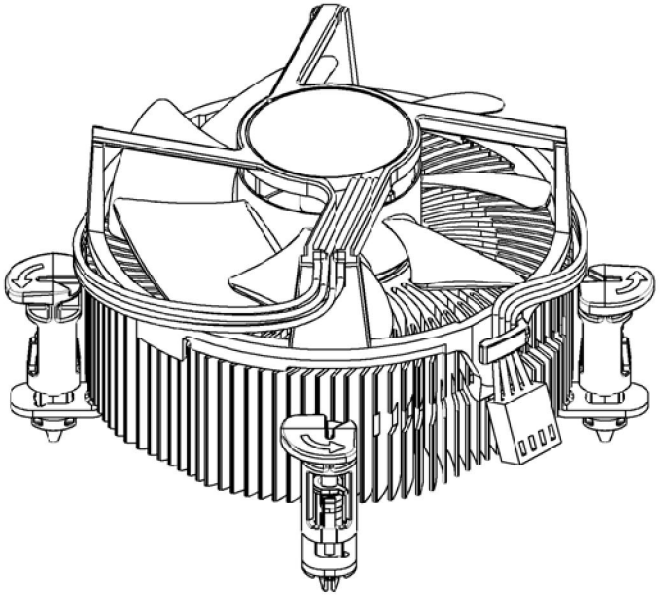
Optimization
Heat Sink

JACK POT



Optimum Design

HANYANG UNIVERSITY

04 김형균
05 선준원

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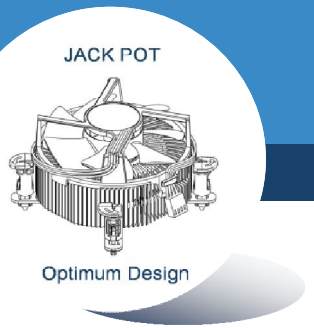
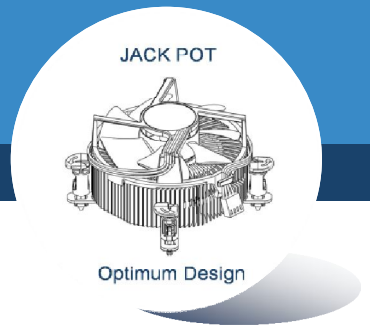
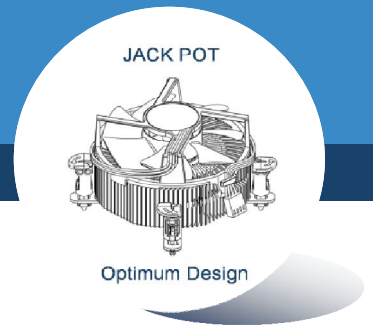




Introduction

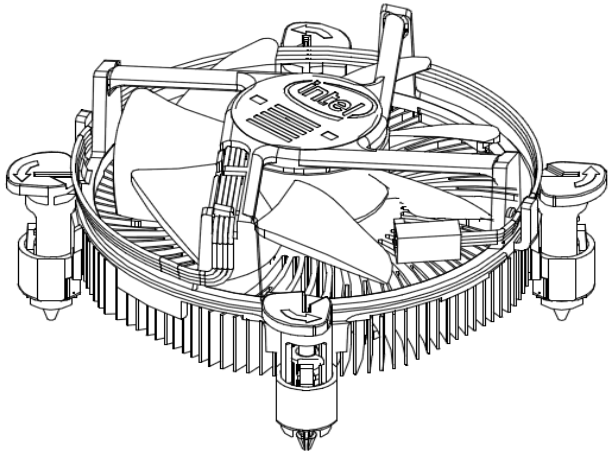
1. Introduction

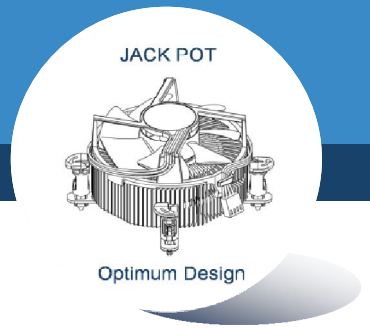


Heat

To prevent from being broken CPU

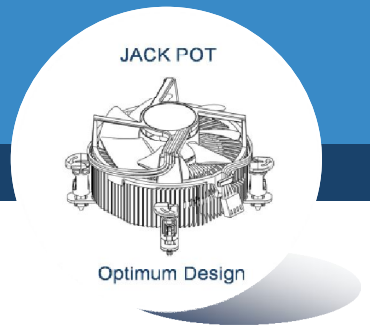
Cooling





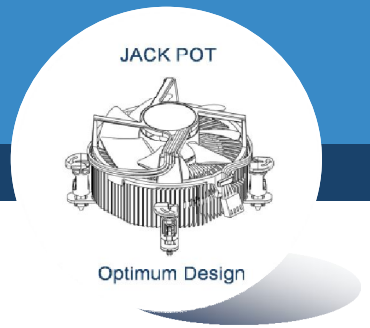
Problem Statement

2. Problem statement



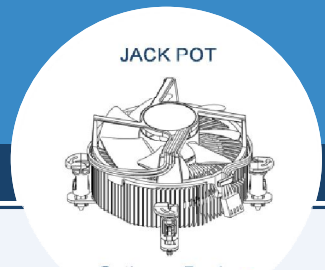
❖ Heat sink

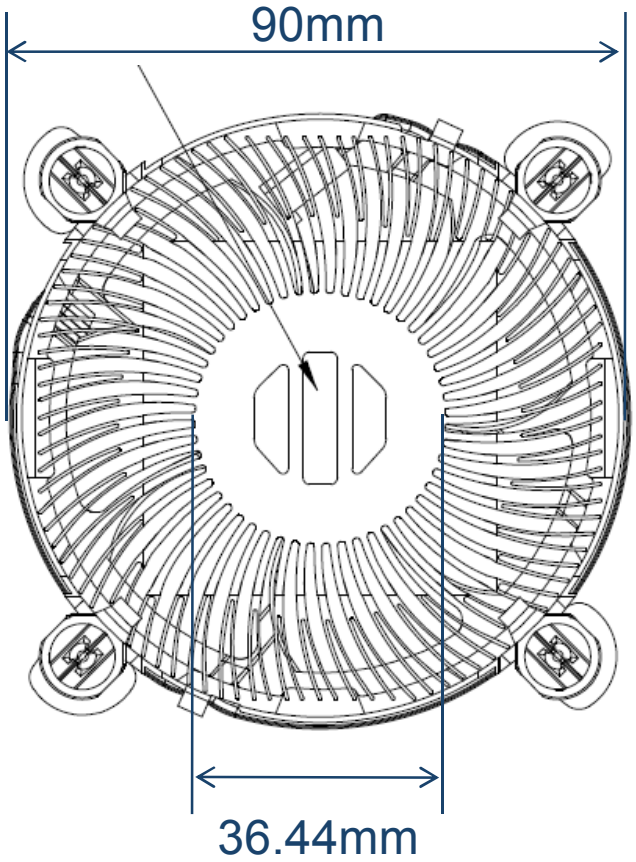
- 모든 CPU에는 fin이 부착 (대량생산)
- CPU온도는 40℃ 이하로 유지되어야 한다.
- fin의 두께는 26mm
- fin이 부착되는 구리심의 온도는 base온도와 같다.
- T_∞는 PC내부의 온도 (상온보다 높음)→ T_∞ =28℃



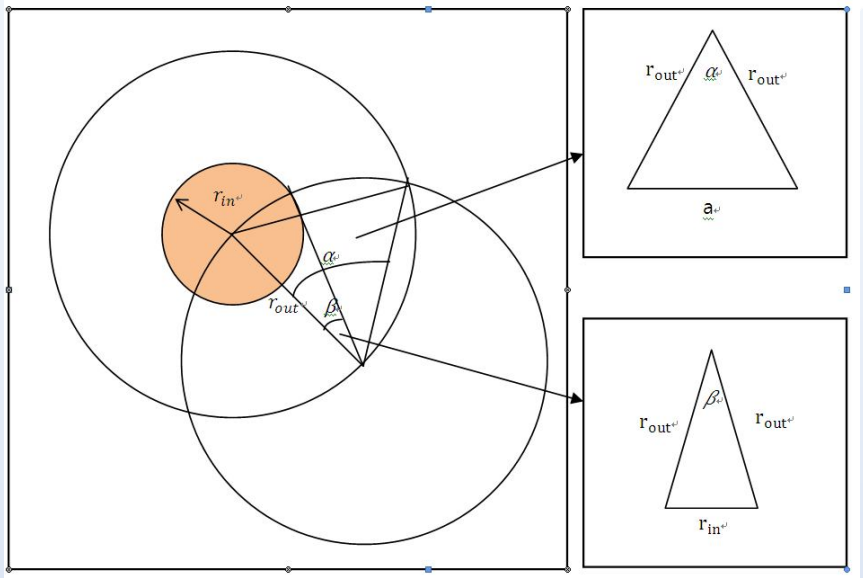
Data Information

3. Data Information





▷ Decision of L



Using the 2nd low of cosine

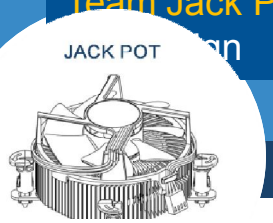
$$a^2 - 2r_{out}^2 - 2r_{out}^2 \cos\alpha$$

$$\cos\alpha = \frac{2r_{out}^2 - a^2}{2r_{out}^2}$$

$$\cos\beta - \frac{2r_{out}^2 - {r_{core}}^2}{2r_{out}^2}$$

l_{max}=39.65mm

3. Data Information



Air

	density	Cp	k	alpha	mu	nu	Pr
28	1.172	1007	0.02573	2.2E−05	1.9E−05	1.6E−05	0.72876

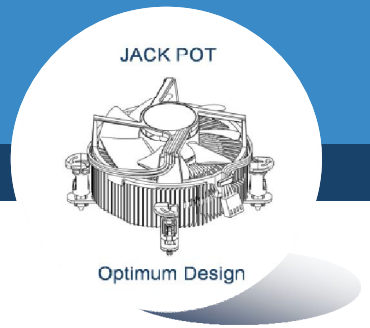
flow velocity

	value	unit
Flow rate=	0.0151	$[m^3/s]$
v=	2.37357	[m/s]

← from Airflow in CFM=32CFM

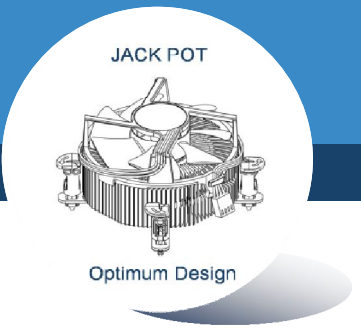
Aluminum

k[W/m.℃]	Density[kg/m^3]	R_{in}[m]	R_{out}[m]	l[m]
240	2702	0.01822	0.045	0.03964



Problem Analysis

4. Problem Analysis



Problem
(중간발표자료)

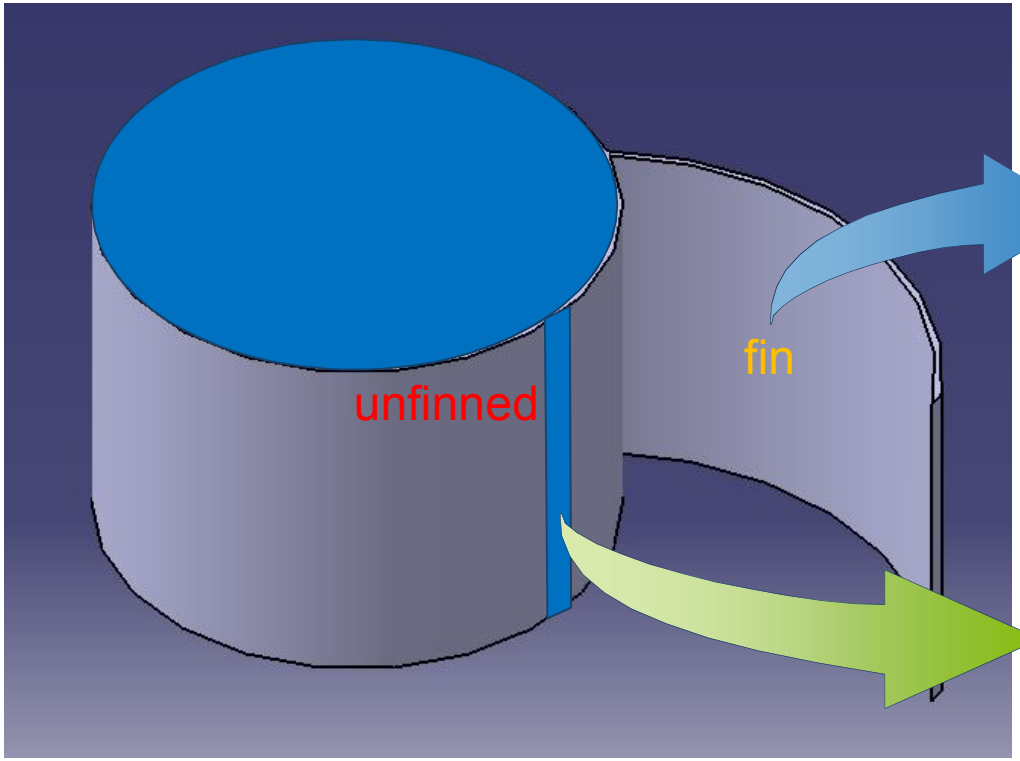
문제점

1. 금속이 얇다
   - 작은 충격에도 손상
2. 곡률이 너무 크다
   - fin 끝부분에서 겹친다
3. 가정에 의한 h(열전달계수)
   - 부정확한 데이터 ⇒신뢰성↓
4. 평행평판 사이에서의 얇은 공간에서 fin으로 유체가 흐를 수 있는가?
   - 너무 얇으면 유체가 흐르지 않는다.

개선책

1. 금속 두께에 제한조건 제시
   - 일반적으로 사용되는 가공최소조건
2. 곡률 제한 제시
   - fin 의 길이를 감소
3. Nusselt No.를 이용한 h계산
   - h=h(n , w)
4. $w_{fin} < w_{Gap}$

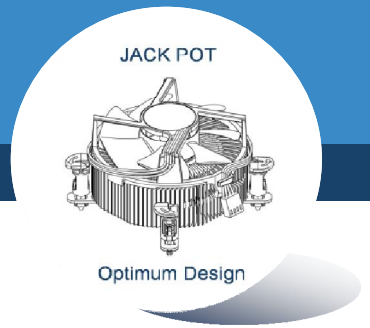
4. Problem Analysis



$$\dot{Q}_{fin} = nh\Delta T\sqrt{hpkA_c}\tanh(al)$$

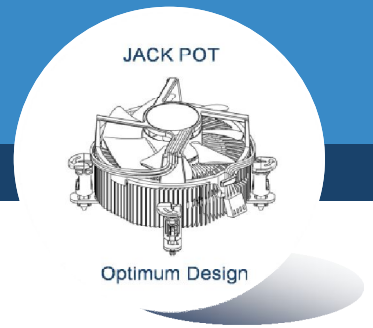
$$\dot{Q}_{unfinned} = h\Delta TA_{unfinned}$$

$$\dot{Q}_{total} = \dot{Q}_{fin} + \dot{Q}_{unfinned}$$



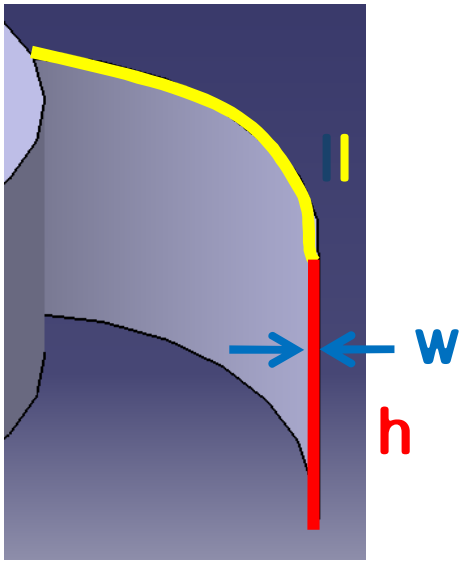
Optimum Design

5. Optimum Design



Design Variables

- n : the number of fins
- w : the thickness of a fin



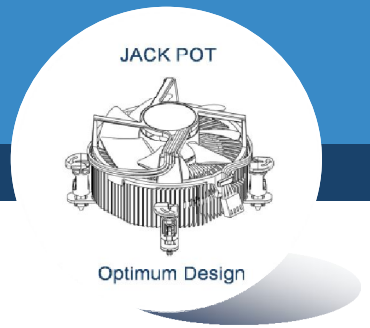
Cost Function

- Cost $\propto$ Mass(total)=M(Al)+M(Cu)

constant

$\therefore$ **Minimize** $f=Mass(al)=\rho al \cdot l \cdot h \cdot n \cdot w$

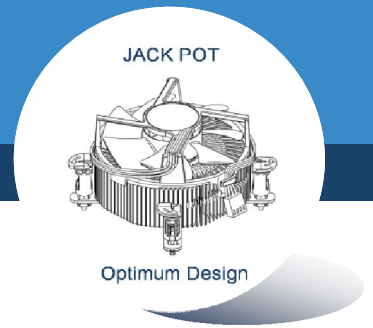
5. Optimum Design



Constraints

- $g_1 = \dot{Q}_{elect} - \dot{Q}_{elect} \leq 0$
- $g_2 = nw - 2\pi r_{in} \leq 0$
- $g_3 = 0.0005 - w \leq 0$
- $g_4 = w - \dfrac{2\pi r_{in} - nw}{n} \leq 0$
- $g_5 = -n \leq 0$ (n: integer)

5. Optimum Design



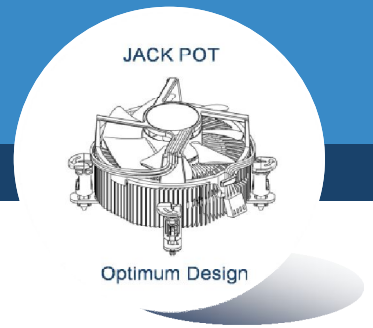
Using Excel

Propeties(Initial State1)	
n=	**89**
w=	**0.0006**
b=	**0.026**
l=	0.039649
ri=	0.01822
ro=	0.045
c=	0.000686288
p=	0.0532
a=	22.88186082

Re=	3882.286135
Using Eqn of Nu at Parallel Plate	
h(n,c)=	**36.84740323**
Nu=	37.23117068
tanh(al)=	0.719810752
Qfin=	65.85924713
Qconv=	1.163337385
Qelect=	**65**

function f=	**0.148743025**		
g1	-2.022584516	<=	0
g2	-0.061079636	<=	0
g3	-1E-04	<=	0
g4	-8.6288E-05	<=	0
g5	89	=	intager

5. Optimum Design



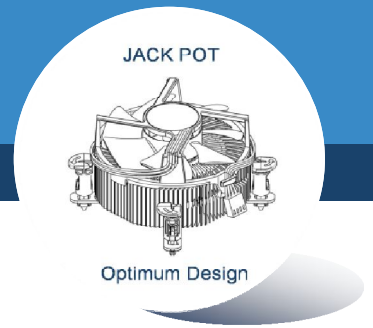
Using Excel

Propeties(Final State1)	
n=	**89**
w=	**0.000518662**
b=	**0.026**
l=	0.039649
ri=	0.01822
ro=	0.045
c=	0.000767626
p=	0.053037325
a=	24.57308151

Re=	3882.286135
Using Eqn of Nu at Parallel Plate	
h(n,c)=	**36.84740323**
Nu=	37.23117068
tanh(al)=	0.750591317
Qfin=	63.7534458
Qconv=	1.246560409
Qelect=	**65**

function f=	**0.128578994**		
g1	-6.2061E-06	<=	0
g2	-0.068318694	<=	0
g3	-1.86623E-05	<=	0
g4	-0.000248963	<=	0
g5	89	=	intager

5. Optimum Design



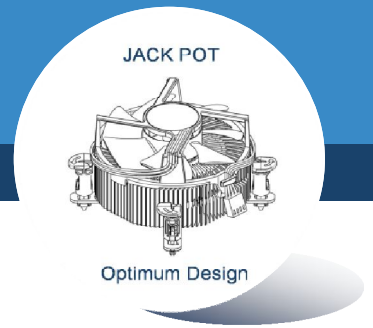
Using Excel

Propeties(Initial State2)	
n=	**90**
w=	**0.0006**
b=	**0.026**
l=	0.039649
ri=	0.01822
ro=	0.045
c=	0.000671996
p=	0.0532
a=	22.88186082

Re=	3882.286135
Using Eqn of Nu at Parallel Plate	
h(n,c)=	**36.84740323**
Nu=	37.23117068
tanh(al)=	0.719810752
Qfin=	66.59923867
Qconv=	1.156439551
Qelect=	**65**

function f=	**0.150414295**		
g1	-2.755678223	<=	0
g2	-0.060479636	<=	0
g3	-1E-04	<=	0
g4	-7.1996E-05	<=	0
g5	90	=	intager

5. Optimum Design



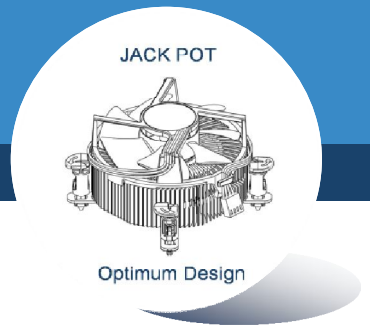
Using Excel

Propeties(Final State2)	
n=	**90**
w=	**0.0005**
b=	**0.026**
l=	0.039649
ri=	0.01822
ro=	0.045
c=	0.000771996
p=	0.053
a=	25.01866208

Re=	3882.286135
Using Eqn of Nu at Parallel Plate	
h(n,c)=	**36.84740323**
Nu=	37.23117068
tanh(al)=	0.758203224
Qfin=	63.91871825
Qconv=	1.259907059
Qelect=	**65**

function f=	0.125345246		
g1	-0.178625309	<=	0
g2	-0.069479636	<=	0
g3	0	<=	0
g4	-0.000271996	<=	0
g5	90	=	intager

5. Optimum Design

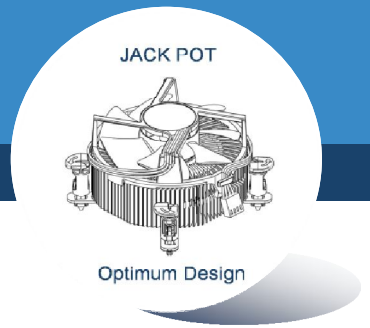


❖ Using Excel

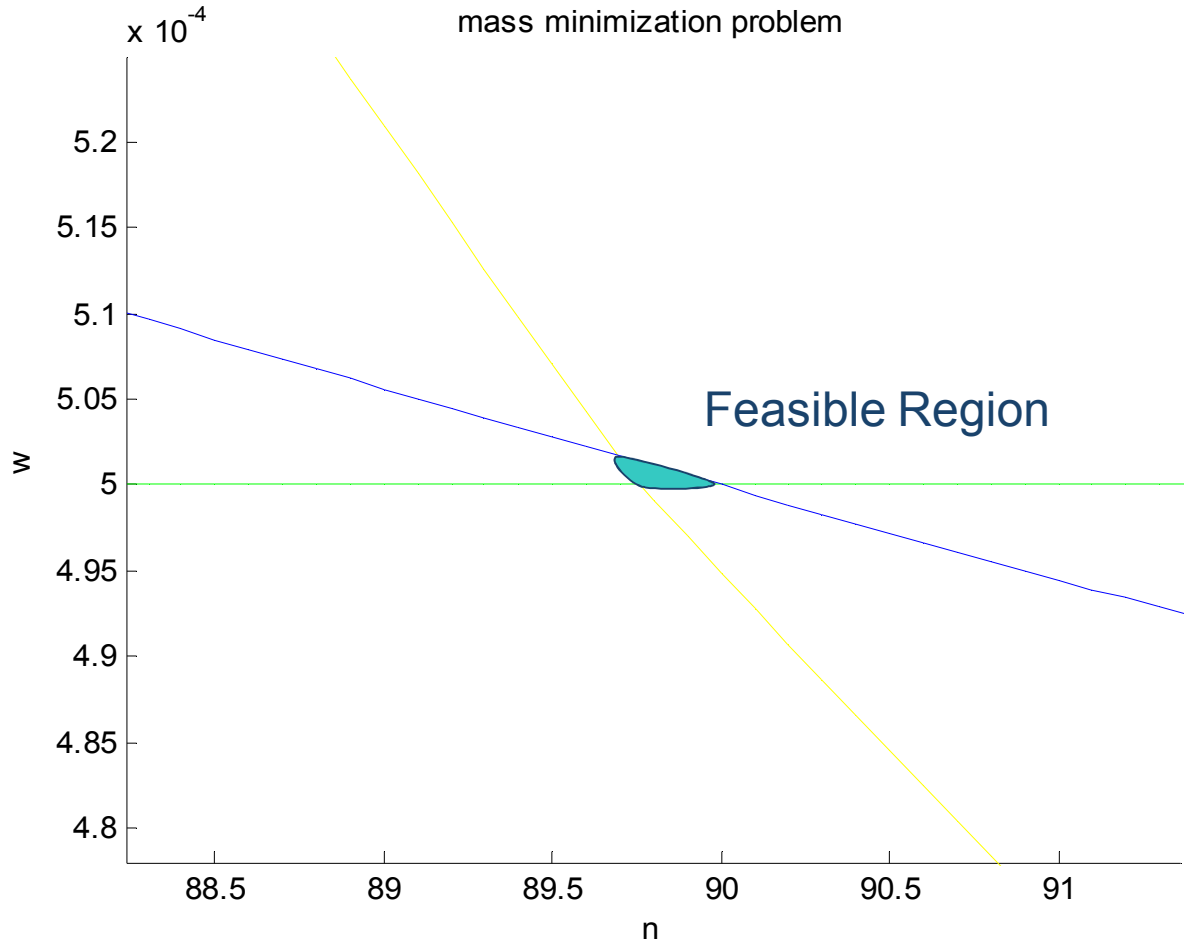
시나리오 요약

	현재 값:	State1_1	State1_2	State2_1	State2_2
변경 셀:					
w	0.0006	0.0006	**0.00051866**	0.0006	**0.0005**
n	89	88.99991	**89**	89.999909	**90**
결과 셀:					최적해!
P14	1.487E-01	1.487E-01	**1.286E-01**	1.504E-01	**1.253E-01**

5. Optimum Design



Graphical Method



5. Optimum Design

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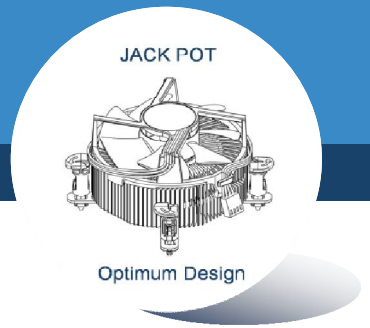
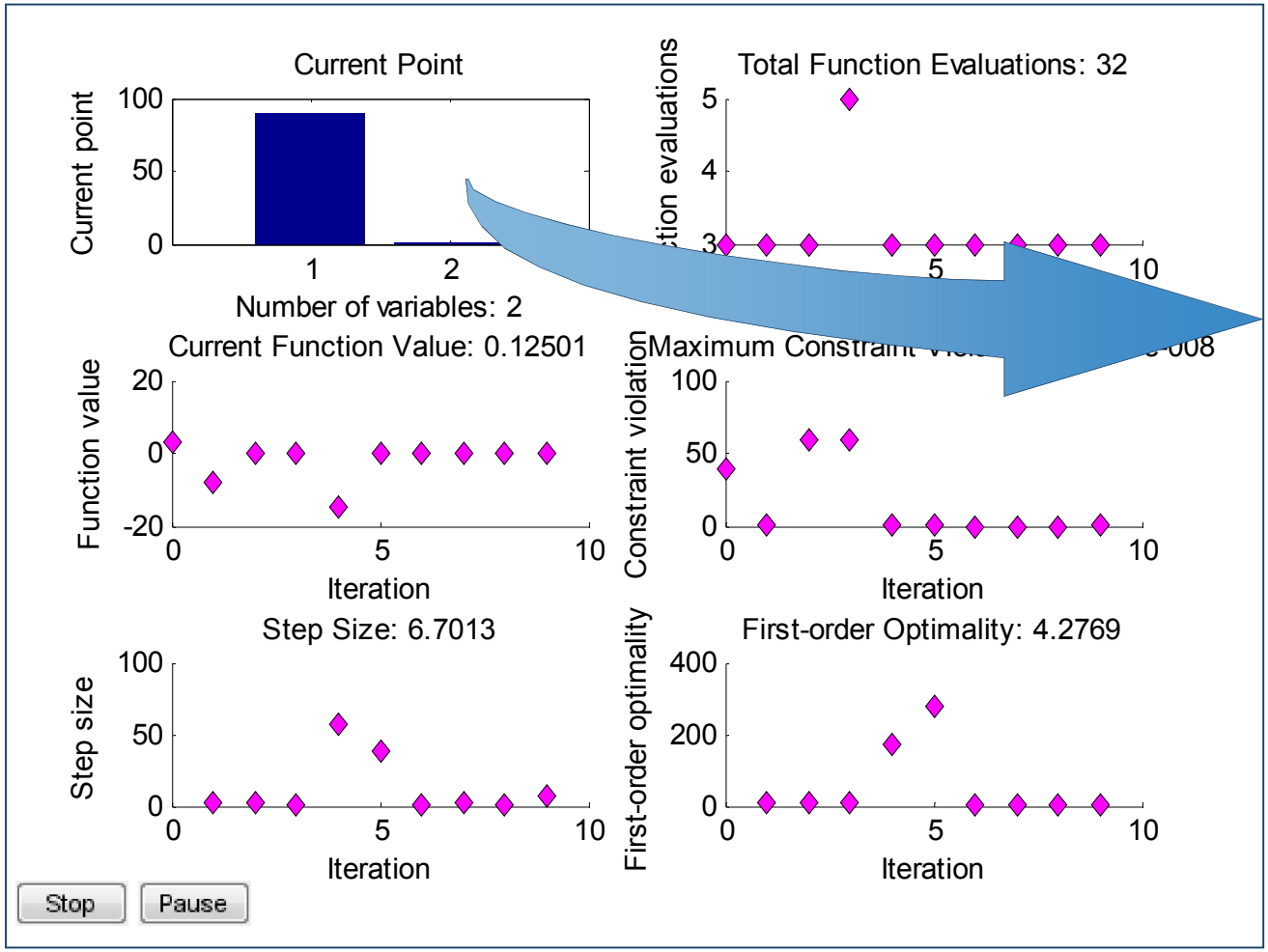


Matlab (fmincon)



n=89.761
w=0.0005
f=0.1250

Company Logo

5. Optimum Design

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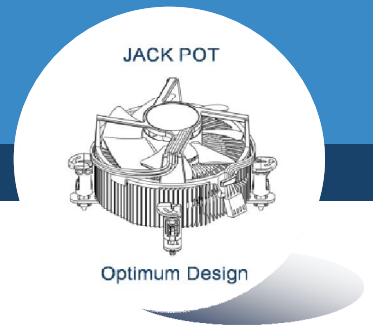
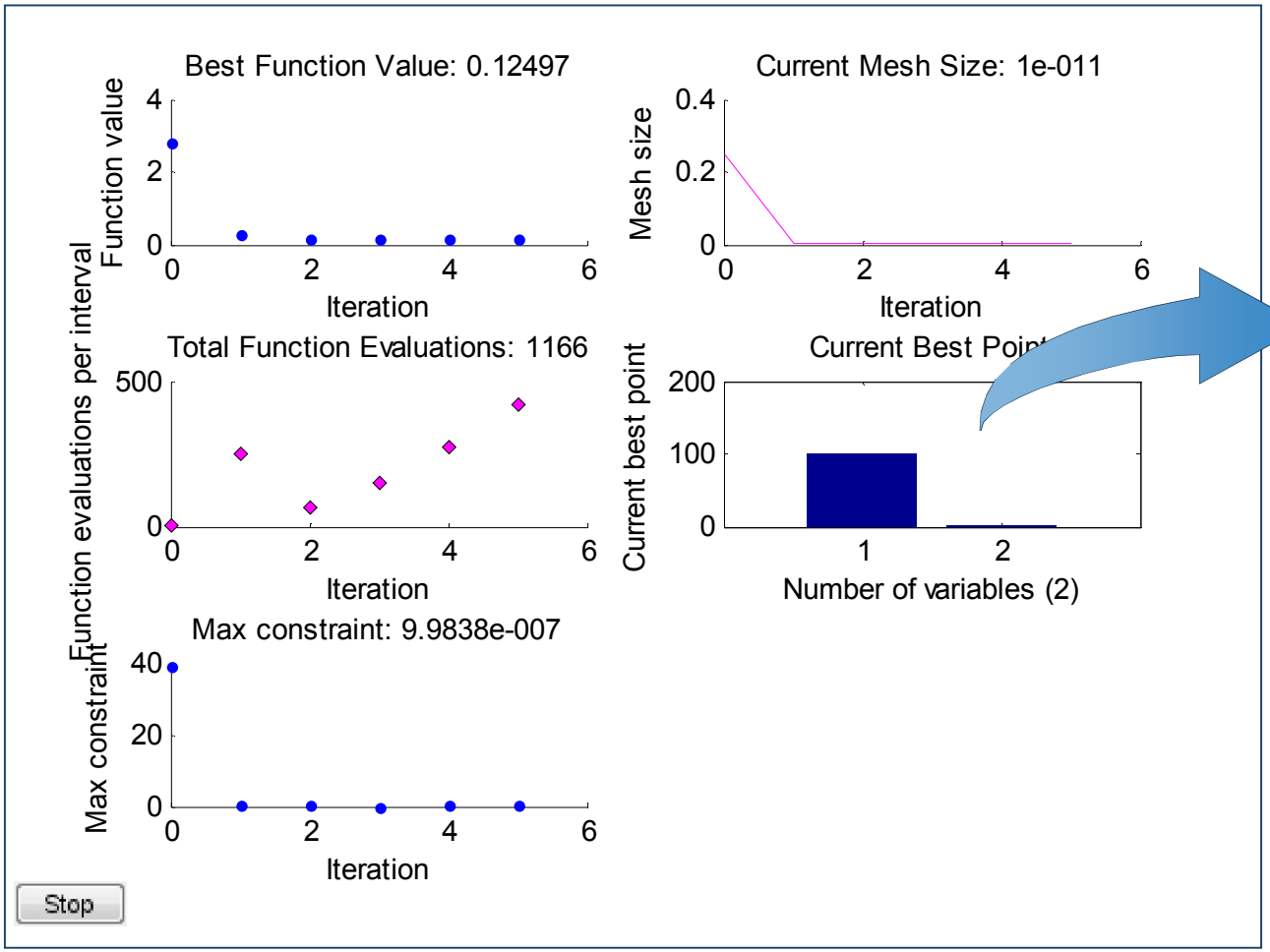
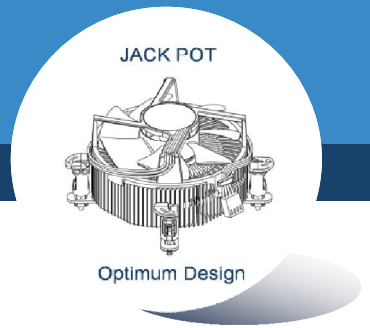


Matlab (Patternsearch)



n=89.912
w=0.0005
f=0.12497

5. Optimum Design



Add another design variable

- Considering that h is design variable

  n : the number of fins
  w : the thickness of a fin
  h : the height of a fin

- Add more constraint for h

$$g_6 = h - 0.026 \leq 0$$

To minimize the volume

5. Optimum Design

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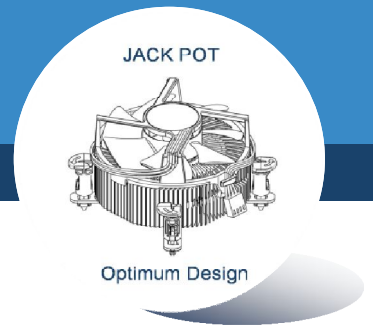
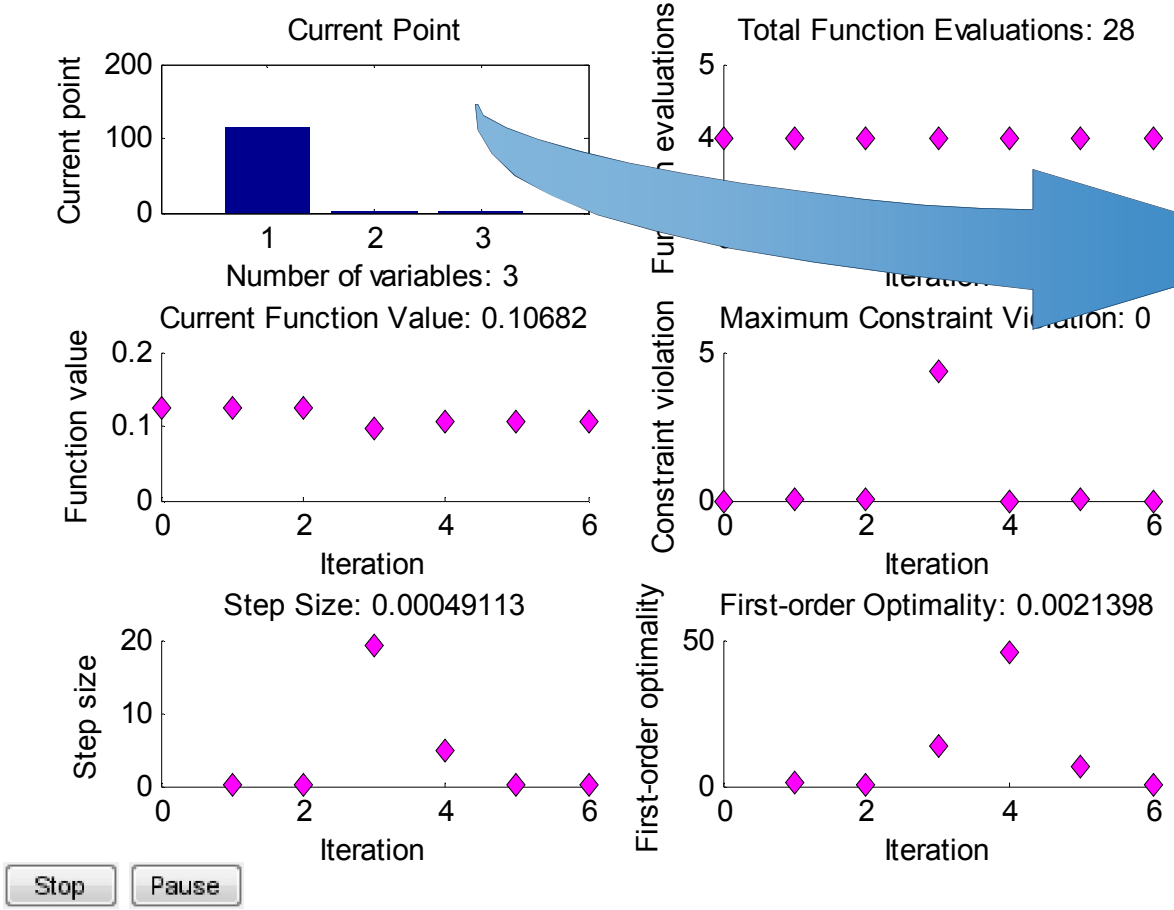
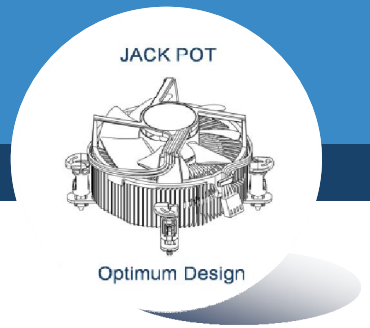


Matlab (fmincon)



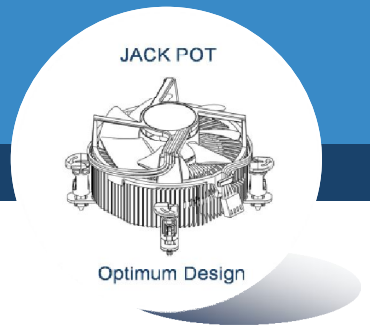
n=114.479
w=0.0005
h=0.0174
f=0.10682

n=114
w=0.0005
h=0.01754
f=0.1071



Conclusion

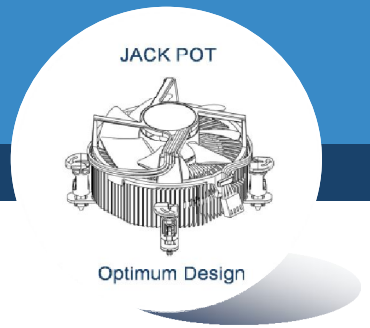
6. Conclusion



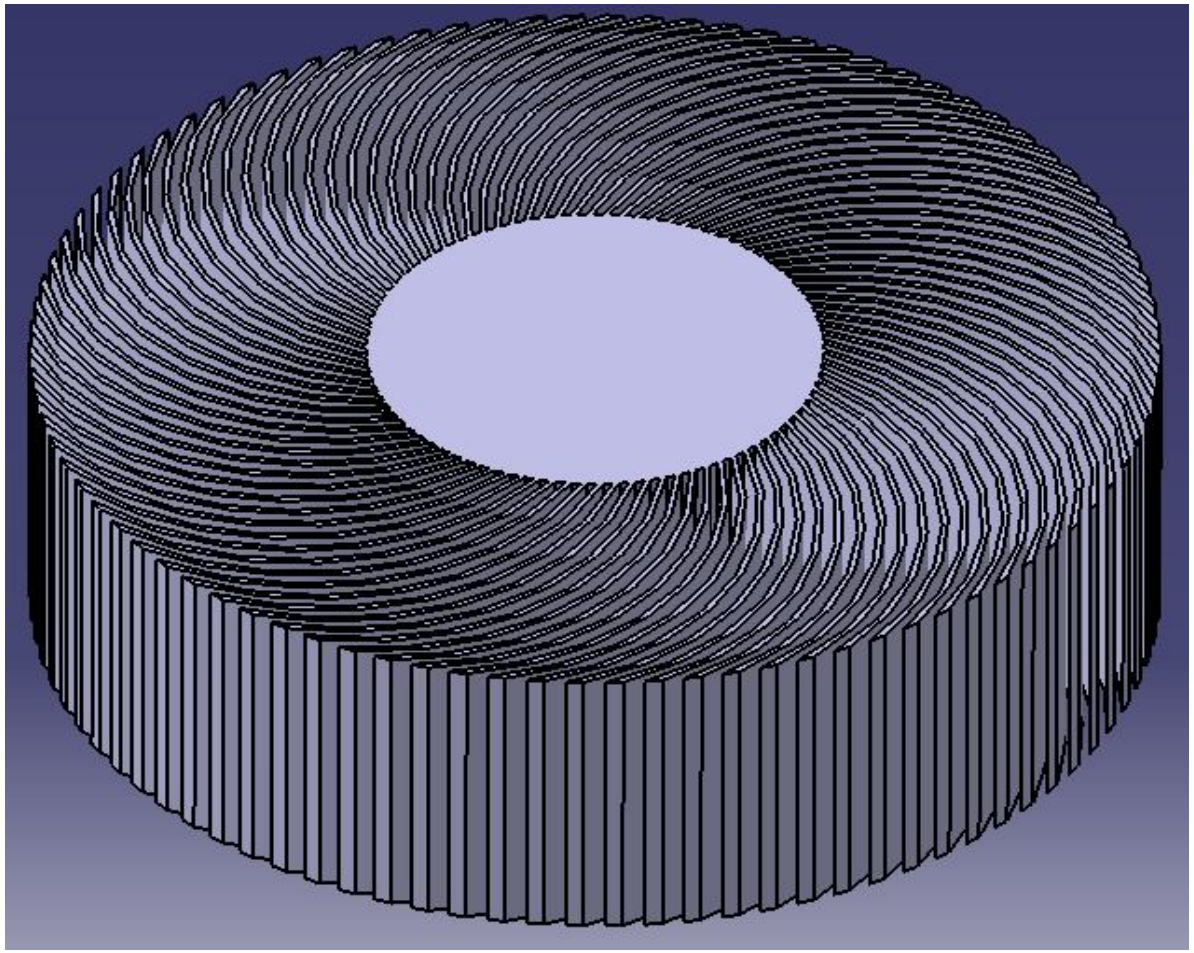
About the result

- From the optimum design
  n=90 w=0.0005 f=0.125345 (2 vriables)
  n=114 w=0.0005 h=0.01754 f=0.1071 (3 vriables)
- w is the least value of the range of w in both case.
- Active constraints to minimize f are g1 and g3.
- Adding constraint h affects to minimize f.
- Comparing the midterm data, f increases.

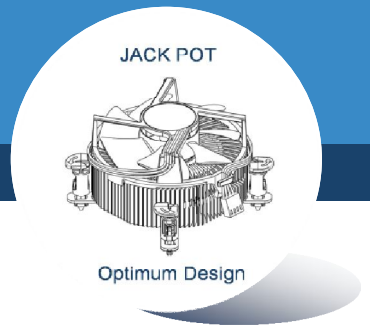
6. Conclusion



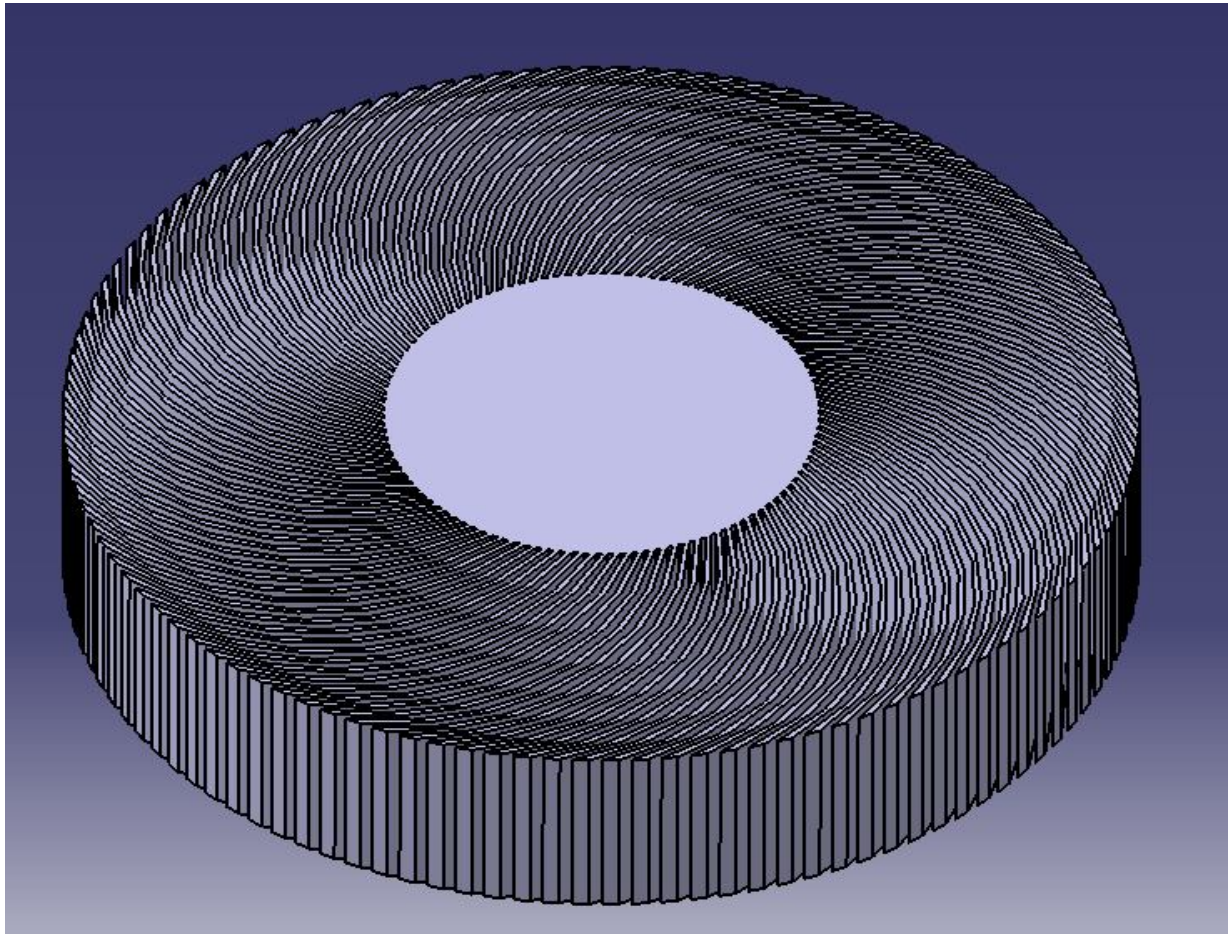
- Optimum Design (2 variables)



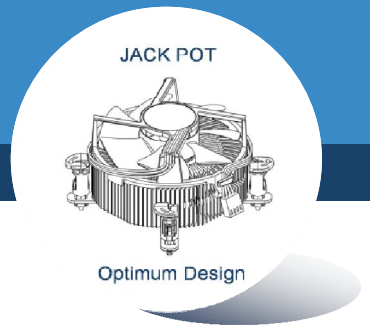
6. Conclusion



- Optimum Design (3 variables)

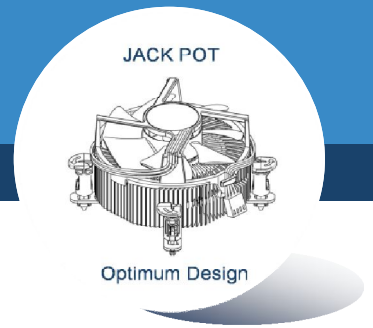


6. Conclusion



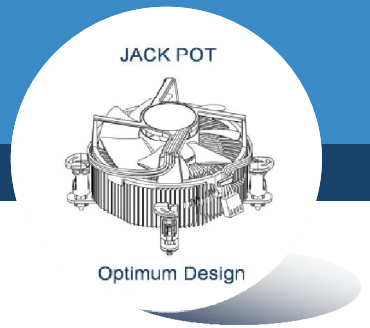
Comparing the existing design

6. Conclusion



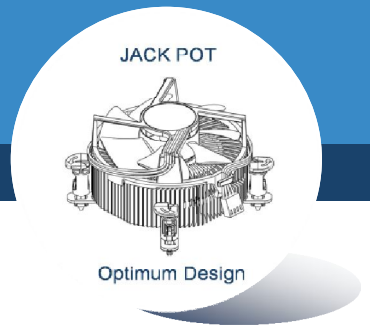
Comments

- Excel Solver를 이용할 때는
  초기값 선정할때 Graphical Method를 이용
  교점부근의 초기값을 잡는다.
- Matlab 사용 시



Reference

7. Reference



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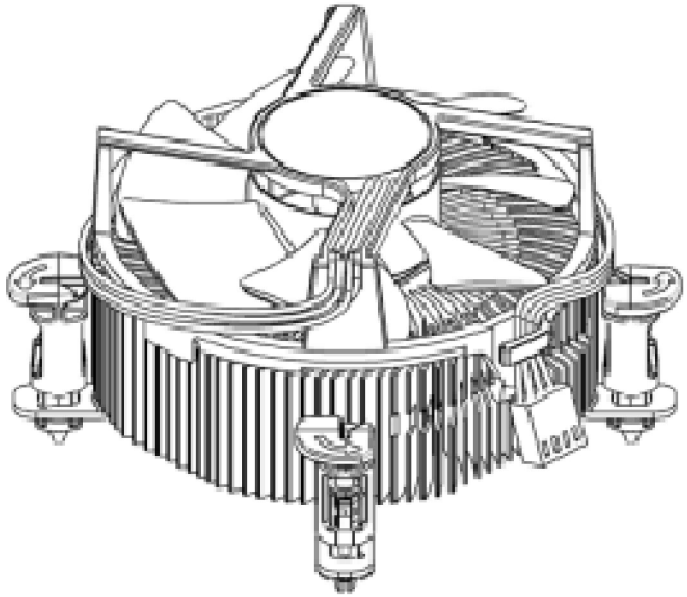
JACK POT



Optimum Design

Thank You !

HANYANG UNIVERSITY