Academic Porfolio

Wei Hao Wang

1. Mechanical Manufacturing, Course Project
   Case Western Reserve University,
   - Manufacturing Design Project Prototype Version (Bus Holding Handle)
   - Manufacturing Design Project Mass Production Version (Bus Holding Handle)
   - Hammer Manufacturing Project (Manually Machining)
   - SolidWorks Trophy Design (Formula One car 3D model)

2. Detonation 3D Modeling, Master Project
   Case Western Reserve University, January 2020 – May 2020

3. Master Thesis: "The Study of the Effect of Flow Rate for Hybrid Flat Plate Loop Heat Pipe"
   National Taiwan University, August 2016 – July 2017

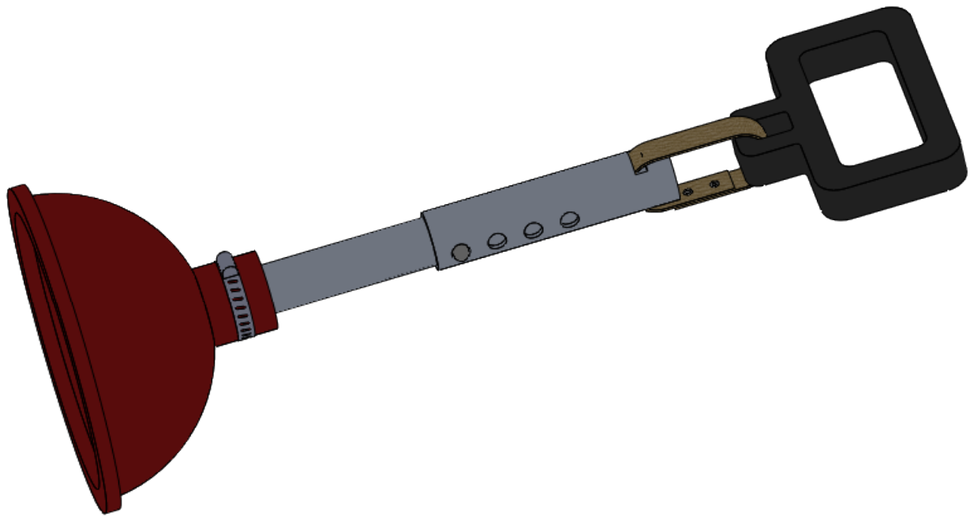
JUNE 14, 2021

CASE WESTERN RESERVE UNIVERSITY, MASTER OF SCIENCE IN MECHANICAL ENGINEERING
wxw351@case.edu

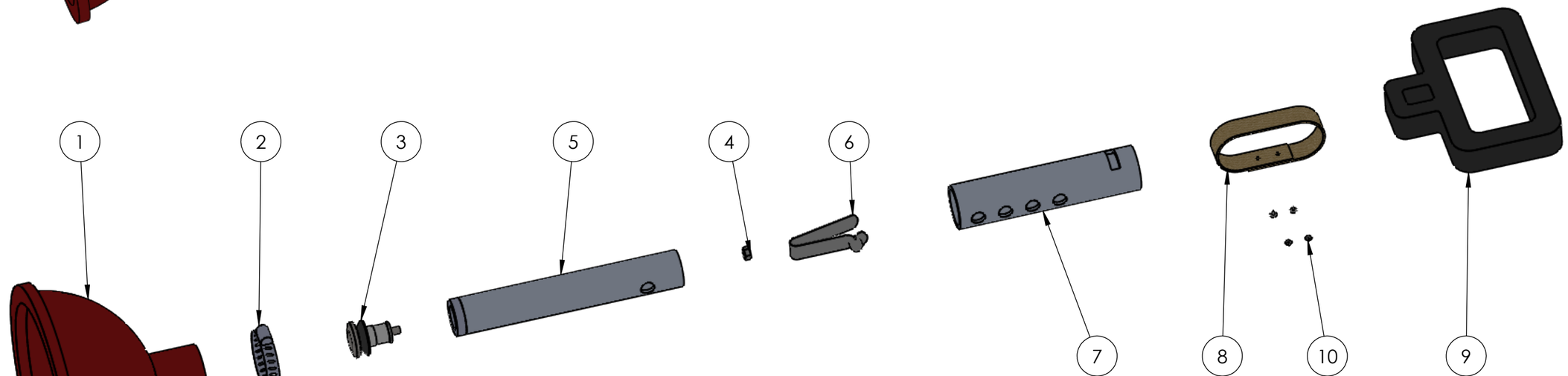
Manufacturing Design Project

Bus Holding Handle – Prototype Version

Wei Hao Wang



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	P-160G19-001	Plunger	1
2	P-160G19-002	Hose Clamp	1
3	P-160G19-003	Pop Up Stopper	1
4	P-160G19-004	Jam Nut	1
5	SA-160G19-001	Cap Weldment	1
6	P-160G19-005	Button Clip	1
7	M-160G19-003	Outside Pole	1
8	M-160G19-004	Fabric	1
9	M-160G19-005	Handle	1
10	P-160G19-006	Two-Piece Press-Fit Rivets	2



NOTE : INSERT FABRIC THROUGH OUTSIDE POLE AND HANDLE

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

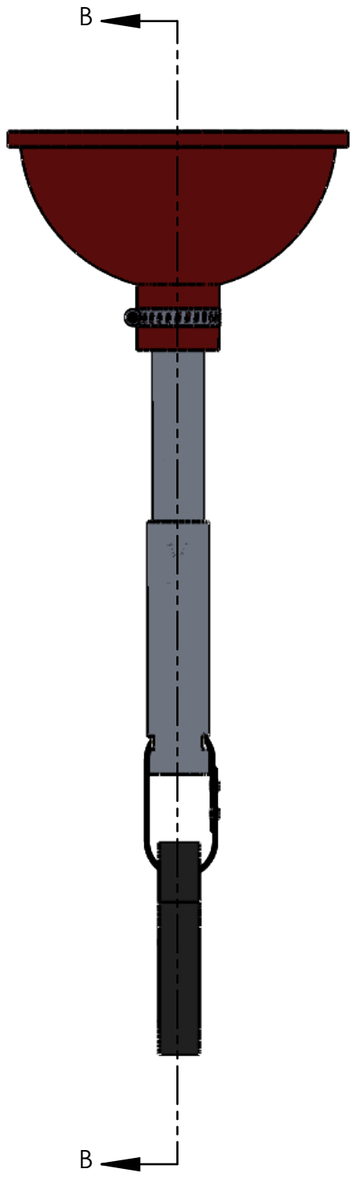
DO NOT SCALE

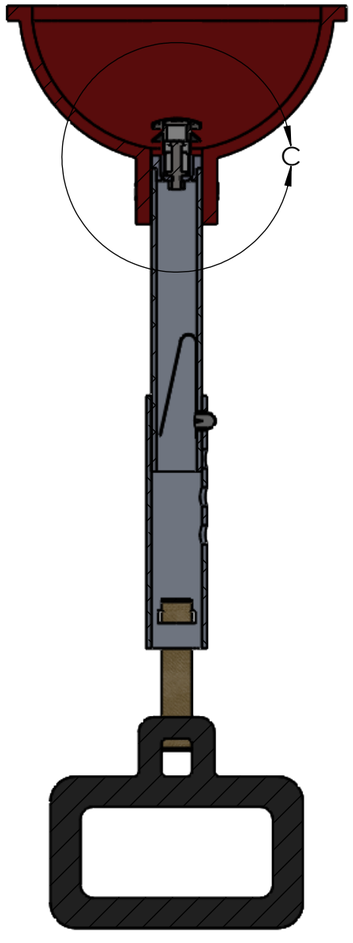
SHEET 1 OF 2

CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

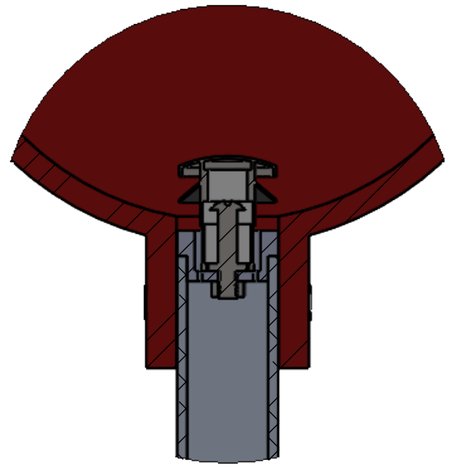
TITLE: BUS HOLDING HANDLE

SIZE:	DATE:	DRAWN BY:	
B	4/20/2020	WEI HAO WANG	
MATERIAL:		PART #: A-160G19-001	REV: 0





SECTION B-B
SCALE 1 : 3



DETAIL C
SCALE 2 : 3

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

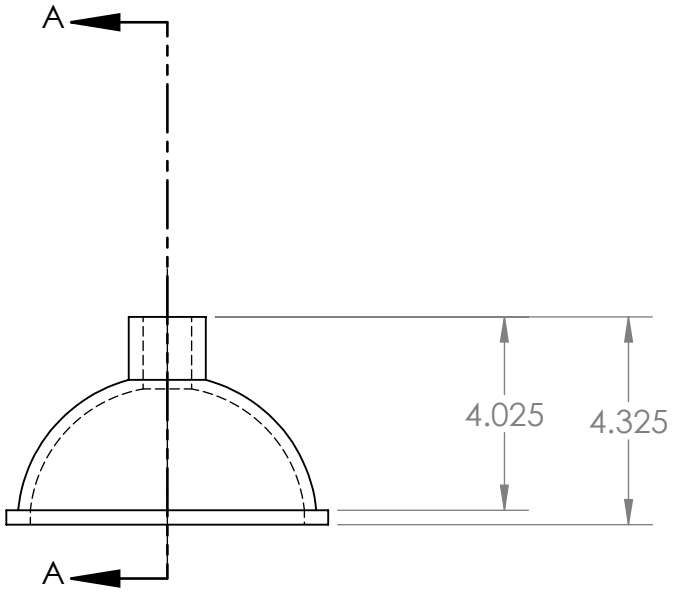
DO NOT SCALE

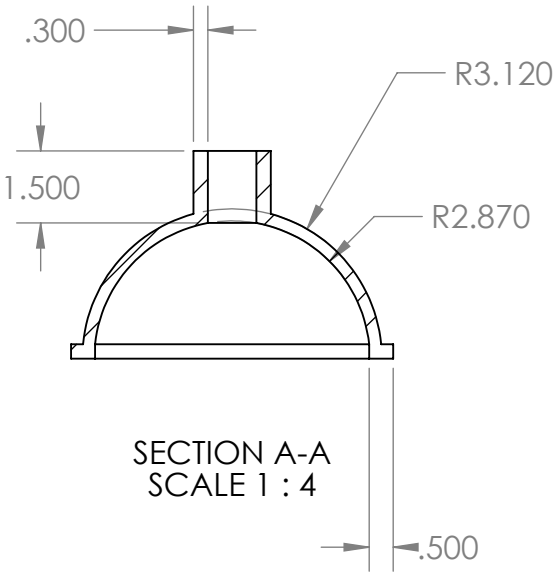
SHEET 2 OF 2

CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

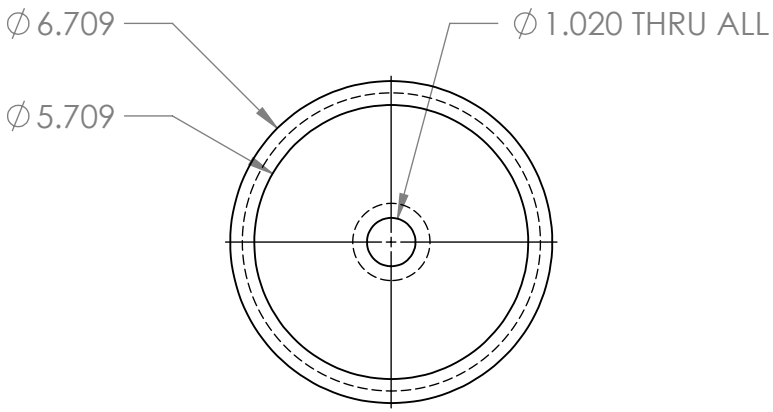
TITLE:
BUS HOLDING HANDLE

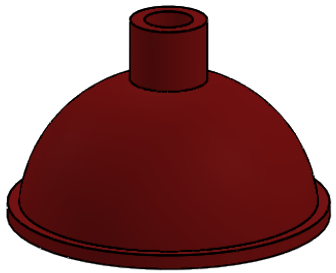
SIZE:	DATE:	DRAWN BY:	
B	4/20/2020	WEI HAO WANG	
MATERIAL:		PART #:	REV:
		A-160G19-001	0





SECTION A-A
SCALE 1 : 4





Buliders
Article number 80908

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

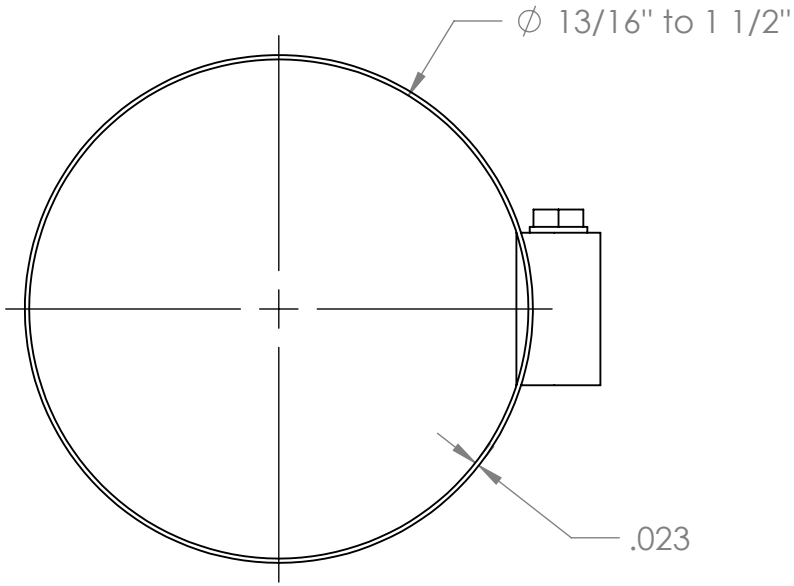
TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

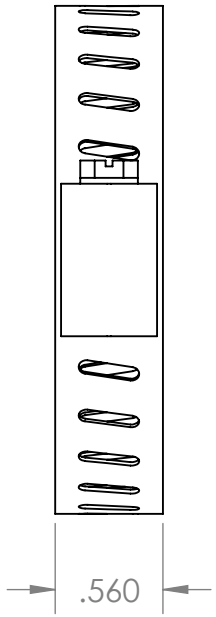
DO NOT SCALE

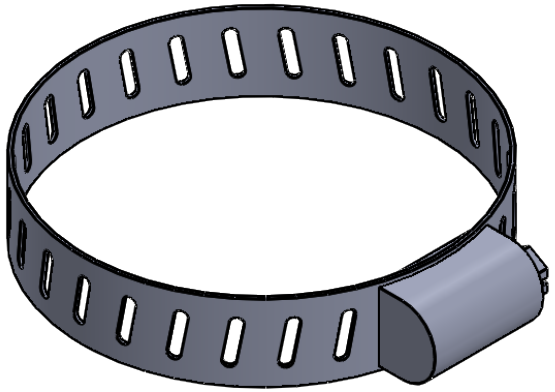
SHEET 1 OF 1

CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

TITLE: Plunger			
SIZE: A	DATE: 4/13/2020	DRAWN BY: Lin Xu	
MATERIAL: Rubber		PART #: P-160 G19-001	REV: 0







McMASTER-CARR
Part Number 5416K15

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

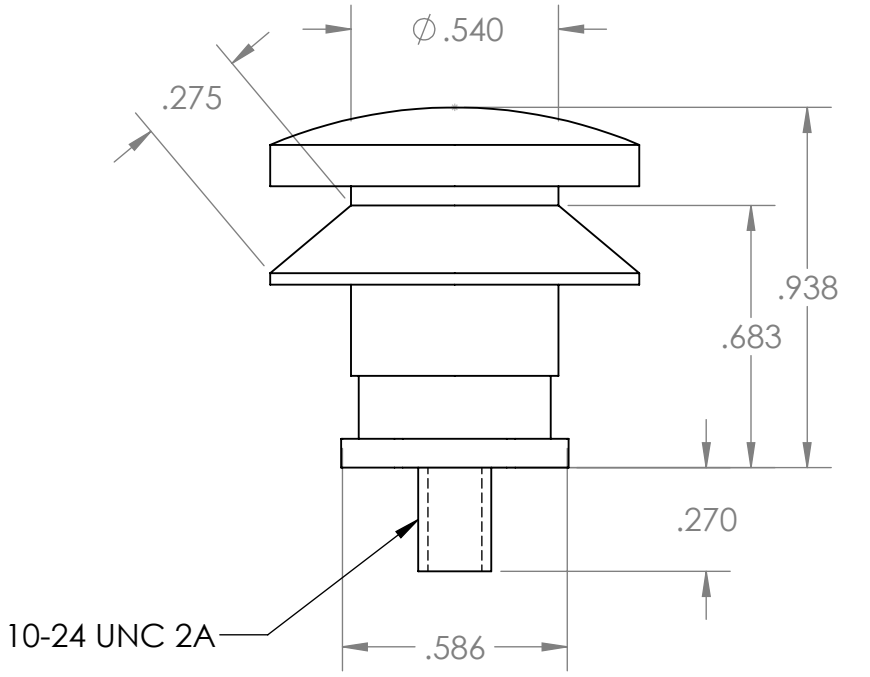
TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

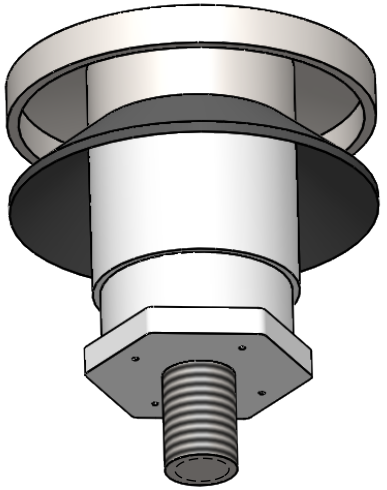
DO NOT SCALE

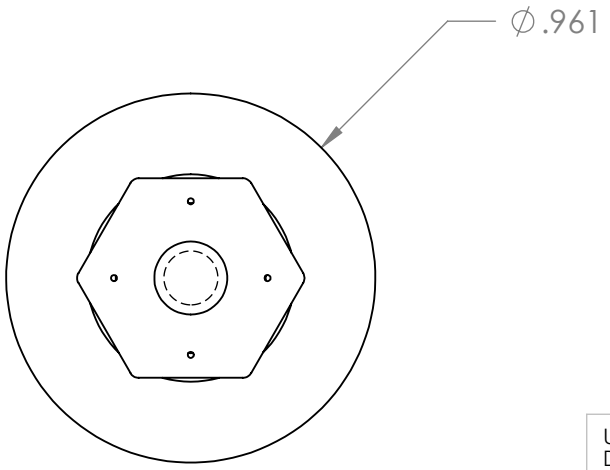
SHEET 1 OF 1

CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

TITLE: Hose Clamp			
SIZE: A	DATE: 4/13/2020	DRAWN BY: LX	
MATERIAL: 301 Stainless Steel/ 410 Stainless Steel		PART #: P-160 G19-002	REV: 0







AMAZON
PART NUMBER GIDS-173087

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

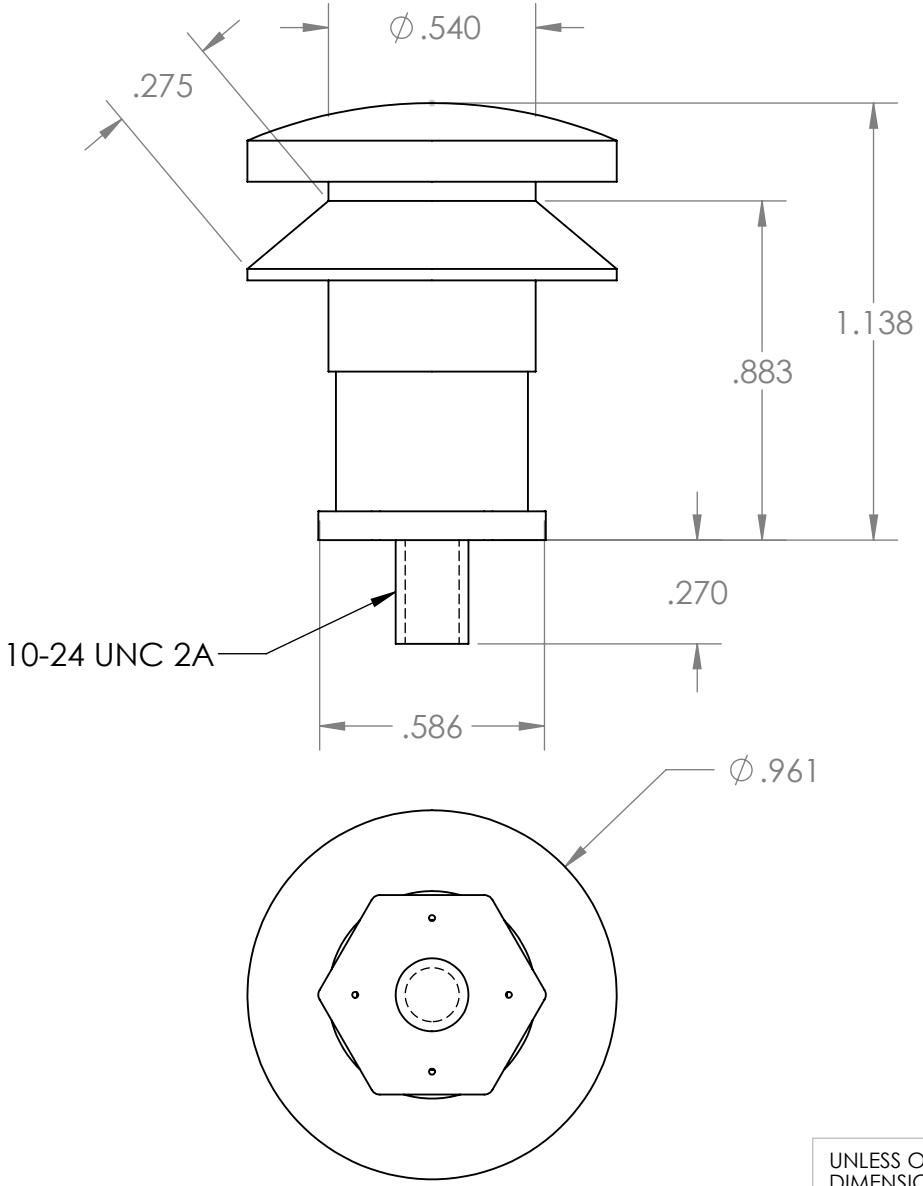
DO NOT SCALE

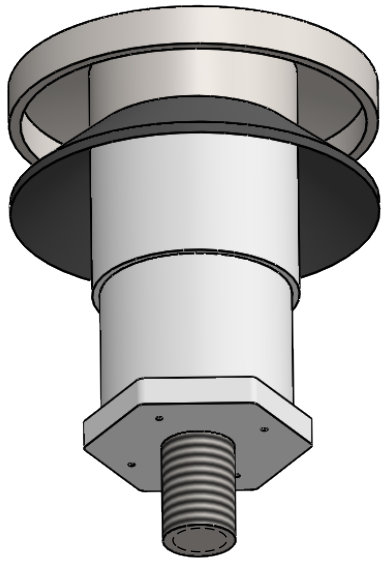
SHEET 1 OF 2

CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

TITLE: POP UP STOPPER

SIZE:	DATE:	DRAWN BY:	
A	2020/4/5	WEI HAO WANG	
MATERIAL:		PART #:	REV:
RUBBER,PLASTIC,STEEL		P-160G19-003	0





AMAZON
PART NUMBER GIDS-173087

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

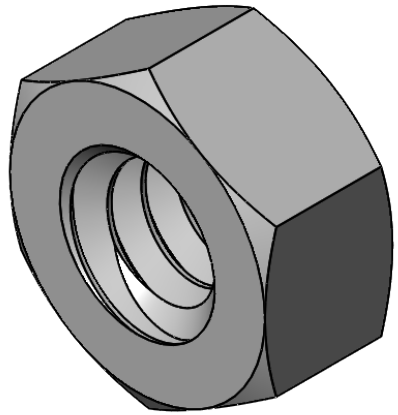
TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

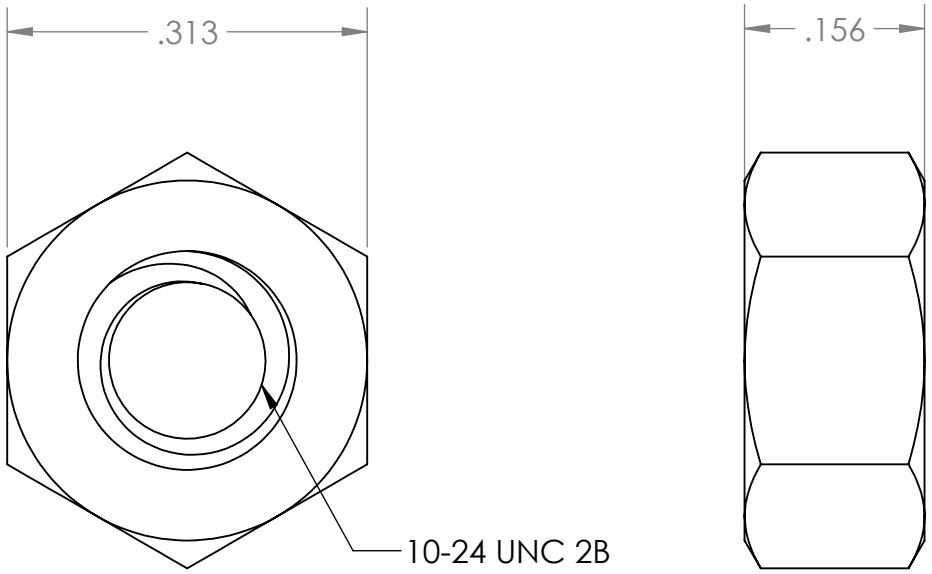
DO NOT SCALE

SHEET 2 OF 2

CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

TITLE: POP UP STOPPER			
SIZE: A	DATE: 2020/4/5	DRAWN BY: WEI HAO WANG	
MATERIAL: RUBBER,PLASTIC,STEEL		PART #: P-160G19-003	REV: 0





MCMASTER CARR
PART NUMBER 3022T721

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

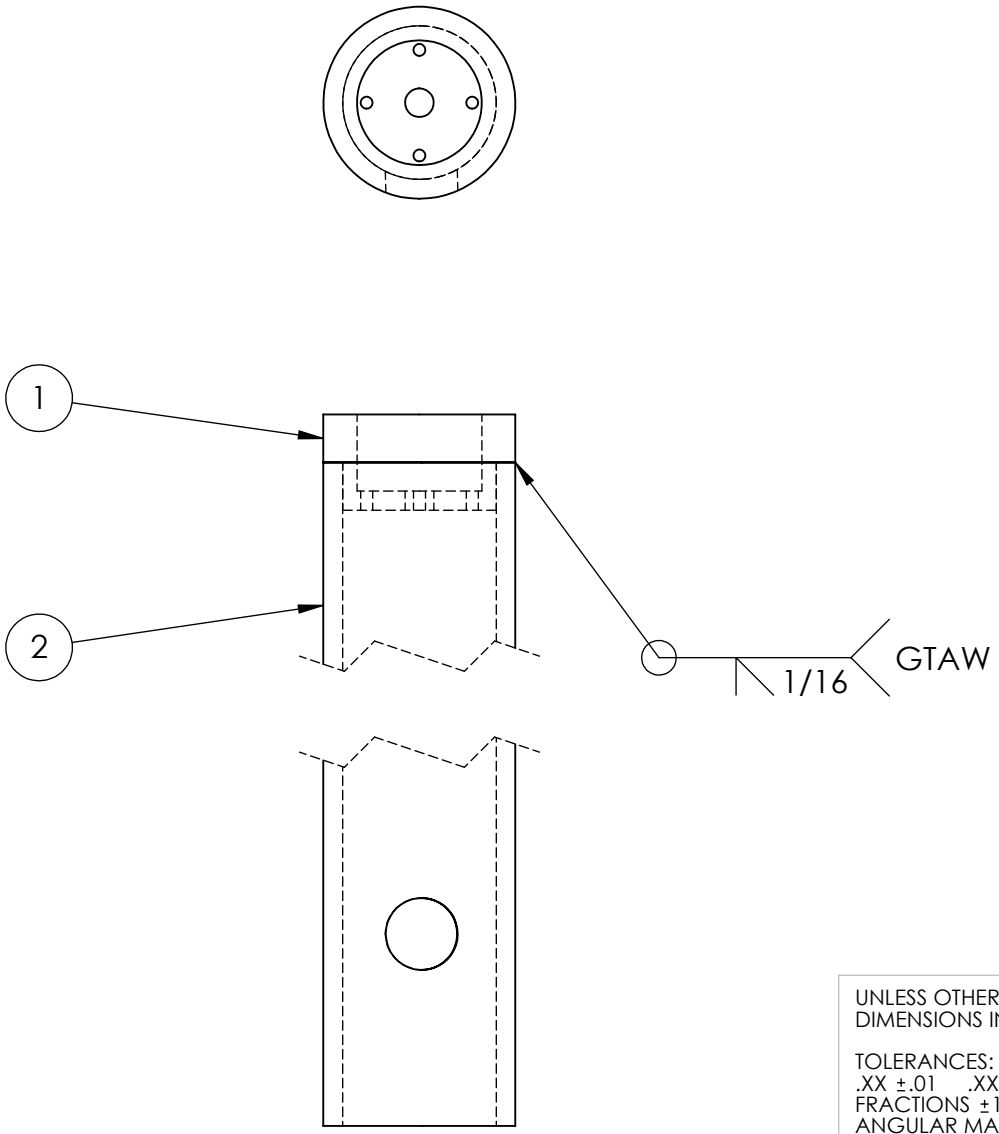
CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

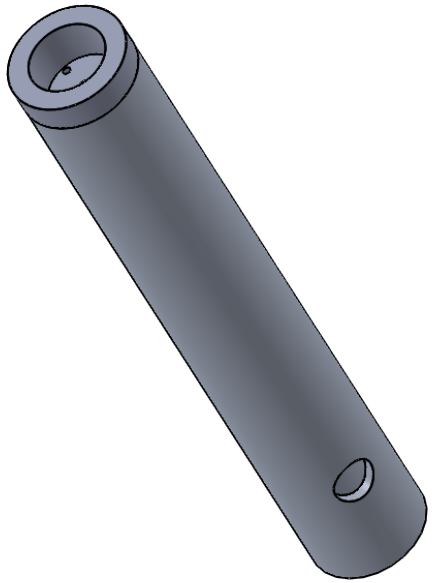
TITLE: JAM NUT

SIZE:	DATE:	DRAWN BY:
A	2020/4/18	WEI HAO WANG

MATERIAL:	PART #:	REV:
316 STAINLESS STEEL	P-160G19-004	0

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	M-160G19-001	CAP ON THE POLE	1
2	M-160G19-002	INSIDE POLE	1





UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

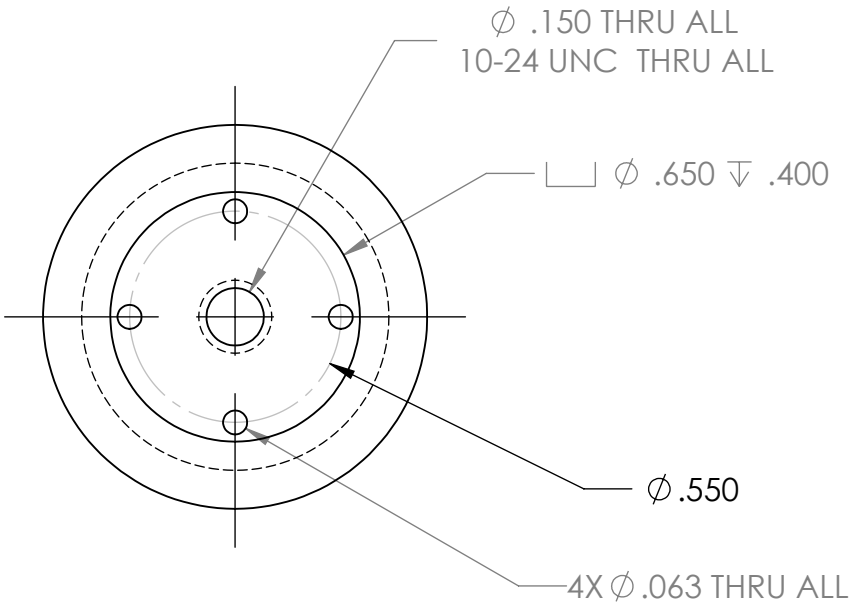
CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

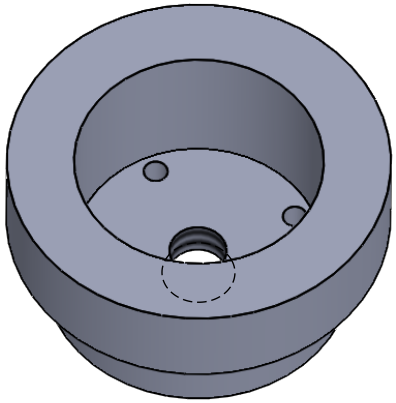
TITLE: CAP WELDMENT

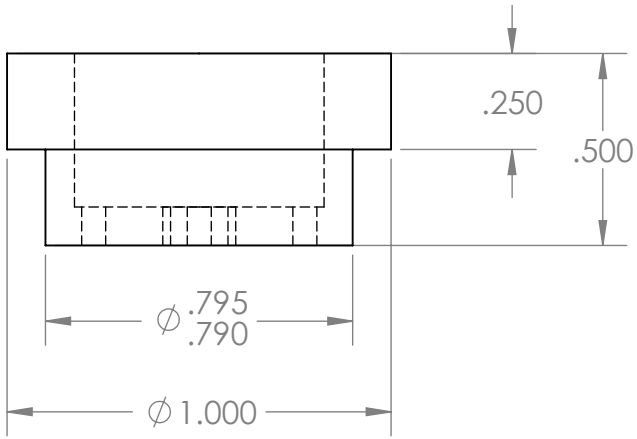
SIZE:	DATE:	DRAWN BY:
A	2020/4/19	WEI HAO WANG

MATERIAL:	PART #:	REV:
ALUMINUM 6061-T6	SA-160G19-001	0

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED
1	ADDED TOLERANCE, SCALED DOWN ALL THE DIMENSIONS	04/19/2020	WXW351







UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

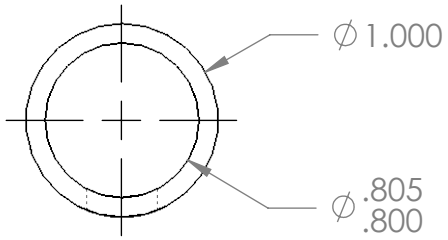
SHEET 1 OF 1

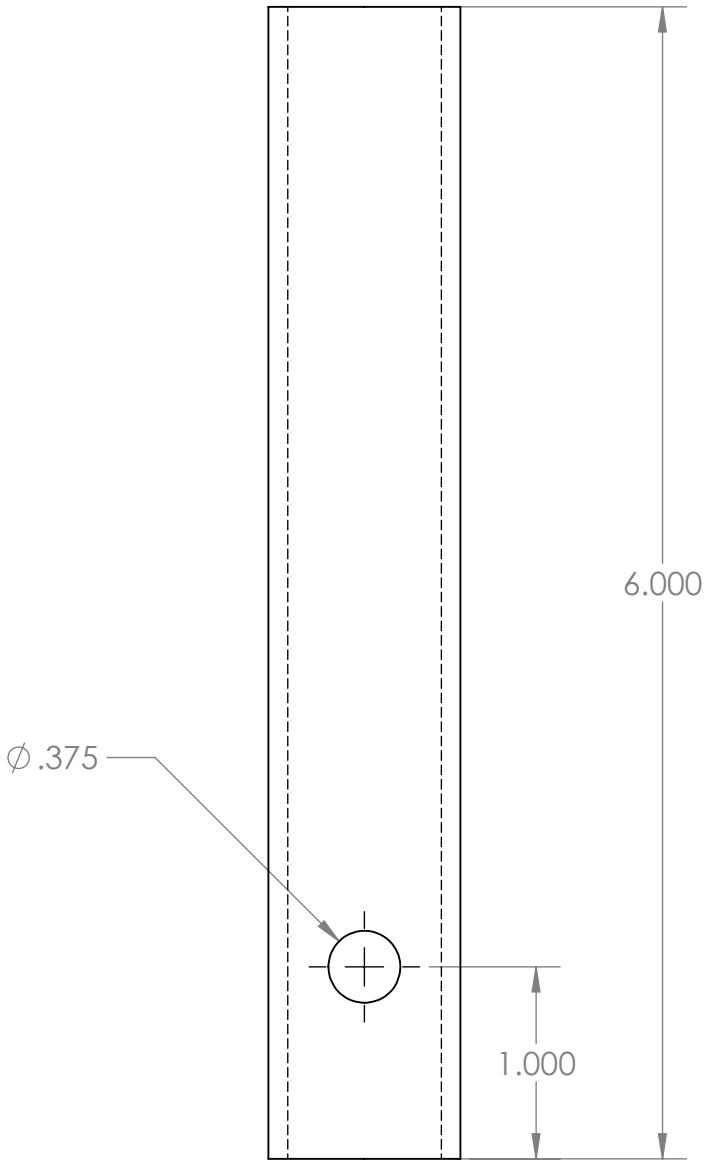
CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

TITLE: CAP ON THE POLE

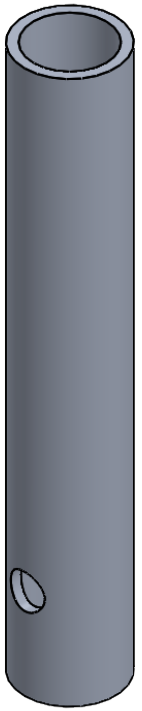
SIZE:	DATE:	DRAWN BY:
A	2020/4/5	WEI HAO WANG

MATERIAL:	PART #:	REV:
ALUMINUM 6061-T6	M-160G19-001	1





REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
1	SCALE INSIDE DIAMETER, OUTSIDE DIAMETER, LENGTH, AND DISTANCE OF HOLE FROM BOTTOM OF POLE BY 1/2.	4/18/20	MRV45
2	DELETED KEYWAY AND CHANGED HOLE DIAMETER TO .375	4/18/20	MRV35
3	ADDED TOLERANCE OF INSIDE DIAMETER	4/19/20	WXW351



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

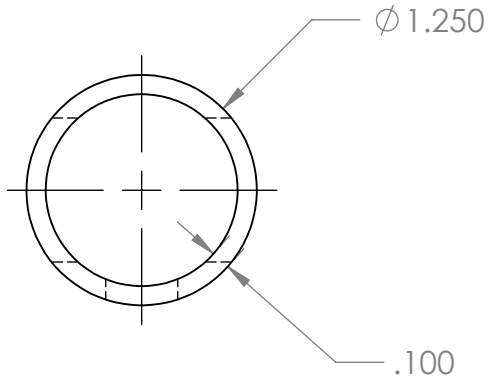
SHEET 1 OF 1

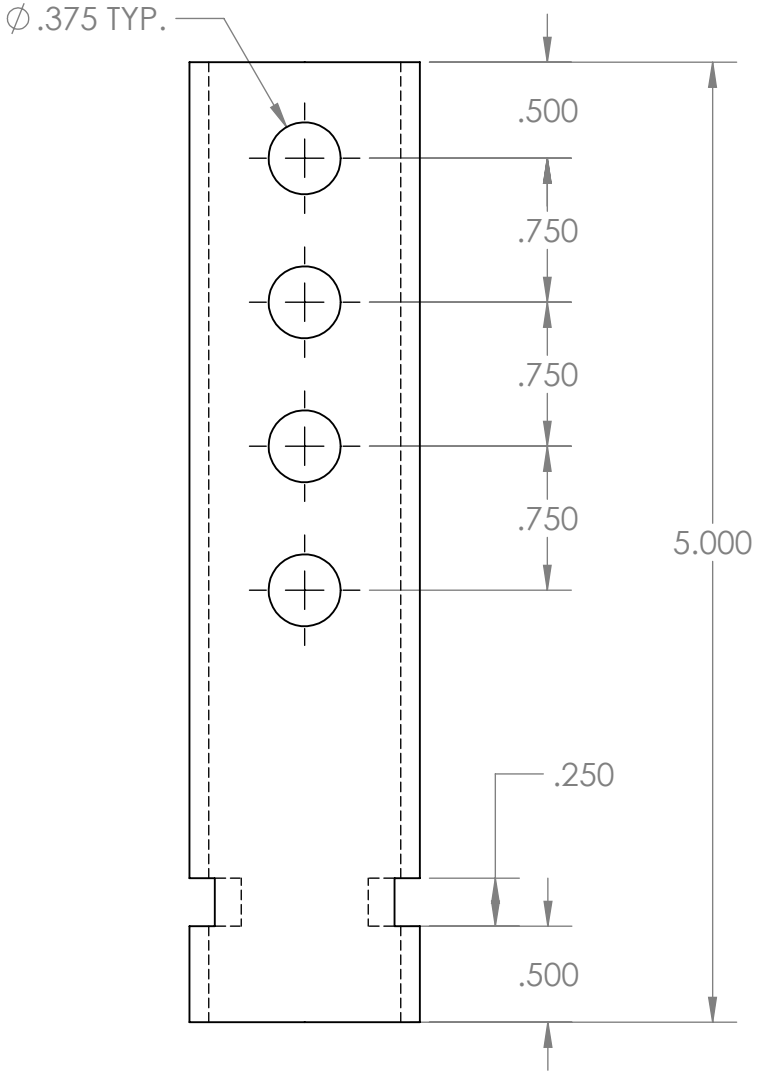
CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

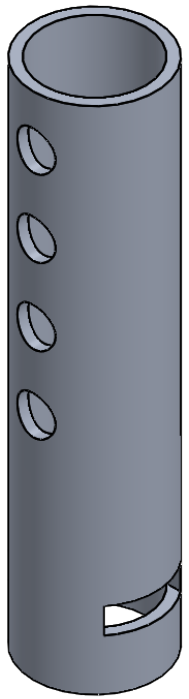
TITLE: INSIDE POLE

SIZE:	DATE:	DRAWN BY:	
A	2020/4/5	MRV35	
MATERIAL:		PART #:	REV:
ALUMINUM 6061-T6		M-160G19-002	3

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
1	SCALE OUTSIDE AND INSIDE POLE DIAMETER, LENGTH OF POLE, AND HEIGHT OF SLOT FROM BOTTOM OF POLE BY 1/2.	4/18/20	MRV35
2	DECREASE SPACE BETWEEN BUTTON HOLES. DELETED KEYWAY AND FILLET OF SLOT	4/18/20	MRV35







UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

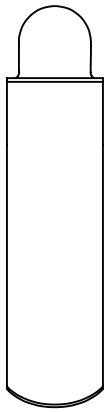
DO NOT SCALE

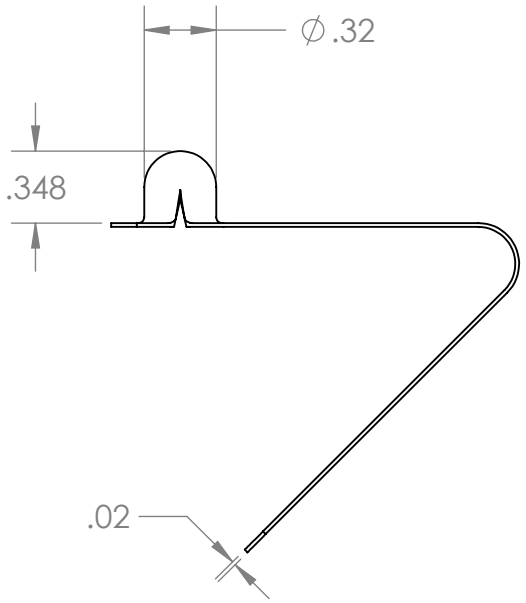
SHEET 1 OF 1

CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

TITLE: OUTSIDE POLE

SIZE:	DATE:	DRAWN BY:	
A	2020/4/5	MRV35	
MATERIAL:		PART #:	REV:
ALUMINUM 6061-T6		M-160G19-003	2





ROCK WEST COMPOSITES
PART NUMBER 1140-SS

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

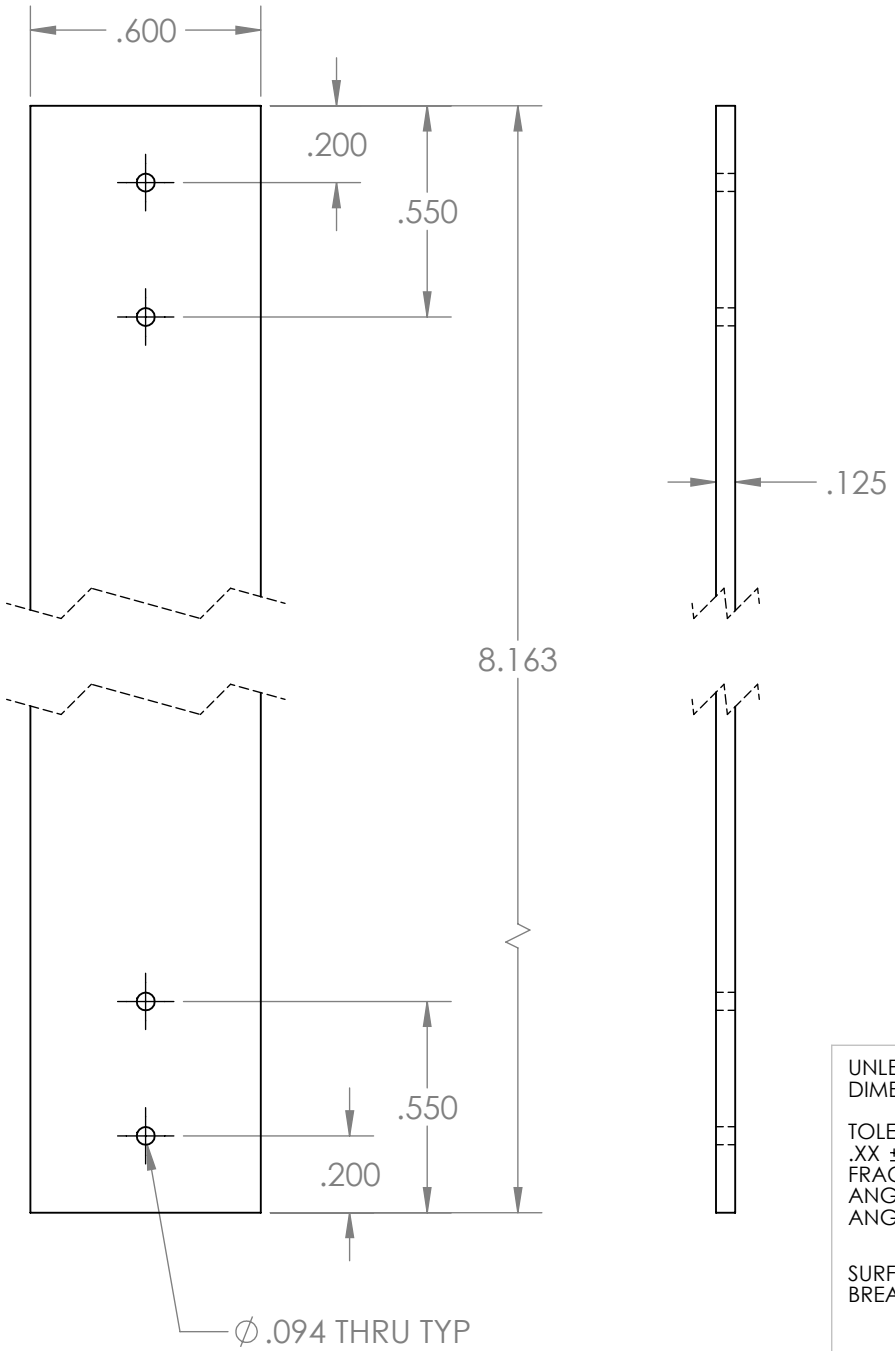
DO NOT SCALE

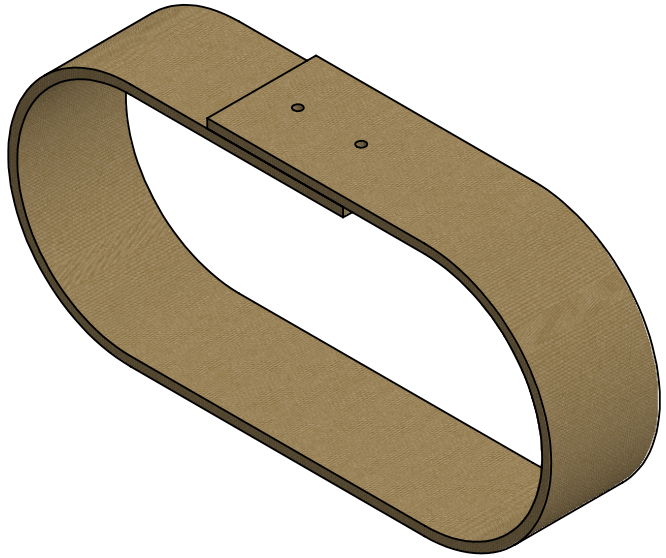
SHEET 1 OF 1

CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

TITLE:			
BUTTON CLIP			
SIZE:	DATE:	DRAWN BY:	
A	2020/4/6	MRV35	
MATERIAL:		PART #:	REV:
410 STAINLESS STEEL		P-160G19-005	0

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
1	REDUCED THE LENGTH BY HALF, CHANGED THE THICKNESS FROM 0.100 TO 0.125	4/19/20	MXO210





UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

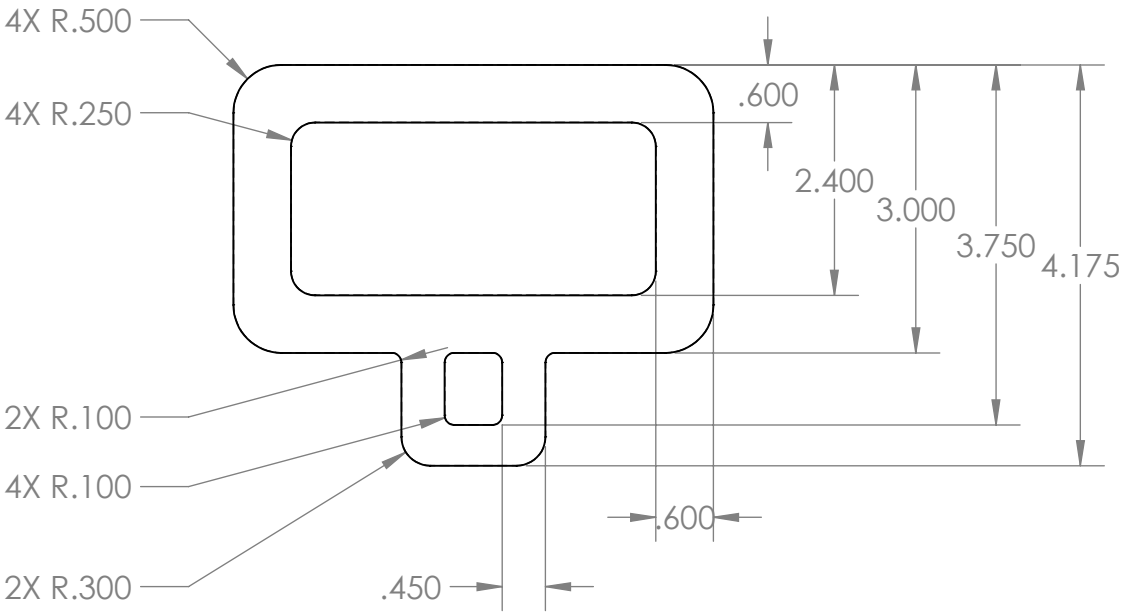
DO NOT SCALE

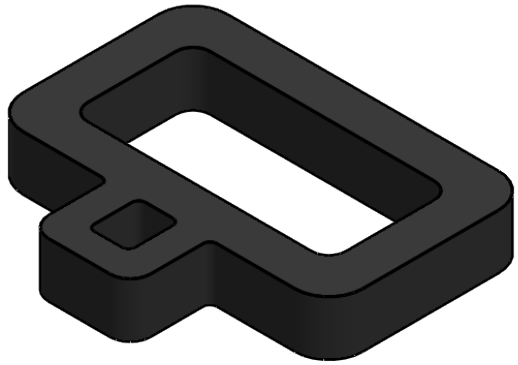
SHEET 1 OF 1

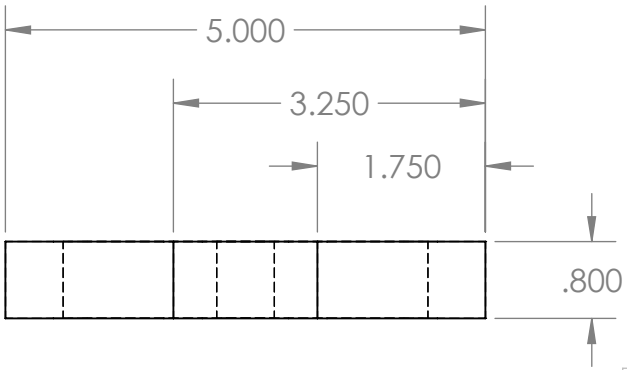
CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

TITLE: FABRIC

SIZE:	DATE:	DRAWN BY:	
A	2020/4/5	MIDUM OH	
MATERIAL:		PART #:	REV:
LEATHER		M-160G19-004	1







UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

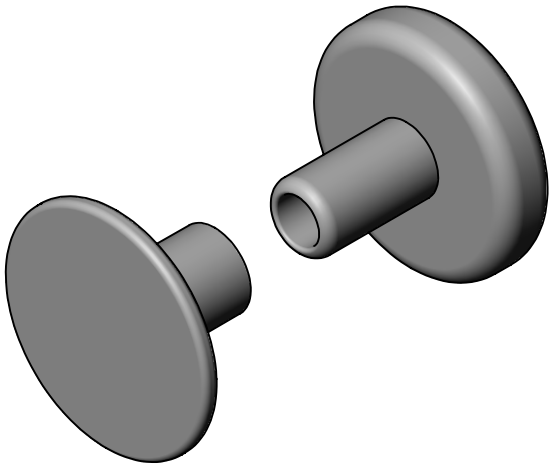
DO NOT SCALE

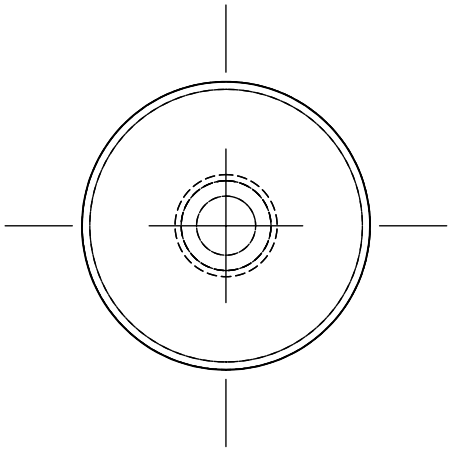
SHEET 1 OF 1

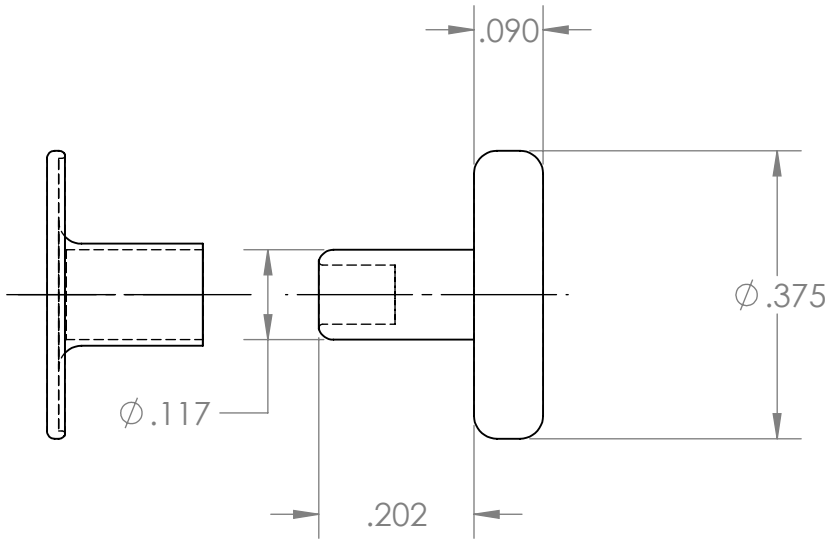
CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

TITLE: HANDLE

SIZE:	DATE:	DRAWN BY:	
A	2020/4/19	MXO210	
MATERIAL:		PART #:	REV:
POLYPROPYLENE		M-160G19-005	0







McMaster Carr
Part Number
97362A300

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

TITLE: TWO-PIECE PRESS-FIT RIVETS

SIZE:	DATE:	DRAWN BY:	
A	2020/4/5	MIDUM OH	
MATERIAL:		PART #:	REV:
NICEKL-PLATED STEEL		P-160G19-006	0

Manufacturing Design Project

Bus Holding Handle – Mass Production Version

Wei Hao Wang

Bus Handle 3000

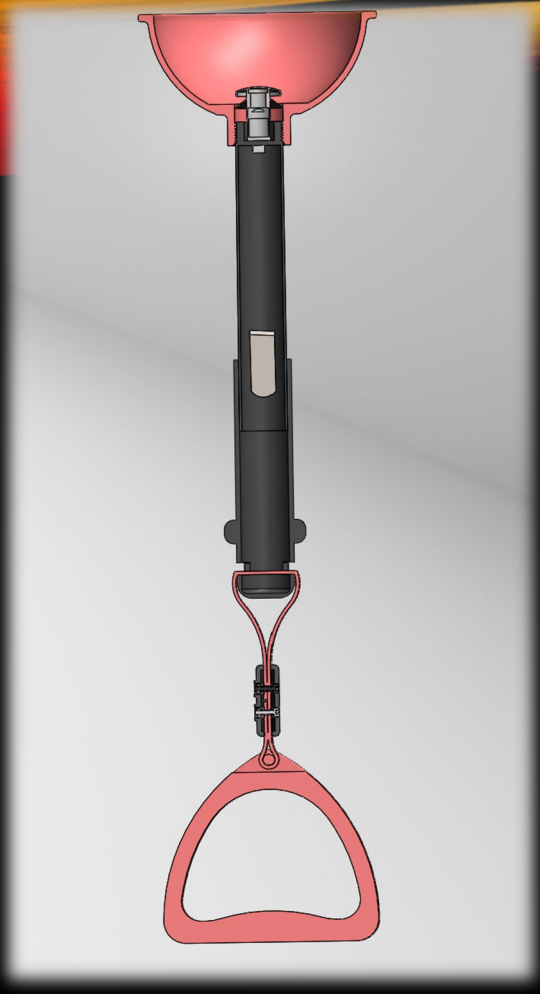
Round 3 Group 19 (Wei Hao Wang, Lin Xu, Matthew Vatne, Midum Oh)

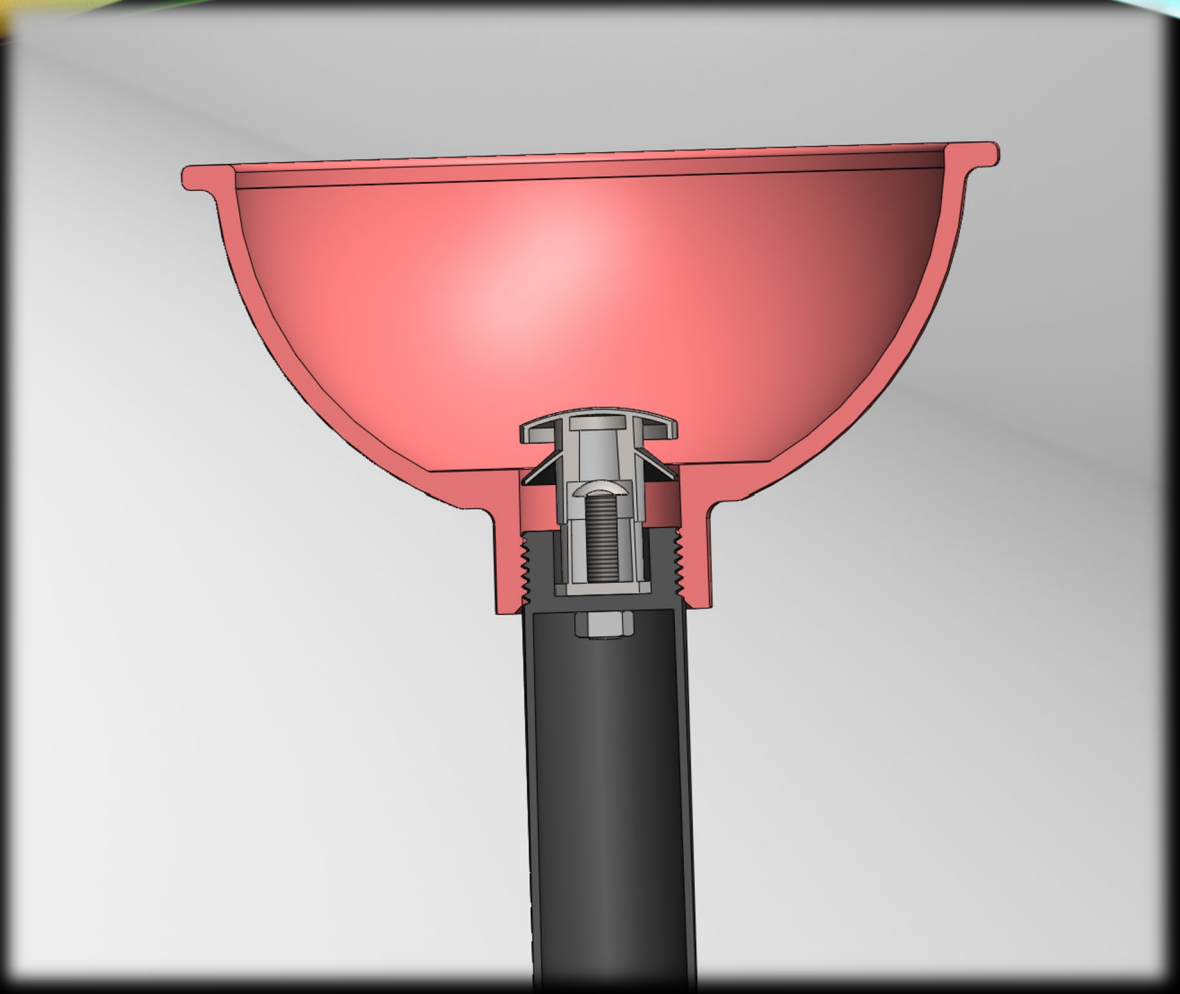
Manufactured parts

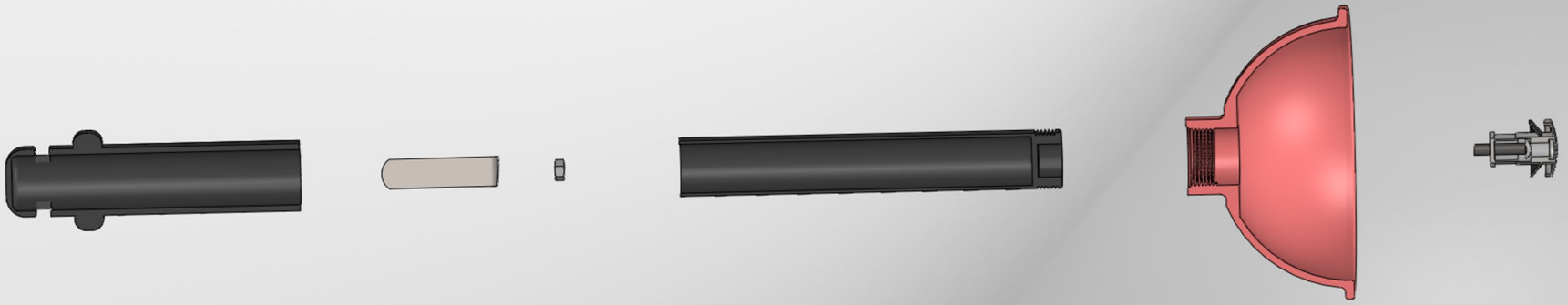
- Plunger
  - Synthetic Rubber
  - Compression Molding
- Inside pole
  - Polyethylene (Plastic)
  - Injection Molding
- Outside pole
  - Polyethylene (Plastic)
  - Injection Molding
- Fabric
  - Leather
  - Machinging
- Fabric clamp
  - Polyethylene (Plastic)
  - Transfer Molding
- Handle
  - Polyethylene (Plastic)
  - Injection Molding

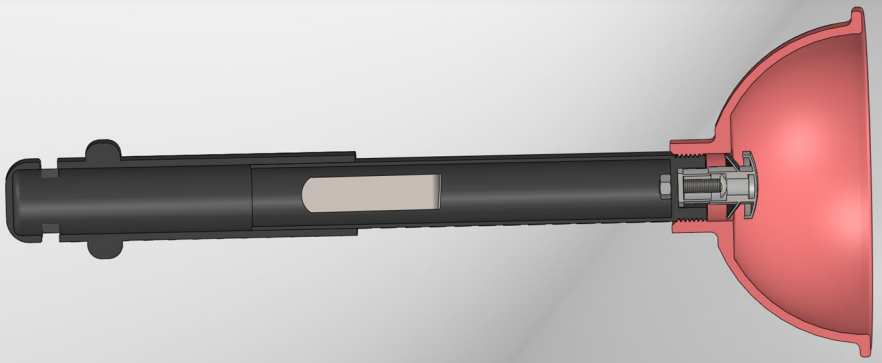
Purchased parts

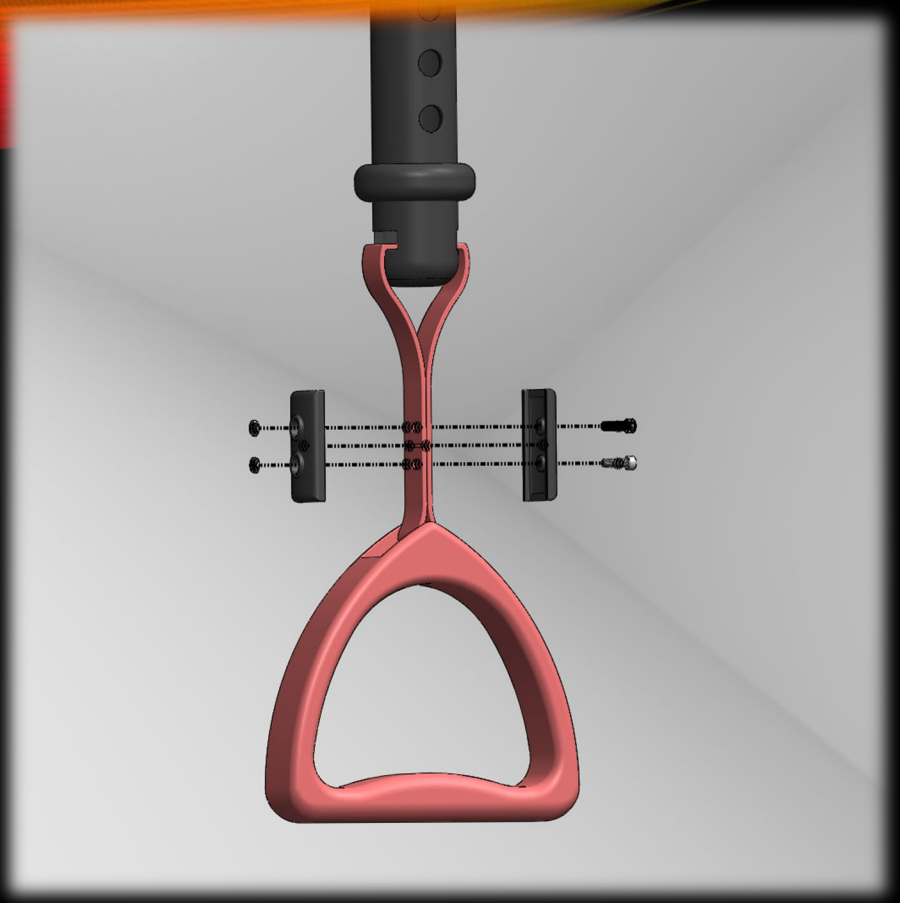
- Pop Up Stopper
- Button Clip
- Nuts x3
- Screws x2

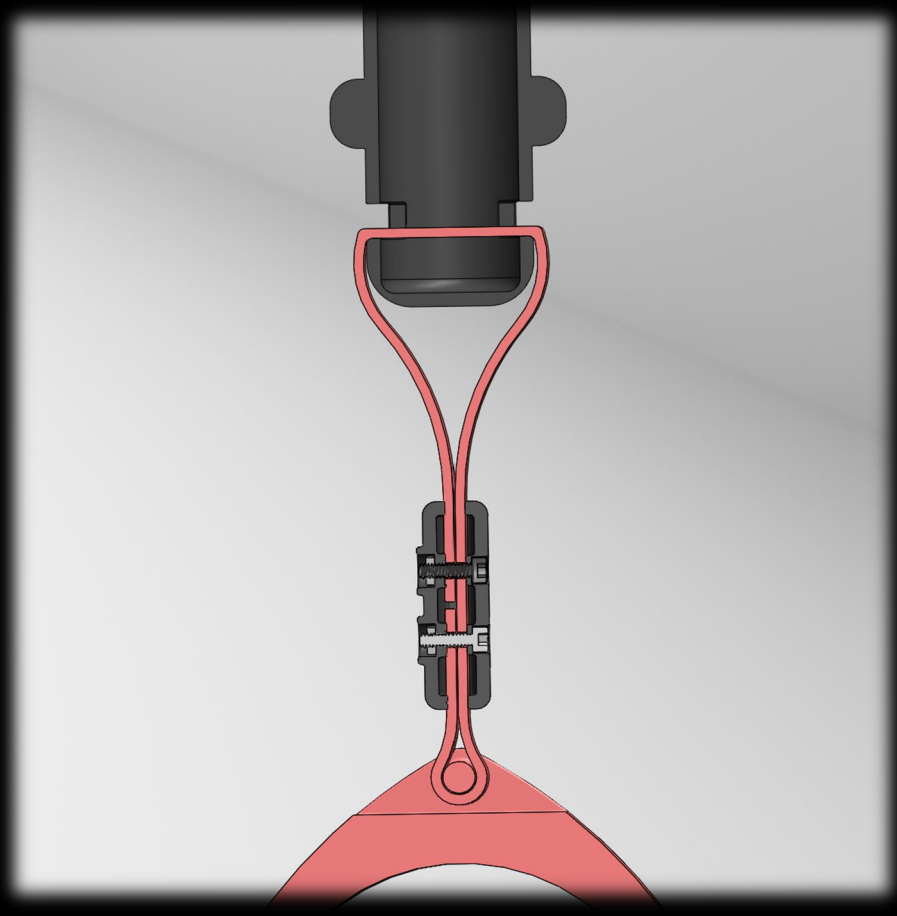








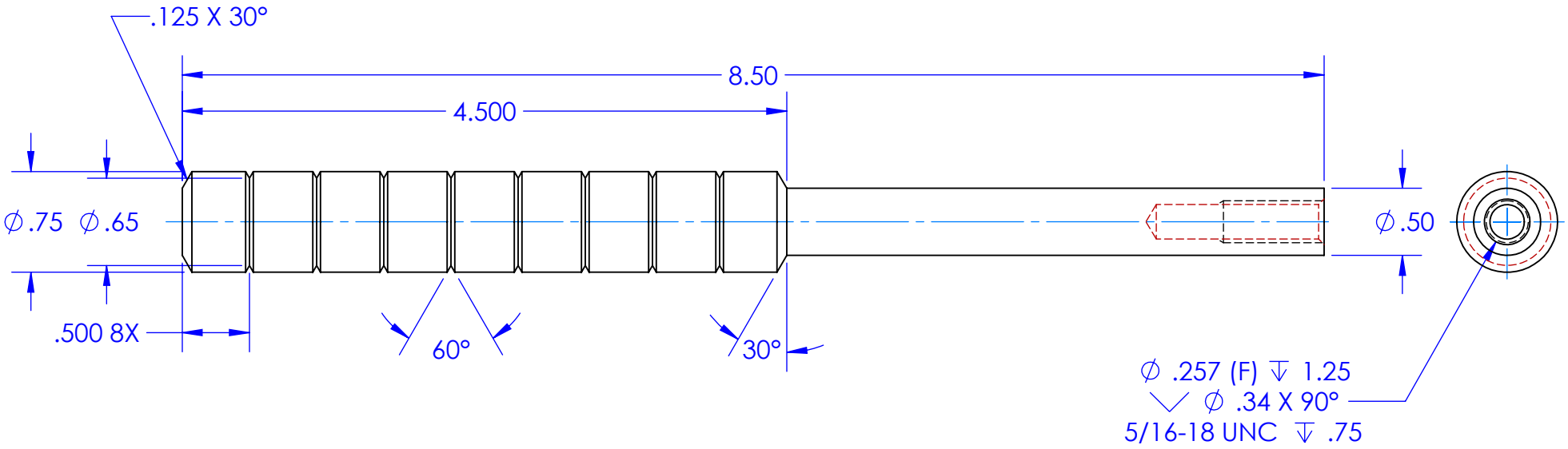




Hammer Manufacturing Project

Manually Machining

Wei Hao Wang



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

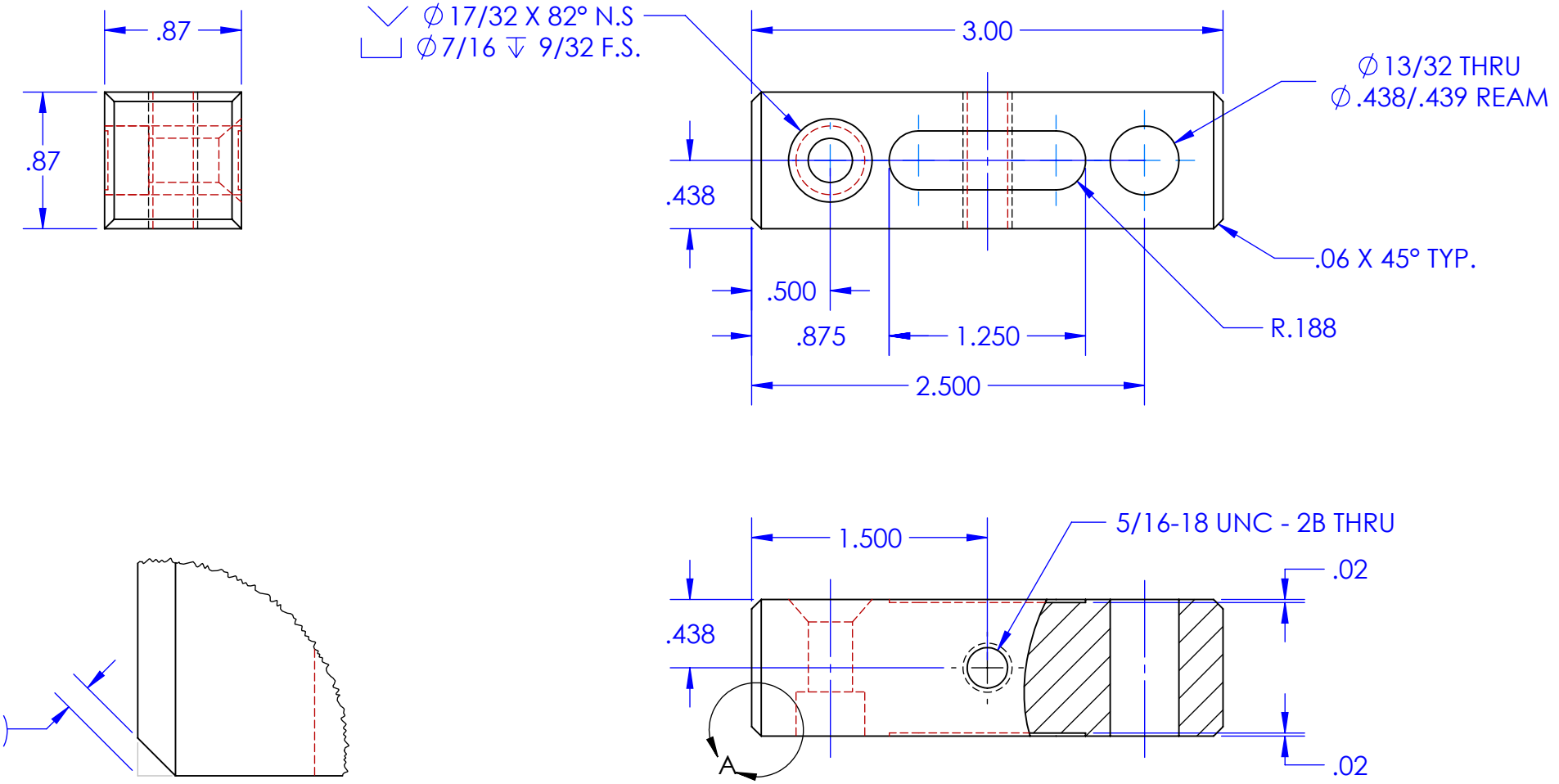
SHEET 1 OF 1

CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

TITLE: 160 HAMMER HANDLE

SIZE:	DATE:	DRAWN BY:
A	1/8/2020	JDB

MATERIAL:	PART #:	REV:
1018 CRS - ∅.750 X 8.56	160HAM-002	0



DETAIL A

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

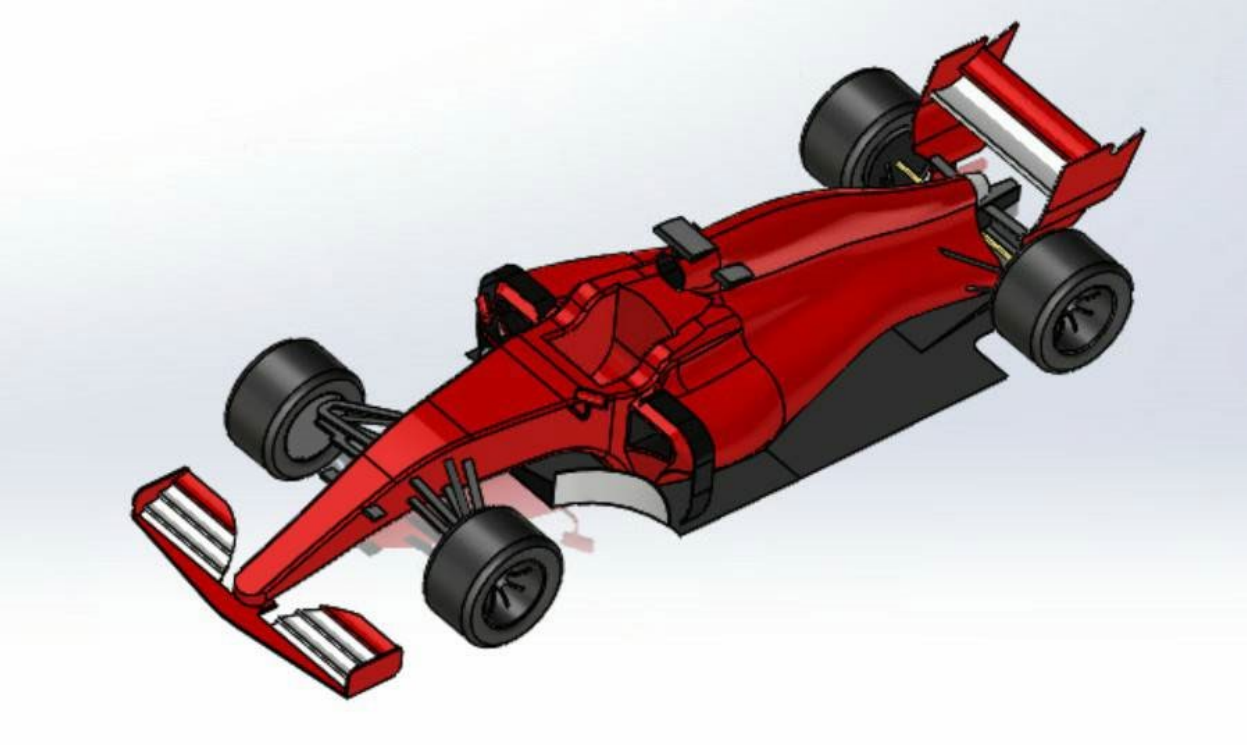
TITLE: 160 HAMMER HEAD

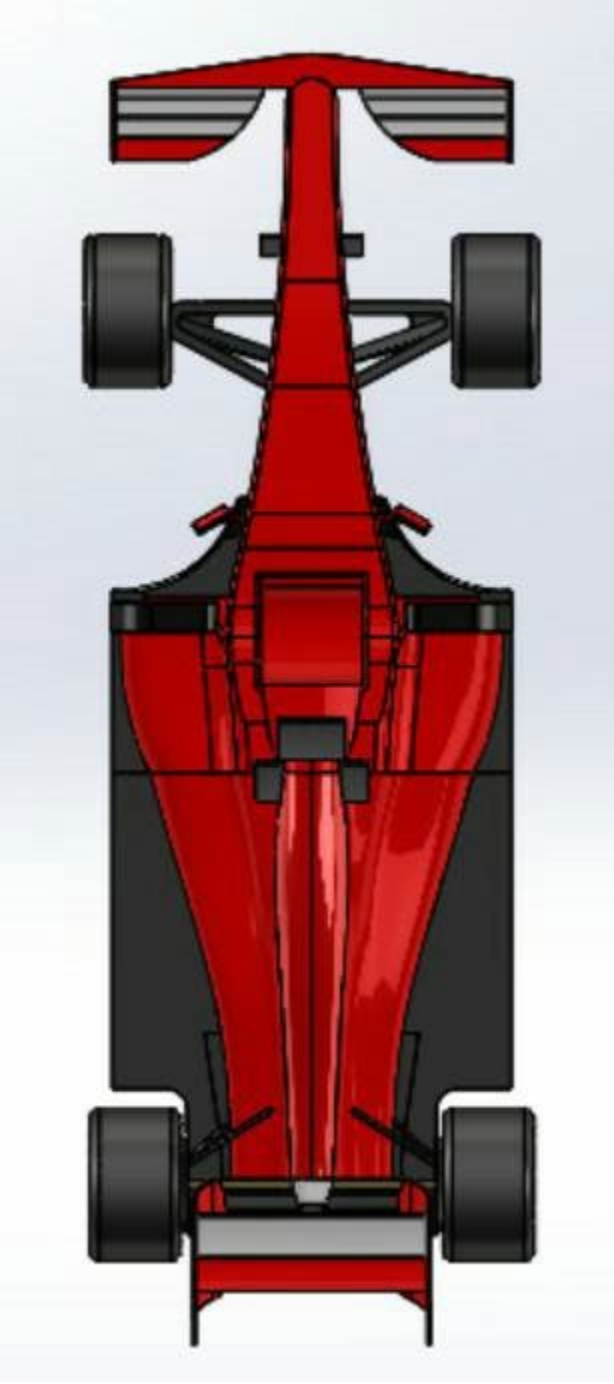
SIZE:	DATE:	DRAWN BY:	
A	12/4/2019	JDB	
MATERIAL:		PART #:	REV:
1018 CRS - 7/8 X 7/8 X 3 1/8		160HAM-001	0

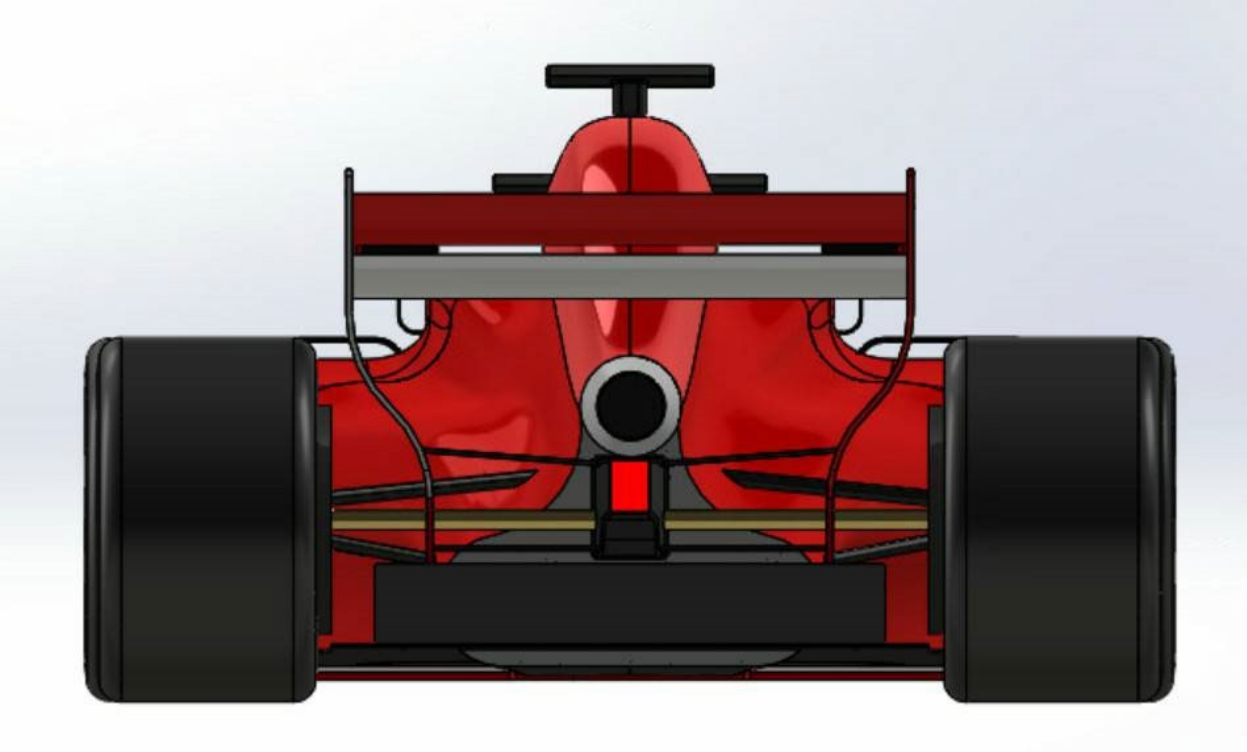
SOLIDWORKS Design Contest

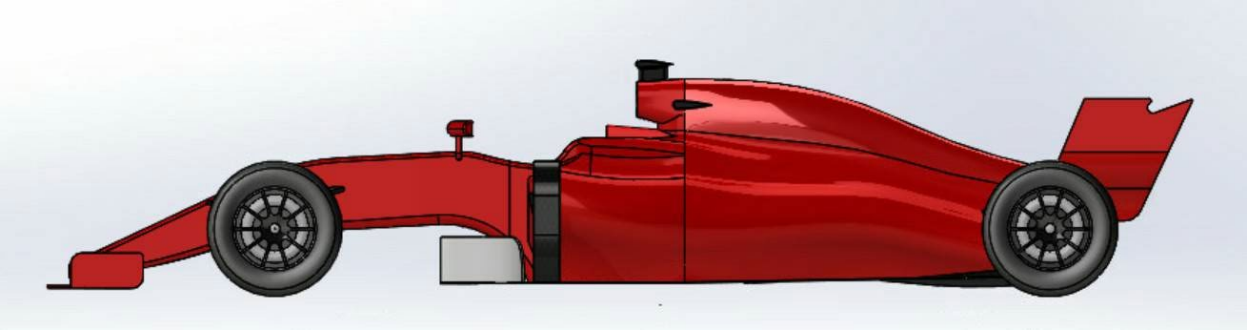
Formula One Car 3D Model

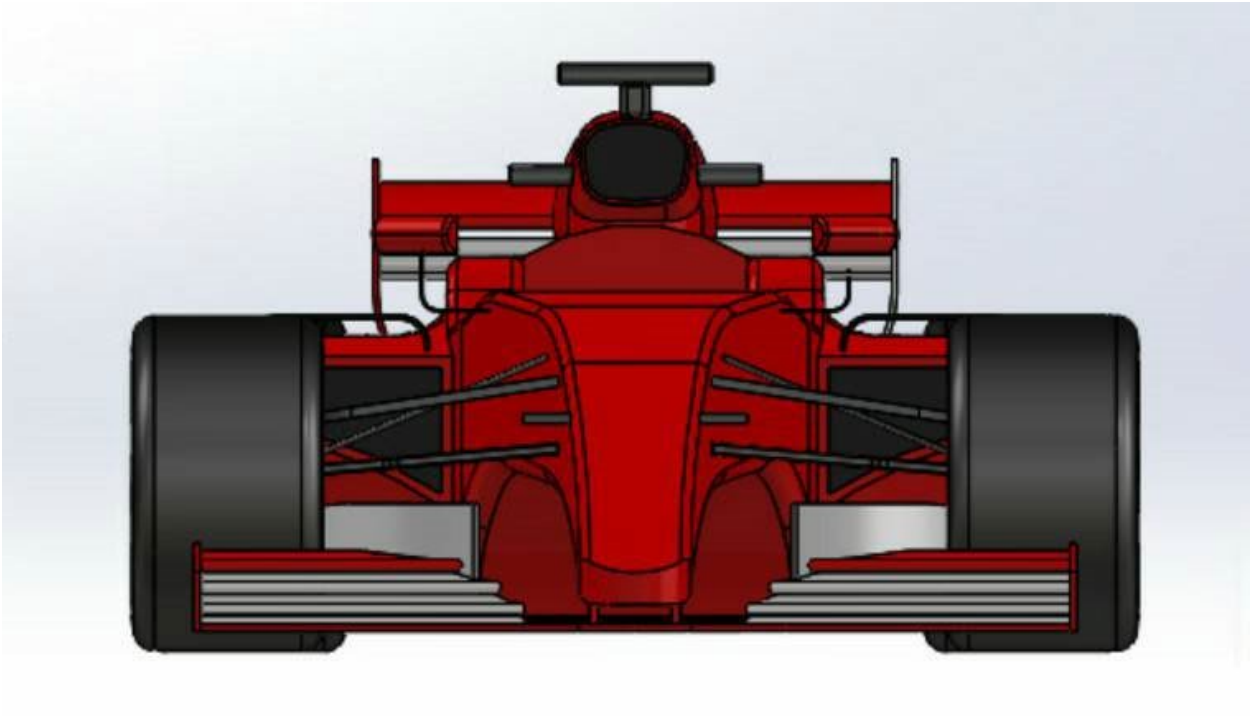
Wei Hao Wang











Detonation 3D Modeling

Master Project

Wei Hao Wang

Master Project Brief Description:

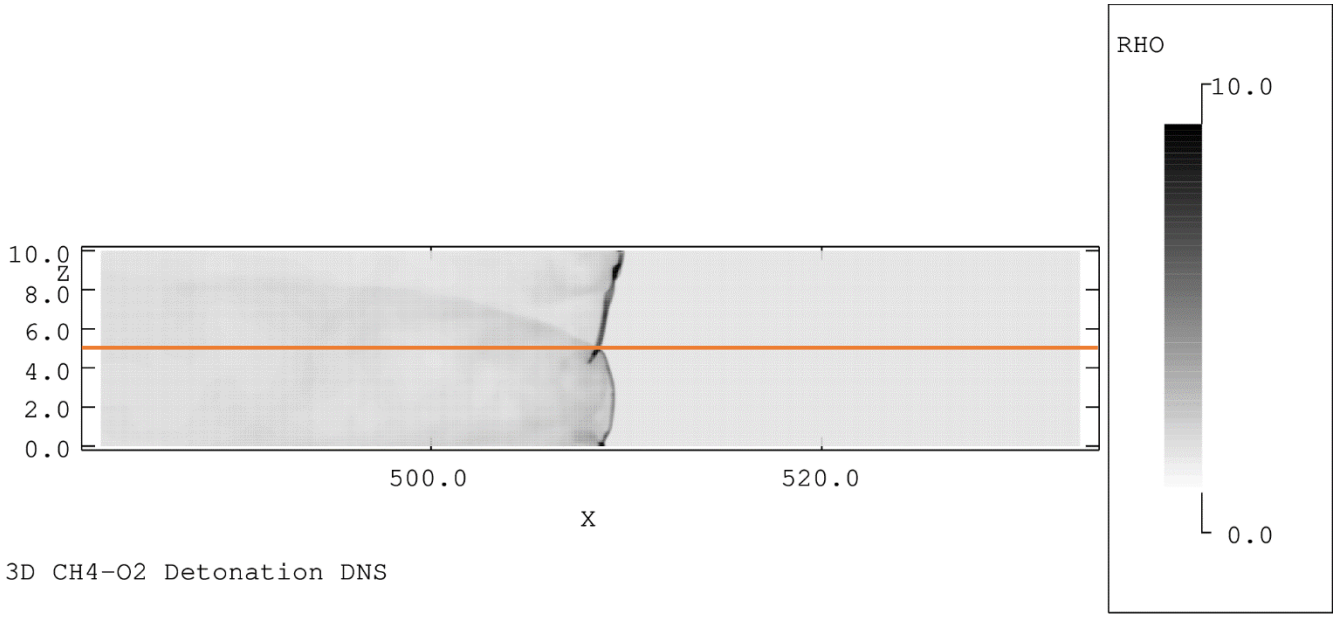
This is a project based on the 3D simulation for (methane + oxygen) detonation. The geometry of simulation is rectangular due to the experimental parameters I want to compare with. The whole simulation is running on Linux and HPC I have at Case Western Reserve University. The method I choose for this topic is DNS.

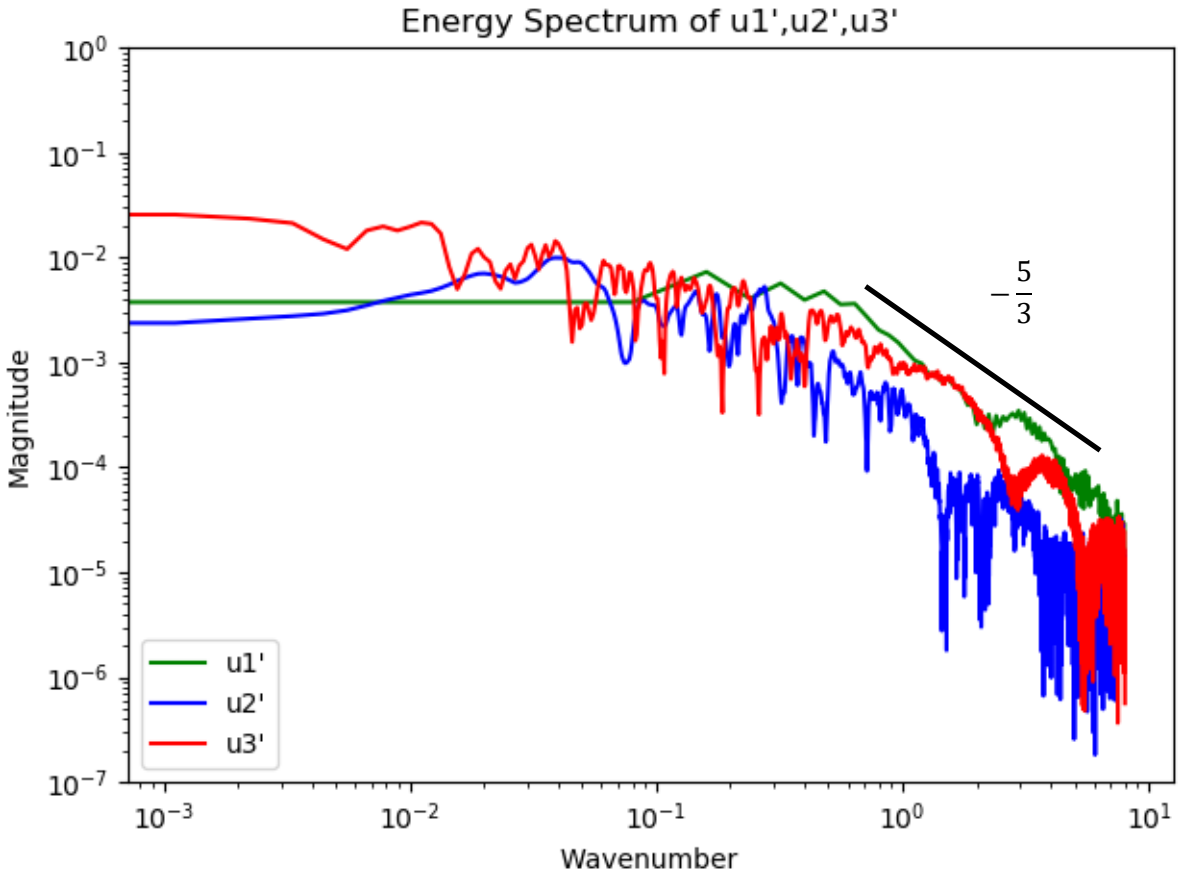
I have two objectives with this master project. First is to verify whether the simulation follows one of the Kolmogorov hypothesis which states that the slope of log-log plot for energy spectrum is -5/3 in inertial subrange. By extracting the velocity data at every loop in each direction and doing discrete Fourier Transform, we can observe that it follows the hypothesis. Moreover, the data also show that this is isotropic. This part was also running on Linux with Python.

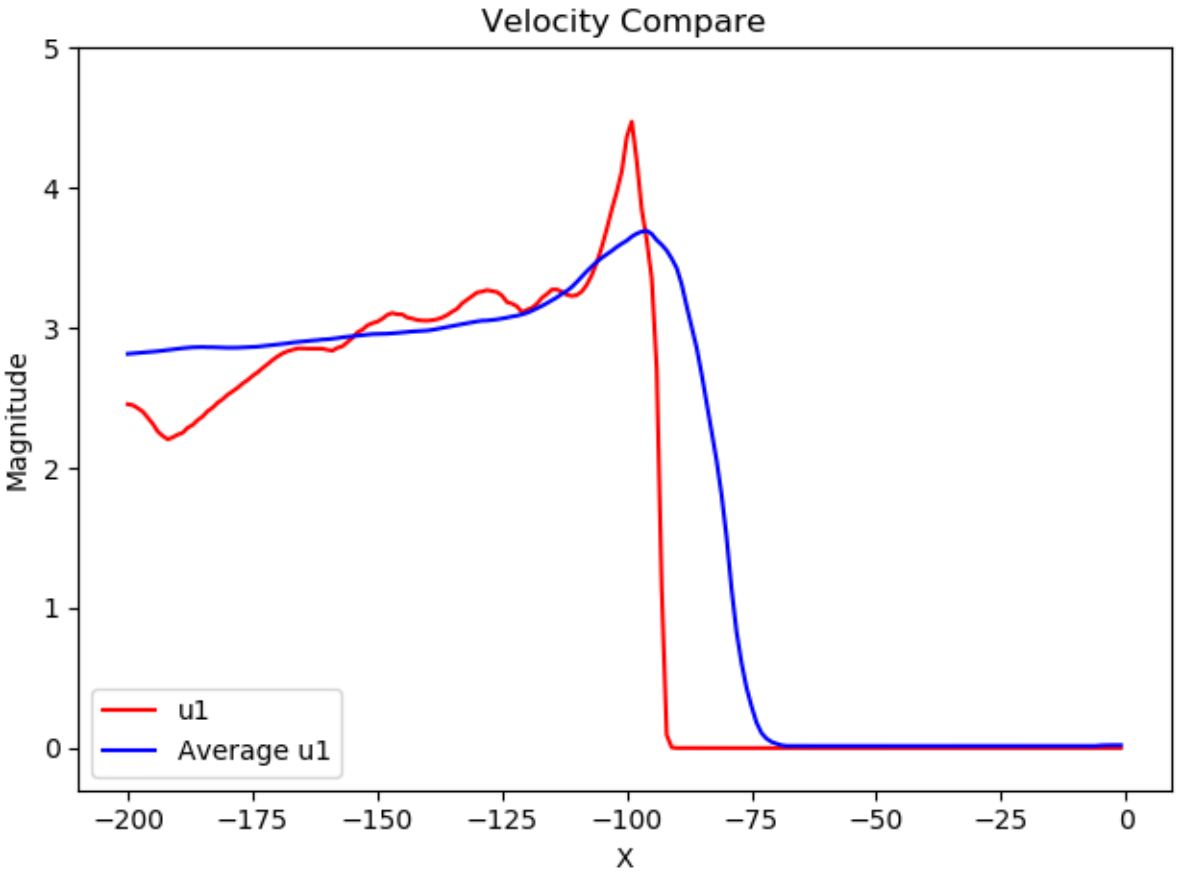
The second part is to increase the mesh grid from 4 grids per half-reaction length to 64 girds per half-reaction length. The ideal situation is that the simulation will be very close to the experimental data I have as the mesh grid increase so that I don't need to take account for heat loss due to wall friction. As the figures shown below, the simulation average velocity of detonation front is pretty close to experiment by using high resolution.

For Loop # 196

Position where data extracted: Y = 1, Z = 5 (X towards the end)

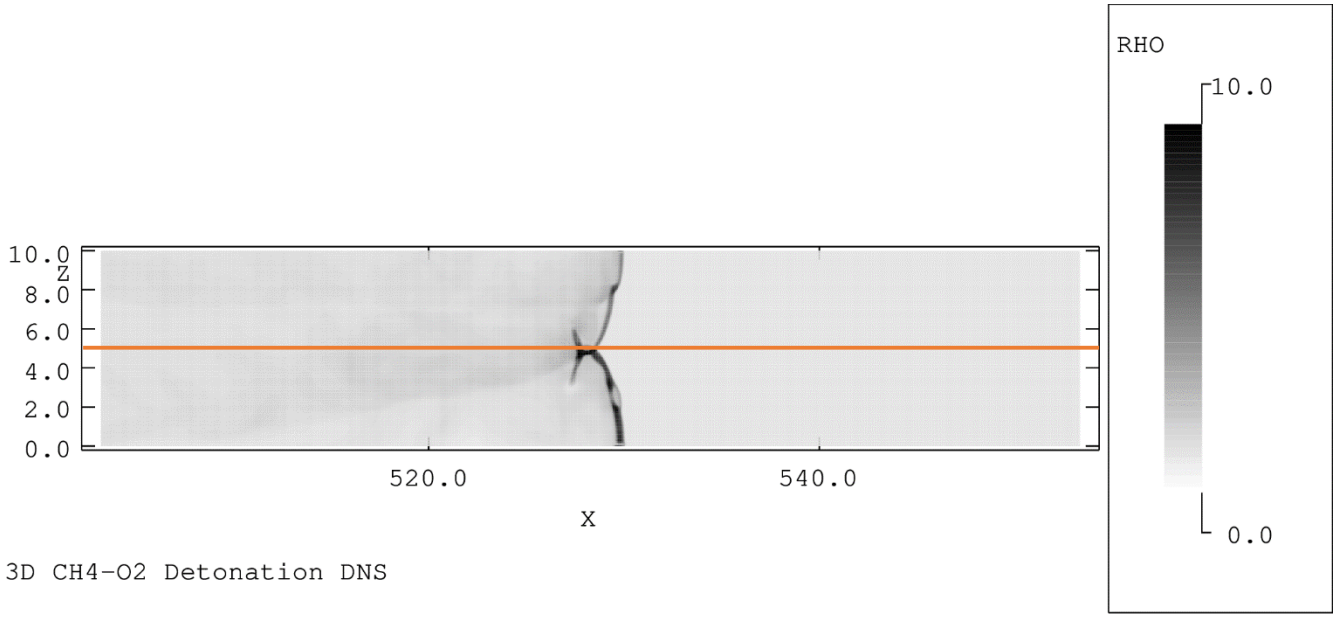


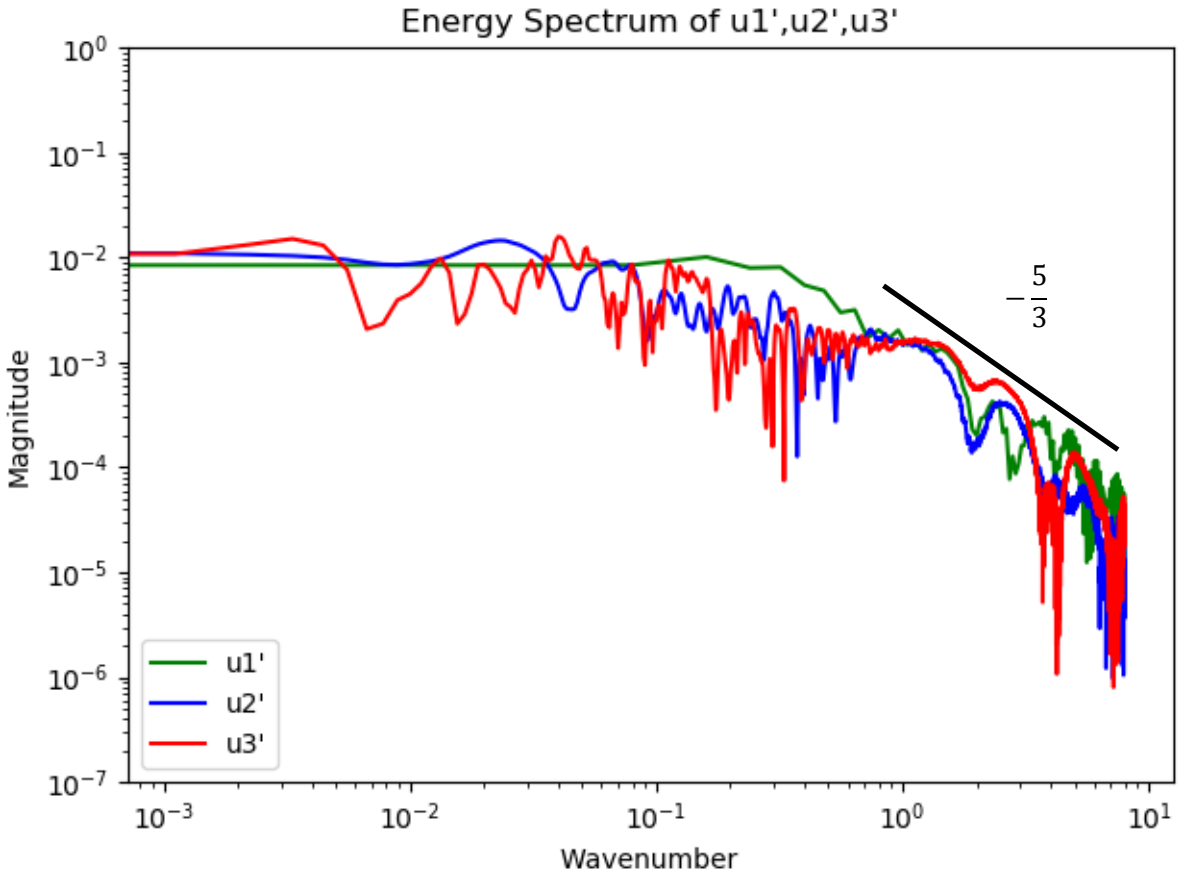


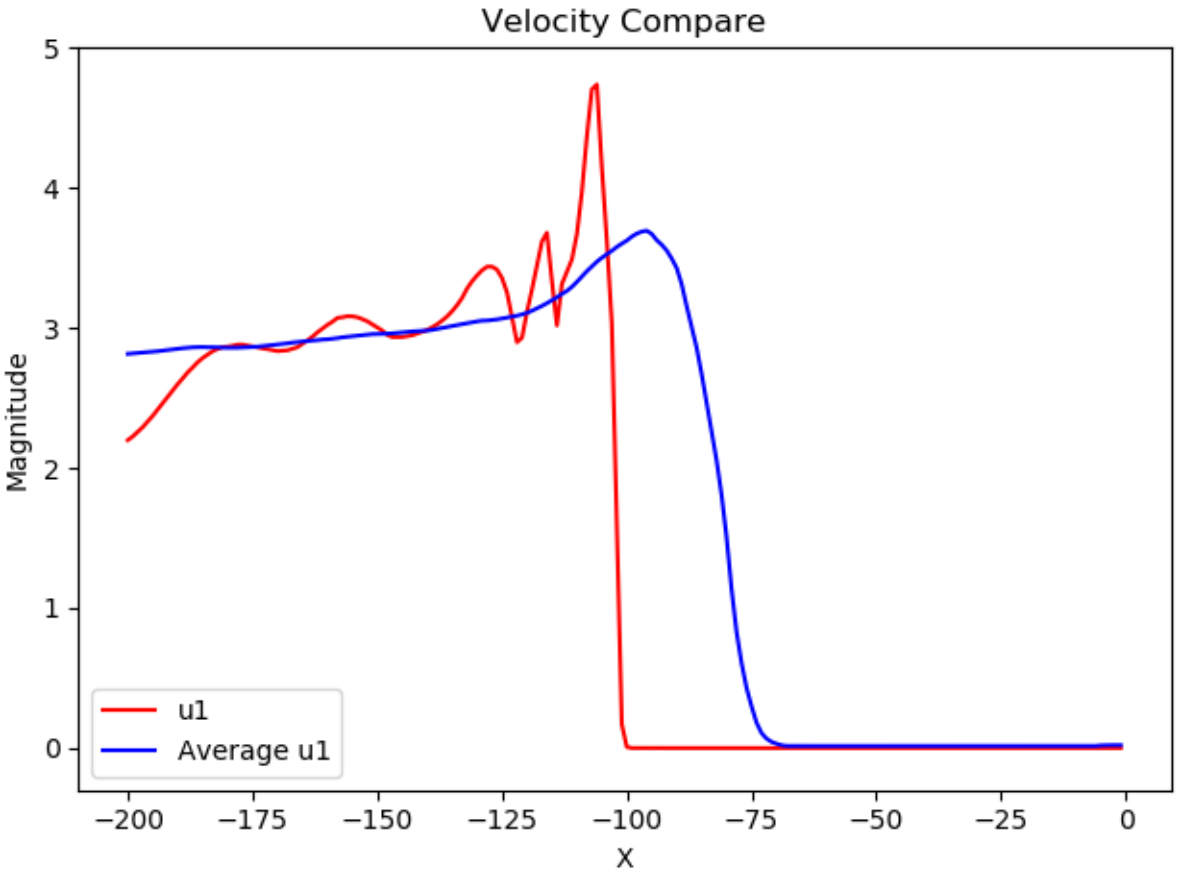

Velocity Compare
Magnitude
X
u1
Average u1
5
4
3
2
1
0
−200
−175
−150
−125
−100
−75
−50
−25
0

For Loop # 204

Position where data extracted: Y = 1, Z = 5 (X towards the end)

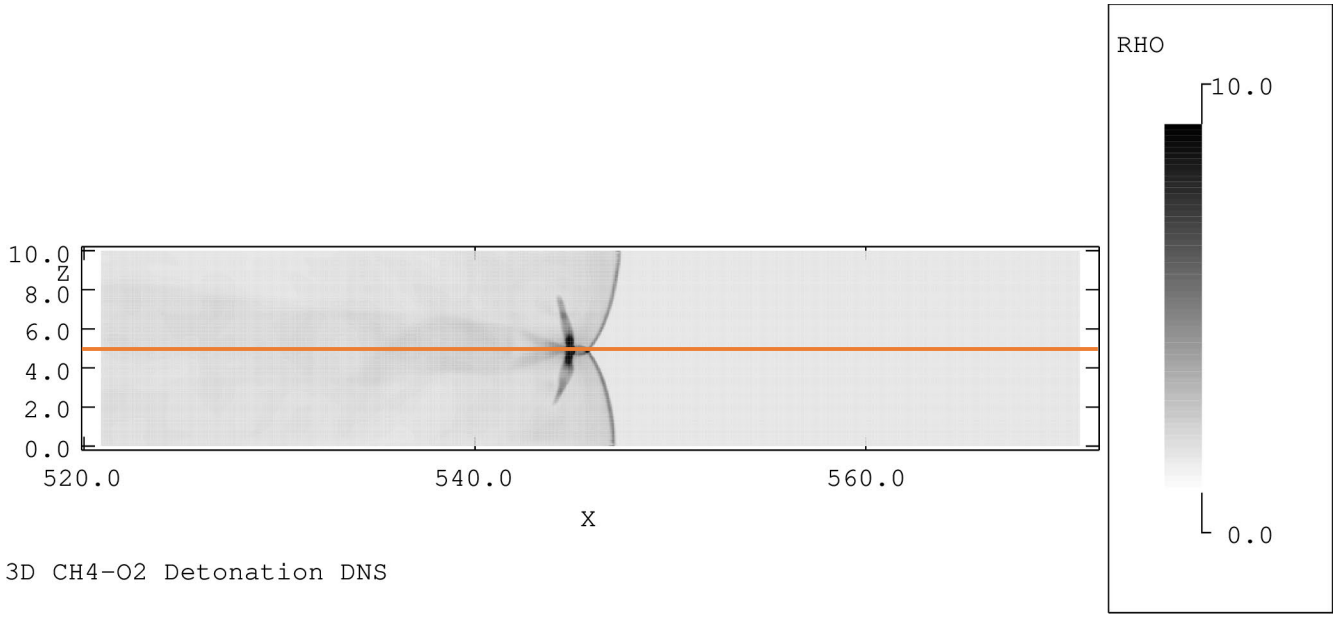


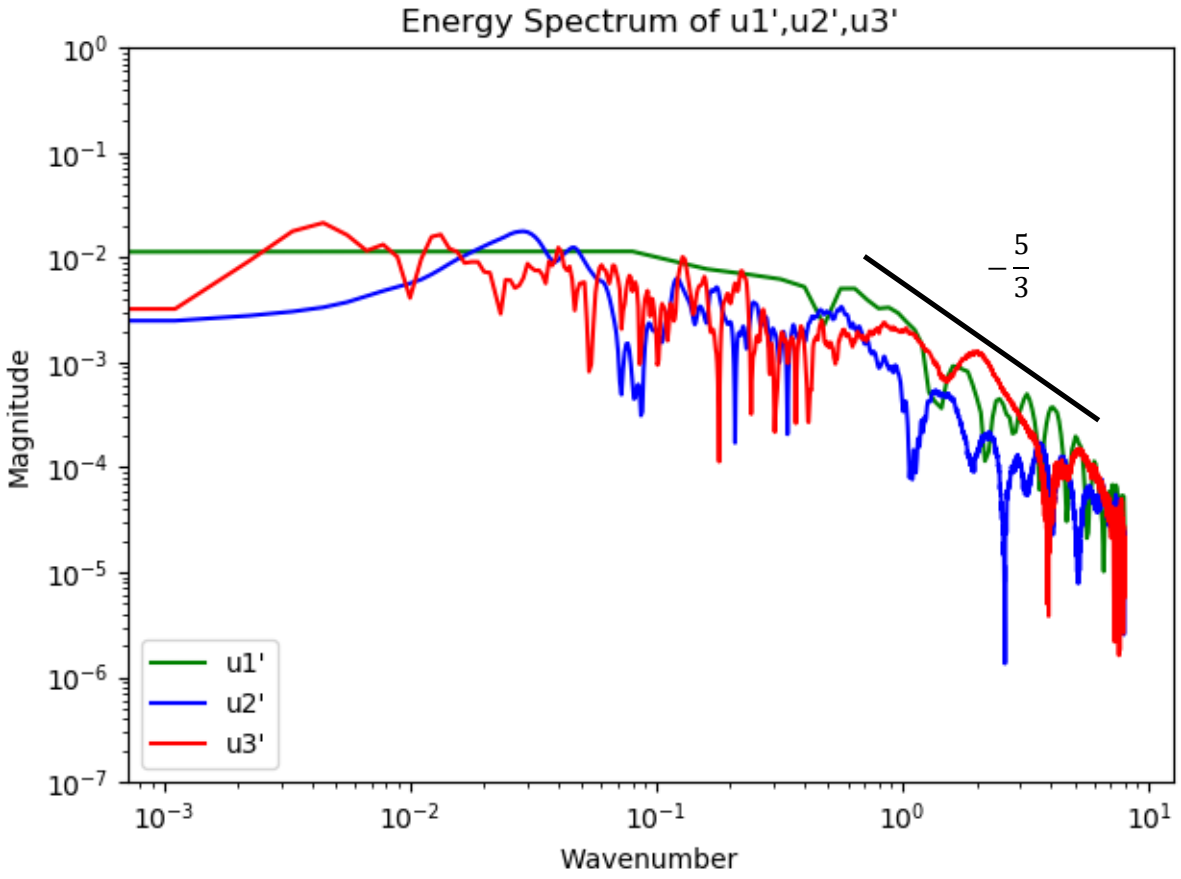


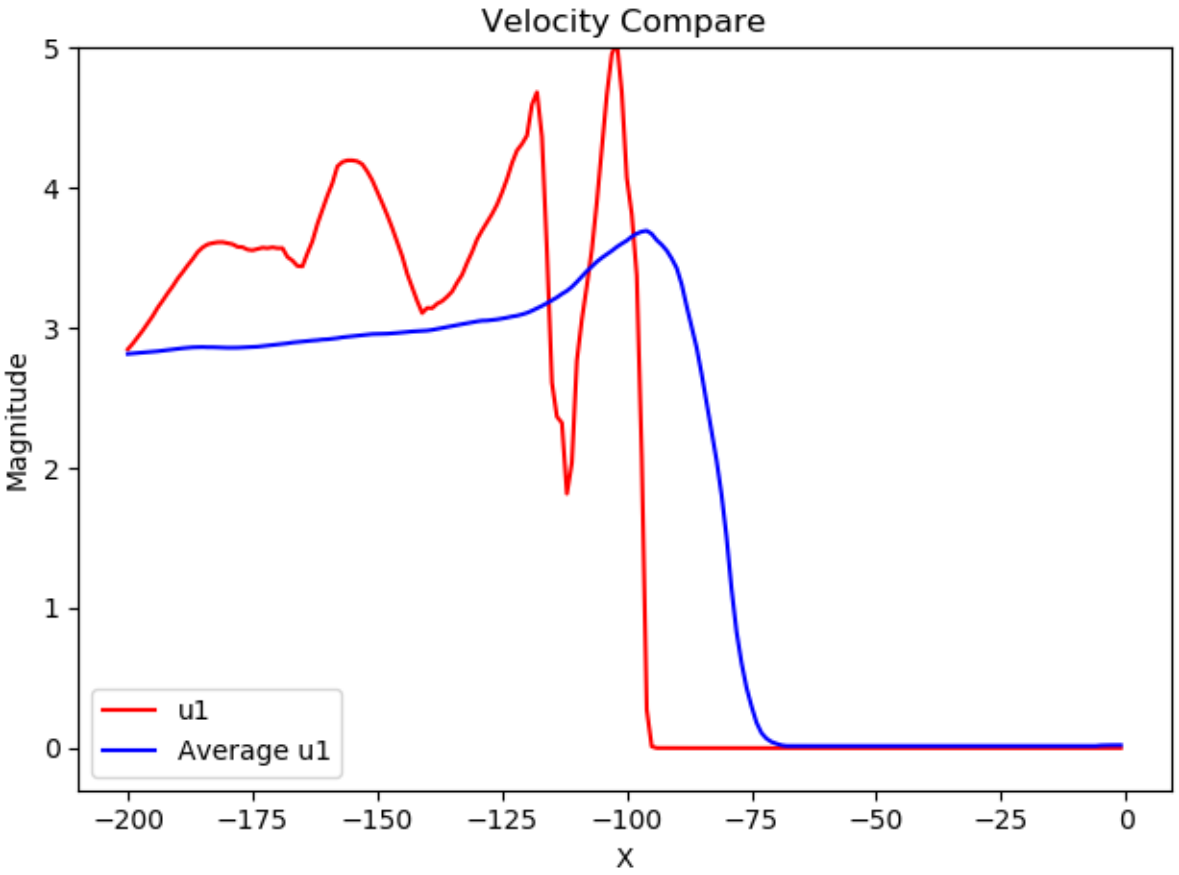

Velocity Compare
Magnitude
X
u1
Average u1
5
4
3
2
1
0
−200
−175
−150
−125
−100
−75
−50
−25
0

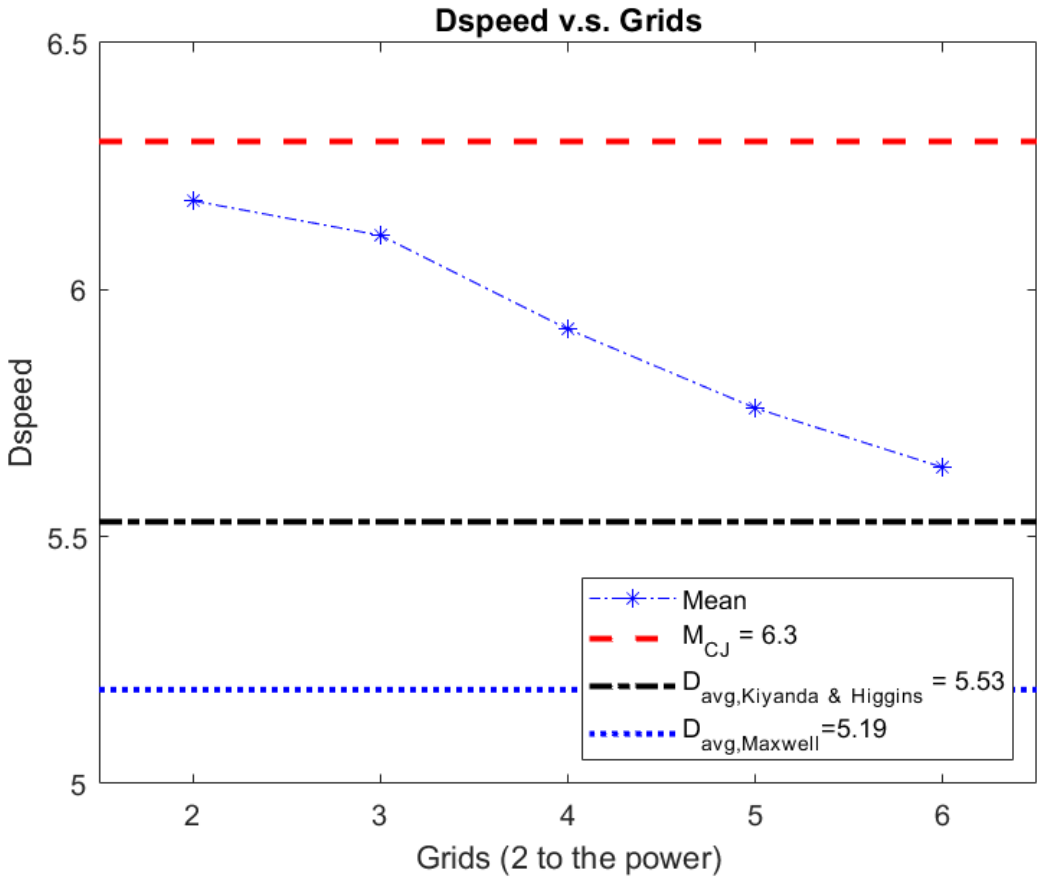
For Loop # 211

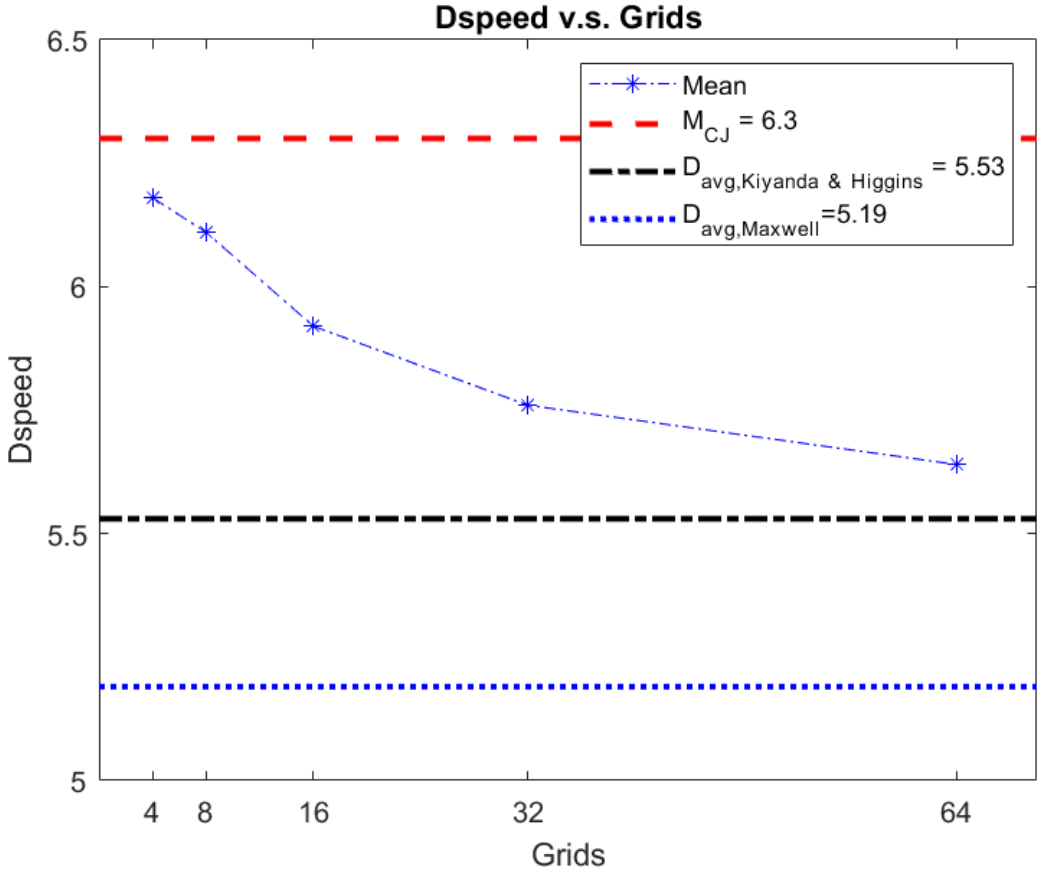
Position where data extracted: Y = 1, Z = 5 (X towards the end)

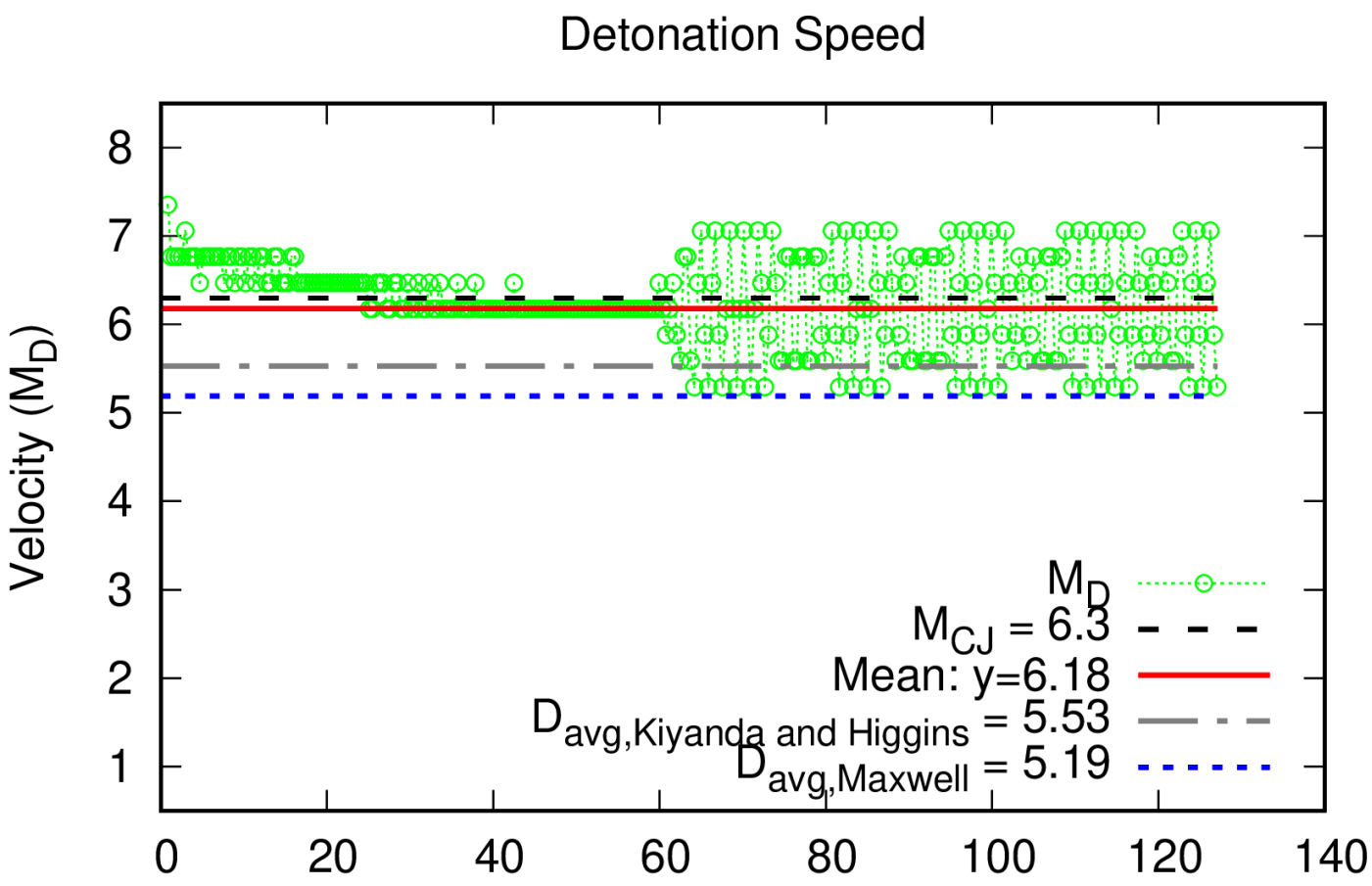


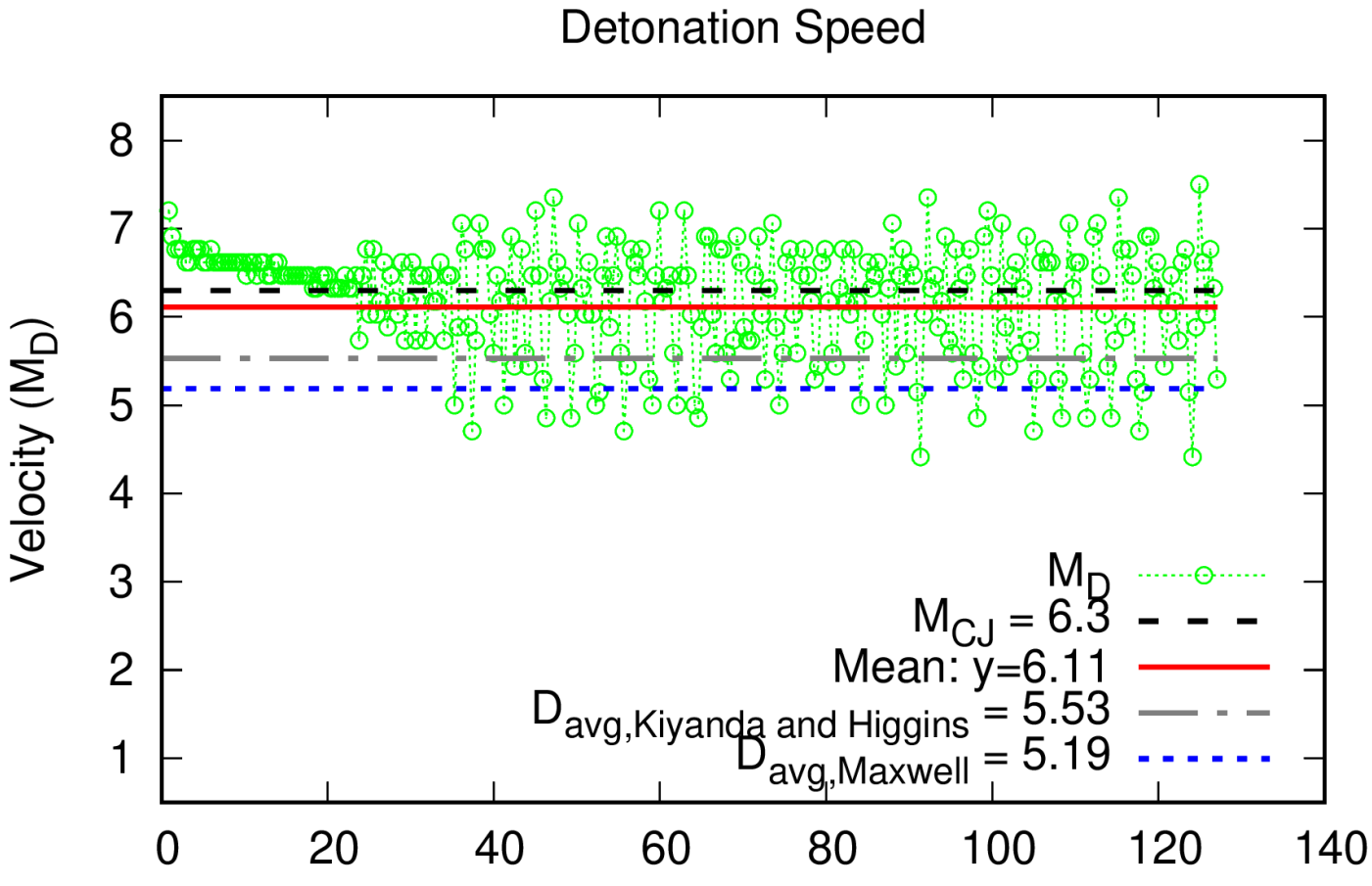


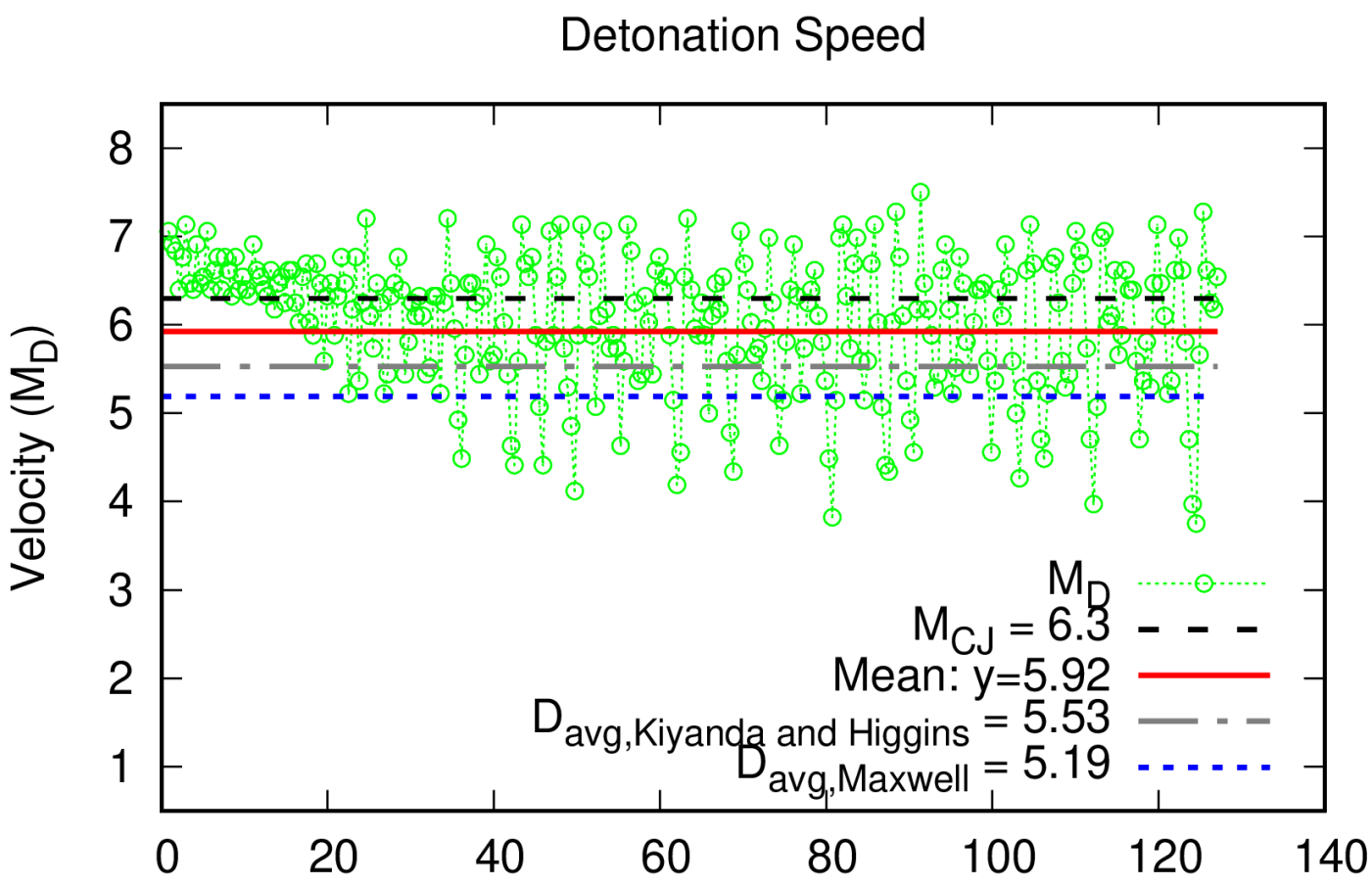

Velocity Compare
Magnitude
X
u1
Average u1
5
4
3
2
1
0
−200
−175
−150
−125
−100
−75
−50
−25
0

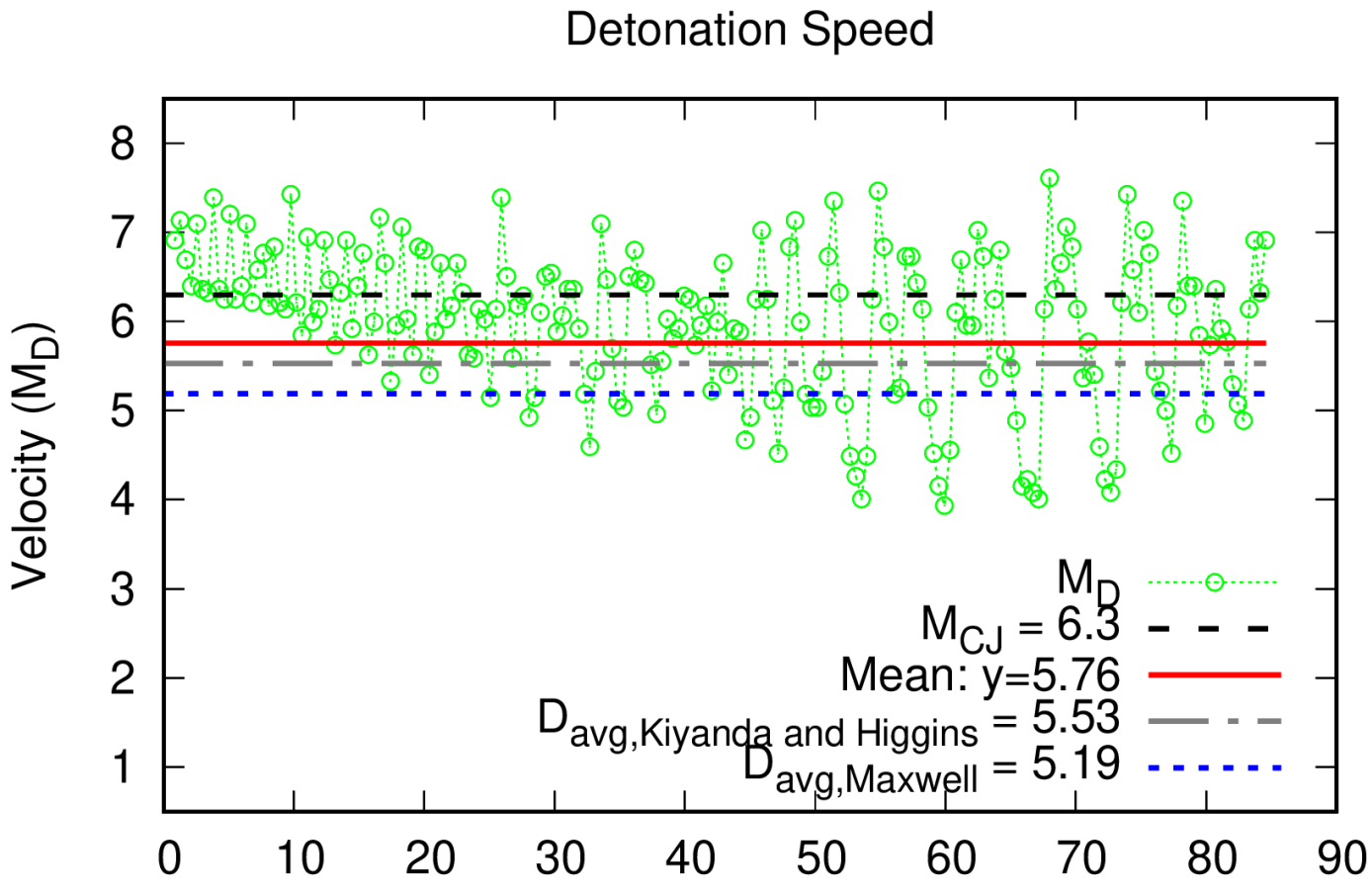

Dspeed v.s. Grids
6.5
6
5.5
5
Dspeed
2
3
4
5
6
Grids (2 to the power)
Mean
M_CJ = 6.3
D_avg,Kiyanda & Higgins = 5.53
D_avg,Maxwell=5.19

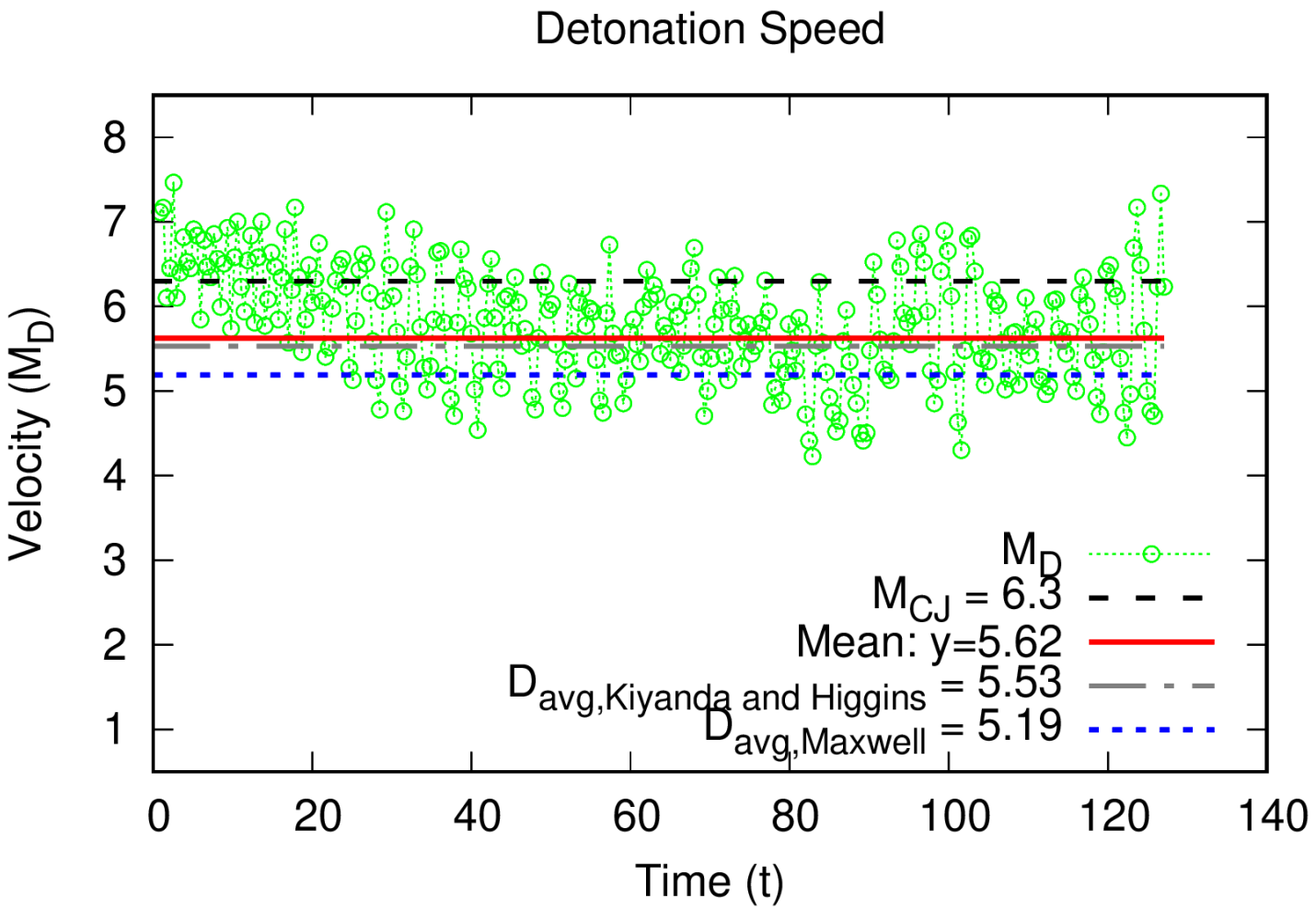

Dspeed v.s. Grids
6.5
6
5.5
5
Dspeed
4
8
16
32
64
Grids
Mean
M_CJ = 6.3
D_avg,Kiyanda & Higgins = 5.53
D_avg,Maxwell=5.19


Detonation Speed
Velocity (M_D)
8
7
6
5
4
3
2
1
0
20
40
60
80
100
120
140
M_D
M_{CJ} = 6.3
Mean: y=6.18
$D_{avg,Kiyanda\ and\ Higgins}$ = 5.53
$D_{avg,Maxwell}$ = 5.19


Detonation Speed
Velocity (M_D)
8
7
6
5
4
3
2
1
0
20
40
60
80
100
120
140
M_D
M_{CJ} = 6.3
Mean: y=6.11
$D_{avg,Kiyanda\ and\ Higgins}$ = 5.53
$D_{avg,Maxwell}$ = 5.19


Detonation Speed
Velocity (M_D)
M_D
M_{CJ} = 6.3
Mean: y=5.92
$D_{avg,Kiyanda\ and\ Higgins}$ = 5.53
$D_{avg,Maxwell}$ = 5.19


Detonation Speed
Velocity (M_D)
M_D
M_{CJ} = 6.3
Mean: y=5.76
$D_{avg,Kiyanda\ and\ Higgins}$ = 5.53
$D_{avg,Maxwell}$ = 5.19

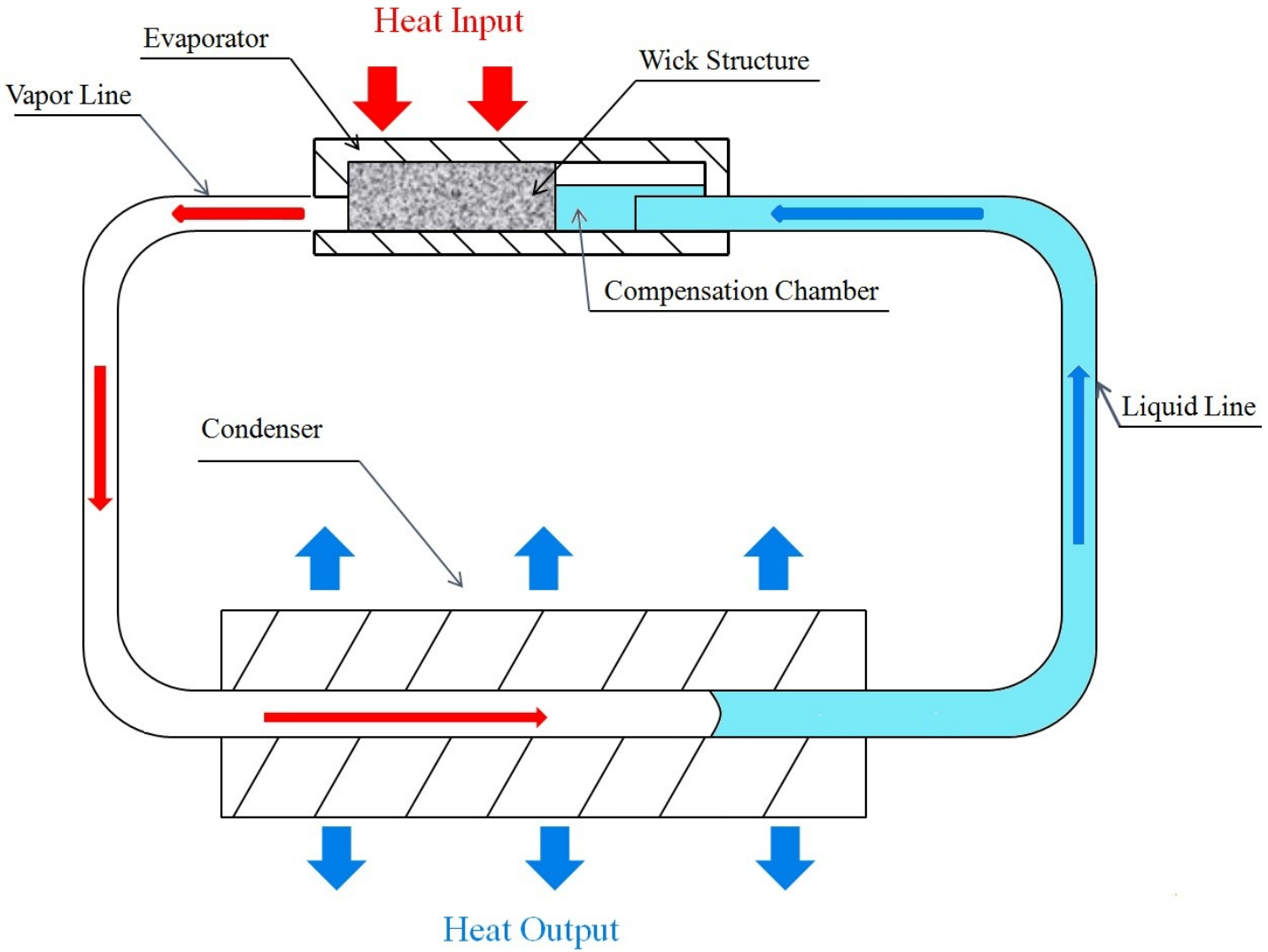

Detonation Speed
Velocity (M_D)
Time (t)
M_D
M_{CJ} = 6.3
Mean: y=5.62
$D_{avg,Kiyanda\ and\ Higgins}$ = 5.53
$D_{avg,Maxwell}$ = 5.19
0
20
40
60
80
100
120
140
1
2
3
4
5
6
7
8

The Study of the Effect of Flow Rate for Hybrid Flat Plate Loop Heat Pipe

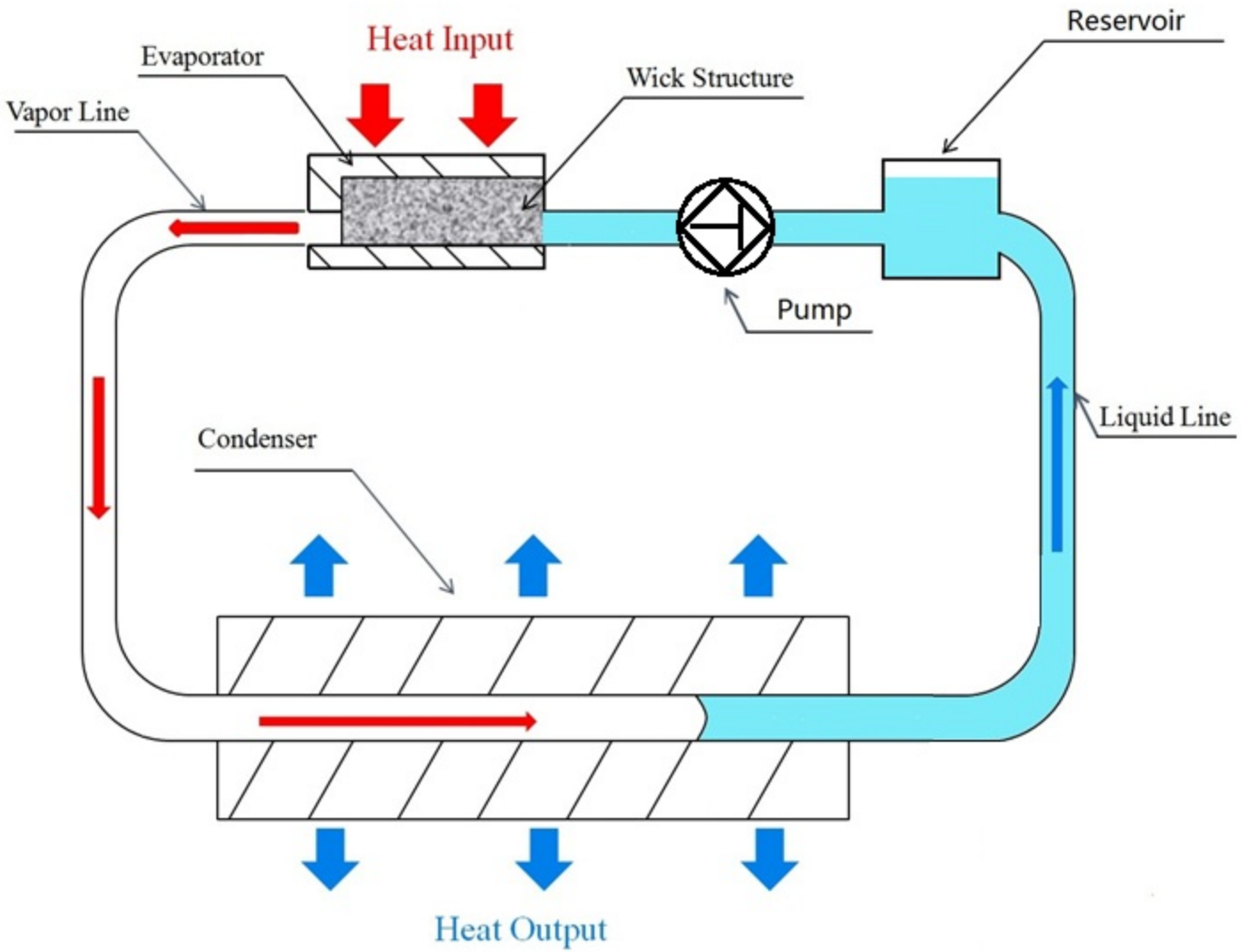
Master Thesis

Wei Hao Wang

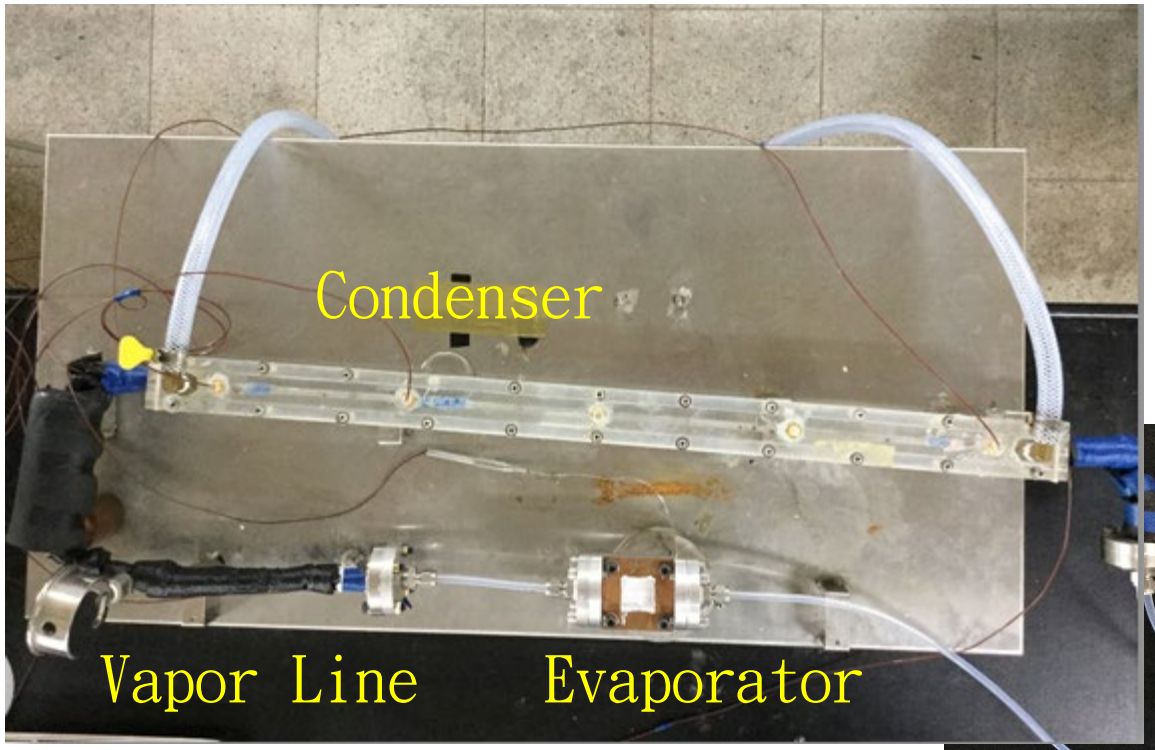
Traditional Flat Plate Loop Heat Pipe

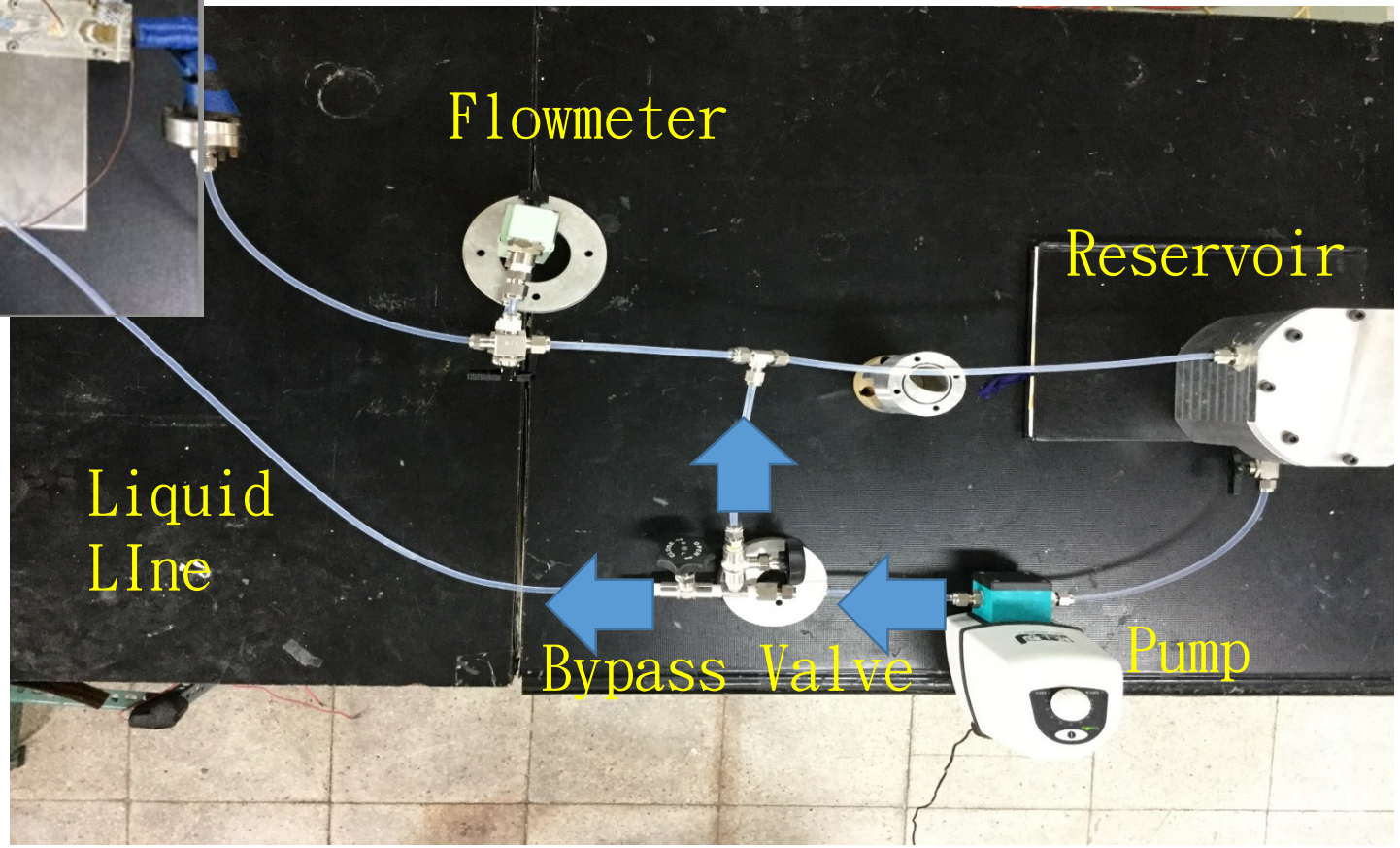


Hybrid Flat Plate Loop Heat Pipe



Hybrid Flat Plate Loop Heat Pipe Testing System





Testing System Parameters

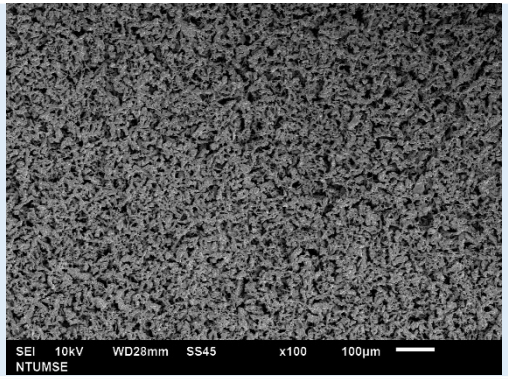
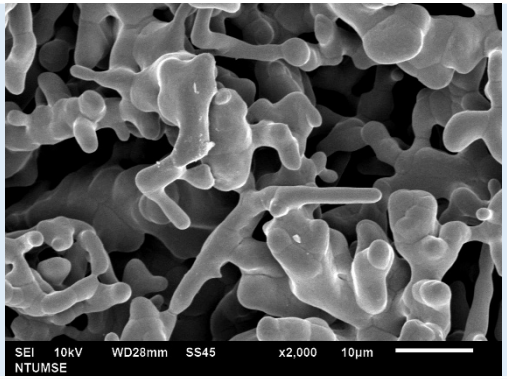
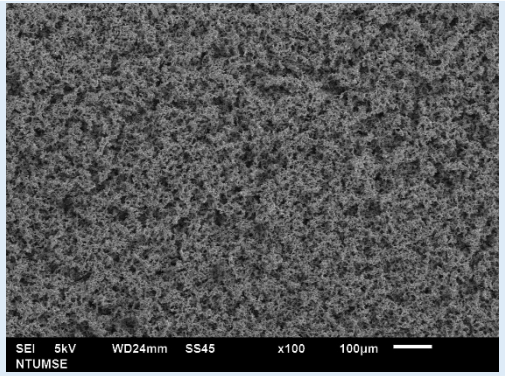
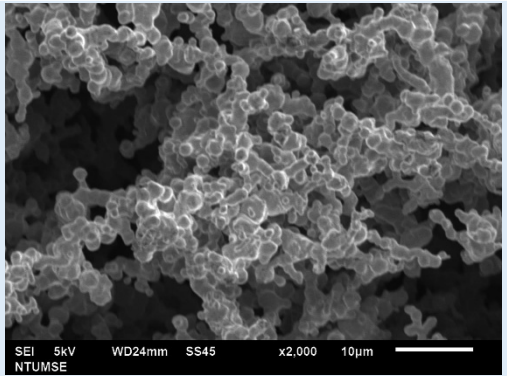
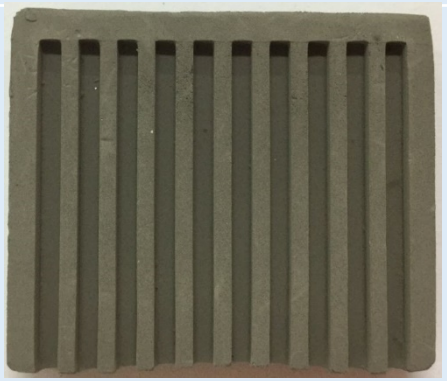
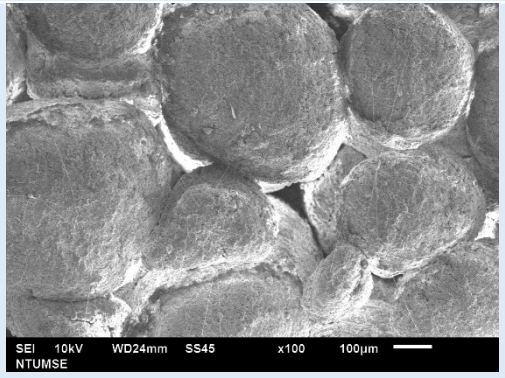
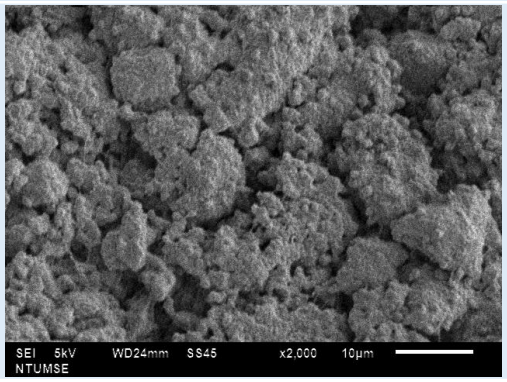
Hybrid Loop Heat Pipe System Dimension			
Working fluid	Acetone	Ambient temperature(C)	20~25
Total Length (mm)	3580	Heat load(W)	100~500
Evaporator		**Condenser**	
Length(mm)	80	Length(mm)	800
Width(mm)	60	O.D/I.D(mm)	6/4
Thickness(mm)	50	Sink Temperature(C)	15
Vapor line		**Liquid line**	
Length(mm)	700	Length(mm)	2000
O.D/I.D(mm)	6/4	O.D/I.D(mm)	6/4
Reservoir		**Pump**	
Volume(cm^3)	900	Flow rate(L/min)	0.05-3
Wick			
Material	Cooper	Nickel	PTFE
Pore radius(μm)	8.4	3.6	4.2
Permeability(m^2)	10^{-13}	10^{-13}	10^{-11}~10^{-12}
Porosity(%)	64.8	81.4	40.8
Length(mm)	40	40	40
Width(mm)	35	35	35
Thickness(mm)	6	6	6

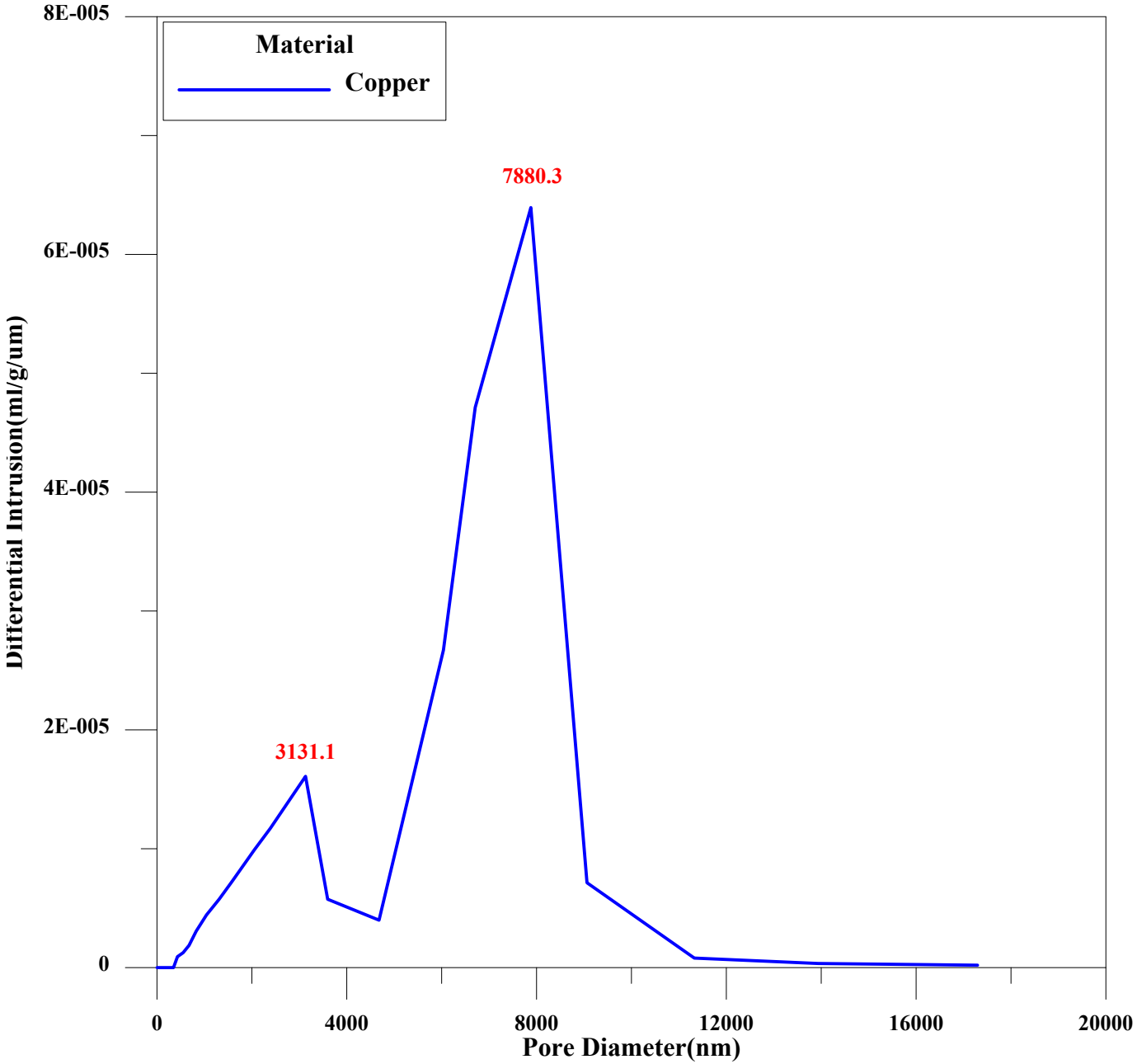
Wick Structure Important Parameters

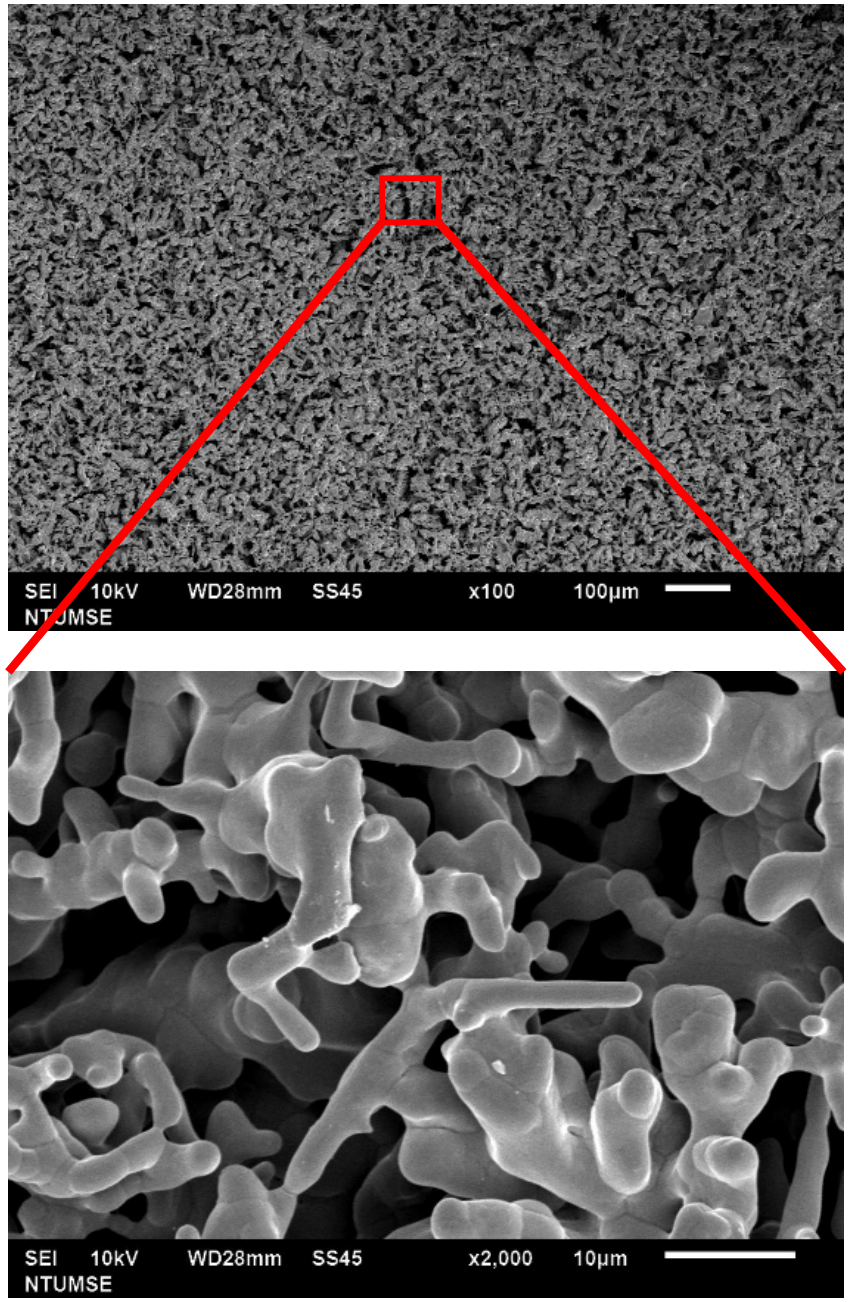
Material	Nickel	Copper	PTFE
Pore radius(μm)	3.6	8.4	4.2
Porosity(%)	81.4	64.8	40.8
Permeability (m^2)	10^{-12}~10^{-13}	10^{-12}~10^{-13}	10^{-11}~10^{-12}

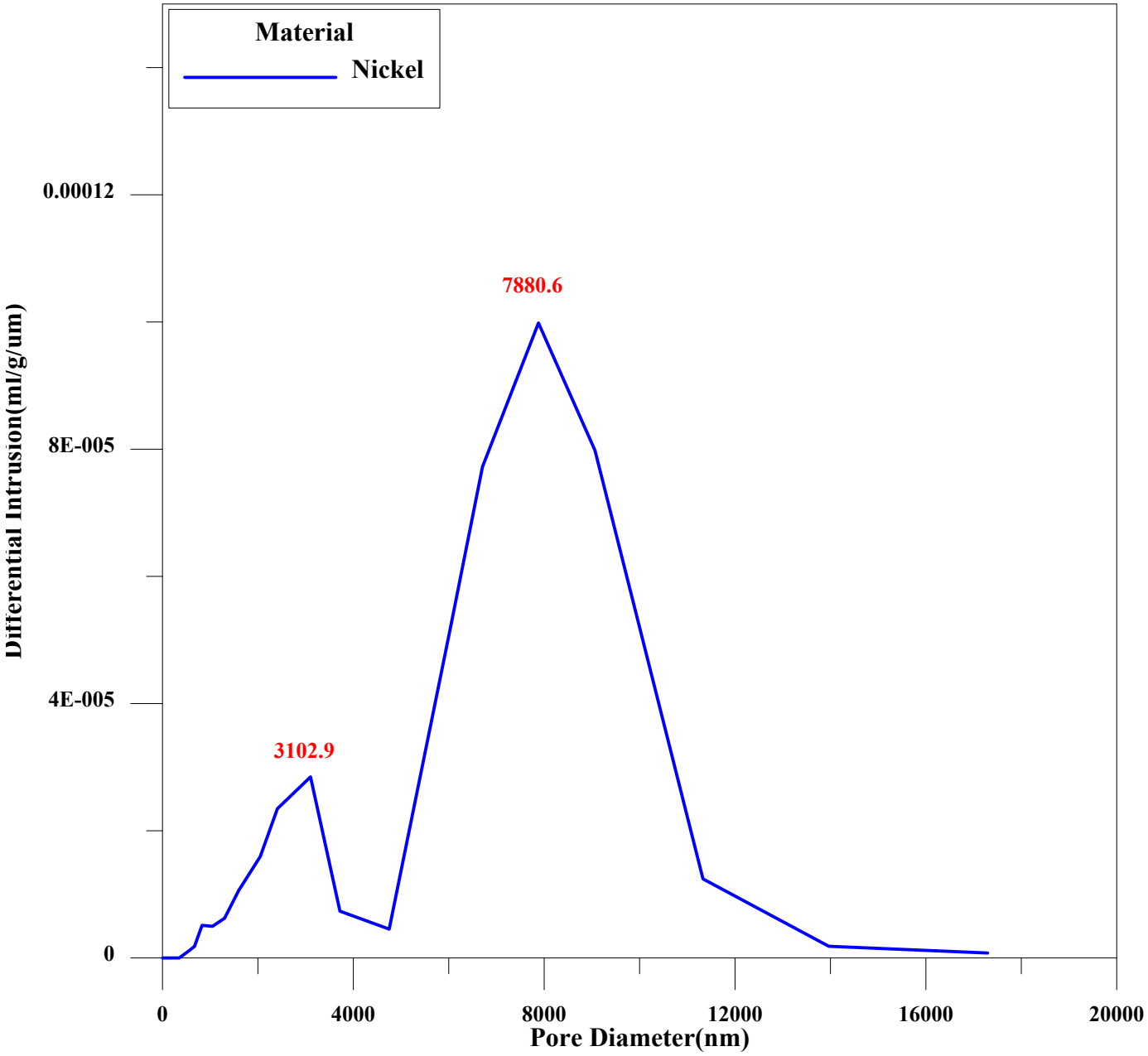
Pore radius(μm)	Porosity(%)	Permeability(m^2)
$r_c = \frac{-2\sigma cos\theta}{P}$	$\varepsilon = \frac{V_{pore}}{V_{total}} = \frac{m_2 - m_1}{\rho V_{total}}$	$K_w = \frac{\mu \dot{m}}{2\pi \rho_{air} \Delta P L_w} \ln(\frac{D_o}{D_i})$

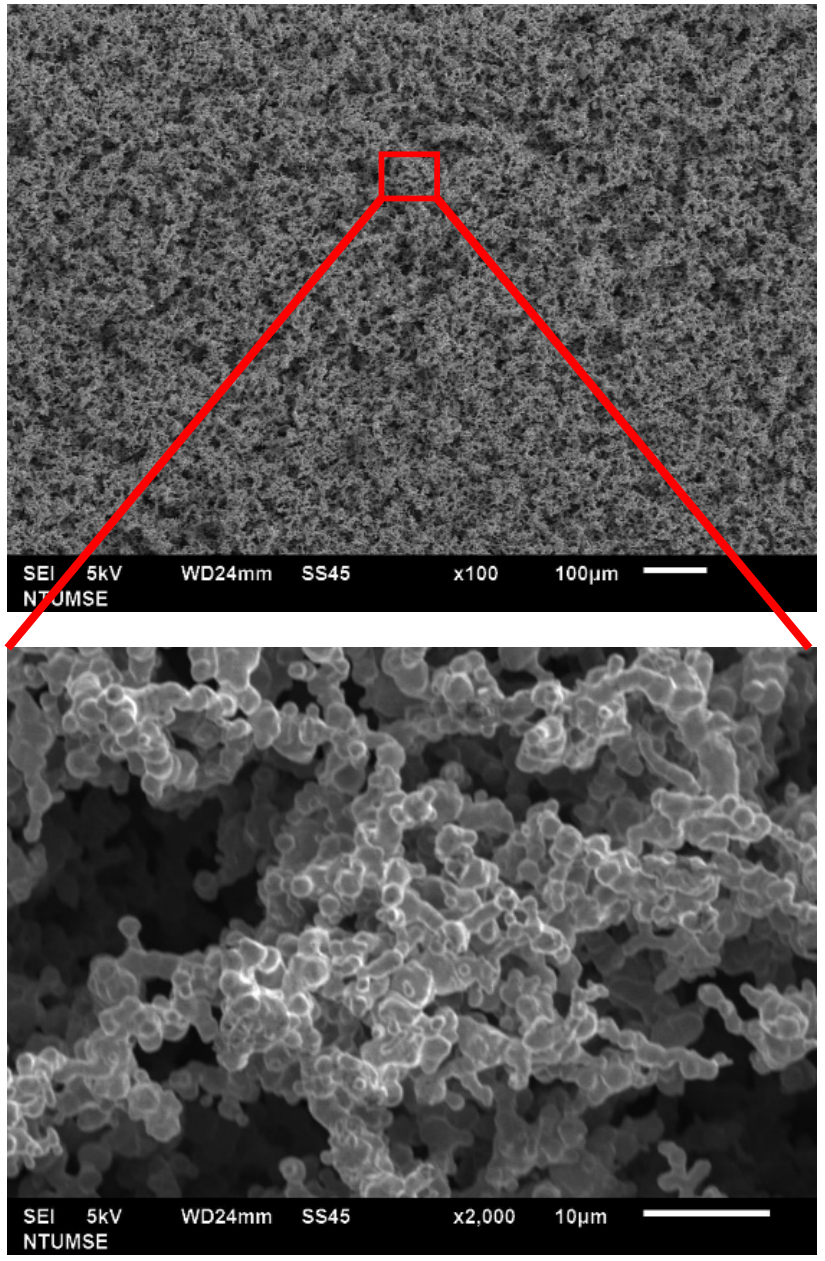
Wick Structure SEM

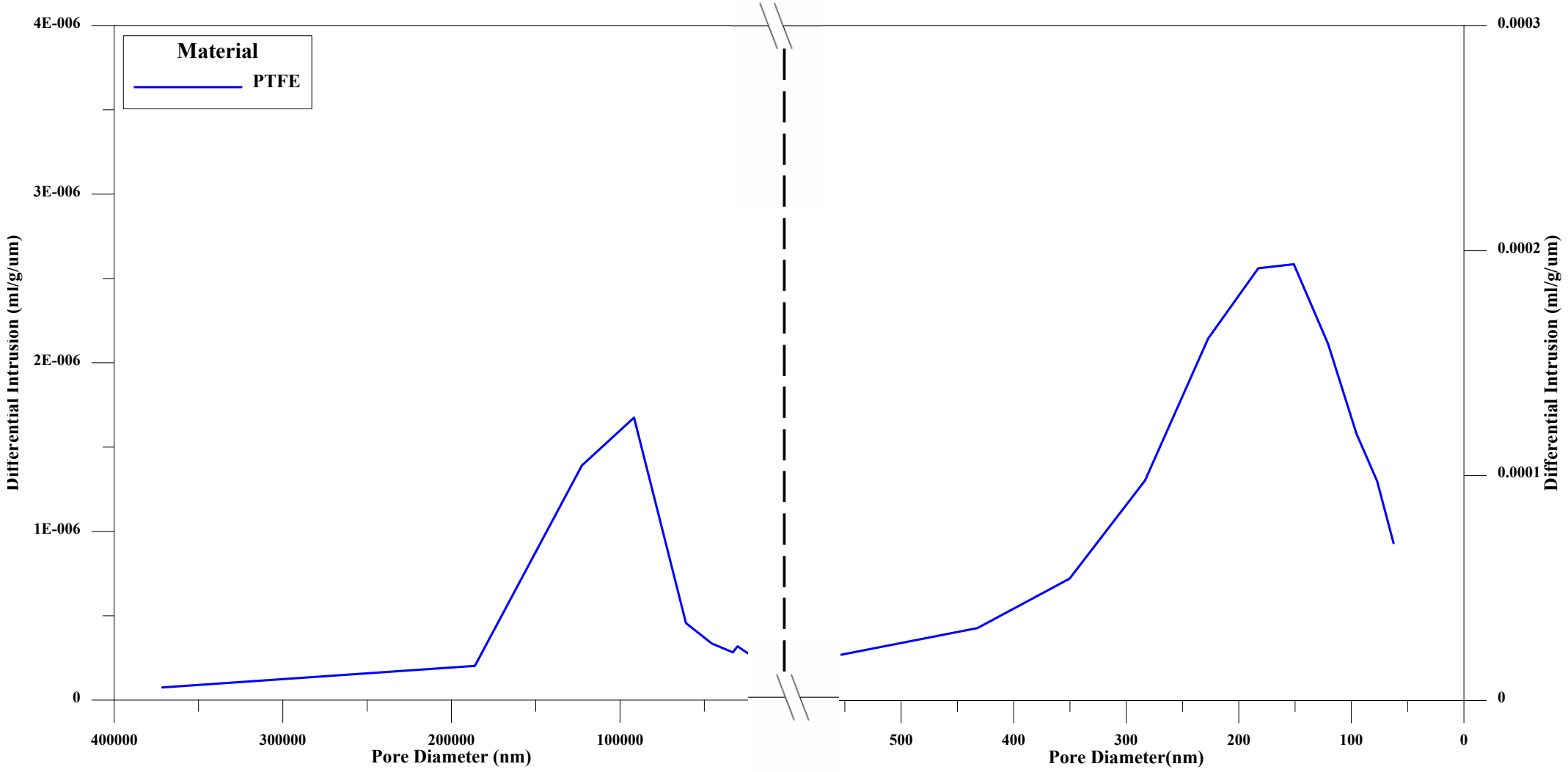
	SEM(x100)	SEM(x2000)	Normal Picture
Copper			
Nickel			
PTFE			

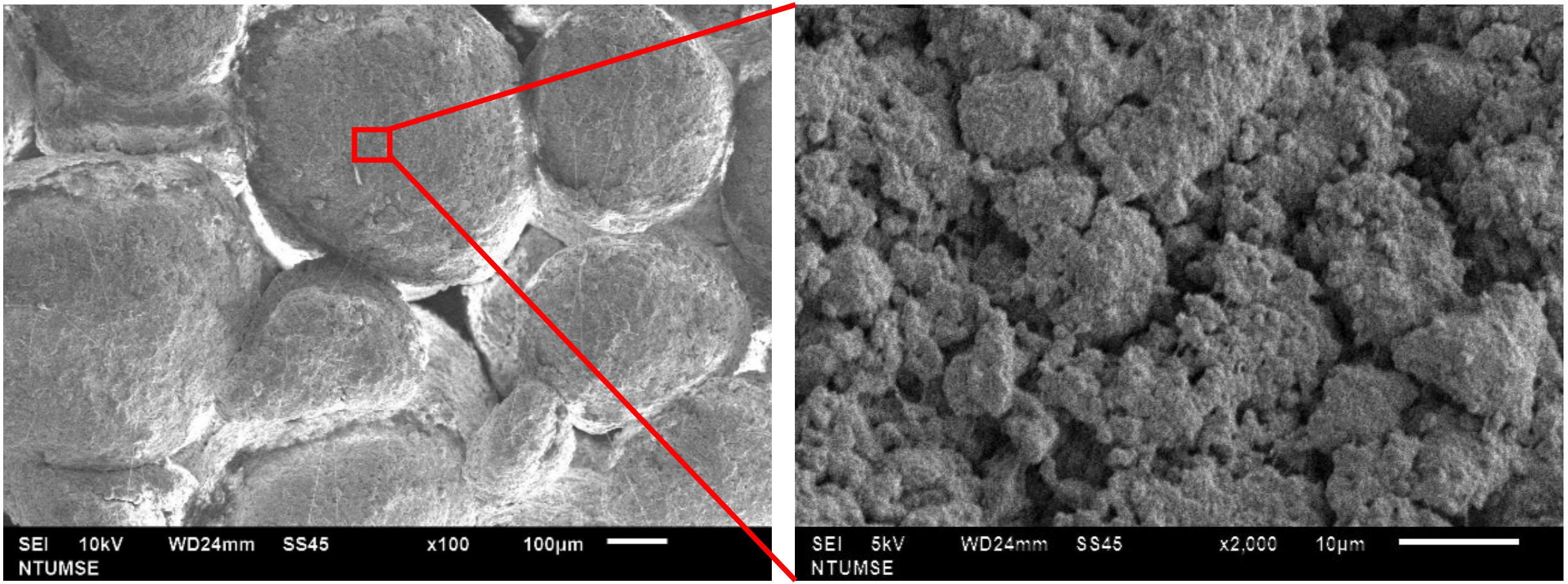

Material
Copper
8E-005
6E-005
4E-005
2E-005
0
Differential Intrusion(ml/g/um)
7880.3
3131.1
0
4000
8000
12000
16000
20000
Pore Diameter(nm)


SEI 10kV WD28mm SS45 x100 100µm
NTUMSE
SEI 10kV WD28mm SS45 x2,000 10µm
NTUMSE


Material
Nickel
0.00012
8E-005
4E-005
0
7880.6
3102.9
Differential Intrusion(ml/g/um)
0
4000
8000
12000
16000
20000
Pore Diameter(nm)


SEI 5kV WD24mm SS45 x100 100µm
NTUMSE
SEI 5kV WD24mm SS45 x2,000 10µm
NTUMSE

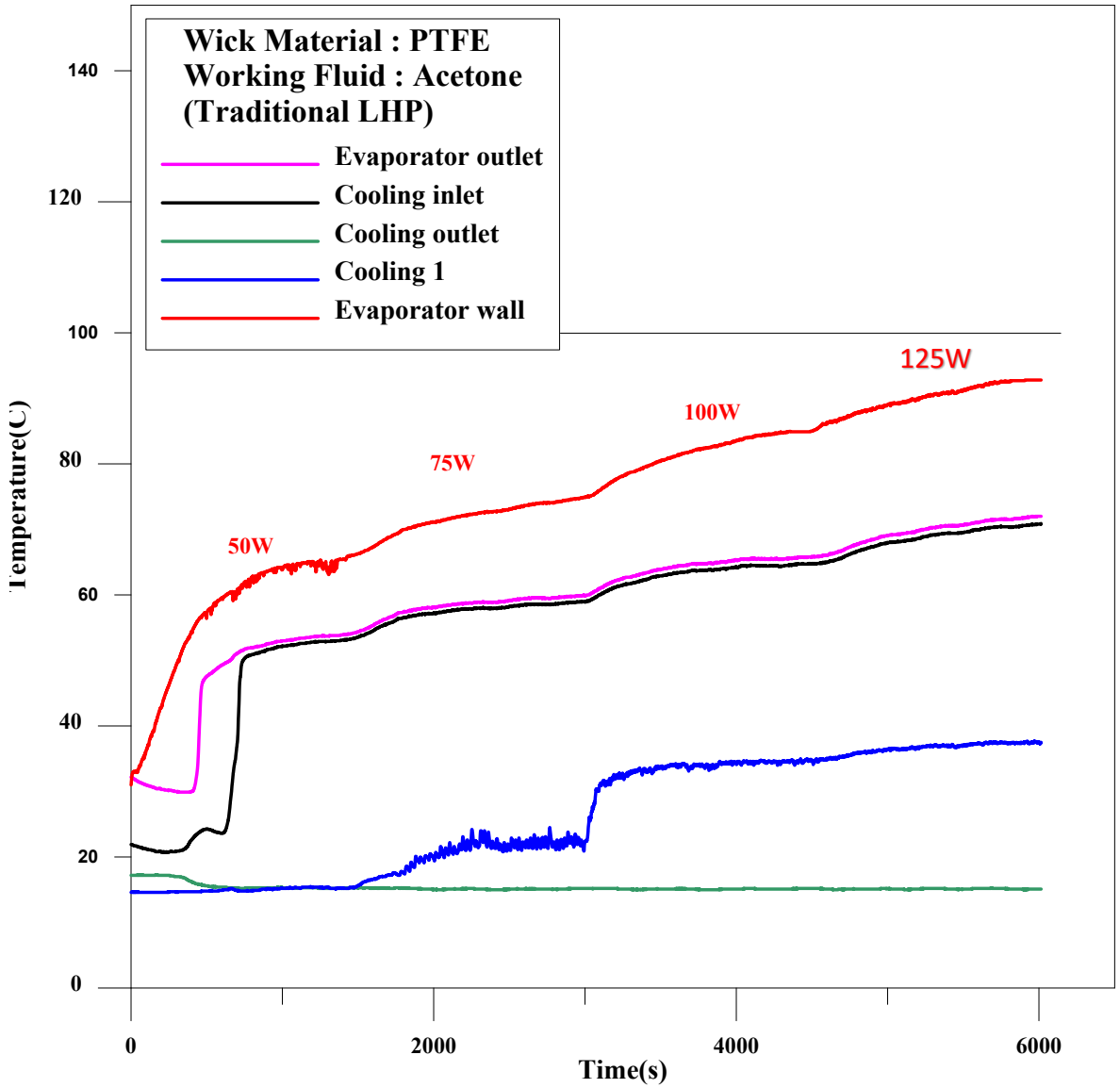

Material
PTFE
4E-006
3E-006
2E-006
1E-006
0
Differential Intrusion (ml/g/um)
400000
300000
200000
100000
Pore Diameter (nm)
0.0003
0.0002
0.0001
0
Differential Intrusion (ml/g/um)
500
400
300
200
100
0
Pore Diameter(nm)

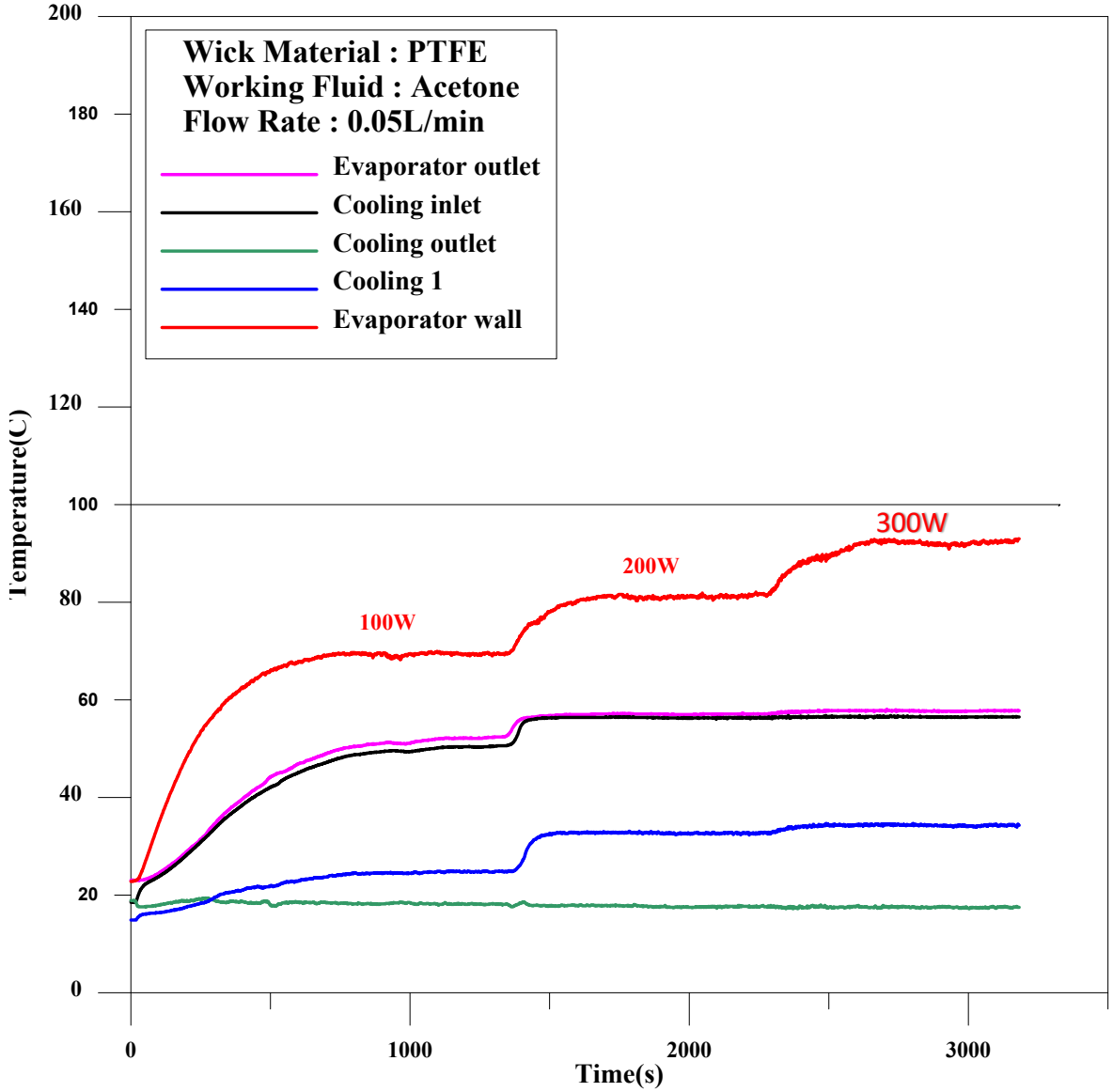

SEI 10kV WD24mm SS45 x100 100µm
NTUMSE
SEI 5kV WD24mm SS45 x2,000 10µm
NTUMSE

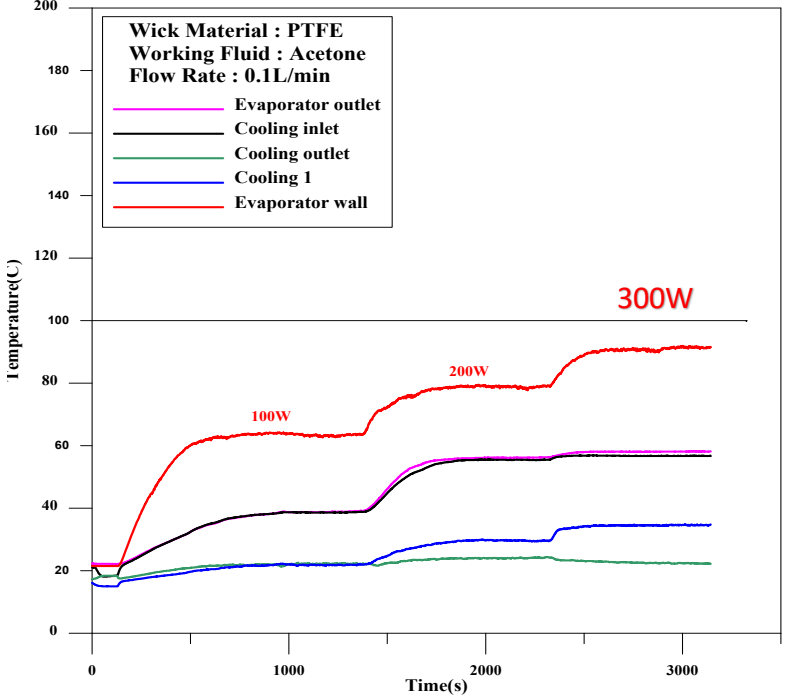
Hybrid Flat Plate Loop Heat Pipe Testing Results

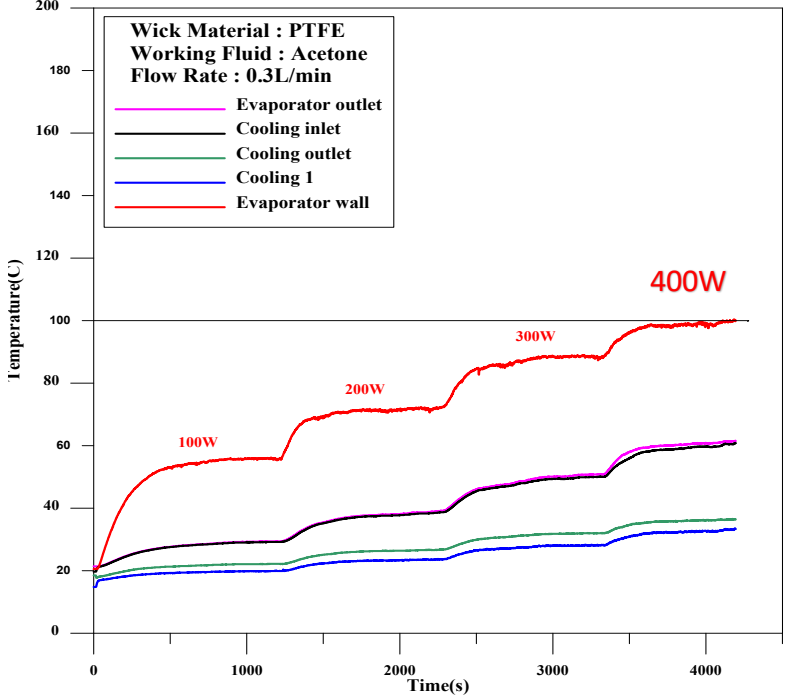
Testing list

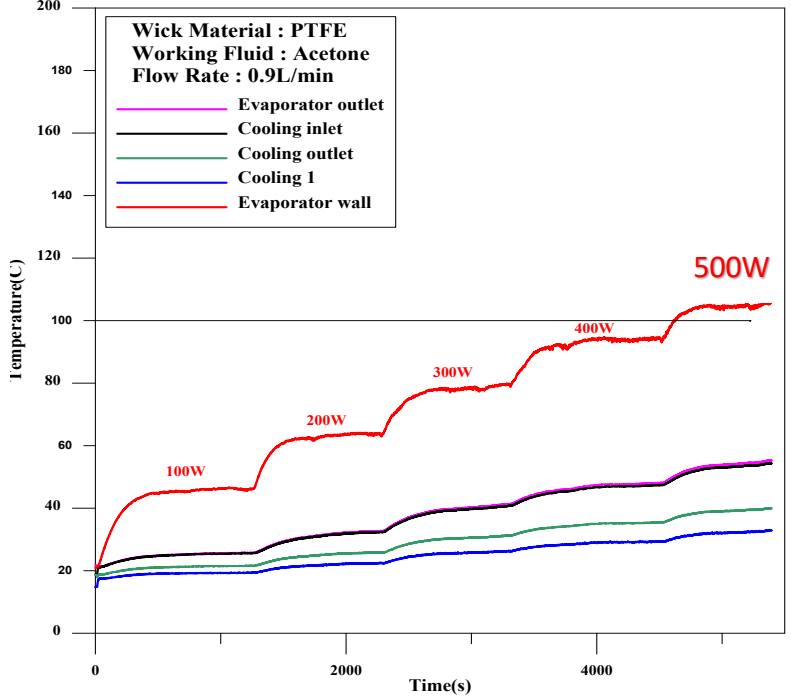
	Traditional	0.05L/min	0.1L/min	0.3L/min	0.9L/min	1.5L/min	2.1L/min	2.7L/min
PTFE	√	√	√	√	√	√	√	√
Cu	√	√	√	√	√	√	√	√
Ni	√	√	√	√	√	√	√	√
Without wick	X	√	√	√	√	√	√	√

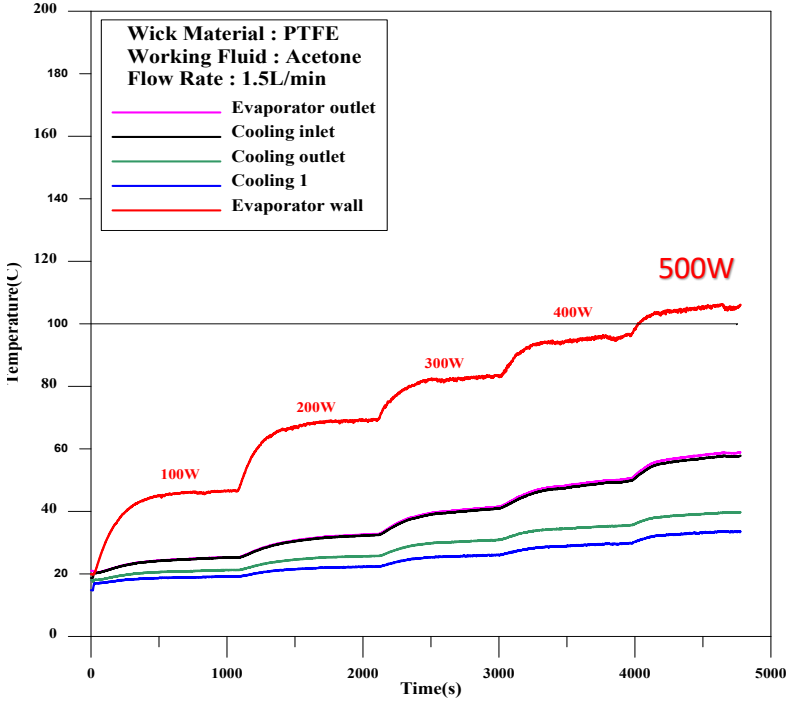

Wick Material : PTFE
Working Fluid : Acetone
(Traditional LHP)
Evaporator outlet
Cooling inlet
Cooling outlet
Cooling 1
Evaporator wall
50W
75W
100W
125W
Temperature(C)
Time(s)
0
20
40
60
80
100
120
140
0
2000
4000
6000

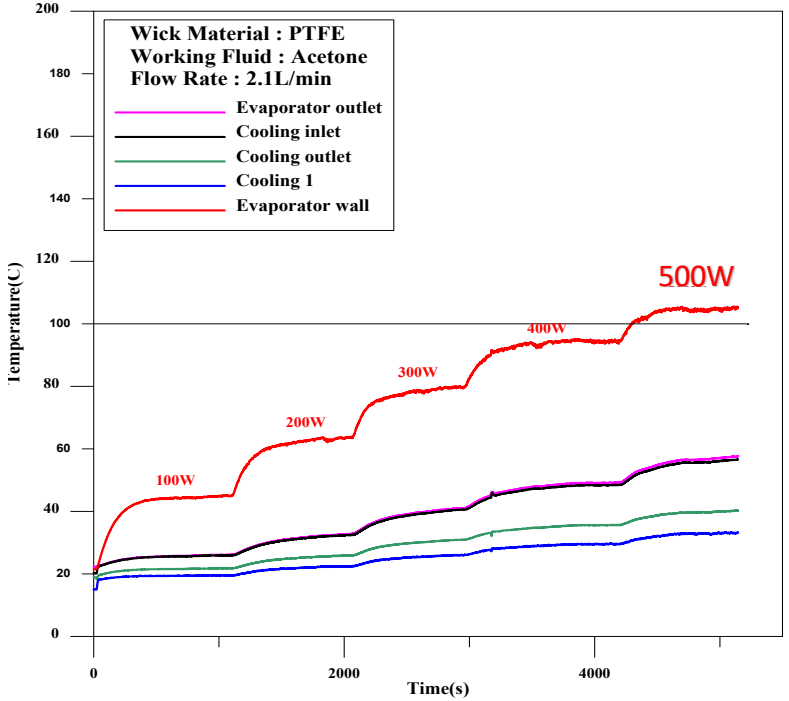

Wick Material : PTFE
Working Fluid : Acetone
Flow Rate : 0.05L/min
Evaporator outlet
Cooling inlet
Cooling outlet
Cooling 1
Evaporator wall
100W
200W
300W
Temperature(C)
Time(s)
0
20
40
60
80
100
120
140
160
180
200
0
1000
2000
3000

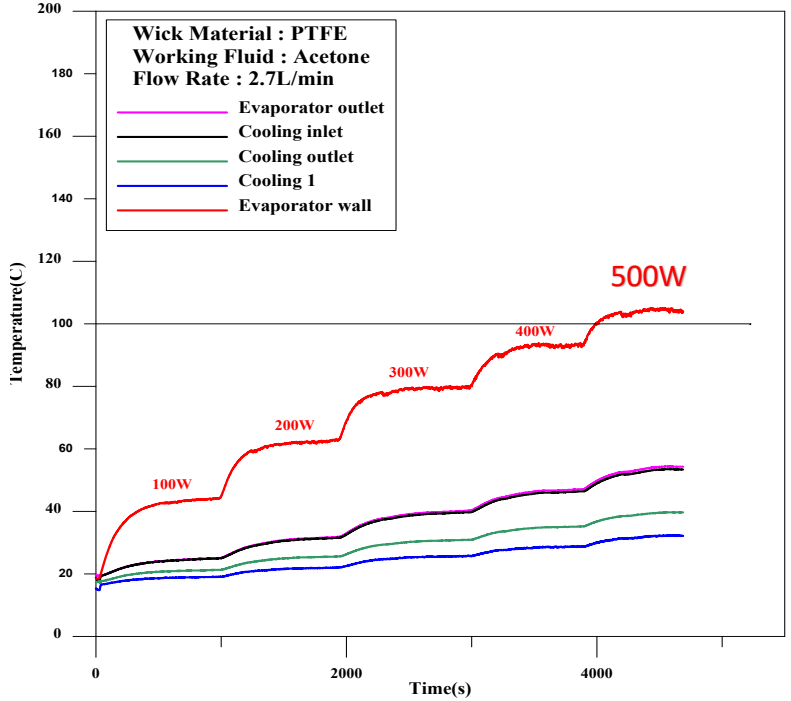

Wick Material : PTFE
Working Fluid : Acetone
Flow Rate : 0.1L/min
Evaporator outlet
Cooling inlet
Cooling outlet
Cooling 1
Evaporator wall
300W
200W
100W
Temperature(C)
Time(s)


Wick Material : PTFE
Working Fluid : Acetone
Flow Rate : 0.3L/min
Evaporator outlet
Cooling inlet
Cooling outlet
Cooling 1
Evaporator wall
400W
300W
200W
100W
Temperature(C)
Time(s)


Wick Material : PTFE
Working Fluid : Acetone
Flow Rate : 0.9L/min
Evaporator outlet
Cooling inlet
Cooling outlet
Cooling 1
Evaporator wall
500W
400W
300W
200W
100W
Temperature(C)
Time(s)


Wick Material : PTFE
Working Fluid : Acetone
Flow Rate : 1.5L/min
Evaporator outlet
Cooling inlet
Cooling outlet
Cooling 1
Evaporator wall
500W
400W
300W
200W
100W
Temperature(C)
Time(s)

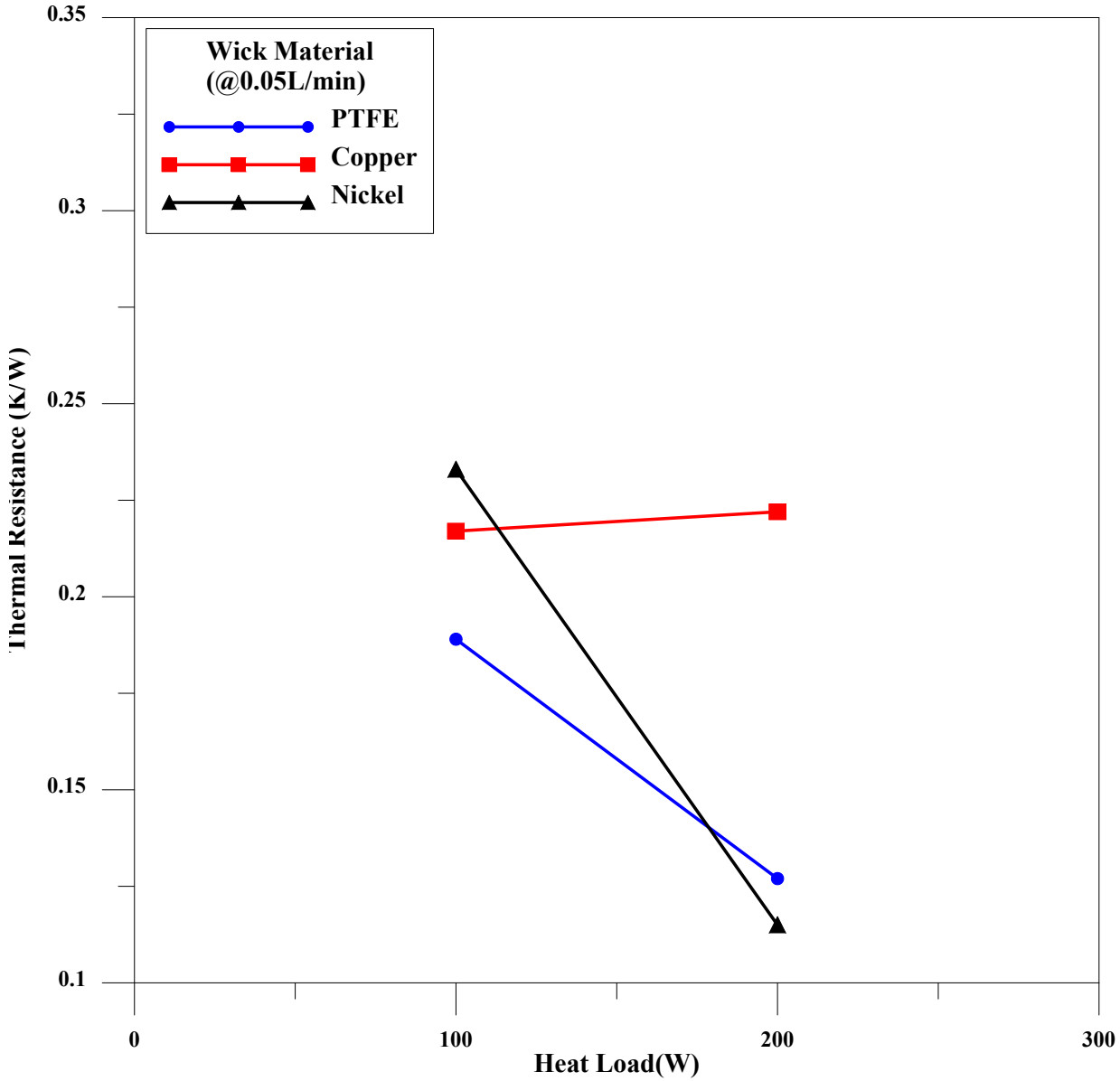

Wick Material : PTFE
Working Fluid : Acetone
Flow Rate : 2.1L/min
Evaporator outlet
Cooling inlet
Cooling outlet
Cooling 1
Evaporator wall
500W
400W
300W
200W
100W
Temperature(C)
Time(s)

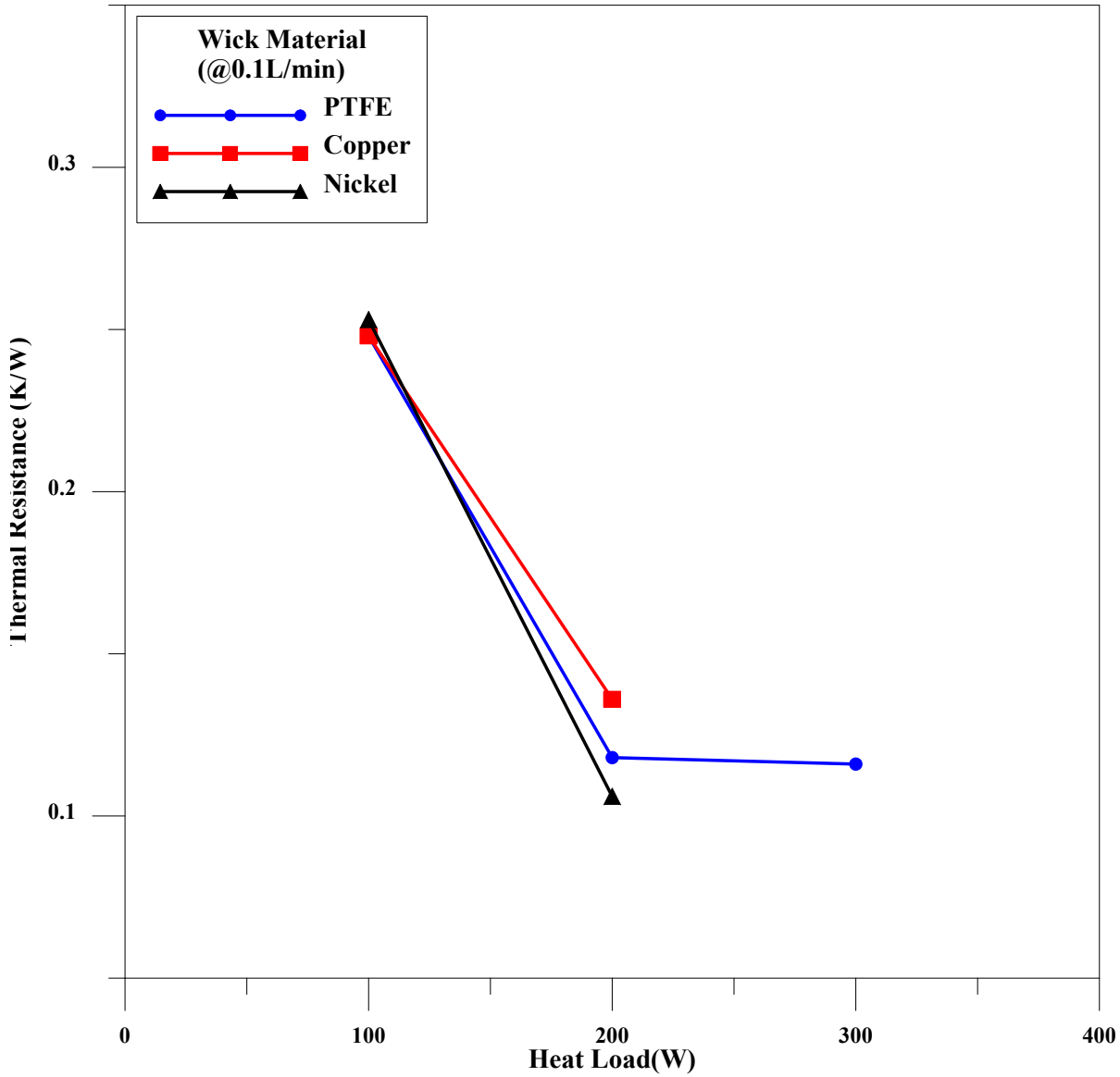

Wick Material : PTFE
Working Fluid : Acetone
Flow Rate : 2.7L/min
Evaporator outlet
Cooling inlet
Cooling outlet
Cooling 1
Evaporator wall
500W
400W
300W
200W
100W
Temperature(C)
Time(s)

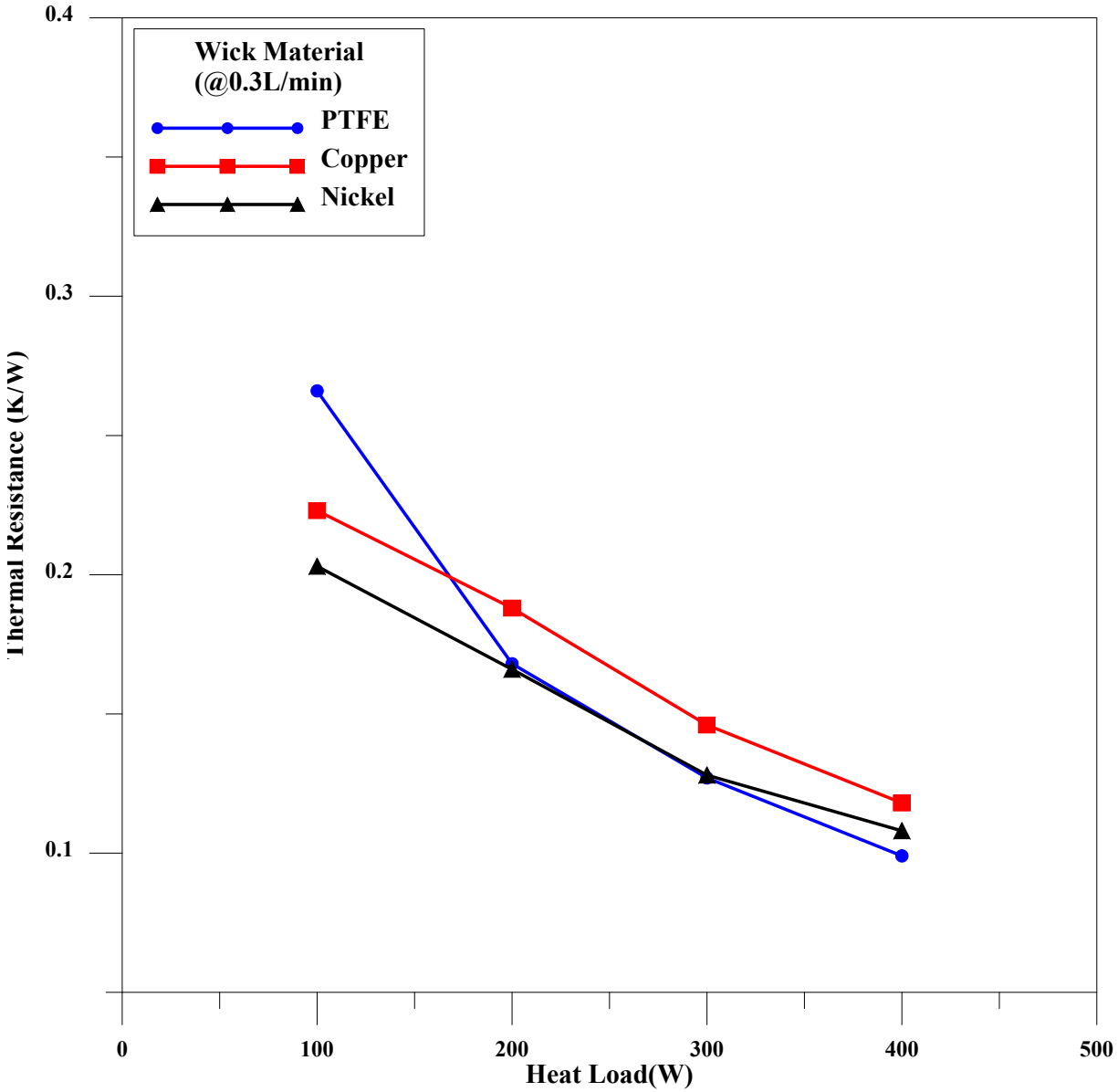
Assessment of material choosing and volumetric flow rate effect

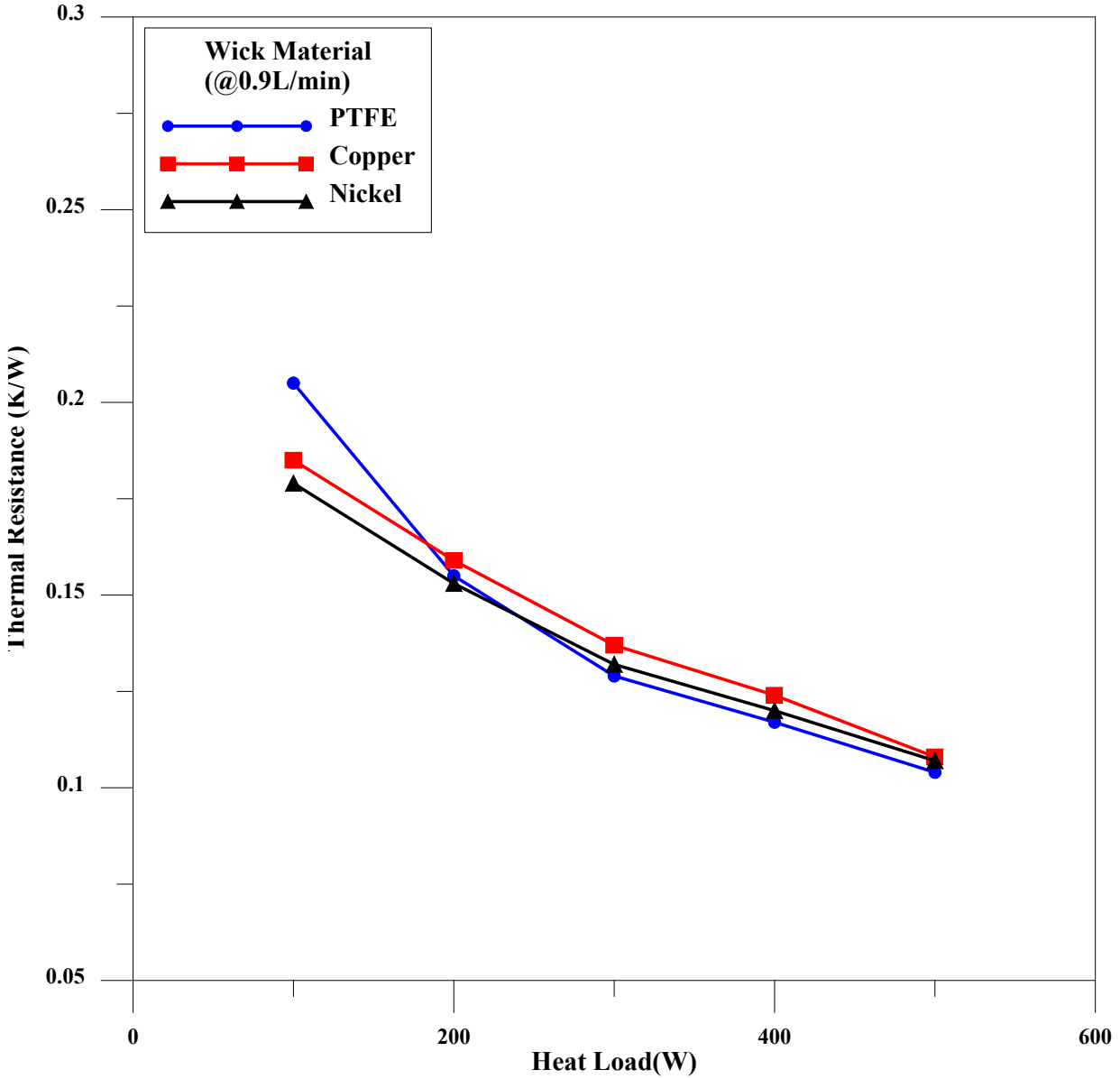
Performance							
	0.05L/min	0.1L/min	0.3L/min	0.9L/min	1.5L/min	2.1L/min	2.7L/min
Without wick	150W	175W	250W	400W	350W	450W	500W
PTFE	300W	350W	400W	450W	450W	450W	500W
Cu	200W	250W	400W	450W	450W	500W	500W
Ni	225W	250W	400W	450W	500W	500W	500W

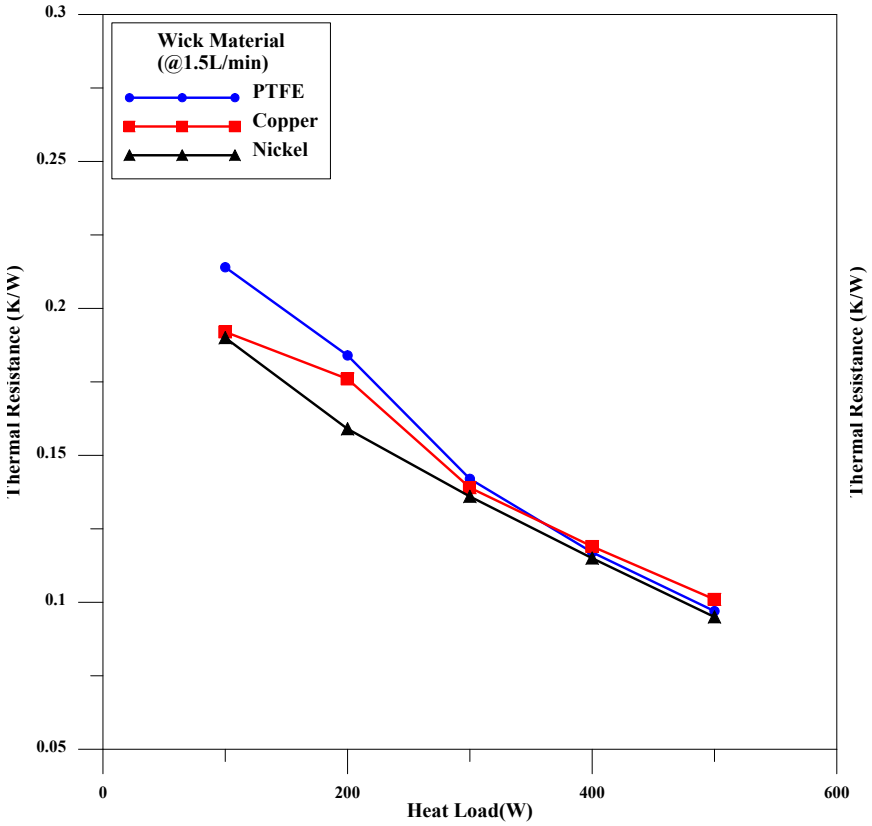
PTFE Vs. Without wick							
	0.05L/min	0.1L/min	0.3L/min	0.9L/min	1.5L/min	2.1L/min	2.7L/min
Without wick	(150W)	(175W)	(250W)	(400W)	(350W)	(450W)	(500W)
PTFE	100%	100%	60%	12.50%	29%	0%	0%

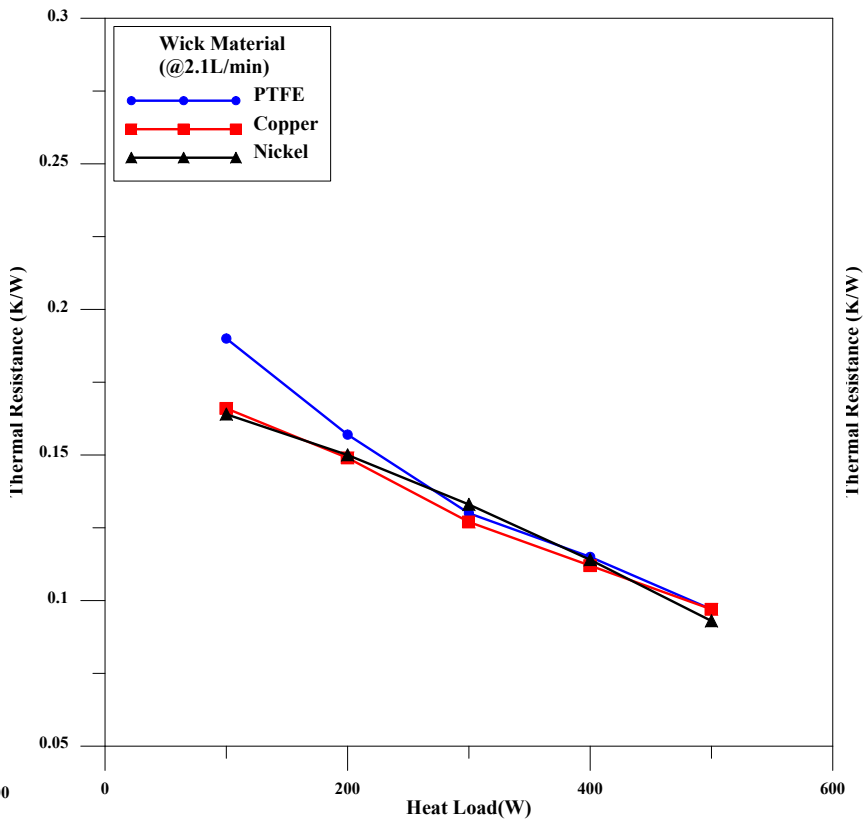

Wick Material
(@0.05L/min)
PTFE
Copper
Nickel
Thermal Resistance (K/W)
0.35
0.3
0.25
0.2
0.15
0.1
0
100
200
300
Heat Load(W)

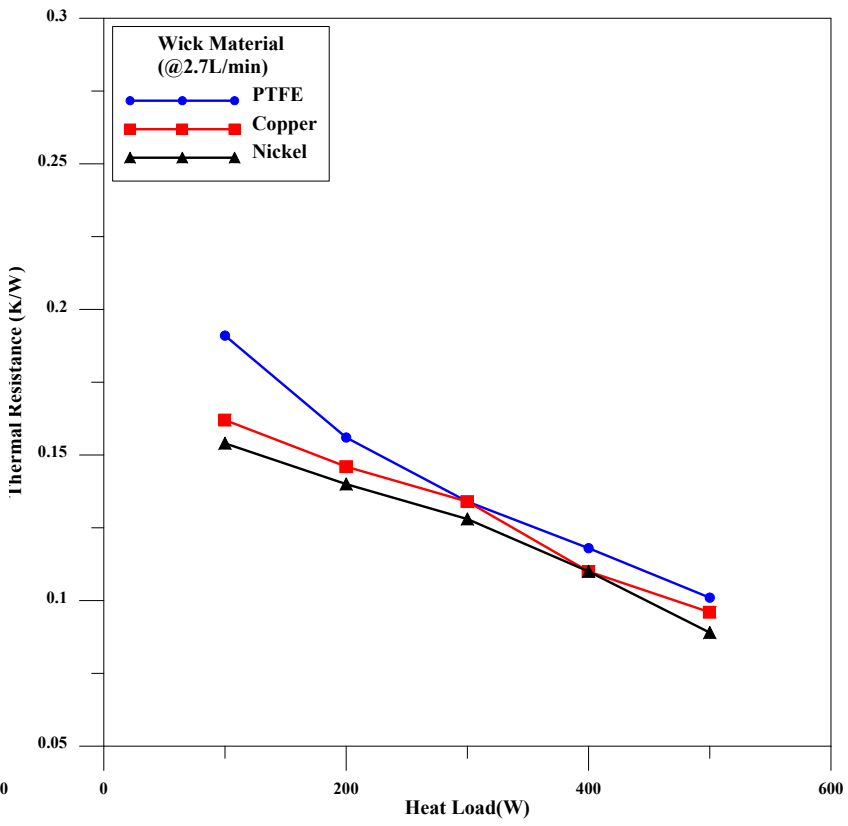

Wick Material
(@0.1L/min)
PTFE
Copper
Nickel
Thermal Resistance (K/W)
0.3
0.2
0.1
0
100
200
300
400
Heat Load(W)

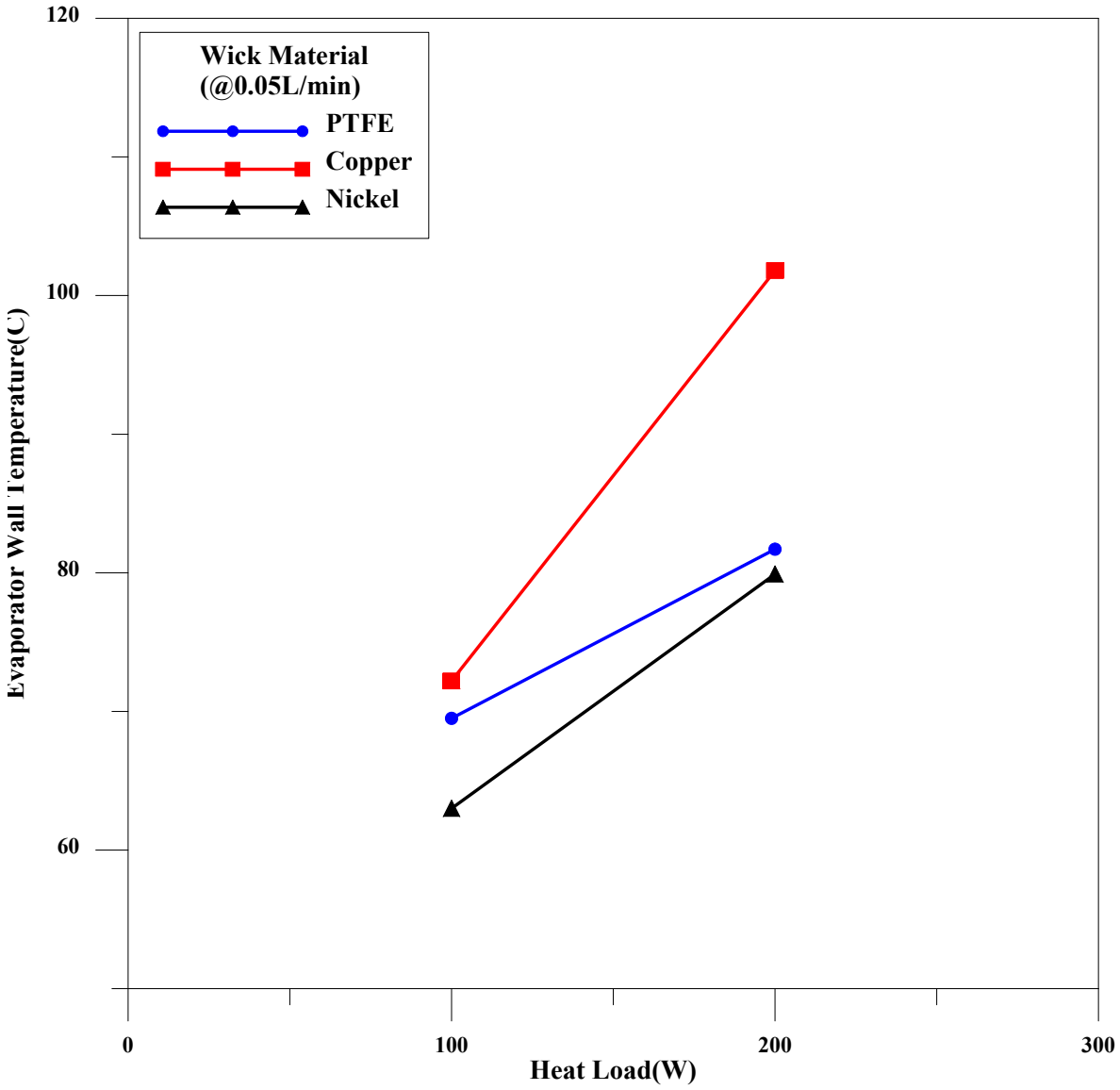

Wick Material
(@0.3L/min)
PTFE
Copper
Nickel
Thermal Resistance (K/W)
0.4
0.3
0.2
0.1
0
100
200
300
400
500
Heat Load(W)

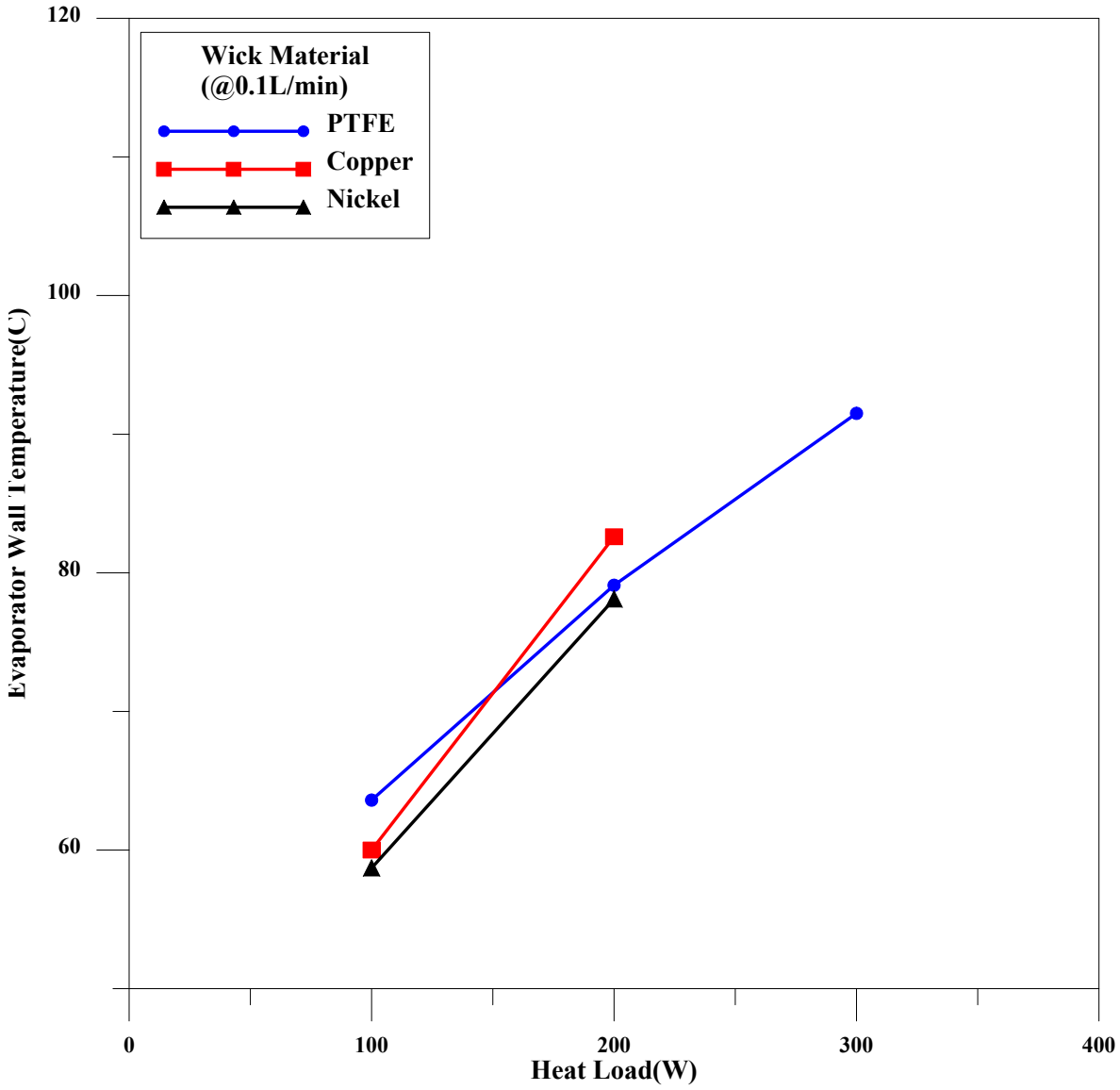

Wick Material
(@0.9L/min)
PTFE
Copper
Nickel
Thermal Resistance (K/W)
0.3
0.25
0.2
0.15
0.1
0.05
0
200
400
600
Heat Load(W)

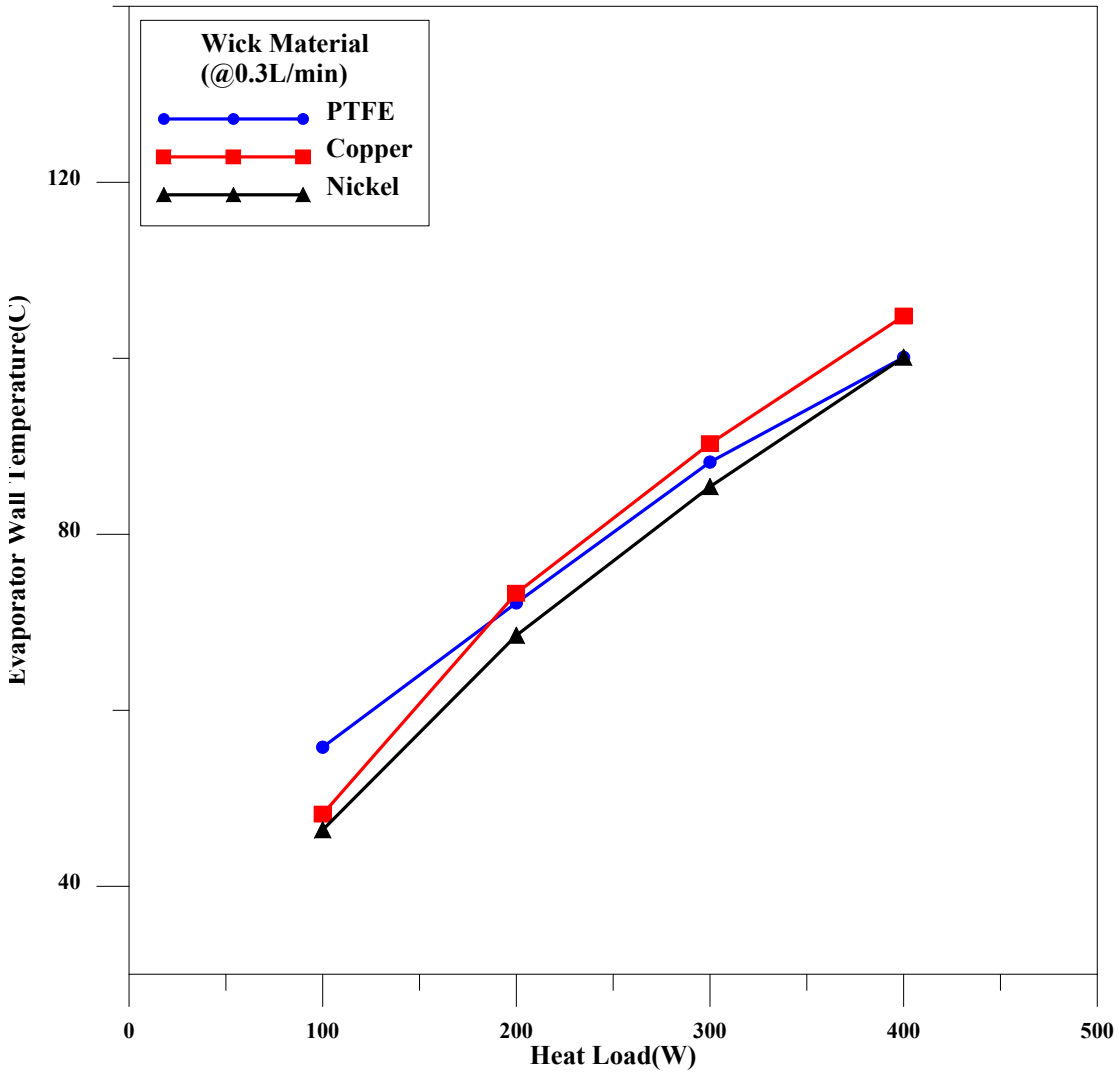

Wick Material
(@1.5L/min)
PTFE
Copper
Nickel
Thermal Resistance (K/W)
Heat Load(W)
0.3
0.25
0.2
0.15
0.1
0.05
0
200
400
600

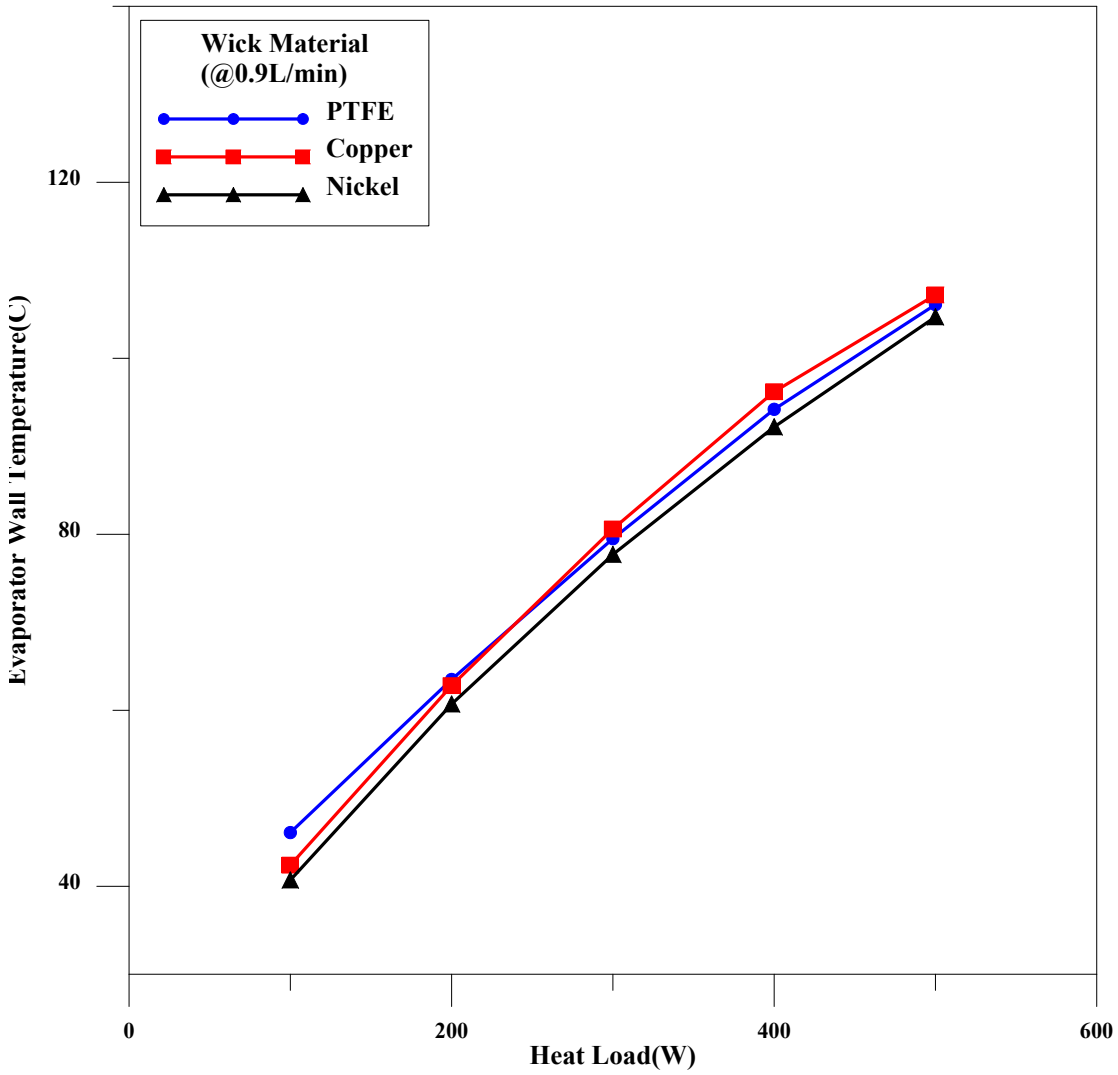

Wick Material
(@2.1L/min)
PTFE
Copper
Nickel
Thermal Resistance (K/W)
Heat Load(W)
0.3
0.25
0.2
0.15
0.1
0.05
0
200
400
600

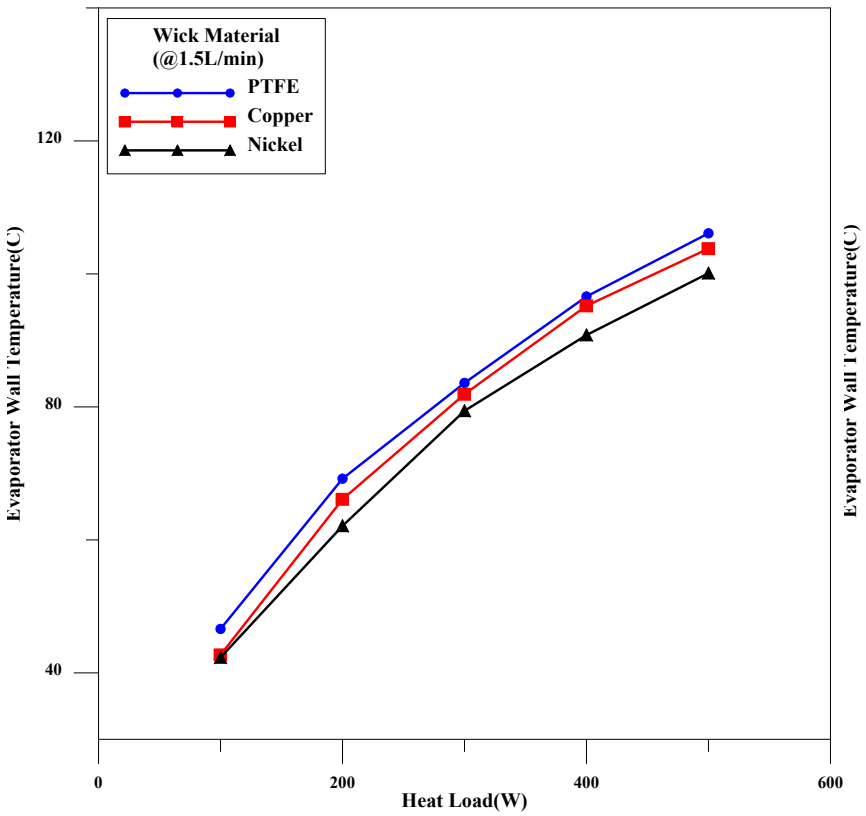

Wick Material
(@2.7L/min)
PTFE
Copper
Nickel
Thermal Resistance (K/W)
Heat Load(W)
0.3
0.25
0.2
0.15
0.1
0.05
0
200
400
600

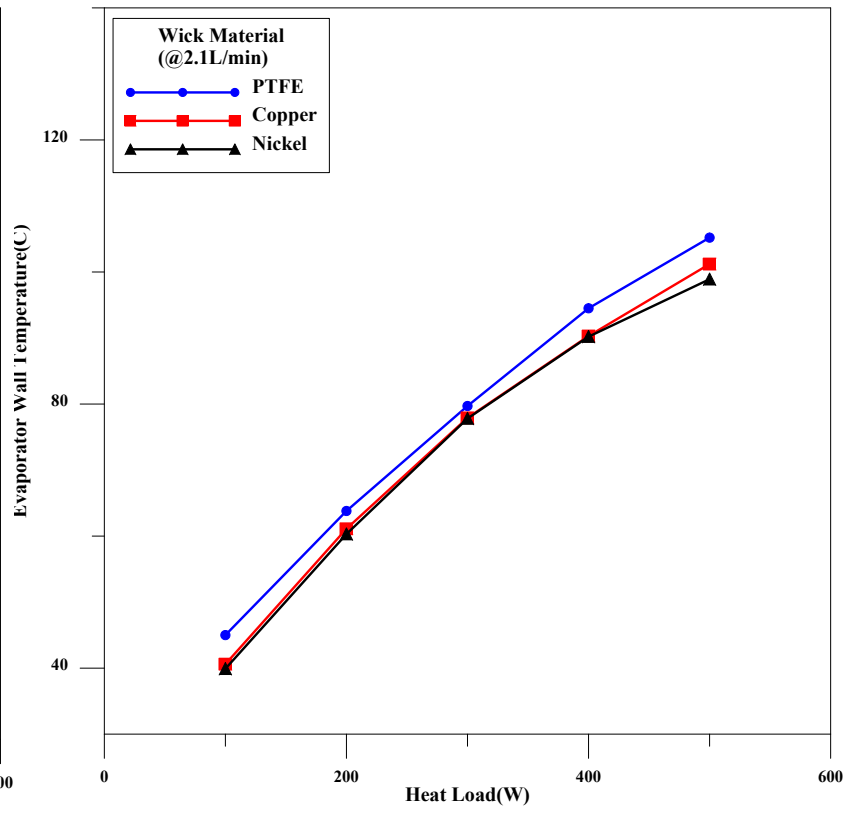

Wick Material
(@0.05L/min)
PTFE
Copper
Nickel
120
100
80
60
Evaporator Wall Temperature(C)
0
100
200
300
Heat Load(W)

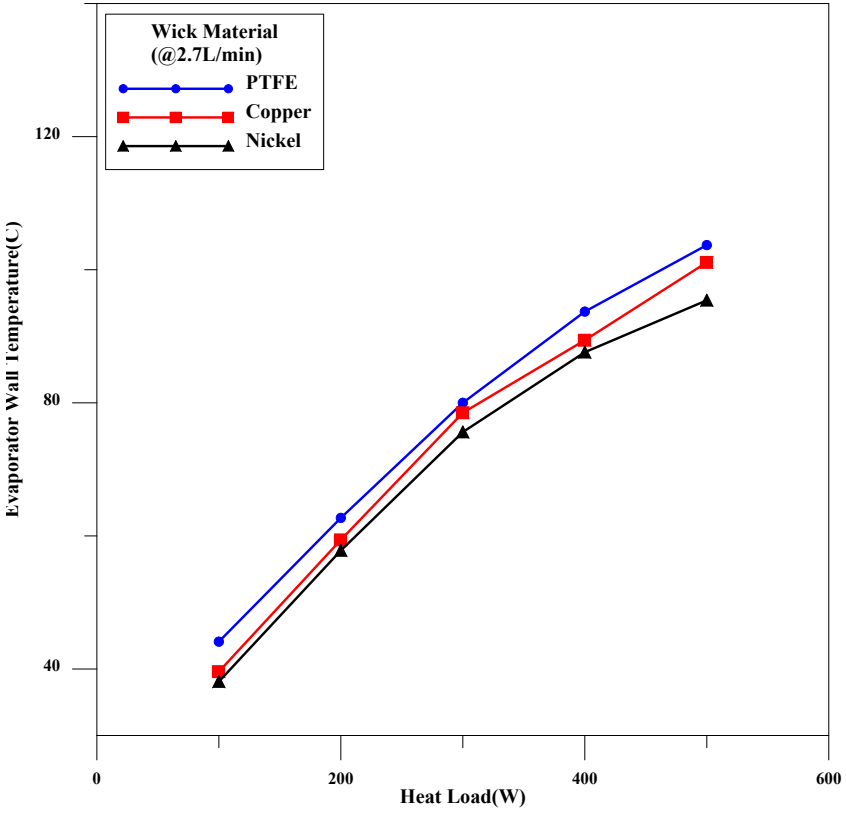

Wick Material
(@0.1L/min)
PTFE
Copper
Nickel
120
100
80
60
Evaporator Wall Temperature(C)
0
100
200
300
400
Heat Load(W)


Wick Material
(@0.3L/min)
PTFE
Copper
Nickel
120
80
40
Evaporator Wall Temperature(C)
0
100
200
300
400
500
Heat Load(W)

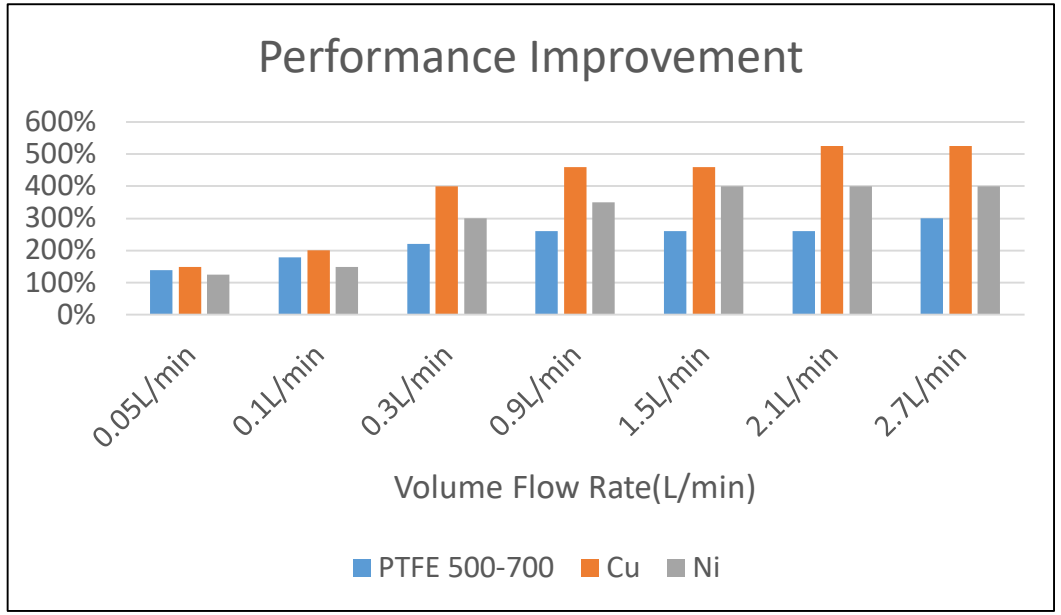

Wick Material
(@0.9L/min)
PTFE
Copper
Nickel
120
80
40
Evaporator Wall Temperature(C)
0
200
400
600
Heat Load(W)


Wick Material
(@1.5L/min)
PTFE
Copper
Nickel
Evaporator Wall Temperature(C)
120
80
40
0
200
400
600
Heat Load(W)


Wick Material
(@2.1L/min)
PTFE
Copper
Nickel
Evaporator Wall Temperature(C)
120
80
40
0
200
400
600
Heat Load(W)


Wick Material
(@2.7L/min)
PTFE
Copper
Nickel
Evaporator Wall Temperature(C)
120
80
40
0
200
400
600
Heat Load(W)

Hybrid Flat Plate Loop Heat Pipe Heat
&
Traditional Flat Plate Loop Heat Pipe



Performance Improvement								
	LHP	0.05L/min	0.1L/min	0.3L/min	0.9L/min	1.5L/min	2.1L/min	2.7L/min
PTFE	125W	300W	350W	400W	450W	450W	450W	500W
		(140%)	(180%)	(220%)	(260%)	(260%)	(260%)	(300%)
Cu	80W	200W	240W	400W	450W	450W	500W	500W
		(150%)	(200%)	(400%)	(460.25%)	(460.25%)	(525%)	(525%)
Ni	100W	225W	250W	400W	450W	500W	500W	500W
		(125%)	(150%)	(300%)	(350%)	(400%)	(400%)	(400%)

Conclusion

1.Effect of Volumetric Flow Rate

(1) Flow rate will be irrelevant to the maximum heat load and heat resistance when it exceeds 0.3L/min, no matter what kind of material we are using with HLHP.

(2) When the flow rate in within 0.3L/min, the maximum heat load has a positive correlation with flow rate and heat resistance has a negative correlation with the flow rate no matter what kind of material we are using with HLHP

Conclusion

2.Effect Of Wick Material

(1) Wick material is irrelevant to cooling capacity when the flow rate exceed 0.3L/min. The maximum cooling capacity difference would be 29% among three wick materials. However, there will be 60% to 100% cooling capacity difference when the flow rate is within 0.3L/min.

(2) PTFE is the best material for wick when the flow rate is under 0.3L/min due to it's lowest evaporator wall temperature and lowest heat resistance.

Conclusion

3.Overall Heat Capacity Improvement Of Hybrid Flat Plate Loop Heat Pipe

In general, hybrid loop heat pipe increases the maximum heat load by 2 to 3 times of traditional loop heat pipe. The heat resistance also decrease massively by using a pump which only need 30W to operate.

Under the optimal volumetric flow rate 0.3L/min:
For PTFE：Maximum Heat Load from 125 to 400W; Heat Resistance from 0.209℃/W to 0.099℃/W
For Nickel: Maximum Heat Load from 100 to 400W; Heat Resistance from 0.280℃/W to 0.108℃/W
For Copper： Maximum Heat Load from 80 to 400W; Heat Resistance from 0.354℃/W to 0.118℃/W