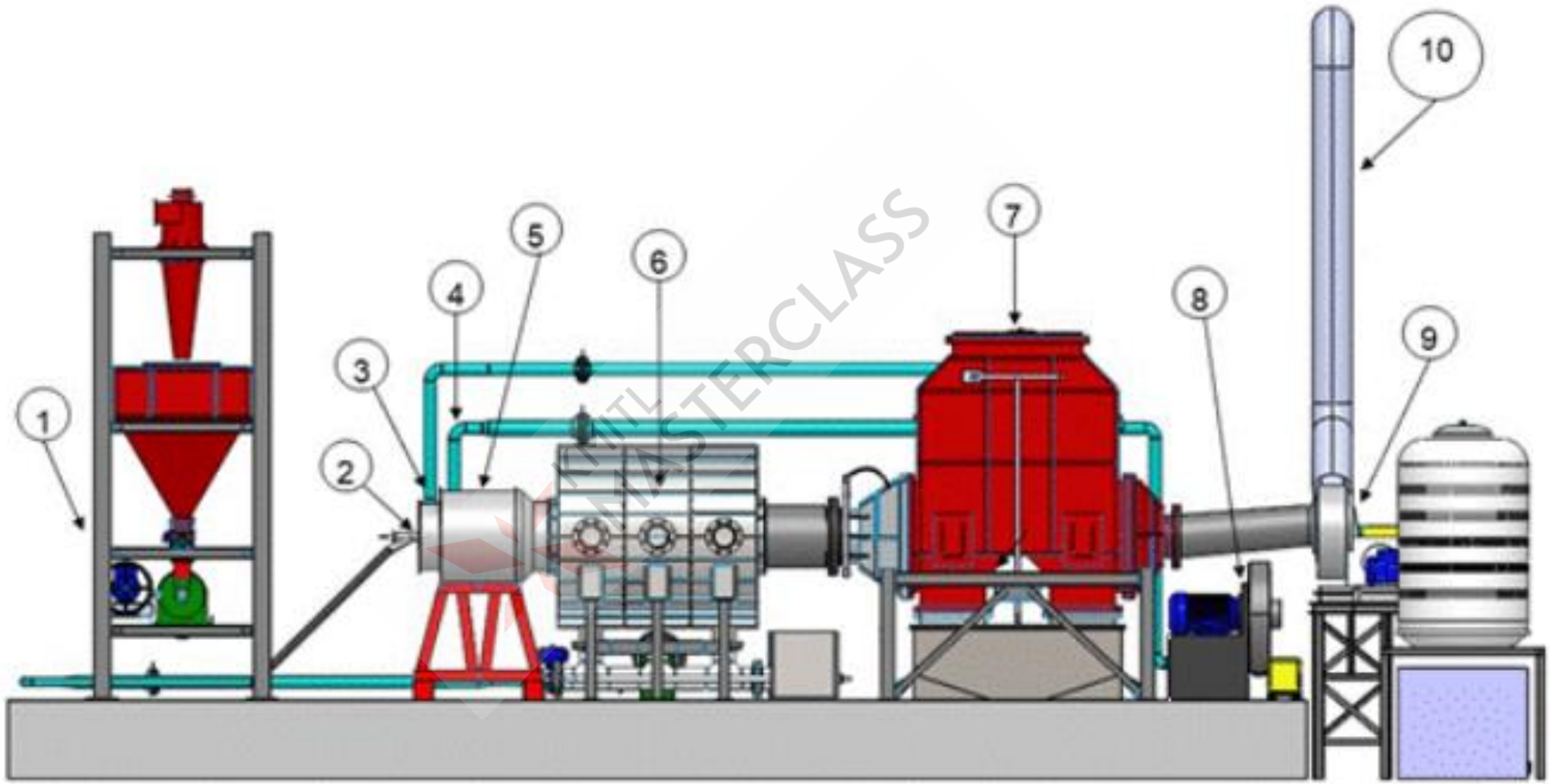
Development of Pulverized Biomass Combustion for Industrial Boiler: A Study on Bluff Body Effect

Niwat Suksam and Jarruwat Charoensuk *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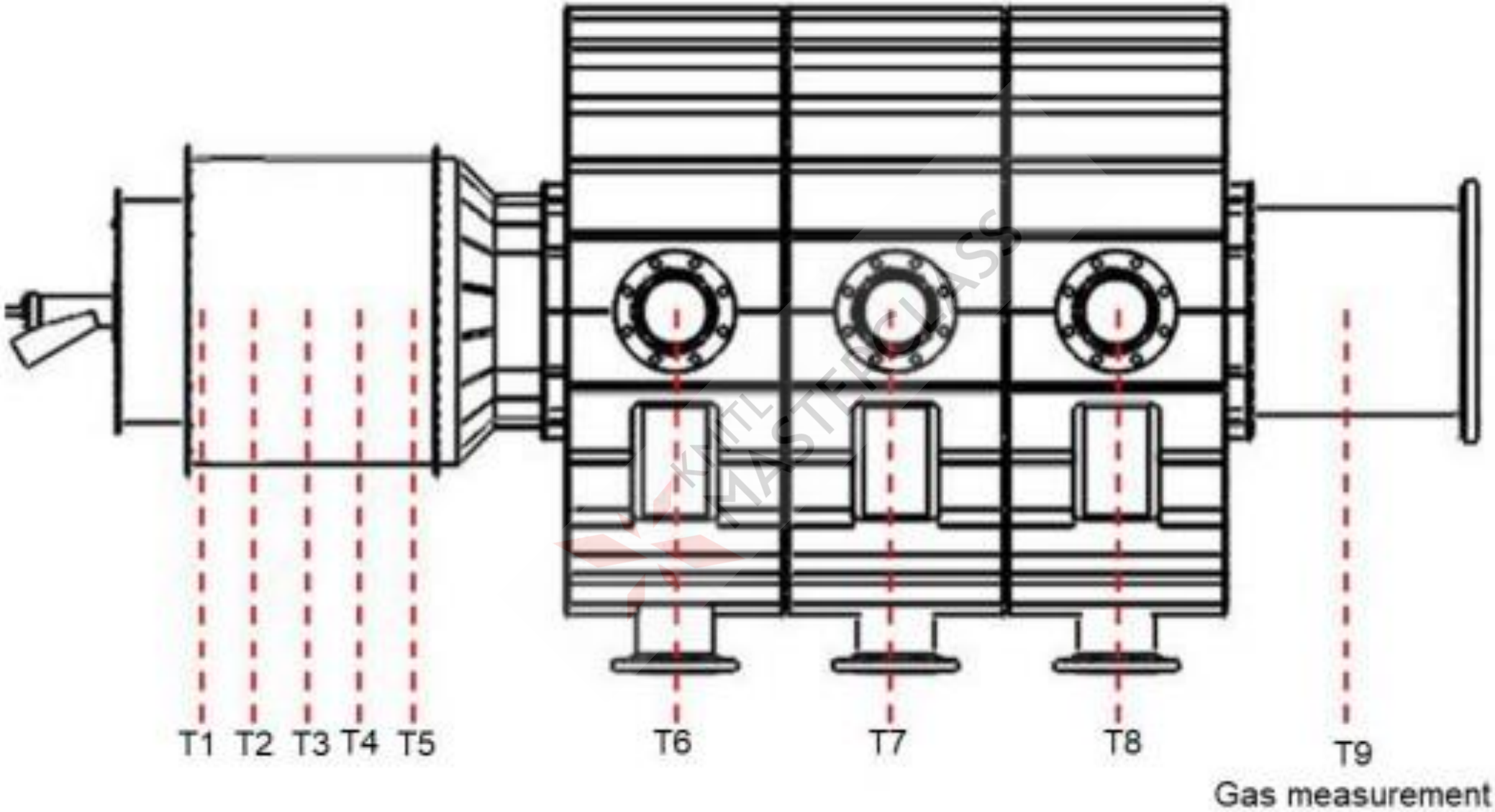
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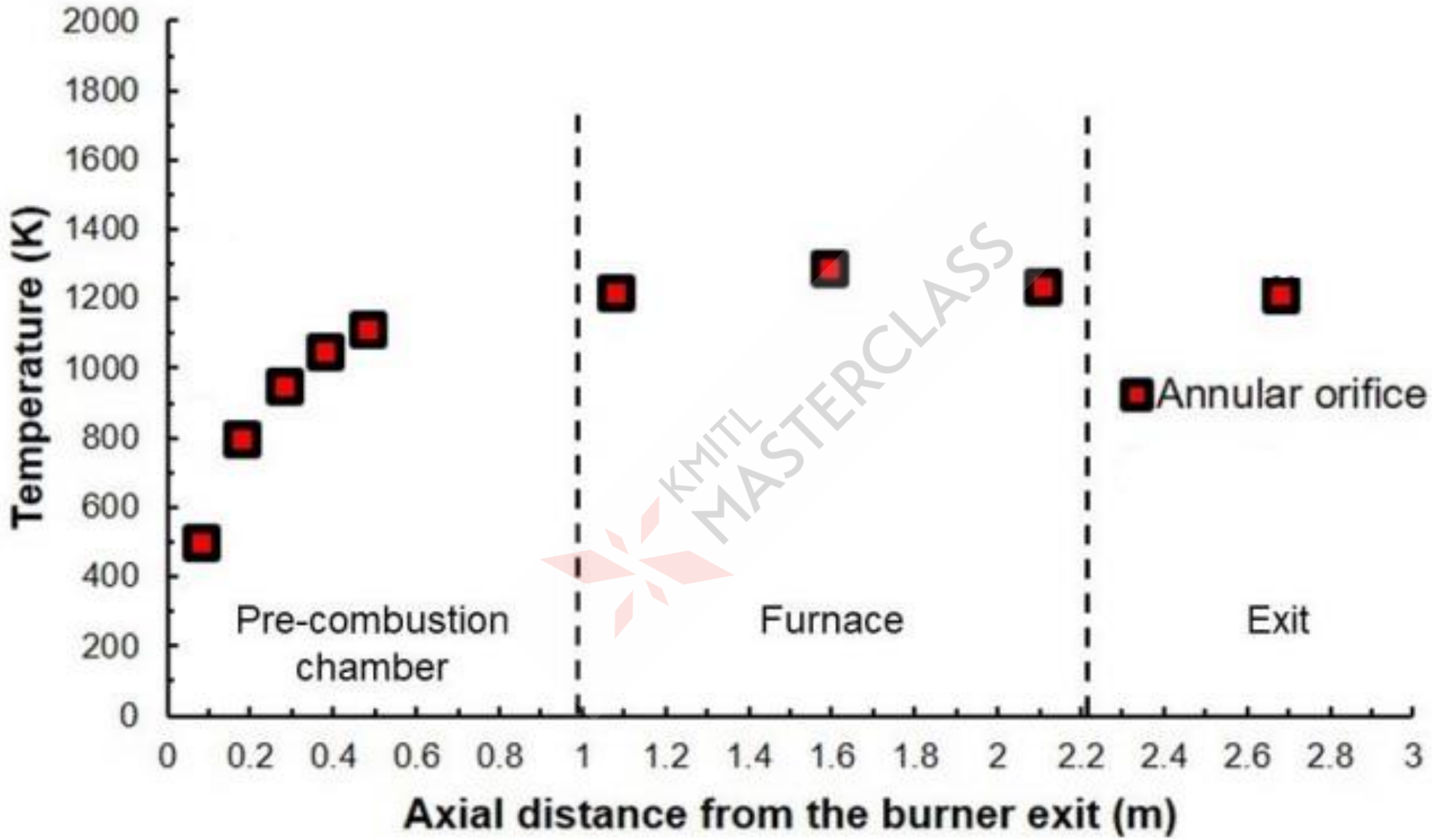
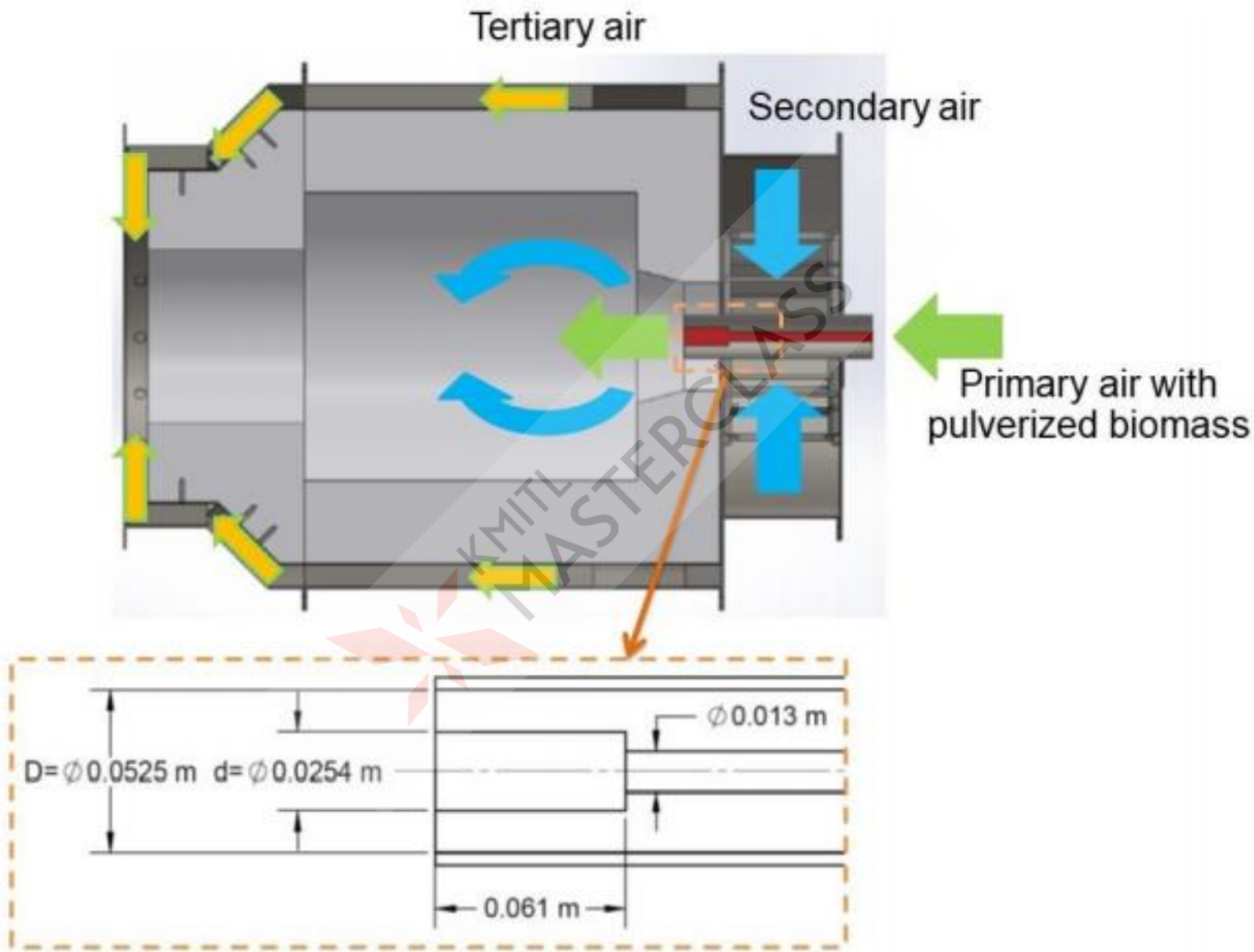
Gas measurement




Tertiary air
Secondary air
Primary air with
pulverized biomass
D= ∅0.0525 m
d= ∅0.0254 m
∅0.013 m
0.061 m

Flame inside the pre-combustion chamber of the annular orifice (

Table 1. Operating Conditions of the Furnace

Parameter	Value	Unit
Thermal throughput (based on fuel lower heating value)	300	kW
Pulverized biomass feed rate at primary inlet	0.0186	kg/s
Excess air ratio	1.2	-
Primary air flow	0.0134	kg/s
Secondary air flow	0.0869	kg/s
Swirl number	0.83	-
Tertiary air flow	0.0334	kg/s
Mole fraction of O_2 in air inlet	0.21	-
Mole fraction of N_2 in air inlet	0.79	-
Temperature of primary, secondary and tertiary air inlet	313	K
Outlet vacuum of flue gas	-1500	Pa

(a)

(b)

Fig. 5. Pulverized biomass fuel, (a) pellet biomass fuel from rubber tree before milling and (b) pulverized biomass fuel after milling

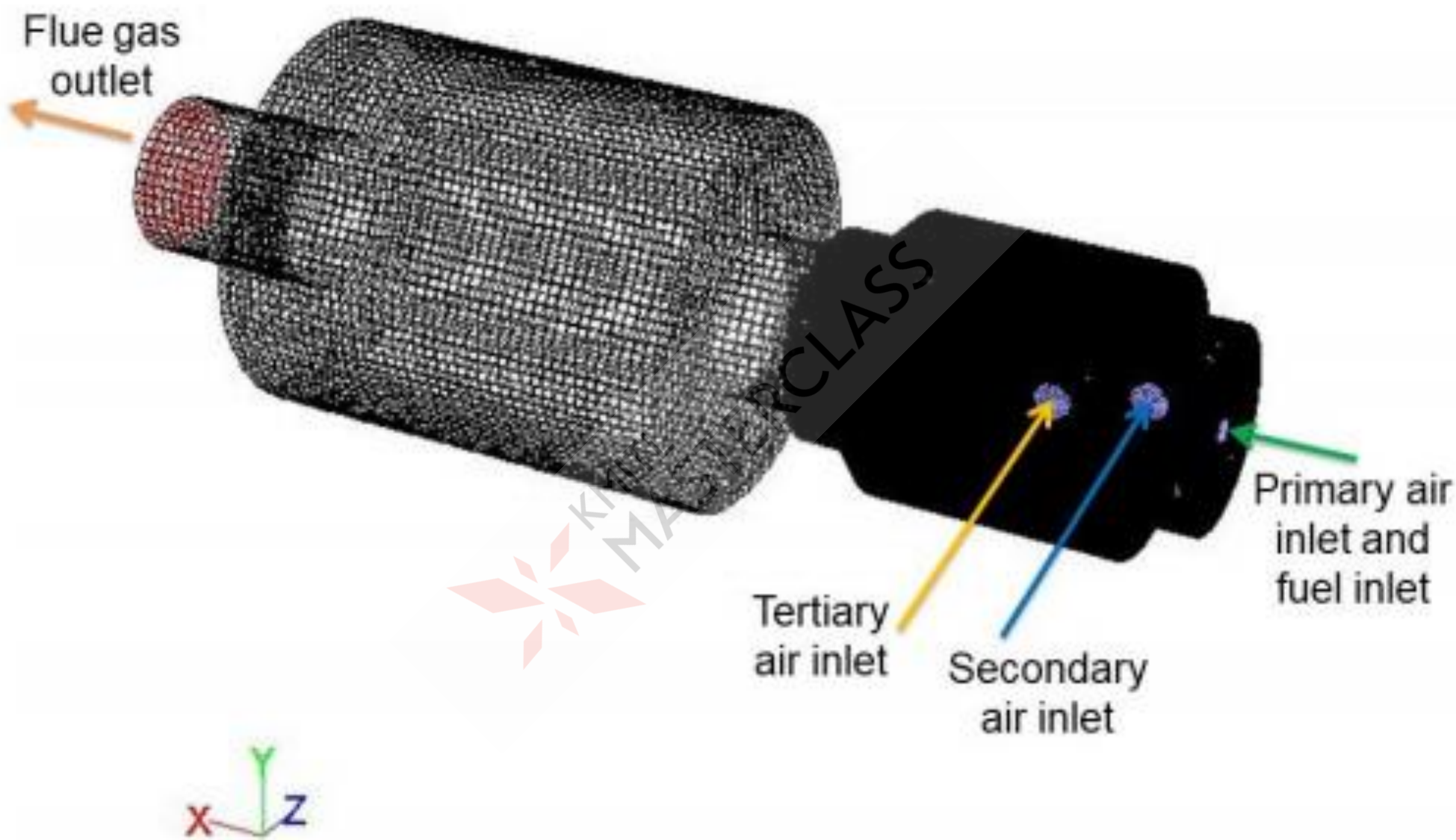
Table 2. Pulverized Biomass Sieve Analysis

Mesh size (μm)	425	300	180	150	75
wt% Passing Through	97.5	80.6	55.1	42.5	24.4

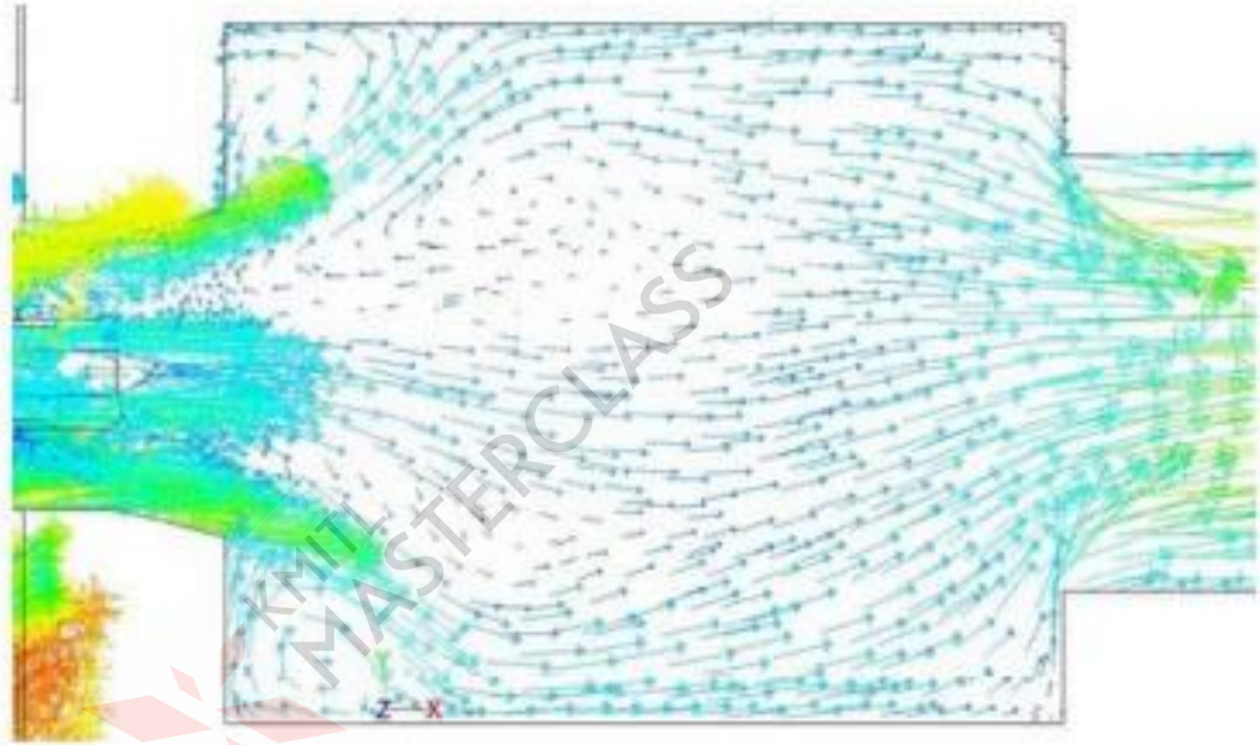
Table 3. Proximate and Ultimate Analysis of Pulverized Biomass Used

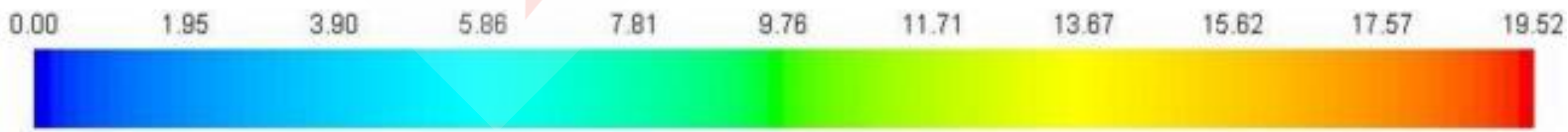
Proximate Analysis (wt%, as received)				Ultimate Analysis (wt%, Dry-Ash-Free)						
Ash	Volatile matter	Moisture	Fixed carbon	C	H	O	N	S	HHV (MJ/kg)	LHV (MJ/kg)
2.28	76.68	5.81	15.23	49.42	6.16	43.93	0.49	0	17.50	16.16

HHV: higher heating value; LHV: lower heating value

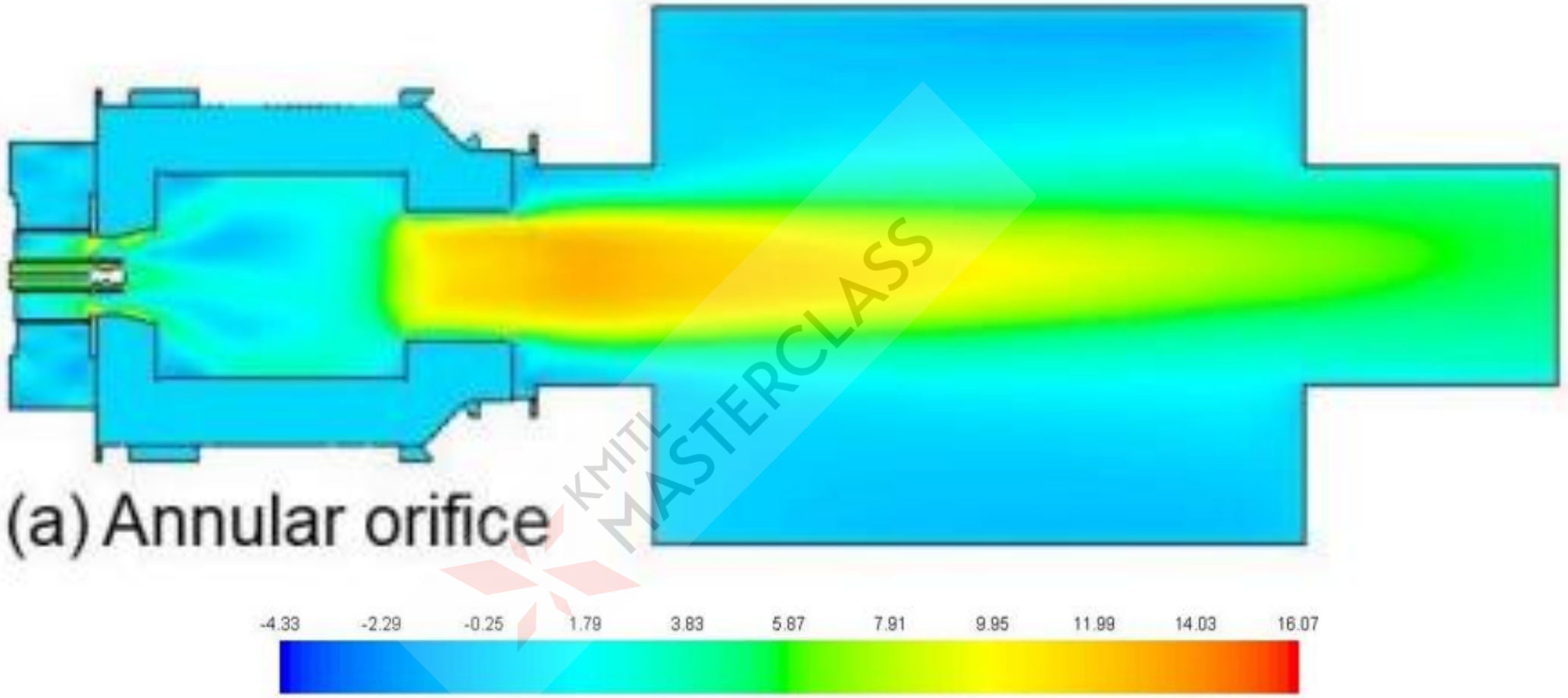

Flue gas
outlet
Primary air
inlet and
fuel inlet
Tertiary
air inlet
Secondary
air inlet
Y
X
Z

(a) Annular orifice



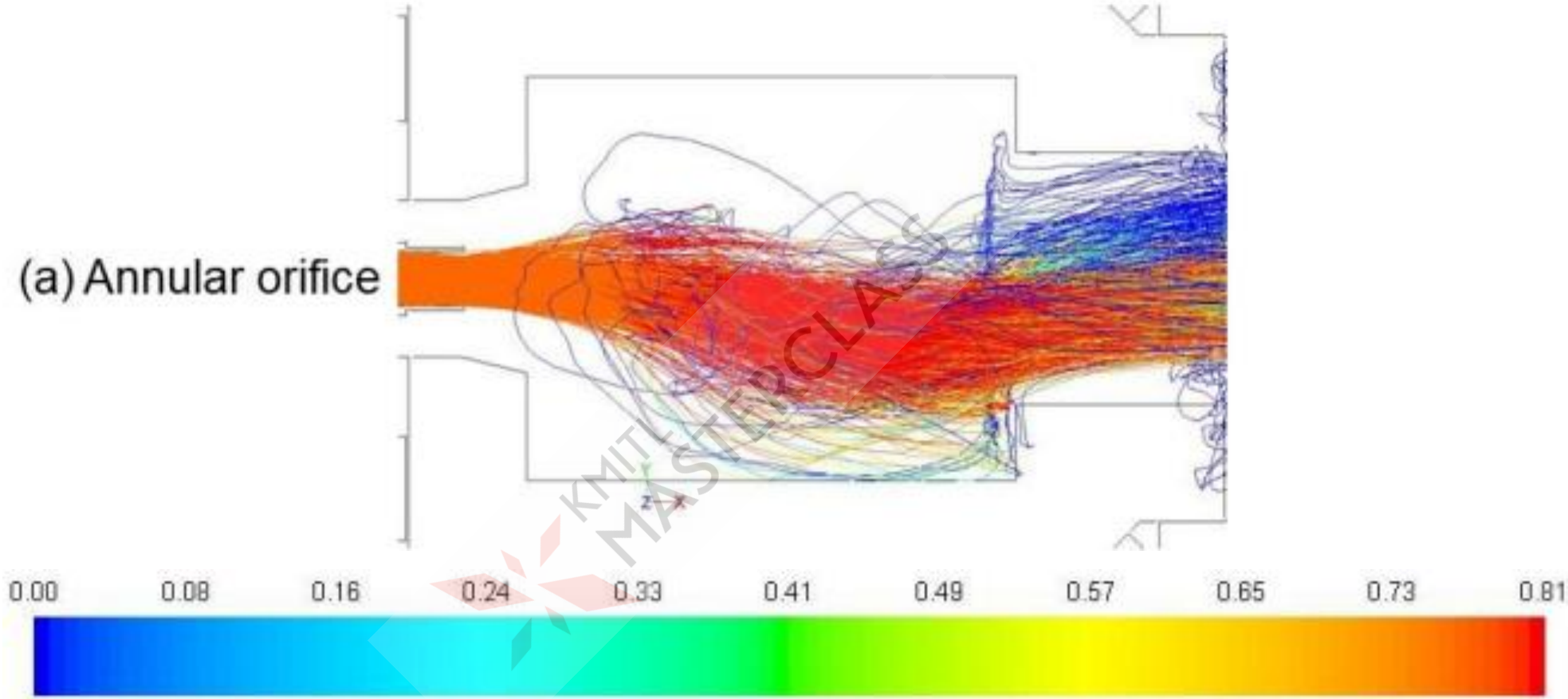


Velocity vectors colored by the velocity magnitude (m/s) i

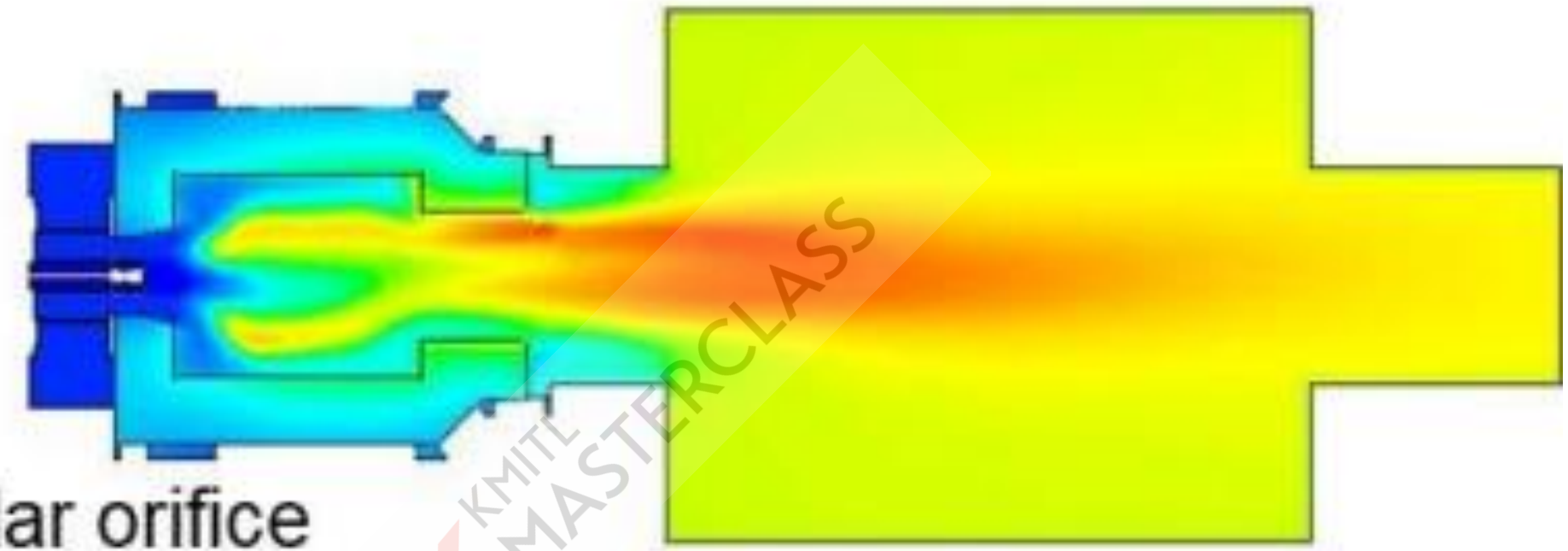


Axial velocity magnitude (m/s) inside the pre-combustion chamber and furnace

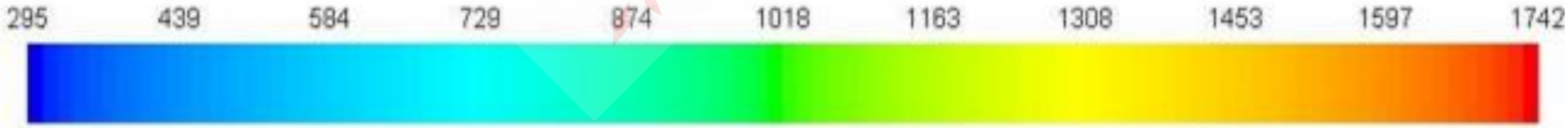
(a) Annular orifice



Particle trajectory colored by a volatiles mass fraction inside the pre-combustion chamber



(a) Annular orifice



Temperature (K) distribution inside the pre-combustion chamber and furnace

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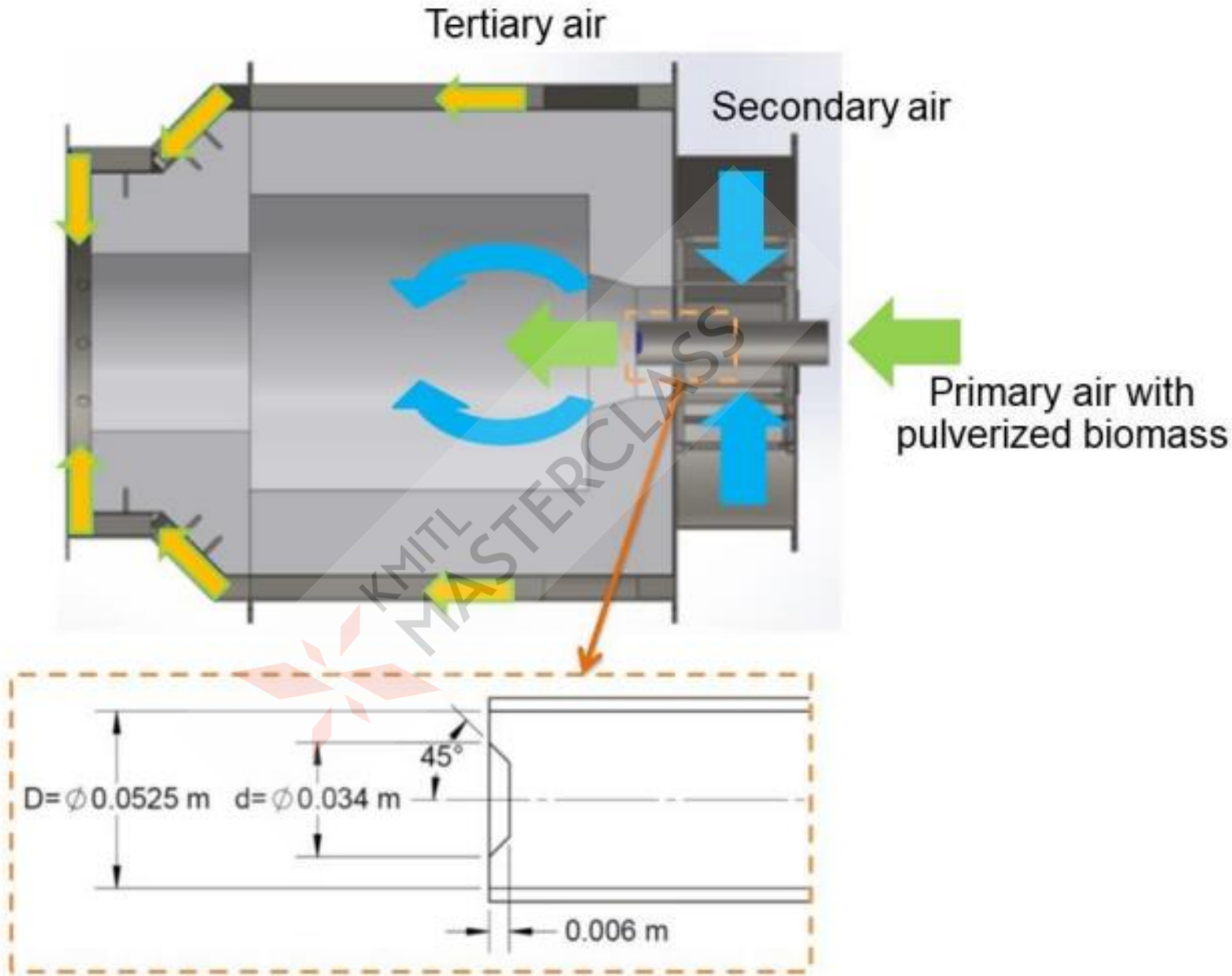
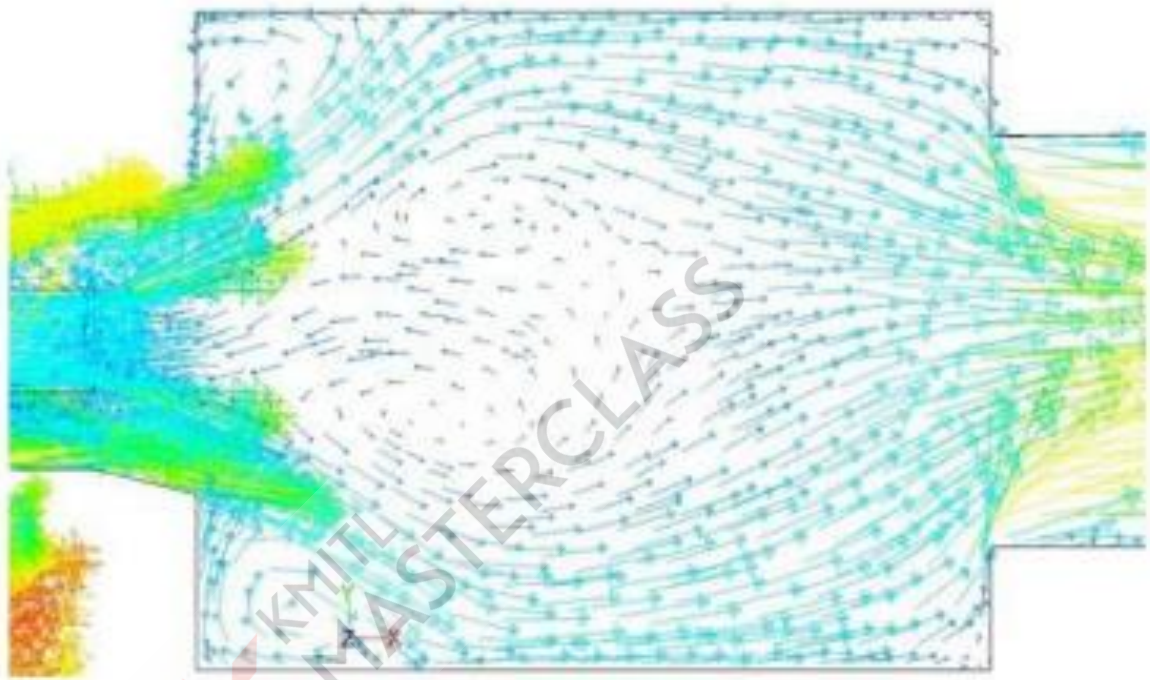
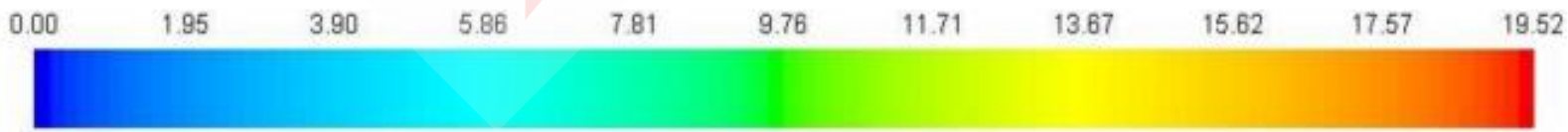
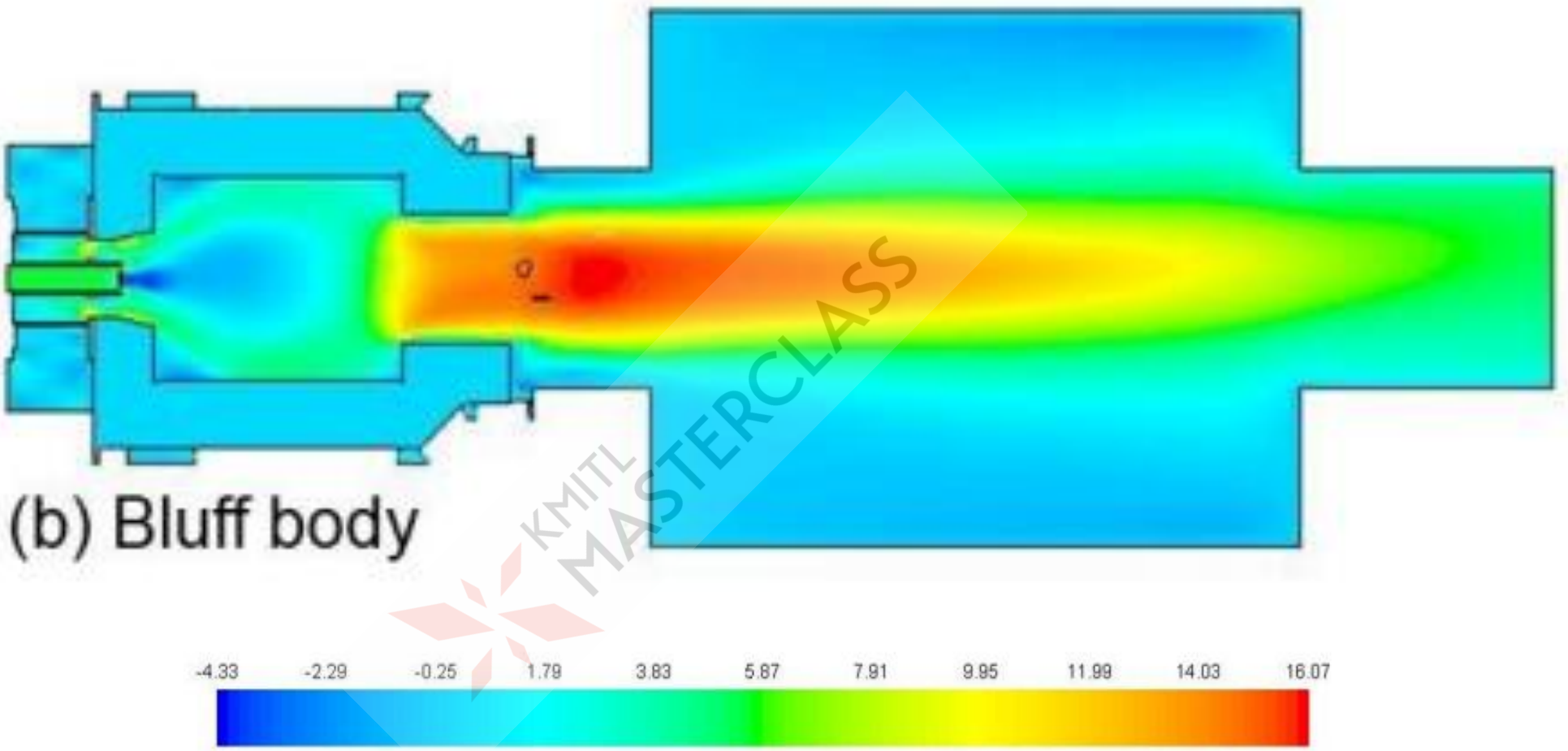


(b) Bluff body



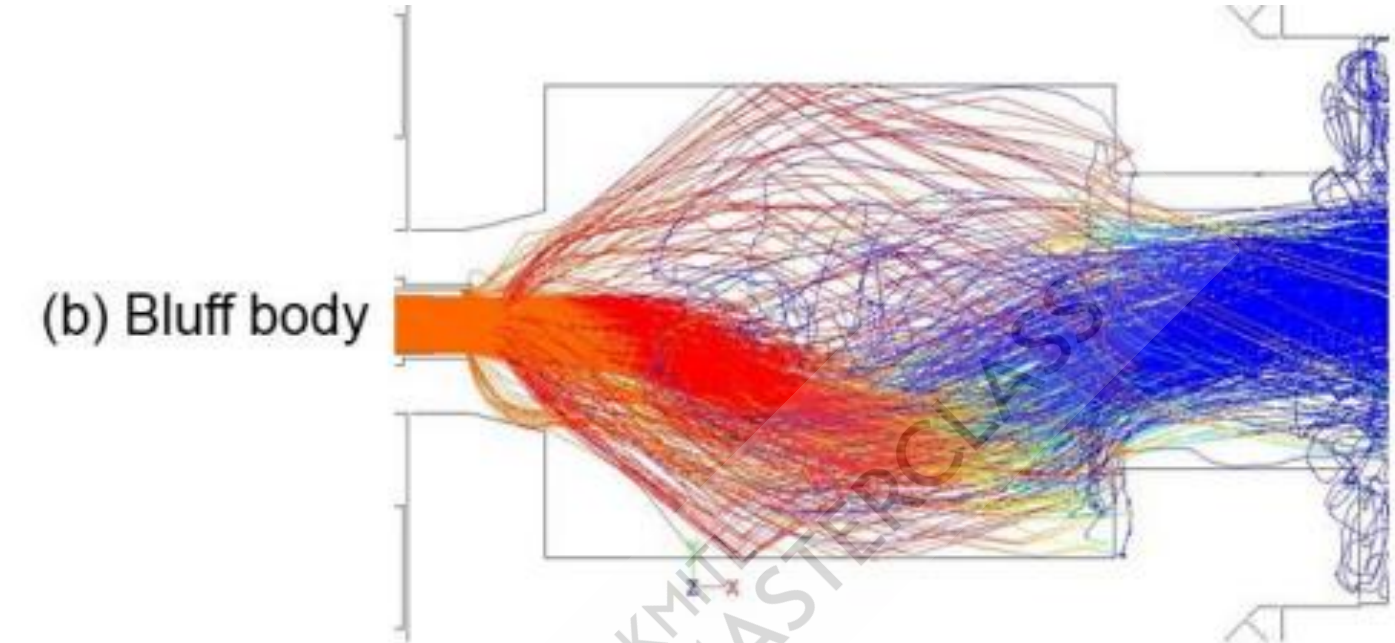


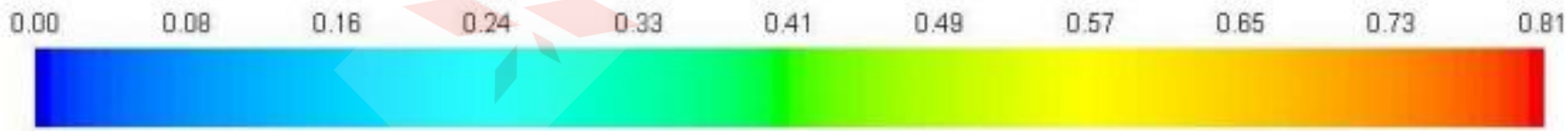
Velocity vectors colored by the velocity magnitude (m/s) i



Axial velocity magnitude (m/s) inside the pre-combustion chamber and furnace

(b) Bluff body





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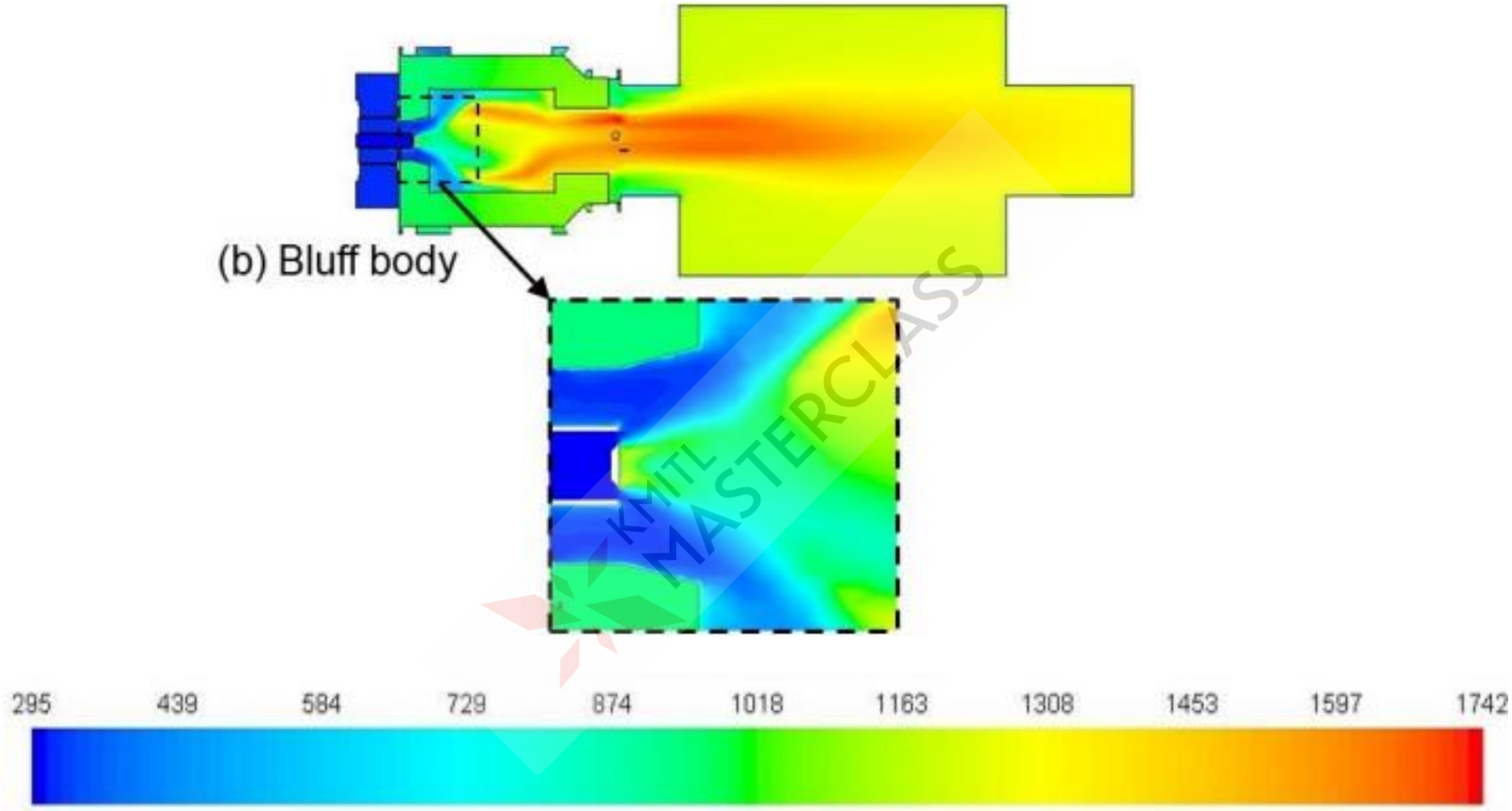
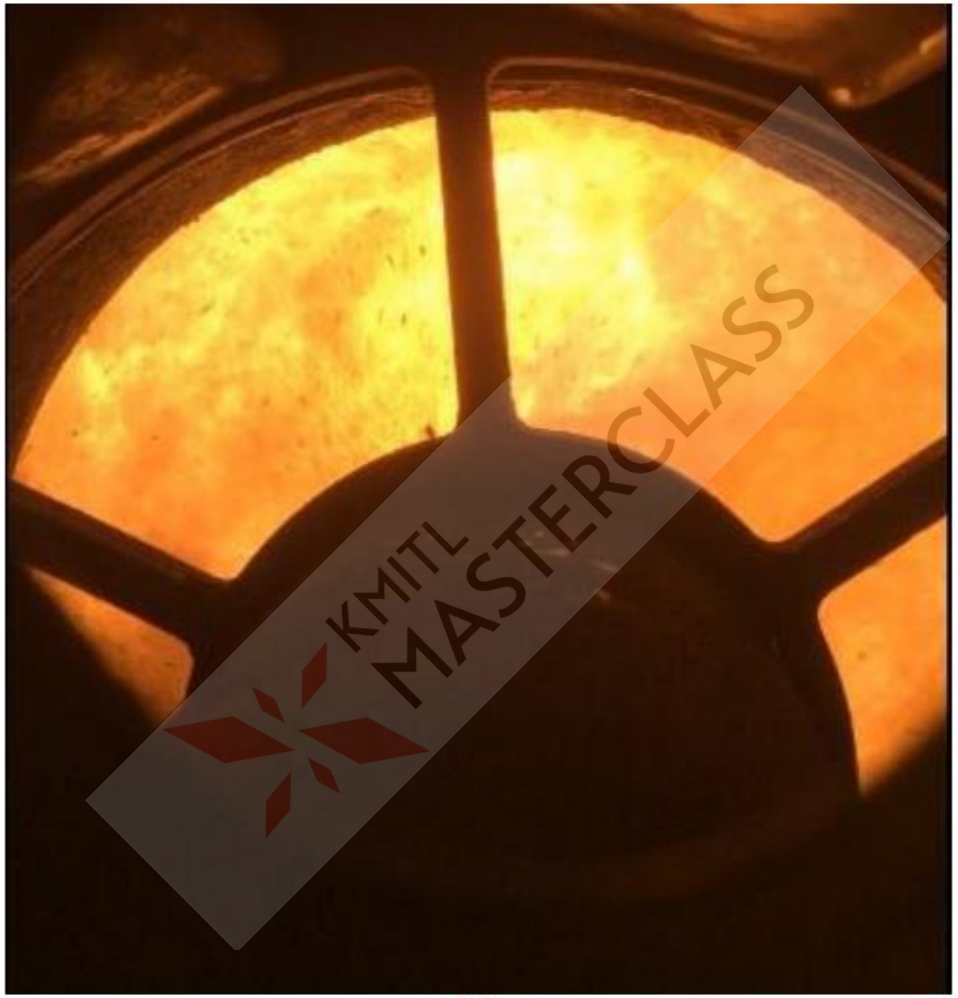
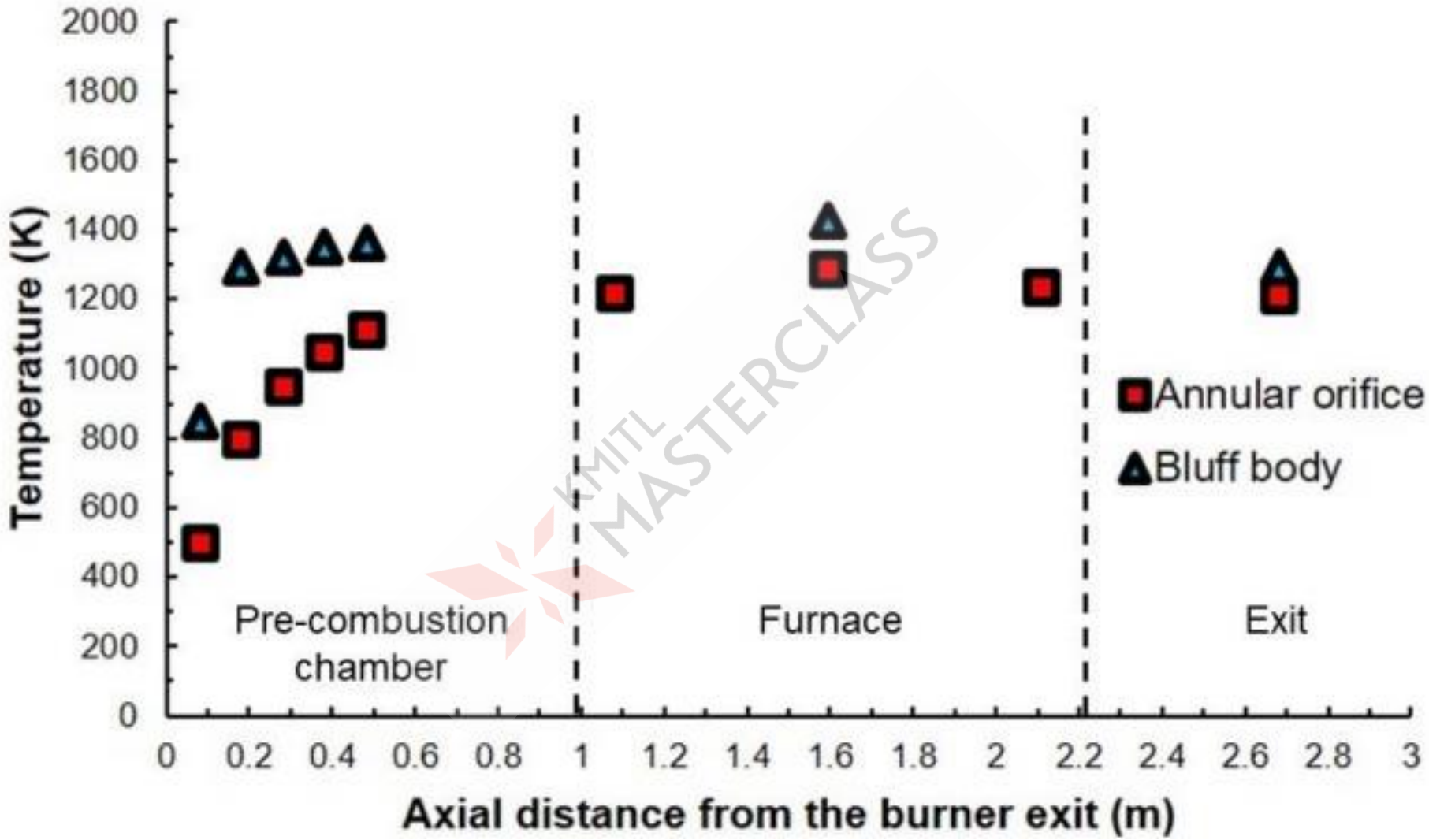


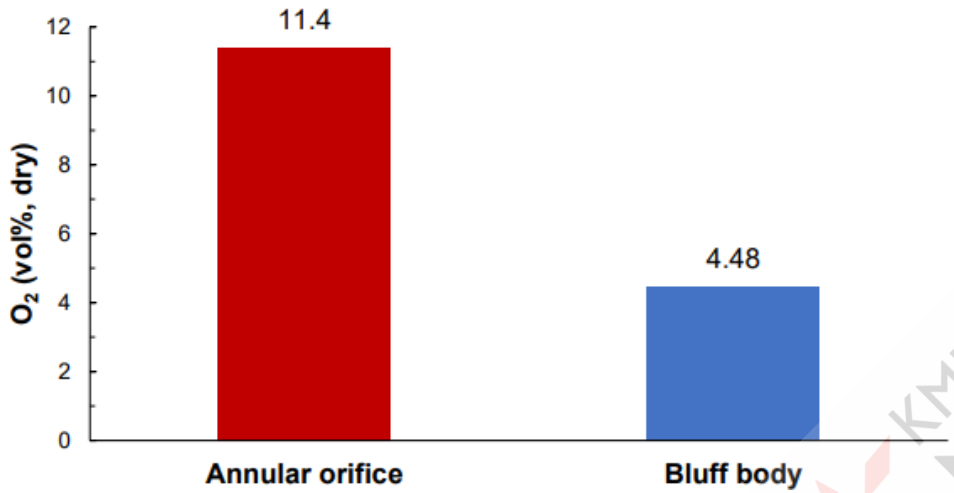
Temperature (K) distribution inside the pre-combustion chamber and furnace

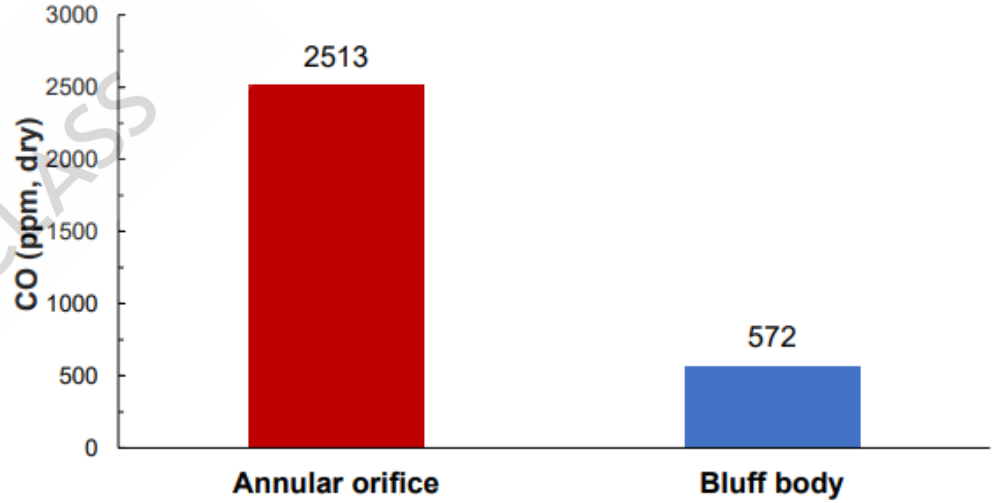


(b)

Flame inside the pre-combustion chamber of the annular orifice (

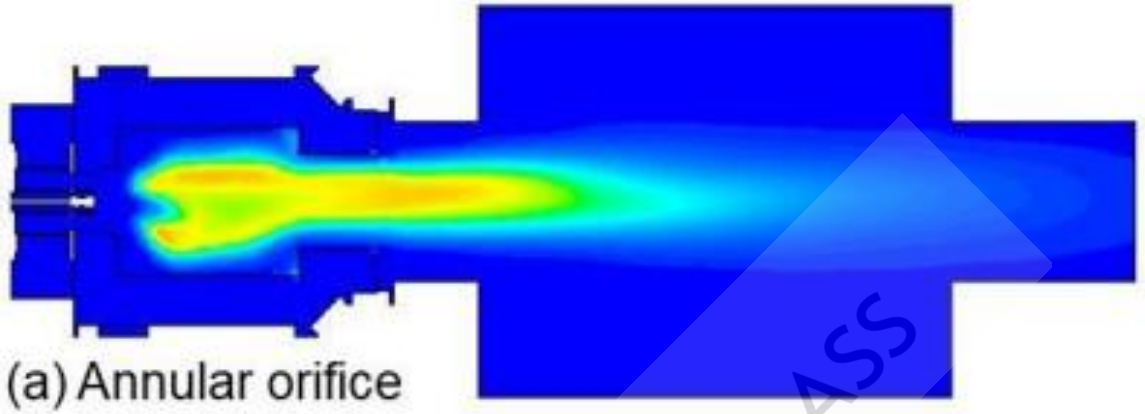




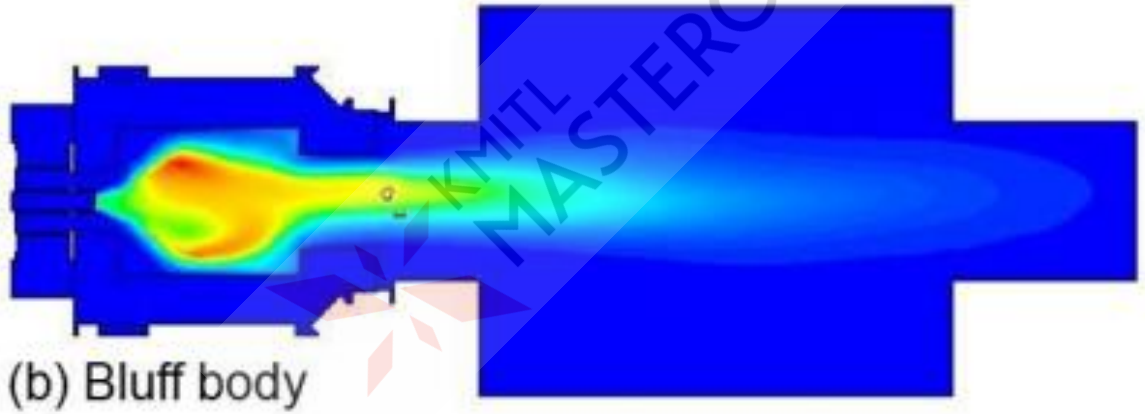


Emissions

CO concentration (vol%, dry)



(a) Annular orifice



(b) Bluff body

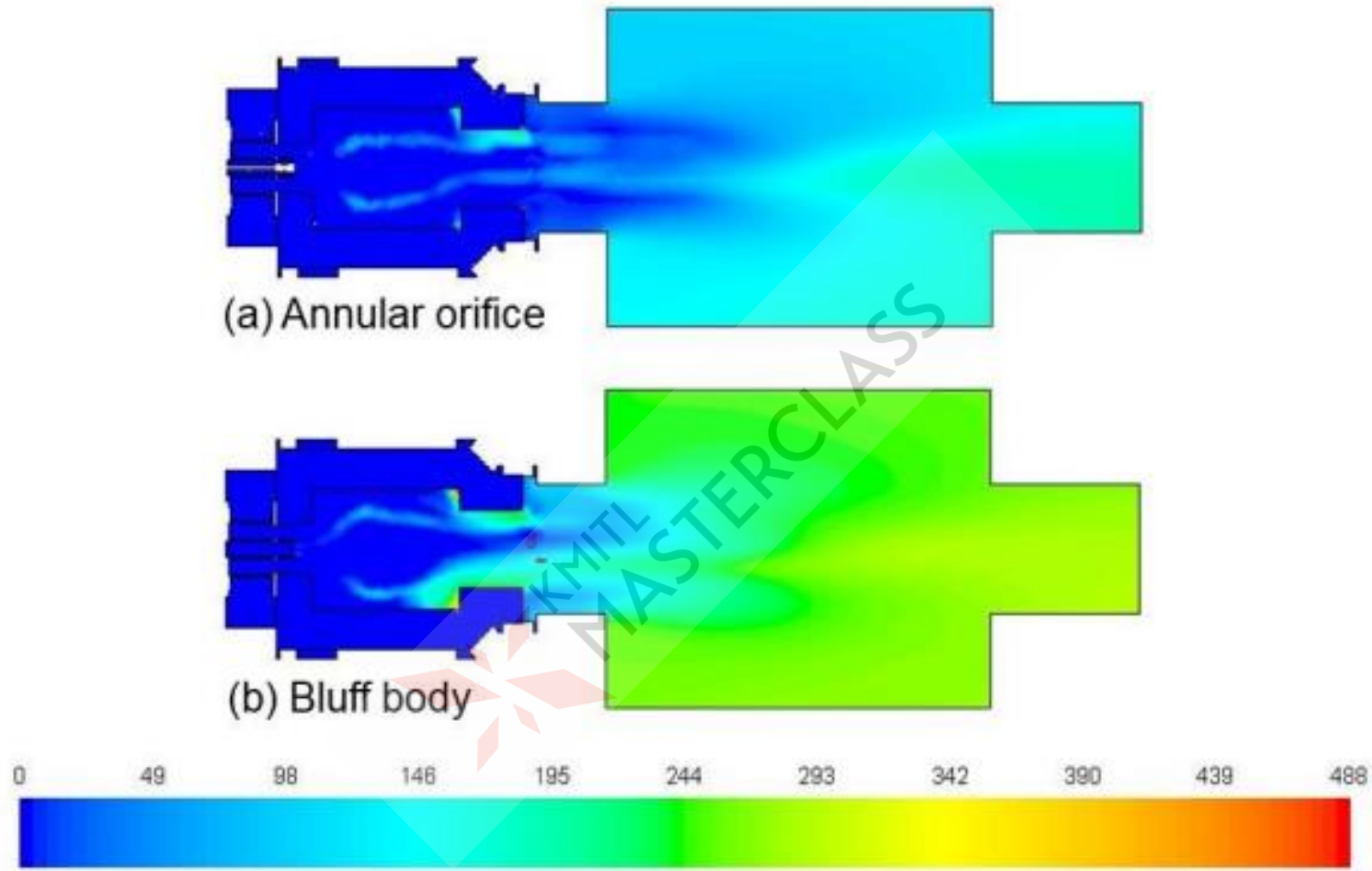


Fig. 23. NO_x concentration (ppm, dry) inside the pre-combustion chamber and furnace for the annular orifice case (a) and the bluff body case (b)