Analisis Biogas Reaktor dengan Side-Entering Mixer Berbasis CFD

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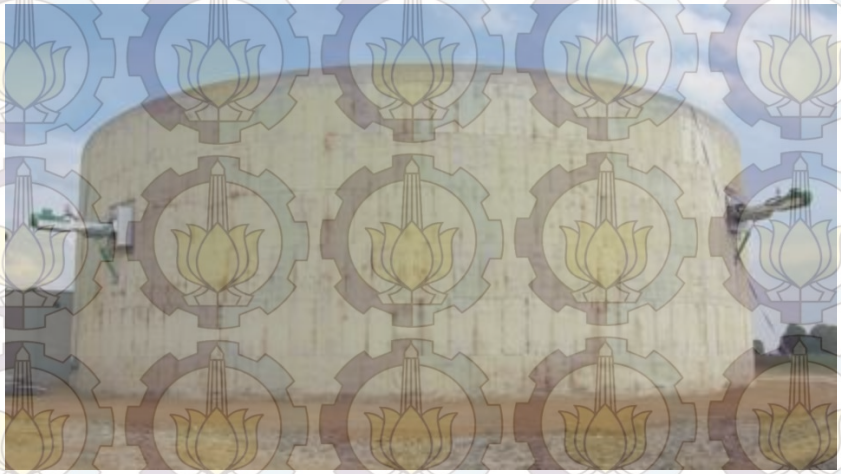
Laboratorium Mekanika Fluida dan Pencampuran

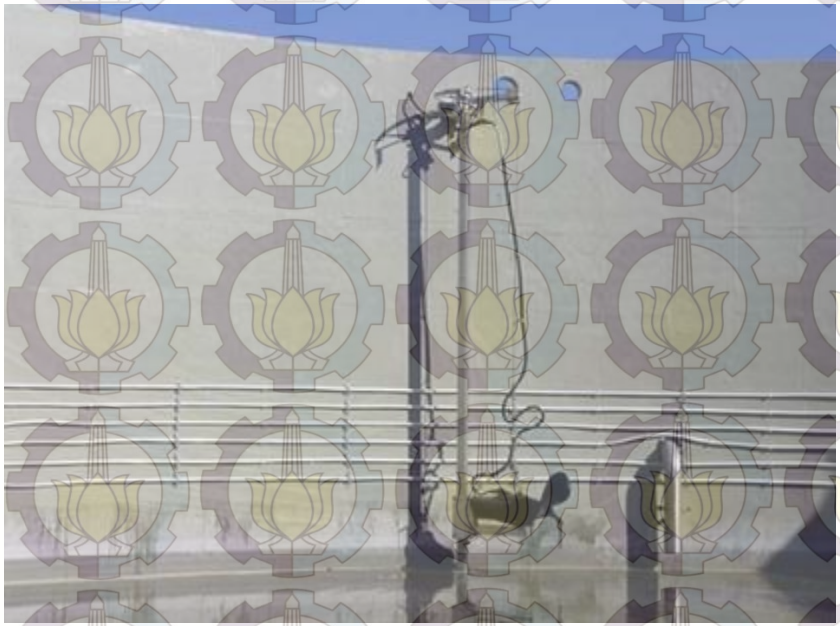
Teknik Kimia

Institut Teknologi Sepuluh Nopember

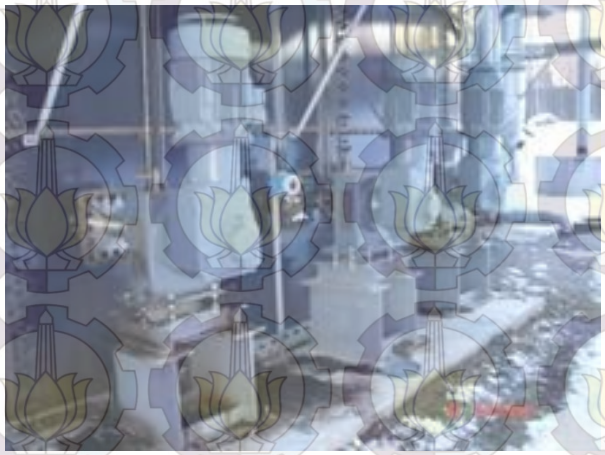
LATAR BELAKANG



Biogas reactor



Biogas reactor

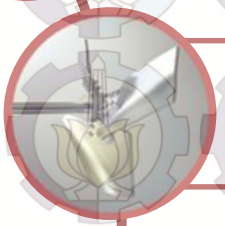


Biogas reactor

LATAR BELAKANG

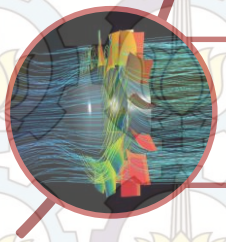
LATAR BELAKANG

Proses biogas menggunakan mikroba anaerobik



Tinggi liquida pada reaktor biogas relatif tinggi

Instalasi lebih mudah dibandingkan dengan top entering mixer



Analisis Biogas Reaktor dengan Side Entering Mixer Berbasis CFD

PENELITIAN TERDAHULU

PENELITI	YANG DITELITI
Dakhel & Rahimi (2004)	CFD Simulation of homogenization in Large-scale crude oil storage tank. Permodelan: CFD, k-ε turbulent, Multiple Frame of Reference (MFR)
Sukmawedha & Sari (2012)	Simulasi Pola Aliran dalam Tangki Berpengaduk menggunakan Side-Entering Impeller untuk Suspensi Padat-Cair Permodelan : CFD, LES, Sliding Mesh
Wu (2012)	Computational Fluid Dynamics Study of Large – scale mixing system with Side Entering Mixer Permodelan : CFD, k-ε turbulent

PERUMUSAN MASALAH

SIDE ENTERING MIXER

- Ukuran
- Multifase
- Jenis Impeller
- Kecepatan

Belum banyak diketahui karakteristik

Pola alir serta **Makro Instabilitas** dari **Multi Fase**

Di dalam aliran **Side Entering Mixer**

TUJUAN PENELITIAN

" Mengetahui **karakteristik pola aliran dan makroinstabilitas** berdasarkan ukuran, jenis dan kecepatan putar impeller dengan sistem **gas liquid** dalam tangki dengan menggunakan ***side-entering mixer*** dengan pendekatan secara simulasi menggunakan **Computational Fluid Dynamics(CFD) "**

MANFAAT PENELITIAN

“ Memberikan informasi valid tentang desain reaktor biogas dengan *side-entering mixer* (SEM) skala laboratorium dengan sistem gas-liquid sebagai acuan desain biogas reaktor skala industri“

METODOLOGI

1 PRE-PROCESSING

Menghimpun Data

Pemodelan Geometri

Meshing

2 SOLVING

- Material Properties
- Boundary Condition

Pemodelan

Equation Solved

3 POST-PROCESSING

Graphics and Animation

Plot

PRE-PROCESSING :
HIMPUN DATA

Variabel Kecepatan Putar :

- 400 rpm
- 500 rpm
- 600 rpm
- 700 rpm

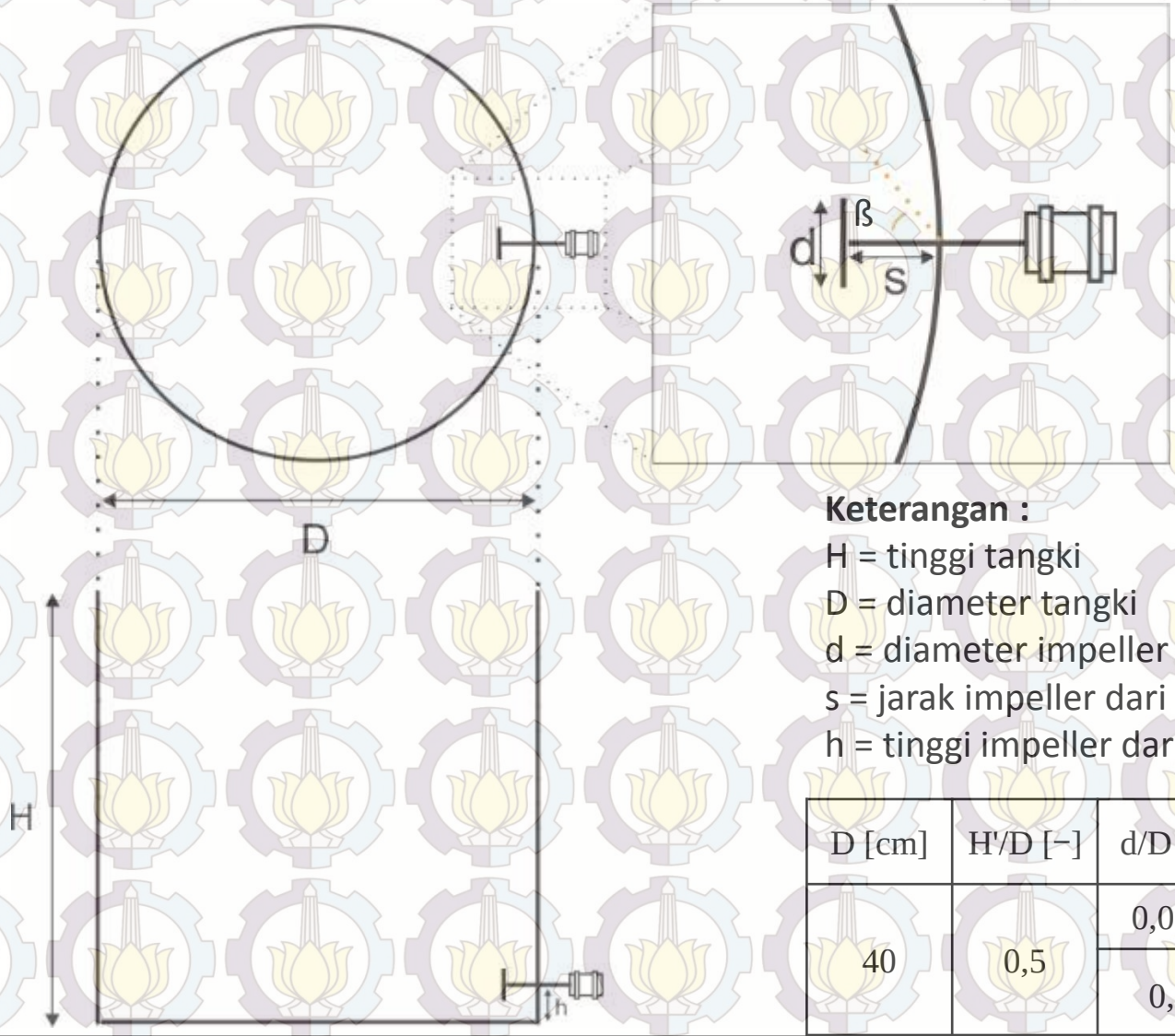
Variabel Ukuran Impeller:

- 3 cm
- 4 cm

Variabel Jumlah Blade:

- 4 blade
- 6 blade

PRE-PROCESSING :
PEMODELAN GEOMETRI

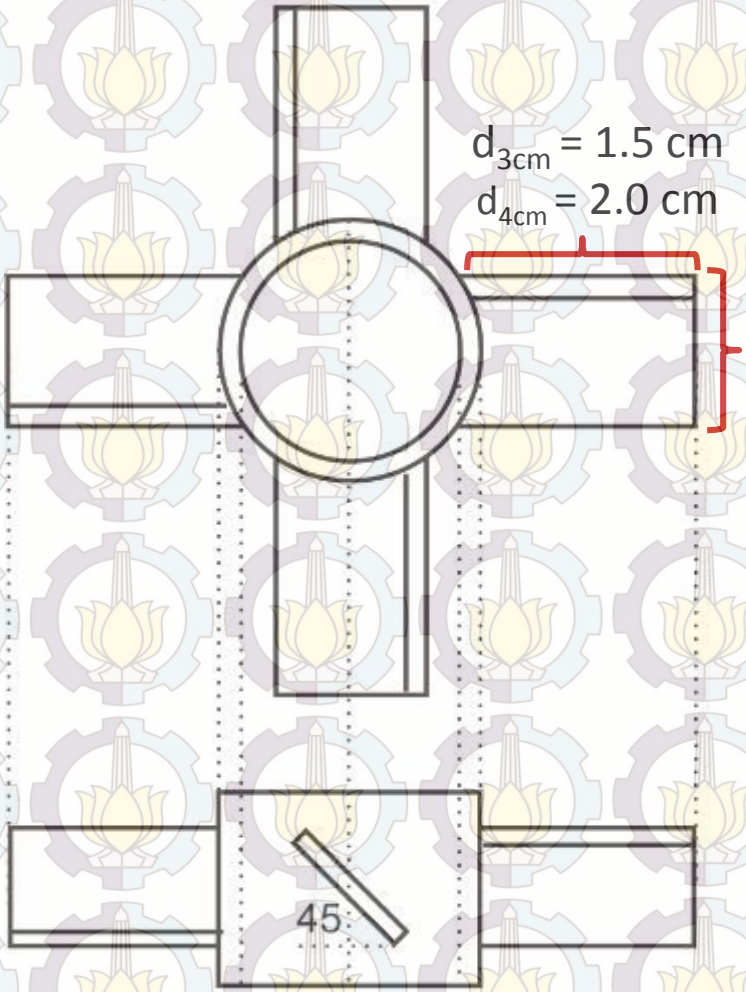


Keterangan :

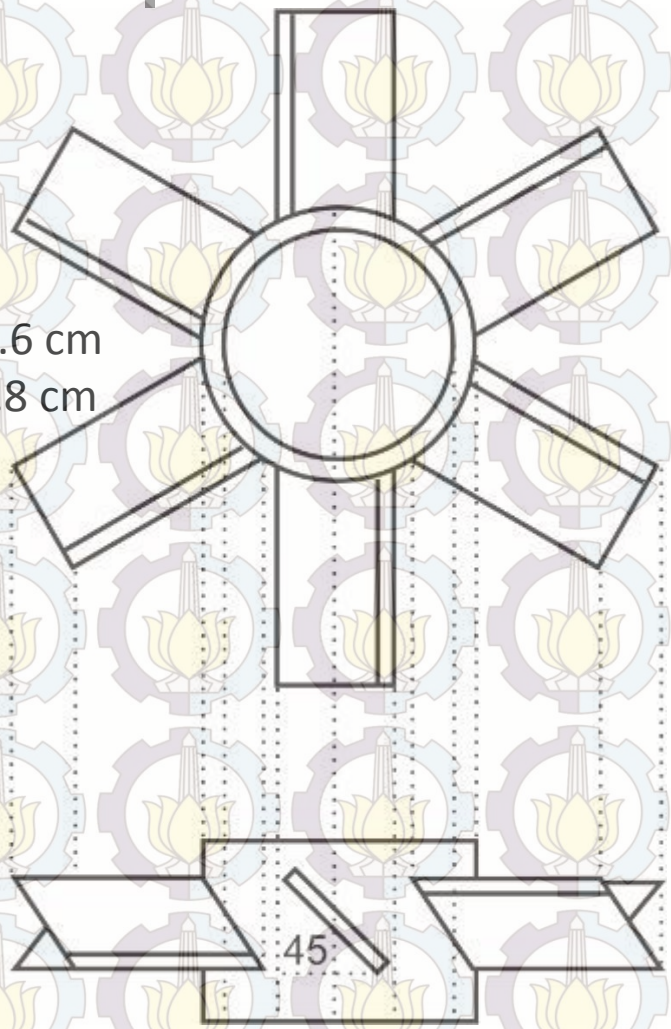
H = tinggi tangki
D = diameter tangki
d = diameter impeller
s = jarak impeller dari dinding tangki
h = tinggi impeller dari dasar tangki

D [cm]	H'/D [−]	d/D [−]	s/D [−]	h/D [−]
40	0,5	0,075	0,075	0,075
		0,1	0,1	0,1

PRE-PROCESSING :
PEMODELAN GEOMETRI



4 blade



6 blade

SOLVING :
MATERIAL PROPERTIES

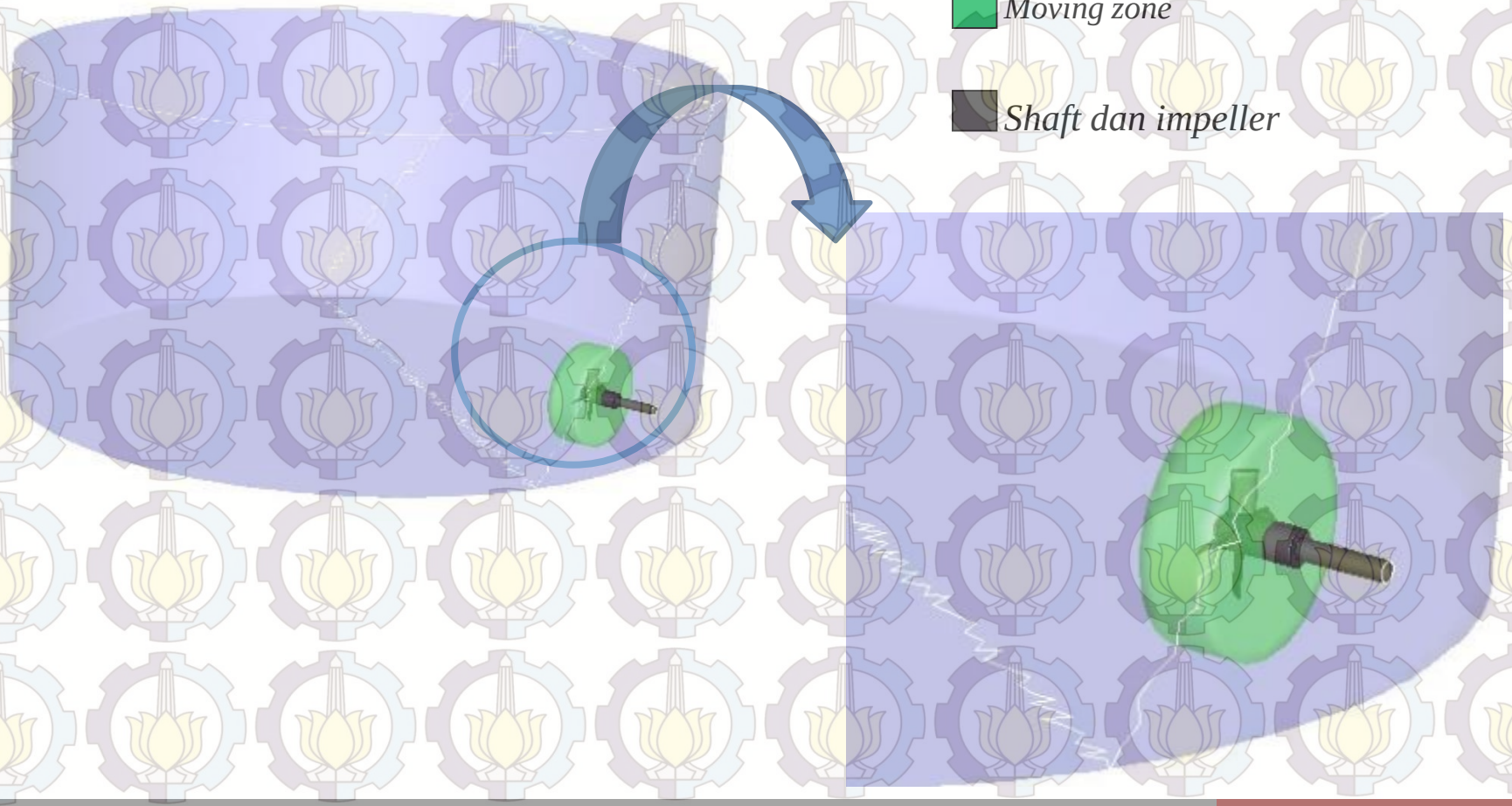
Keterangan	Liquid	Gas
	Air	Methane + CO_2
Reference Temperatur (°C)	37	
Densitas ($kg/m^{3)}$	1000	0,6679
Viskositas (kg/m/s)	0,001003	0,000010875

SOLVING :
GEOMETRI TANGKI

Stationery zone

Moving zone

Shaft dan impeller



SOLVING :
SOLVER

Memilih Persamaan

Mendefinisikan material

Membuat interface

Memodelkan turbulensi dengan *LES*

A

A

Memilih solver

Menghitung penyelesaian model matematis

Menginisialkan System

Time Step Size = 0,01 s
Jumlah time step 1000
1 s dapat 100 frame gambar

SOLVING :
PEMODELAN

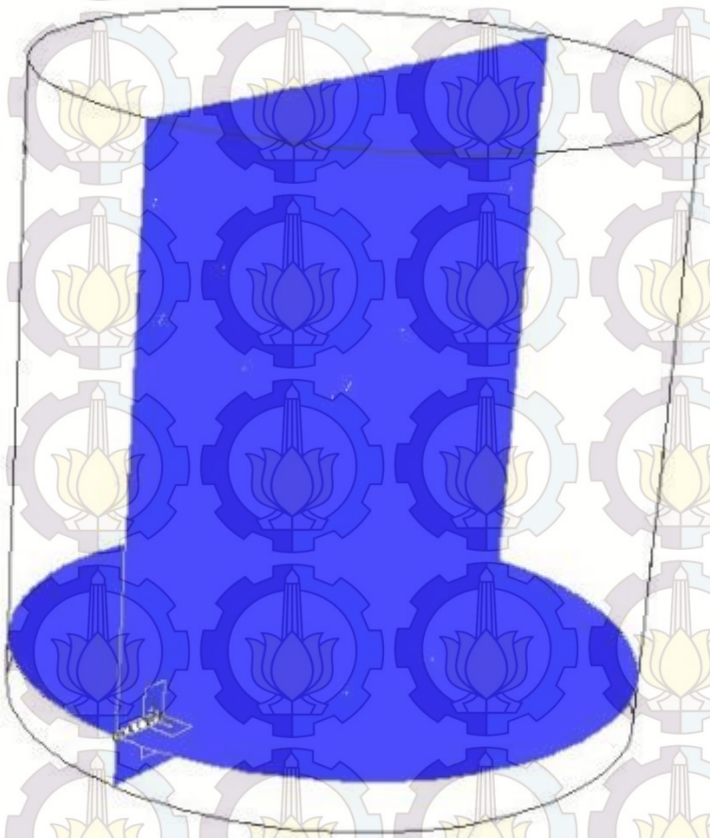
Viscous Model

- Large Eddy Simulation (LES)

Impeller Model

- Sliding Mesh

SOLVING :
BIDANG PENGAMATAN



"Bidang vertikal dan horizontal yang memotong tepat ditengah impeller"

POST-PROCESSING :

Pola alir

Jumlah Makro instabilitas

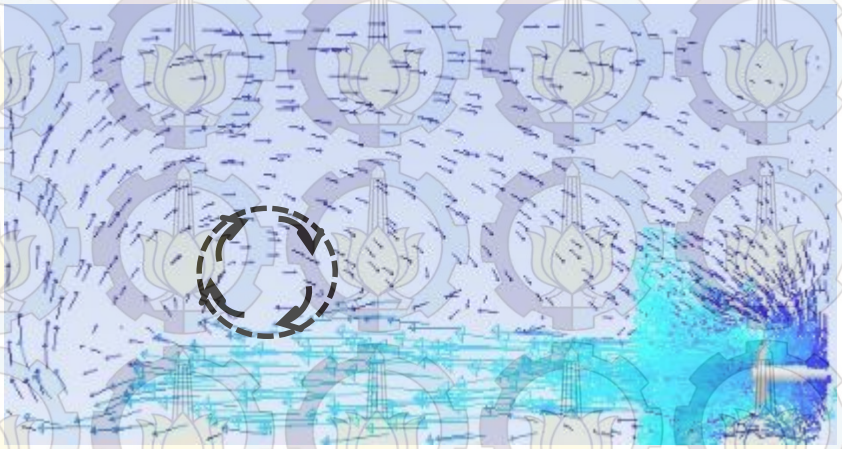
Average life time

Life time ratio

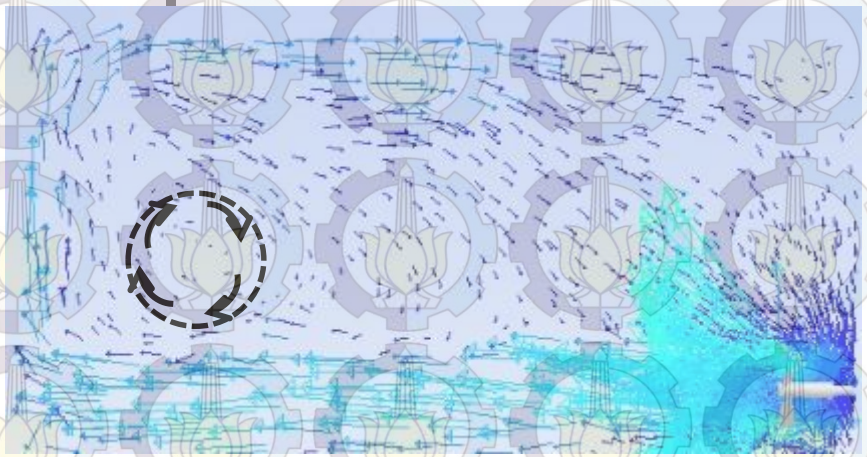
Volume Fraction

HASIL DAN PEMBAHASAN

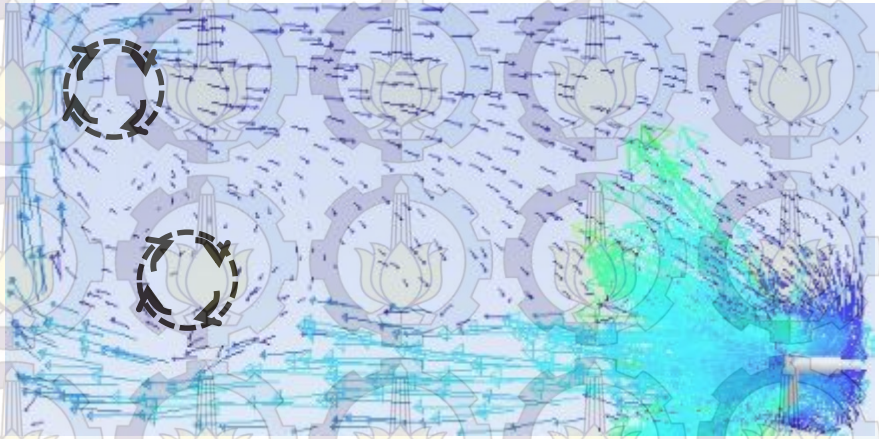
Impeller 4 cm 4 blade dengan kecepatan putar 400 rpm



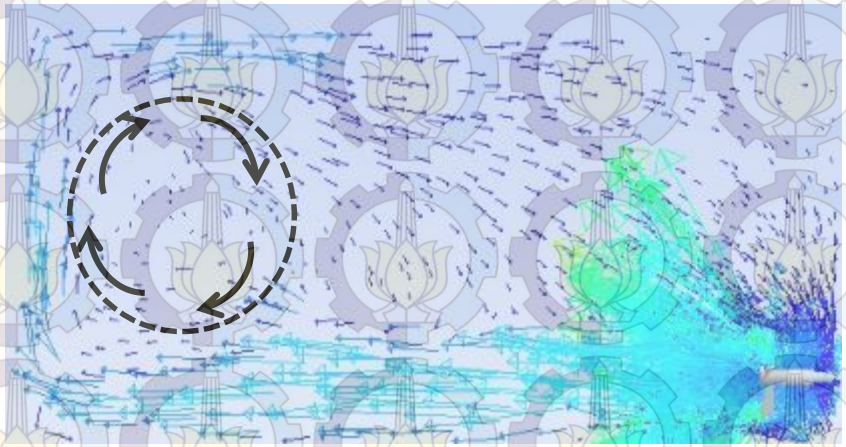
t = 3,01 s



t = 5,06 s

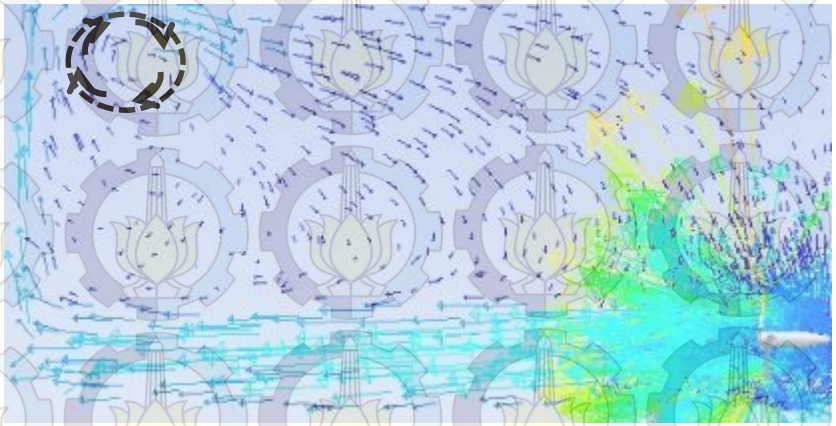


t = 6,41 s

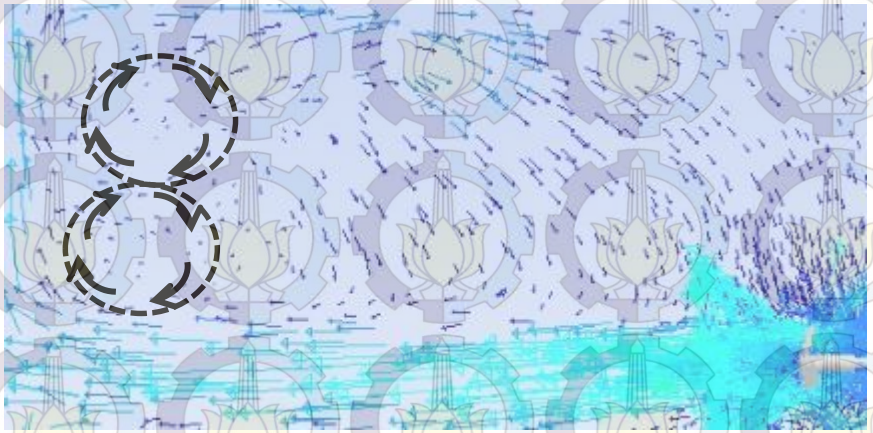


t = 8,14 s

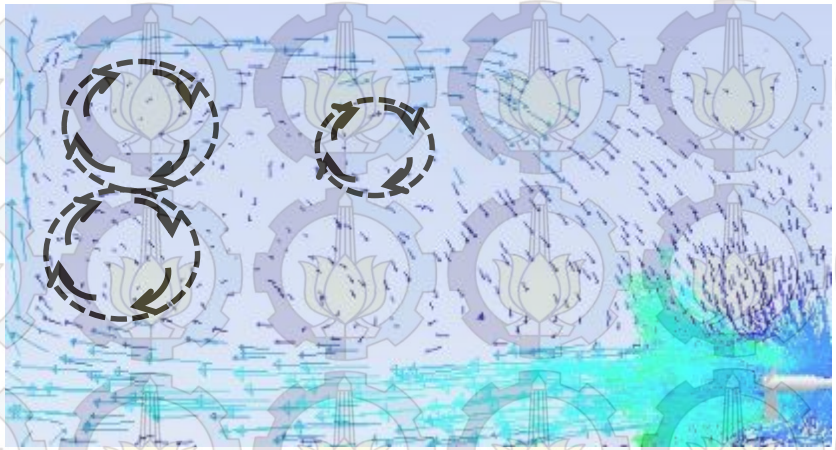
Impeller 4 cm 4 blade dengan kecepatan putar 500 rpm



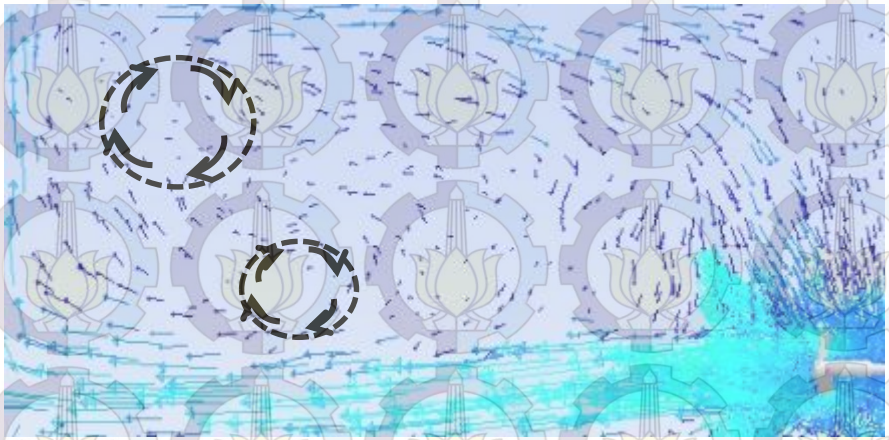
t = 3,68 s



t = 4,98 s

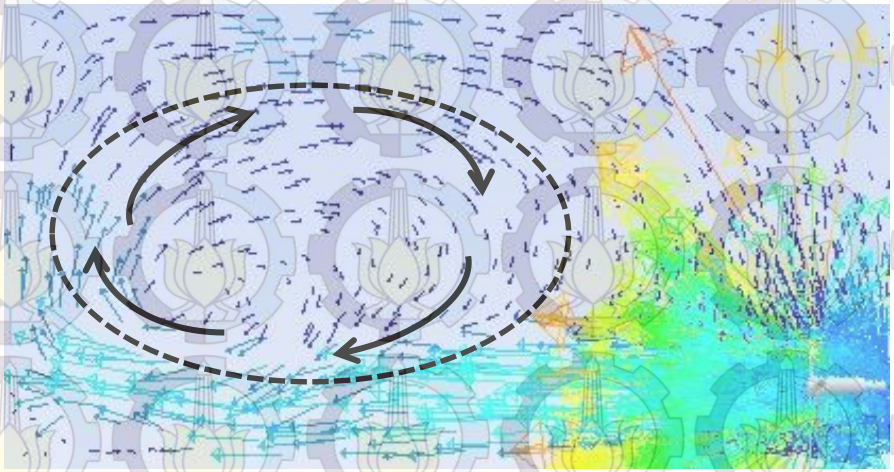


t = 5,64 s

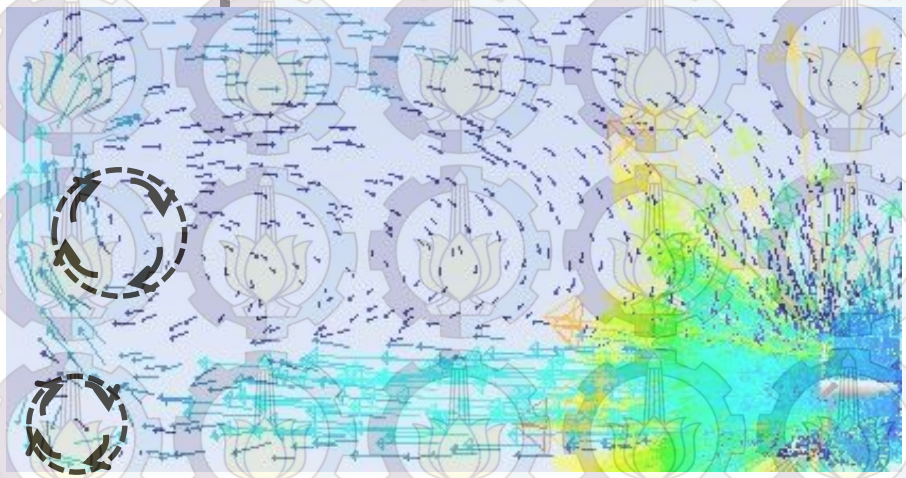


t = 8,47 s

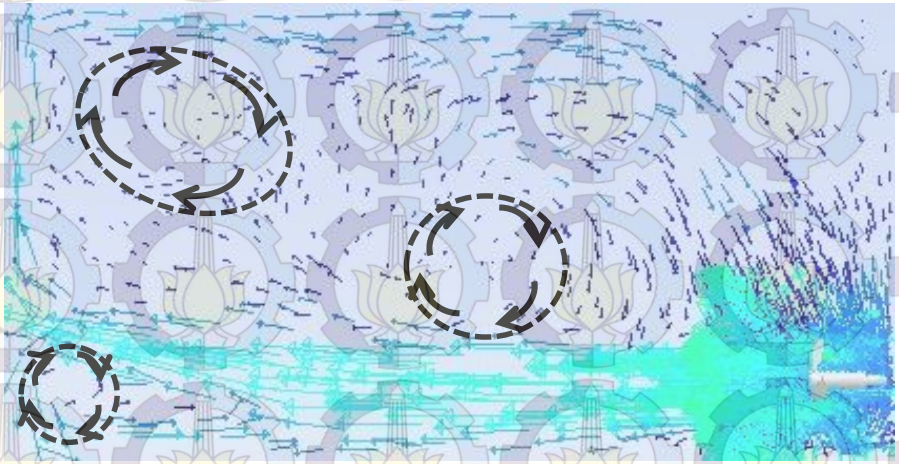
Impeller 4 cm 4 blade dengan kecepatan putar 600 rpm



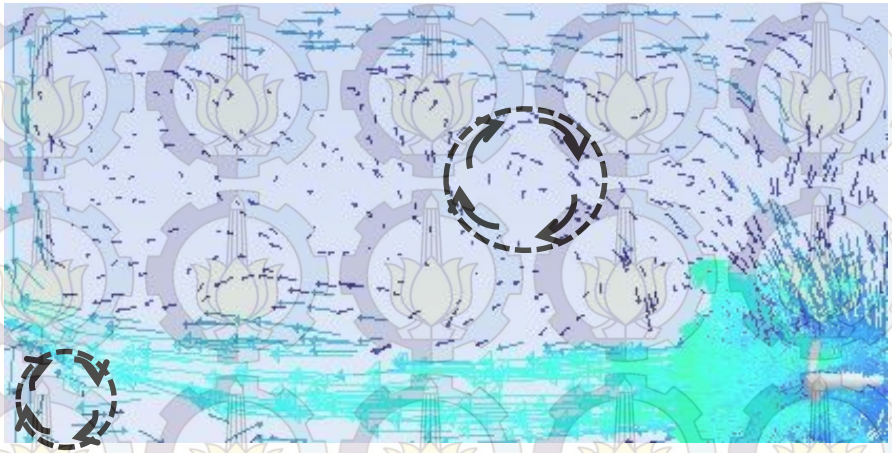
t = 1,54 s



t = 2,14 s

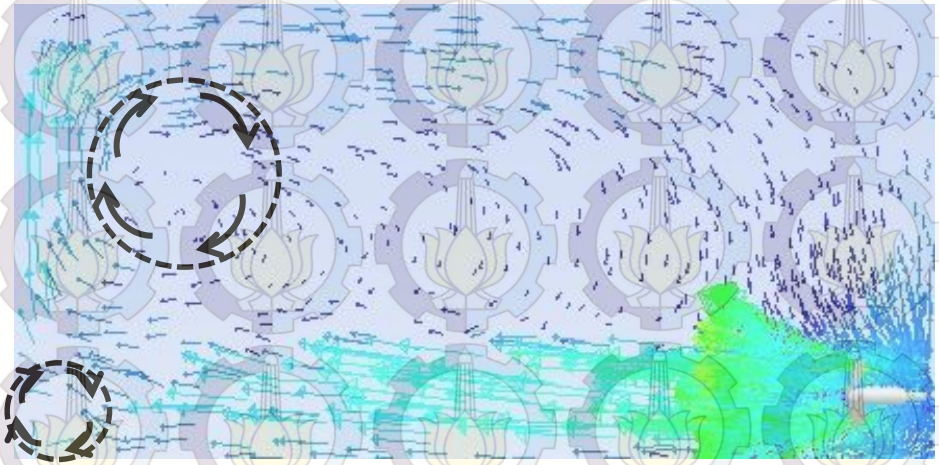


t = 5,51 s

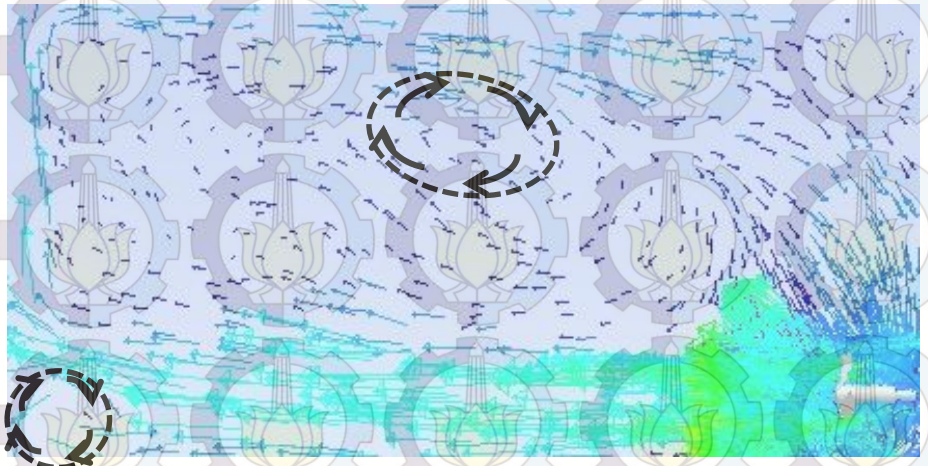


t = 6,86 s

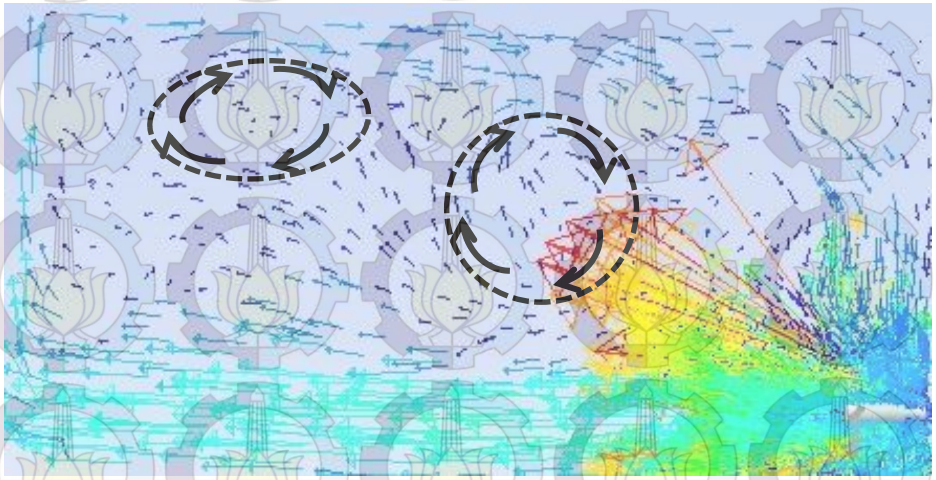
Impeller 4 cm 4 blade dengan kecepatan putar 700 rpm



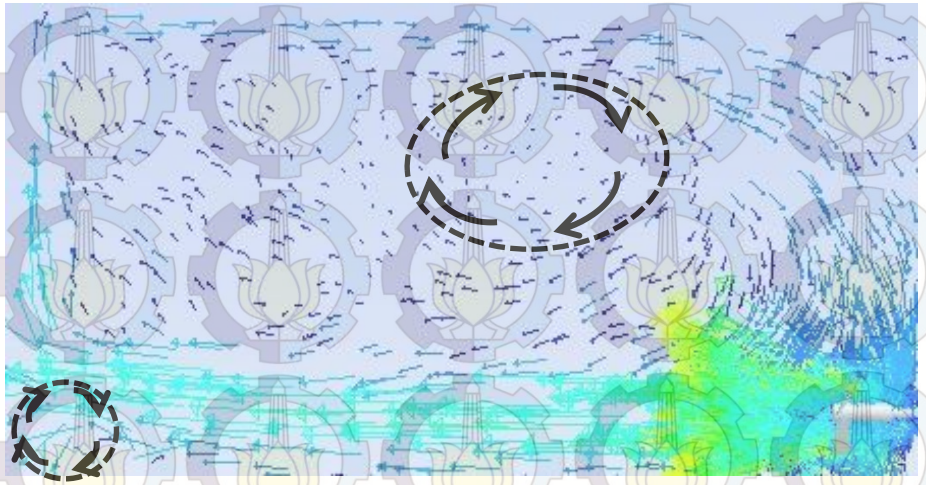
t = 2,04 s



t = 5,30 s



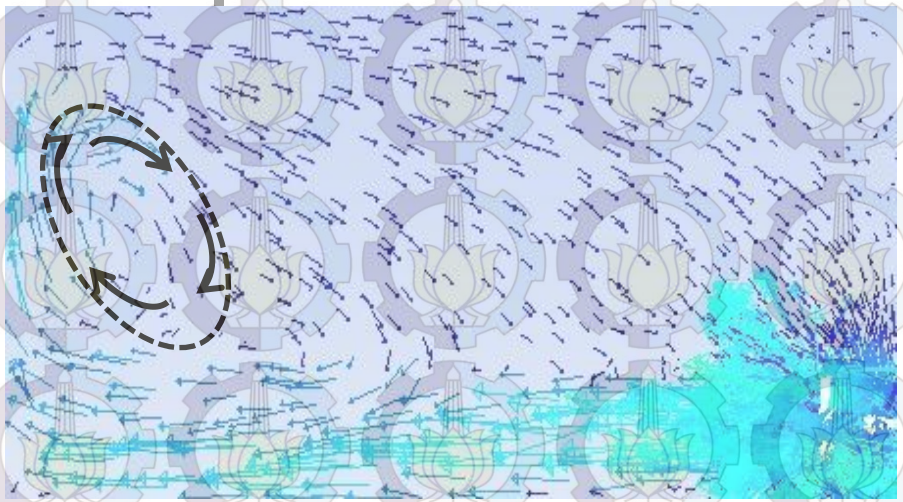
t = 6,42 s



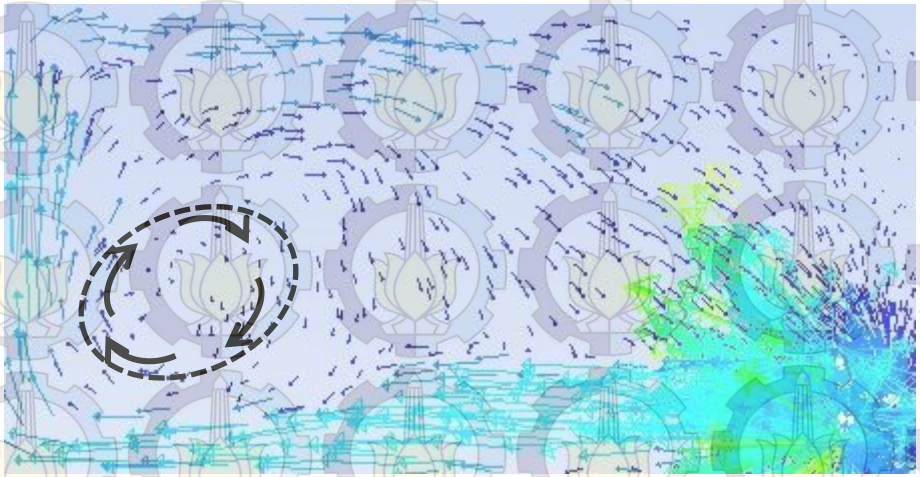
t = 9,07 s

Impeller 4 cm 6 blade dengan kecepatan putar 400 rpm

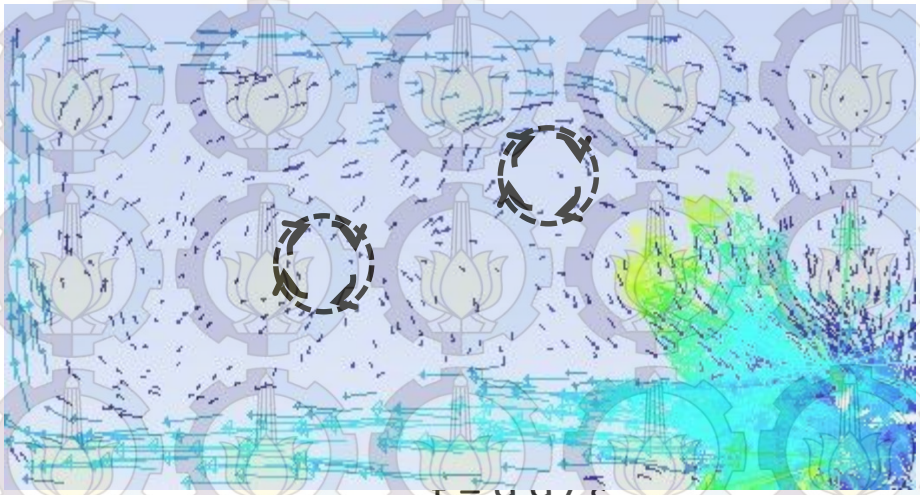
t = 3,41 s



t = 5,16 s

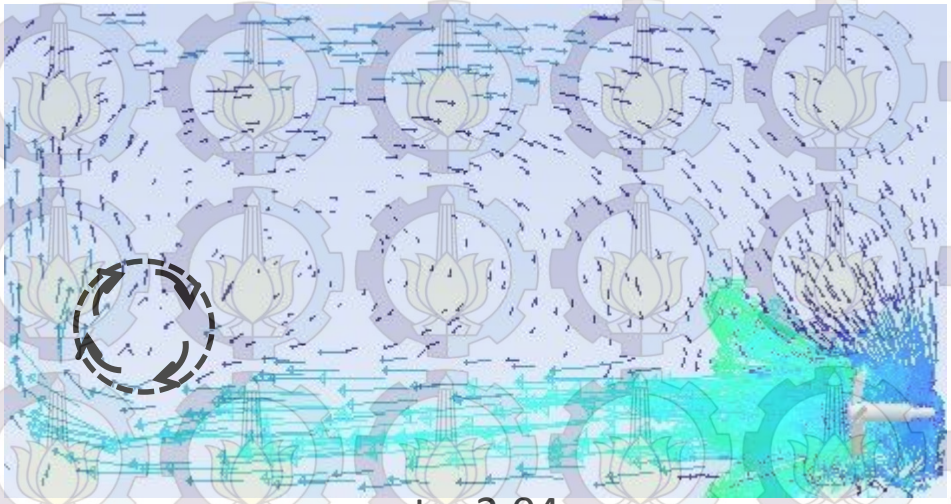


t = 8,04 s

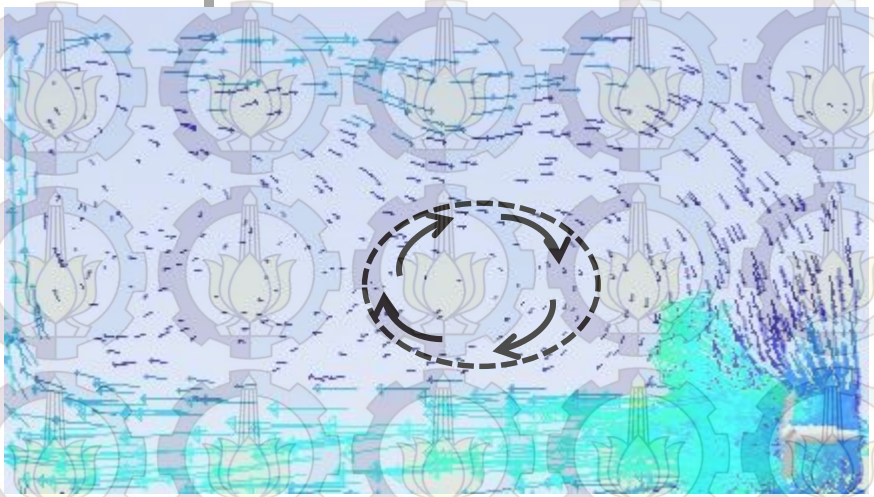


t = 9,97 s

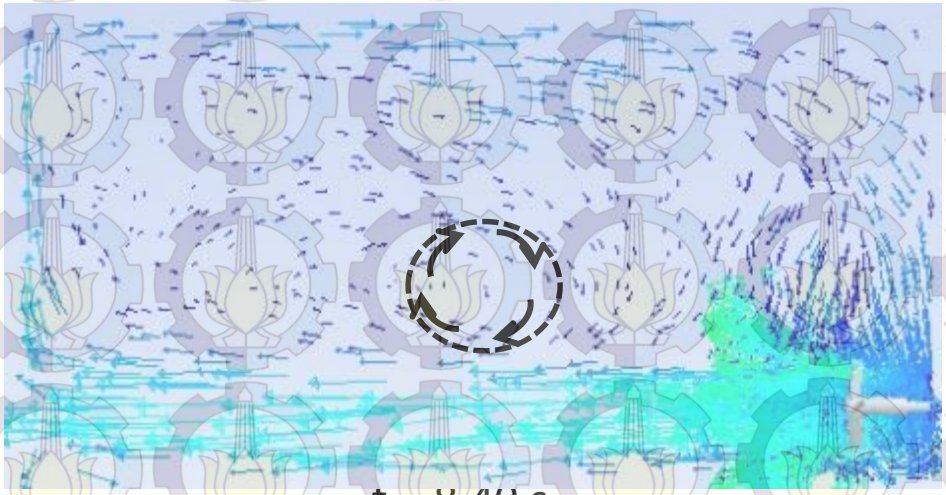
Impeller 4 cm 6 blade dengan kecepatan putar 500 rpm



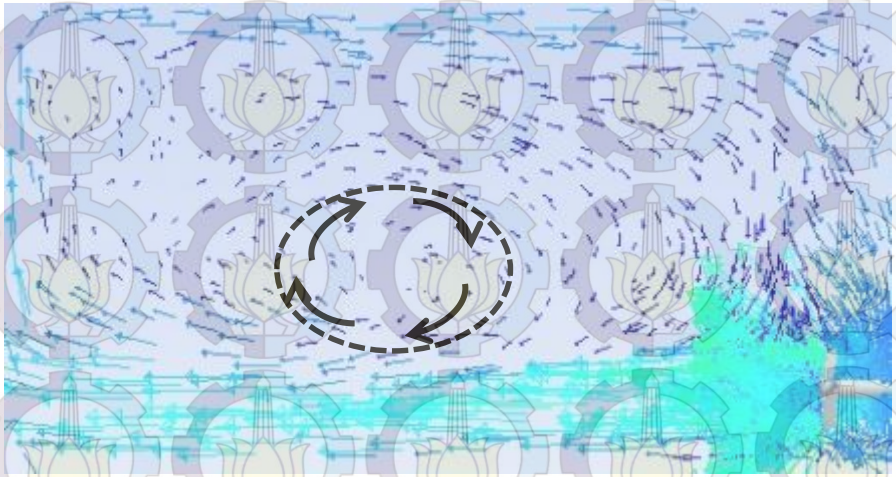
t = 2,04 s



t = 4,42 s

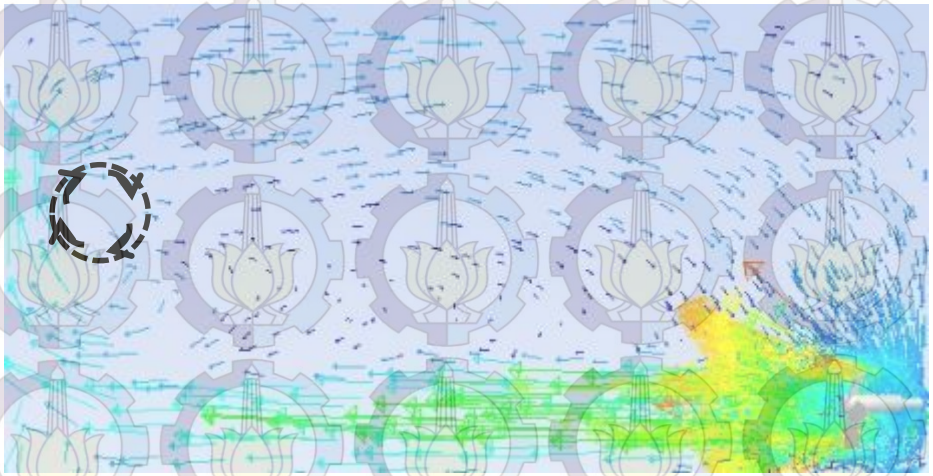


t = 8,40 s

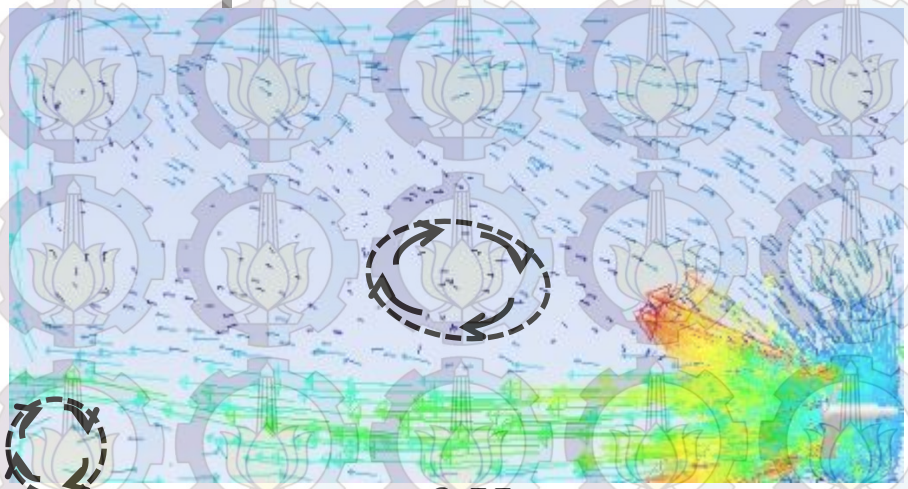


t = 9,68 s

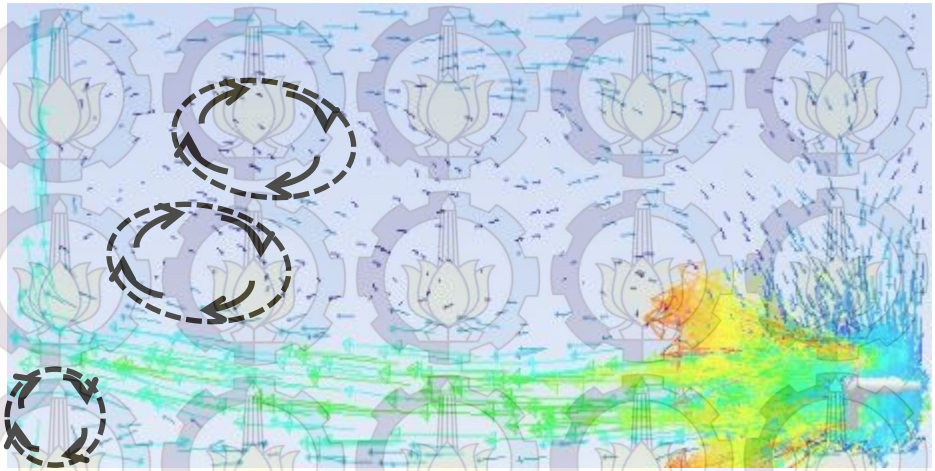
Impeller 4 cm 6 blade dengan kecepatan putar 600 rpm



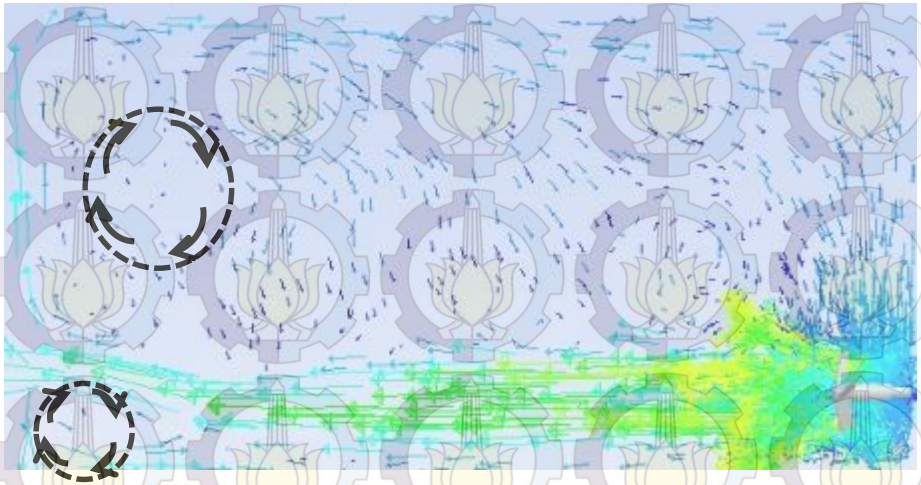
t = 1,78 s



t = 3,55 s

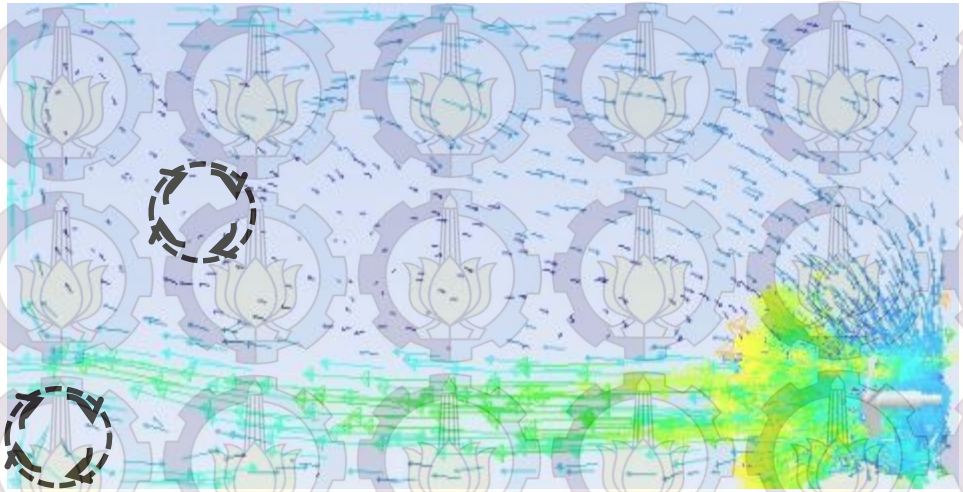


t = 5,55 s

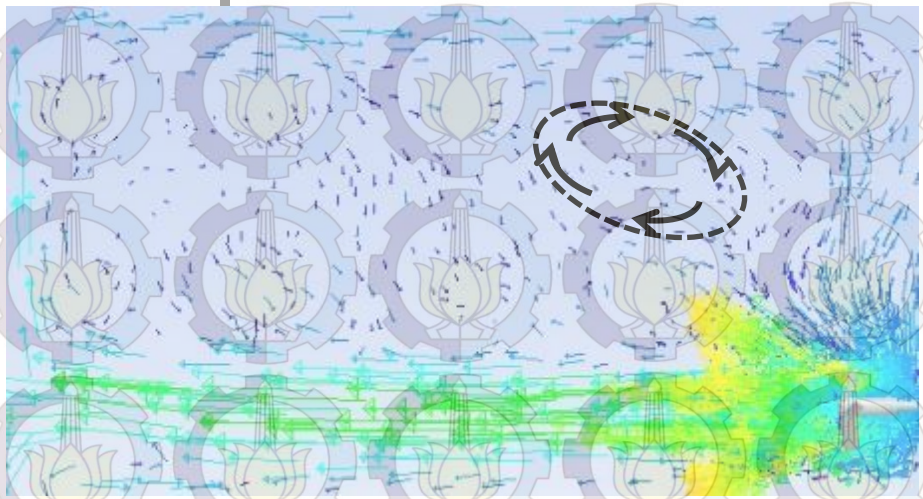


t = 8 s

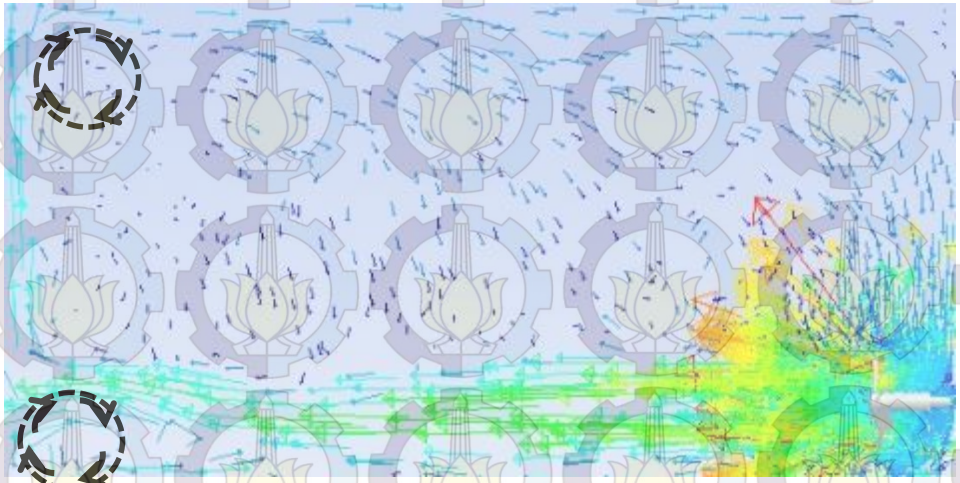
Impeller 4 cm 6 blade dengan kecepatan putar 700 rpm



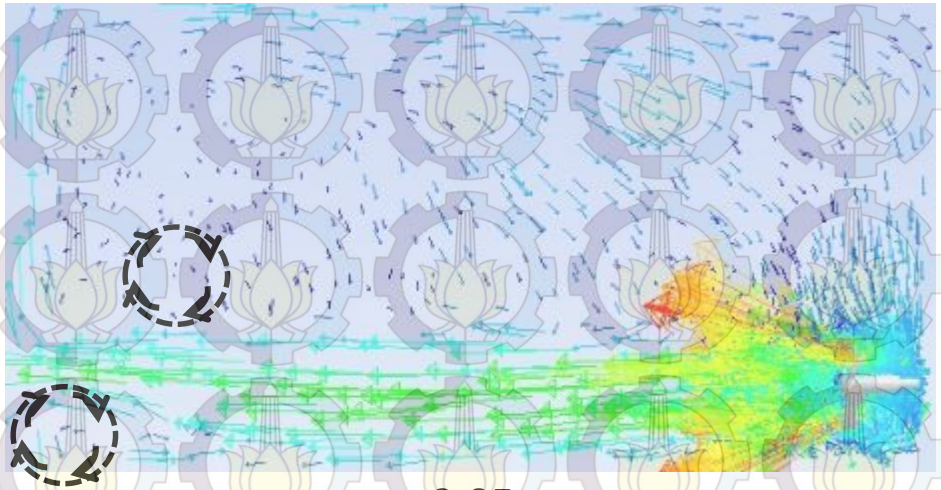
t = 3,13 s



t = 6,64 s



t = 7,79 s



t = 9,05 s

IDENTIFIKASI POLA ALIR (bidang vertical)

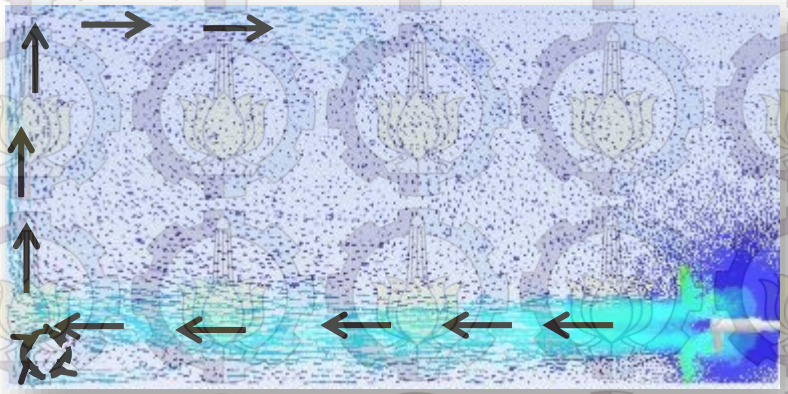
Pengaruh jumlah blade terhadap pola alir (500 rpm)

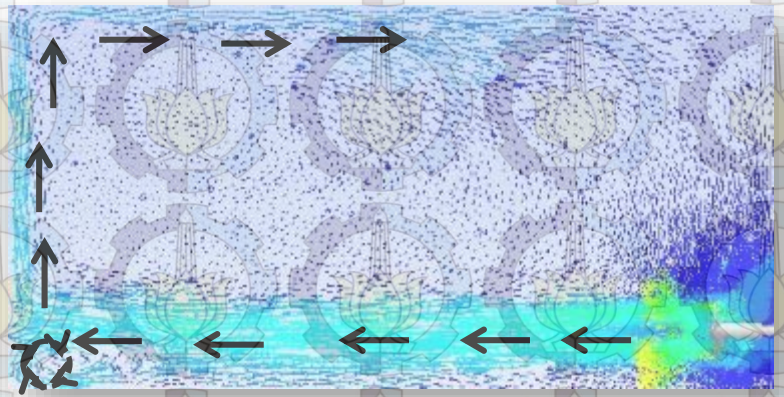
4 blade

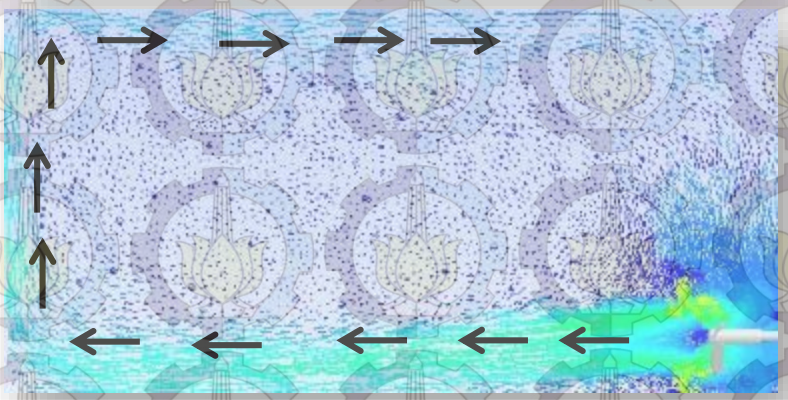
6 blade

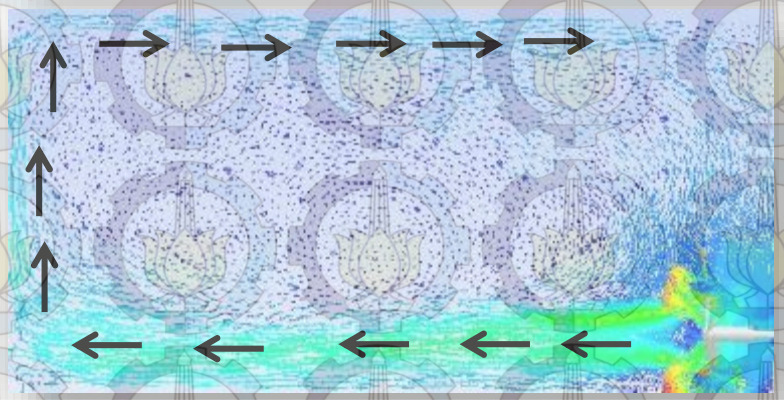
Diameter impeller = 3 cm

Diameter impeller = 4 cm







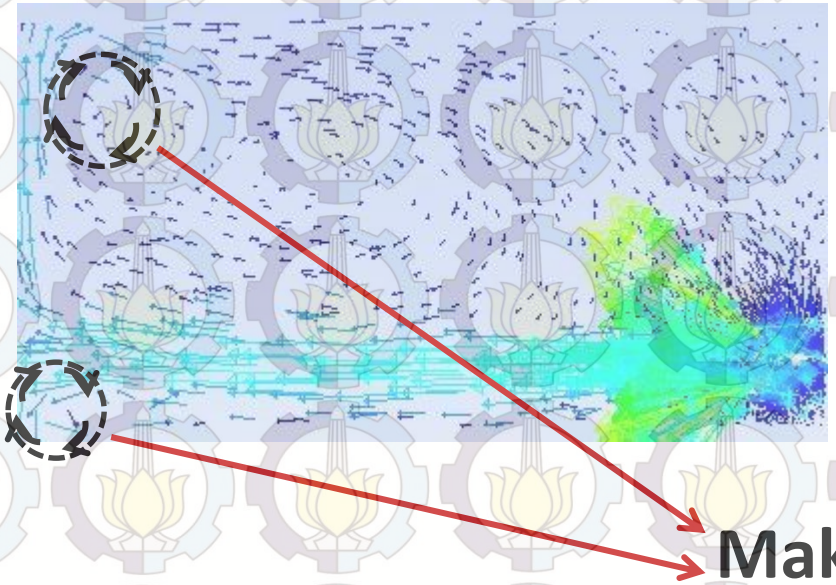


Velocity (m/s)

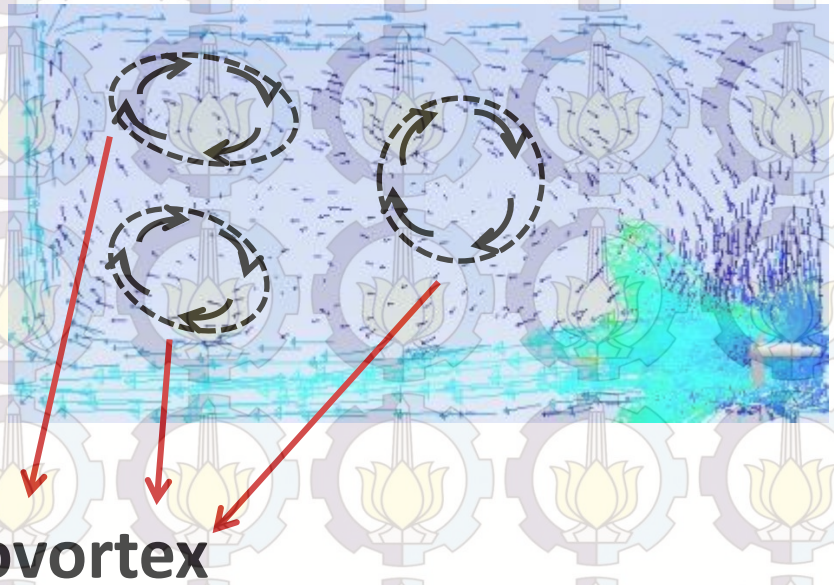
IDENTIFIKASI POLA ALIR (bidang vertical)

Pola alir yang berbeda (500 rpm)

Diameter impeller = 3 cm

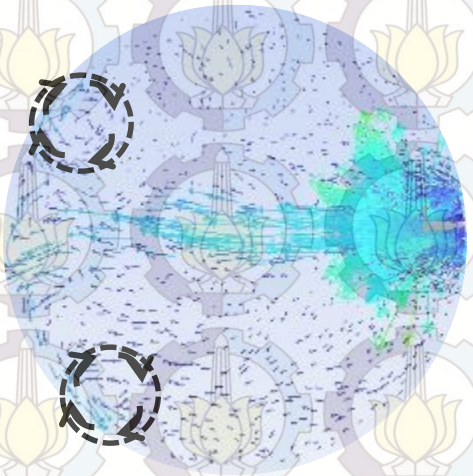


Diameter impeller = 4 cm

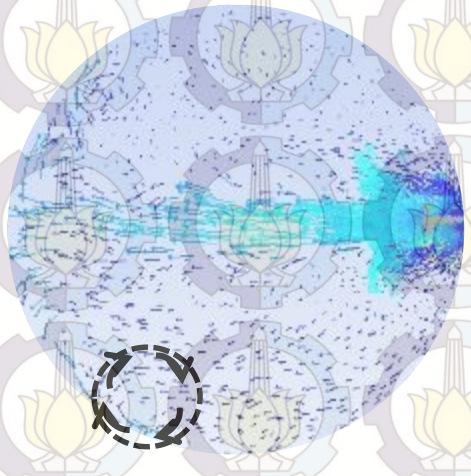


Makrovortex

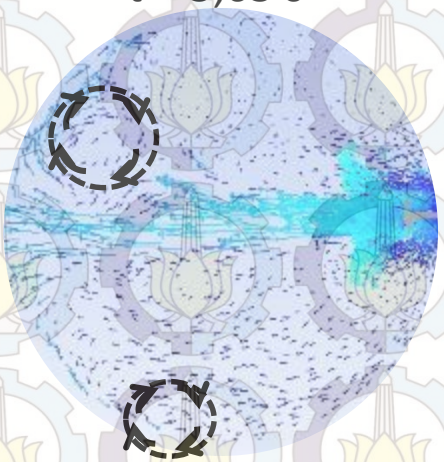
Impeller 4 cm 4 blade dengan kecepatan putar 400 rpm



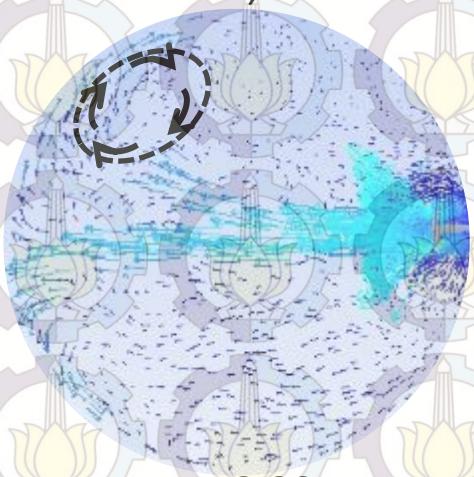
t = 5,65 s



t = 6,05 s

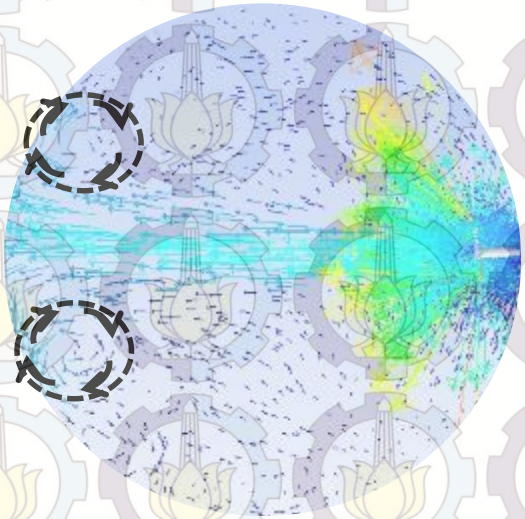


t = 7,1 s

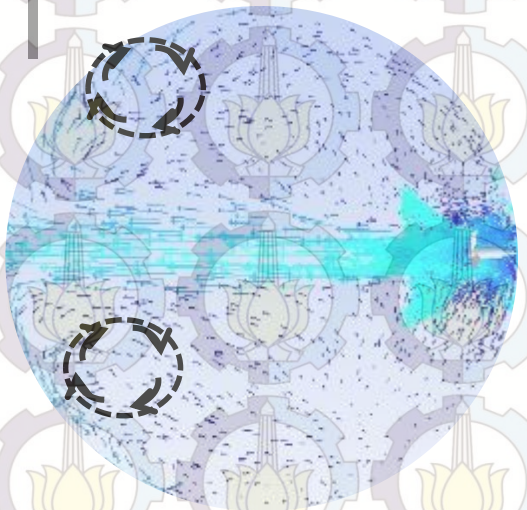


t = 8,22 s

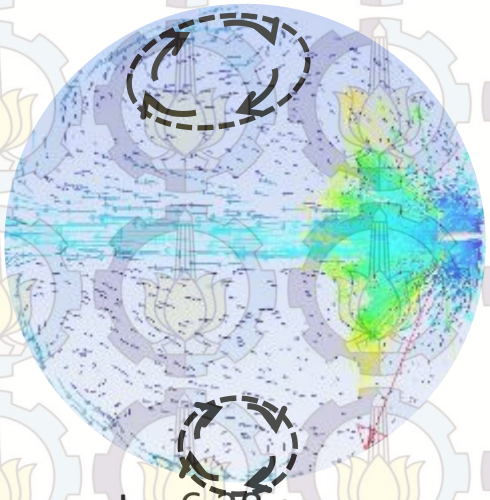
Impeller 4 cm 4 blade dengan kecepatan putar 500 rpm



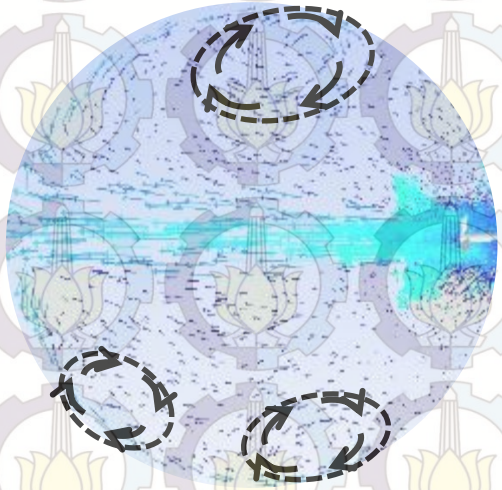
t = 2,57 s



t = 4,63 s

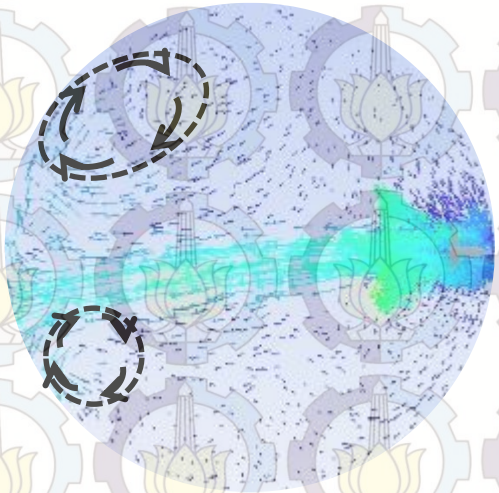


t = 6,38 s

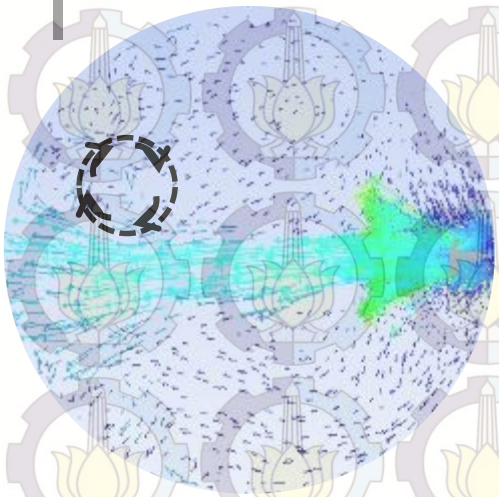


t = 8,35 s

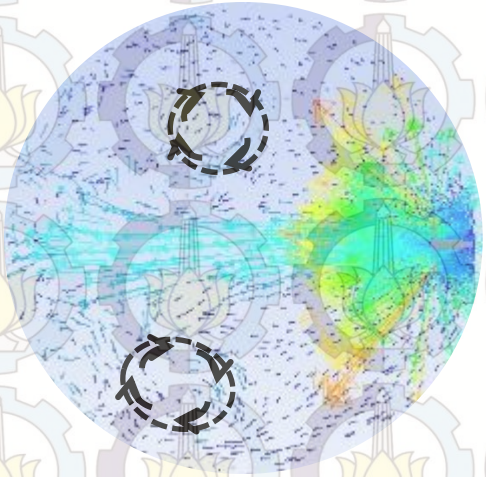
Impeller 4 cm 4 blade dengan kecepatan putar 600 rpm



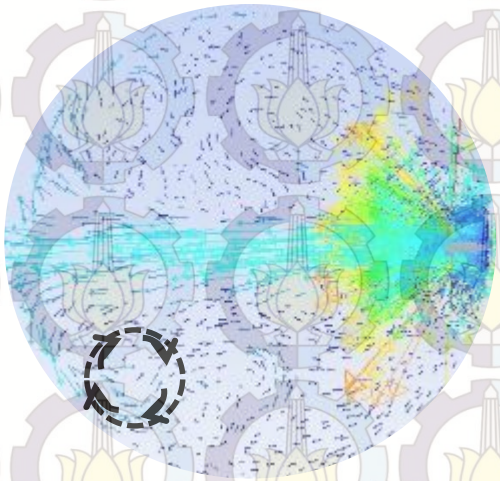
t = 2,08 s



t = 4,5 s

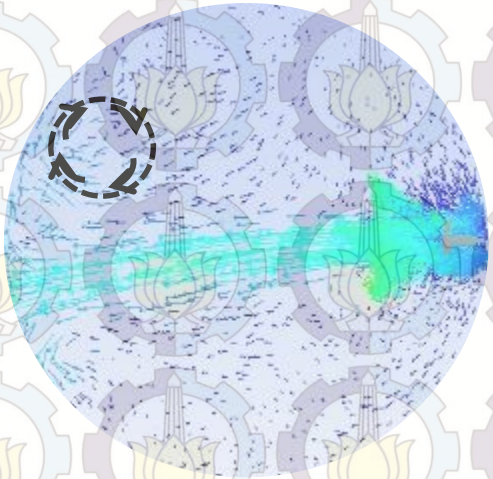


t = 6,74 s

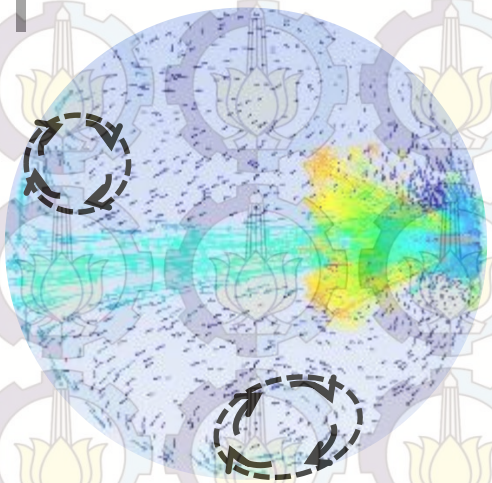


t = 9,19 s

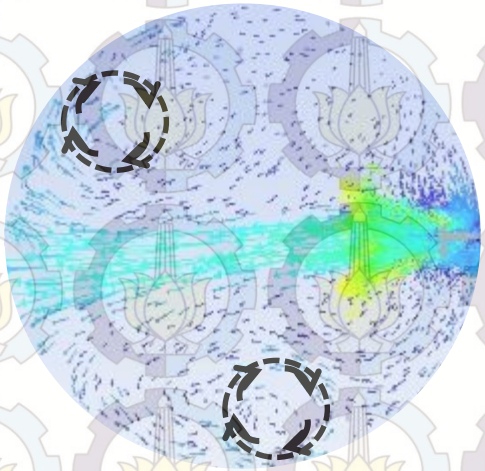
Impeller 4 cm 4 blade dengan kecepatan putar 700 rpm



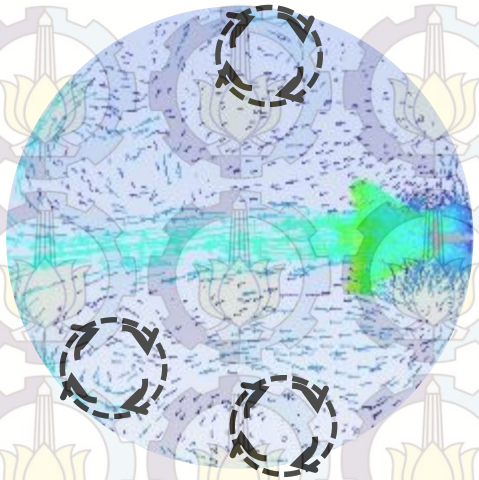
t = 1,63 s



t = 2,95 s

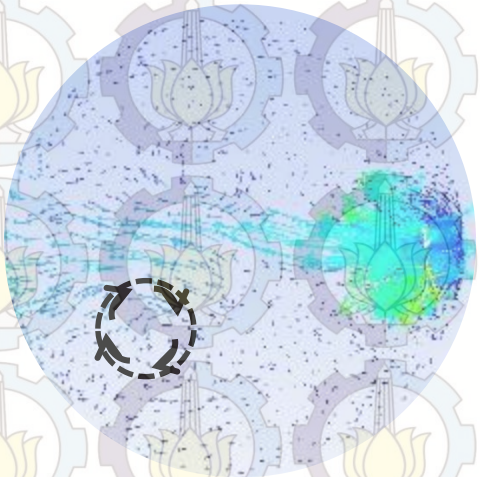


t = 3,64 s

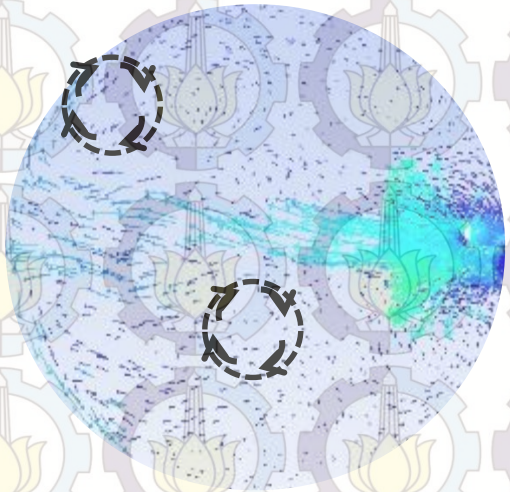


t = 6,56 s

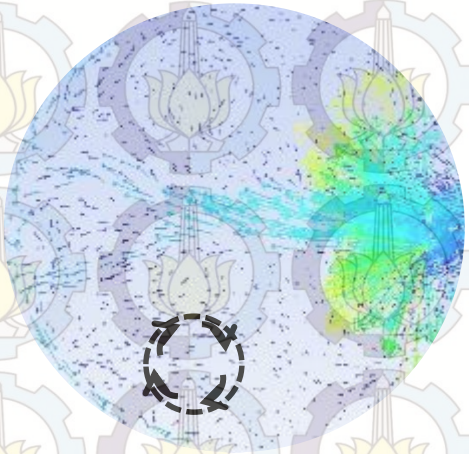
Impeller 4 cm 6 blade dengan kecepatan putar 400 rpm



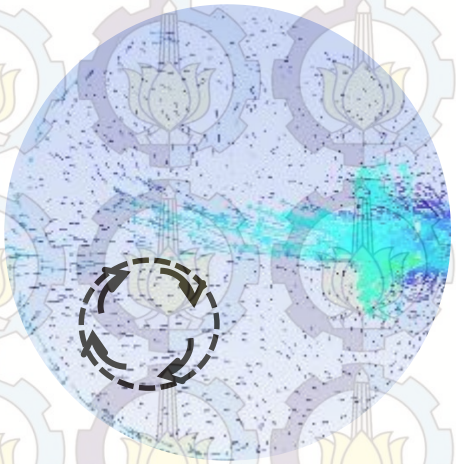
t = 4,2 s



t = 5,94 s

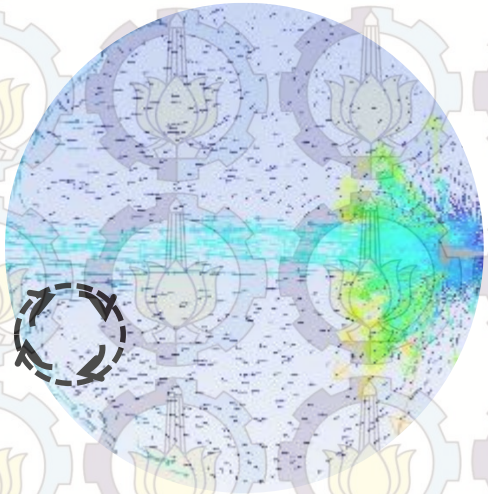


t = 7,23 s

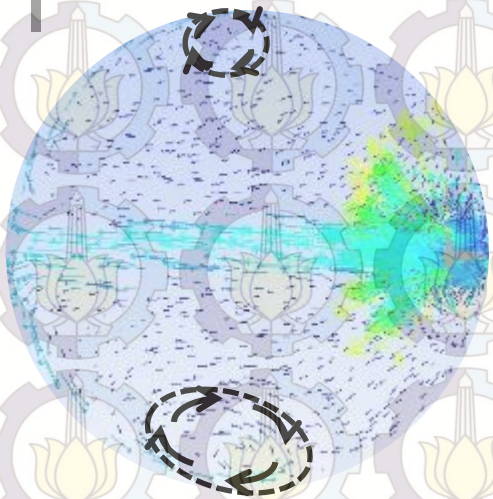


t = 8,92 s

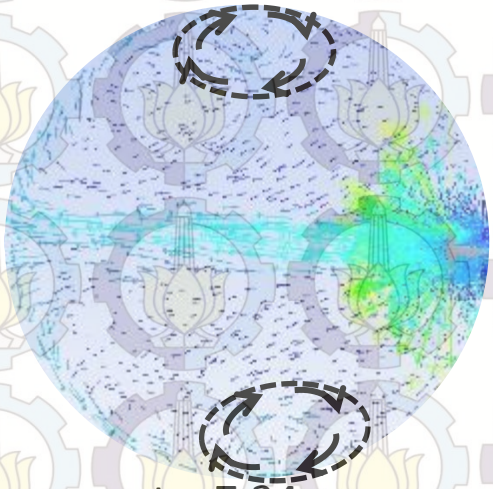
Impeller 4 cm 6 blade dengan kecepatan putar 500 rpm



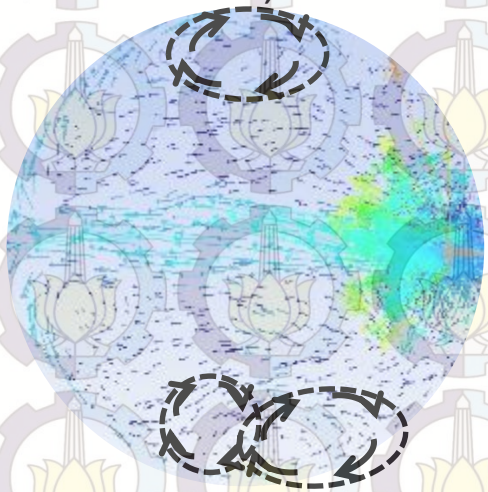
t = 3,84 s



t = 5,14 s

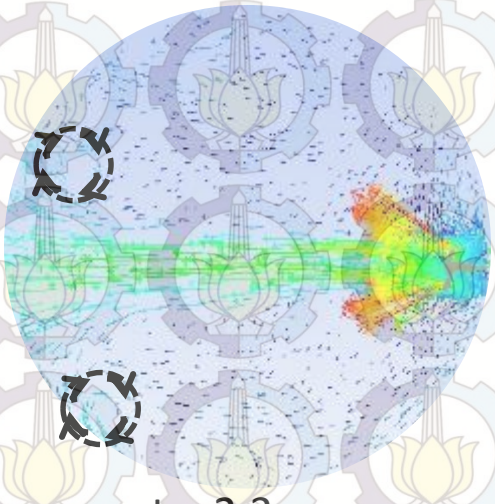


t = 7,34 s

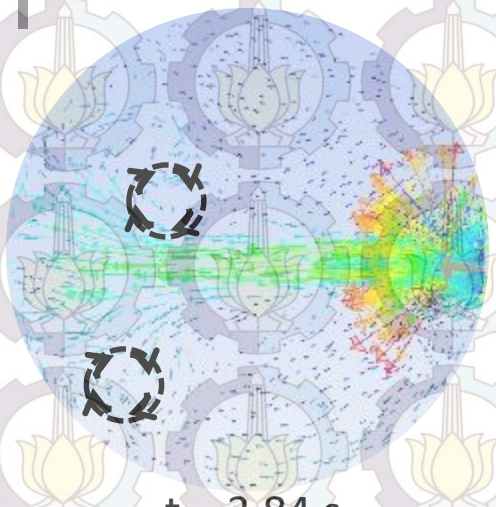


t = 9,8 s

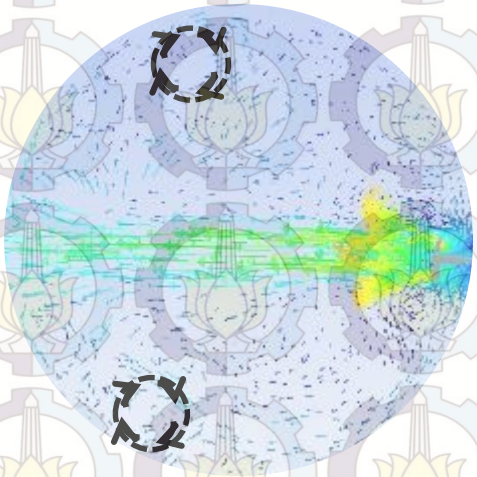
Impeller 4 cm 6 blade dengan kecepatan putar 600 rpm



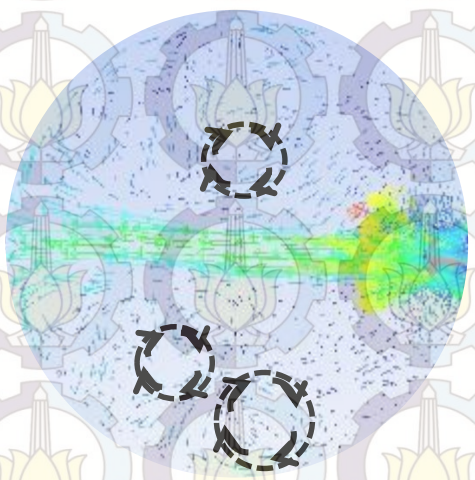
t = 2,3 s



t = 3,84 s

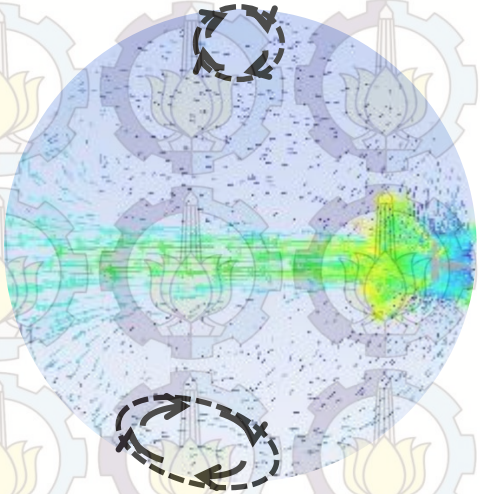


t = 6,26 s

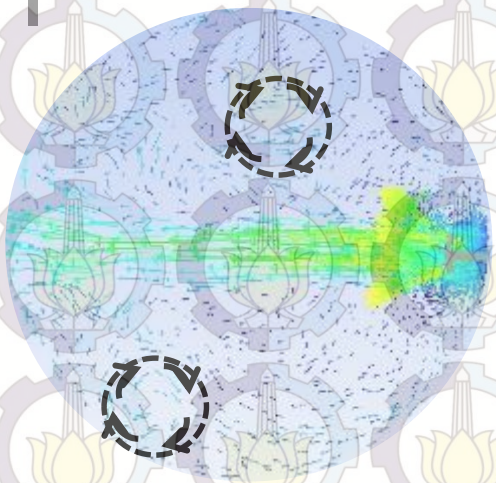


t = 8,28 s

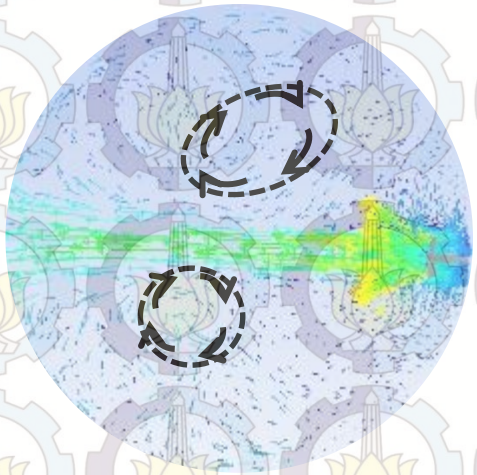
Impeller 4 cm 6 blade dengan kecepatan putar 700 rpm



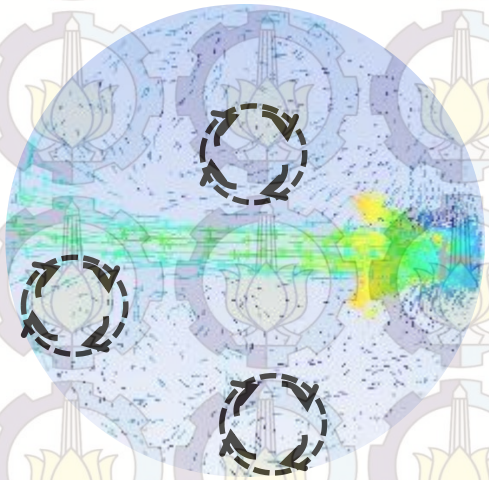
t = 2,78 s



t = 5,85 s



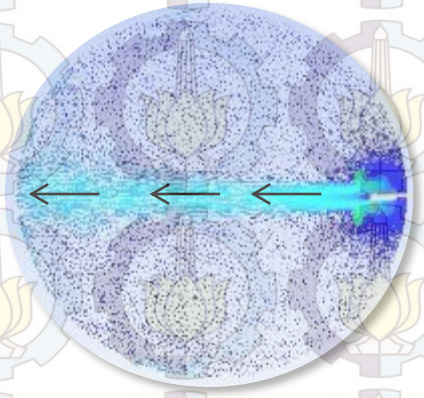
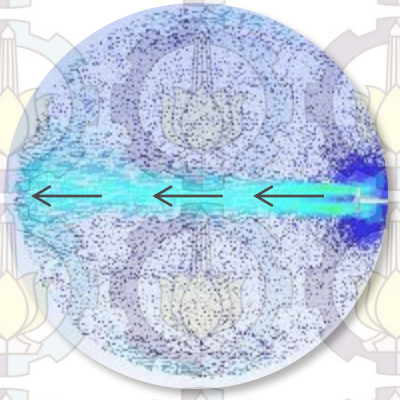
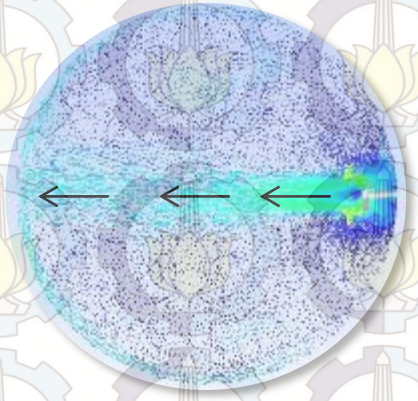
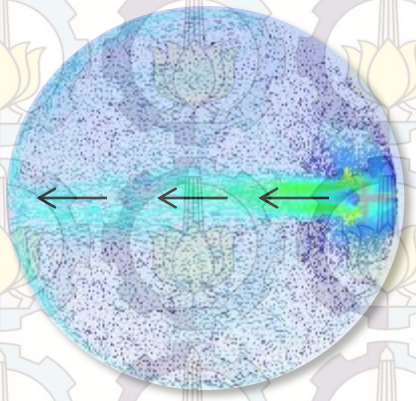
t = 8,49 s



t = 9,06 s

IDENTIFIKASI POLA ALIR (bidang horizontal)

Pengaruh jumlah blade terhadap pola alir (500 rpm)

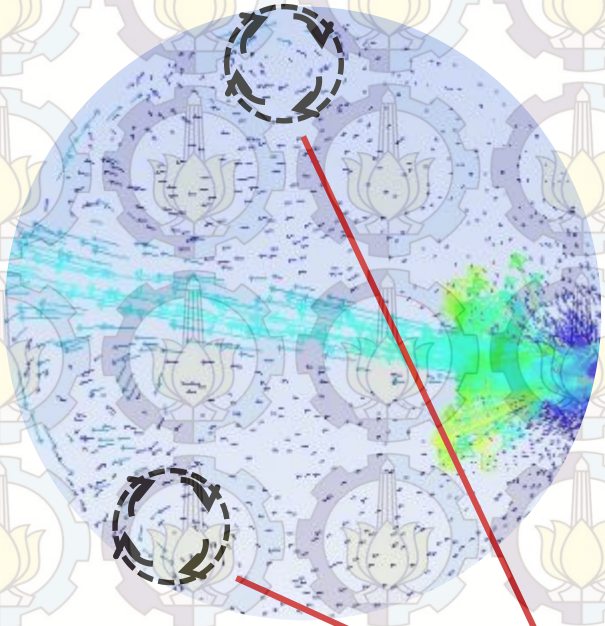
	4 blade	6 blade
Diameter impeller = 3 cm		
Diameter impeller = 4 cm		

Velocity (m/s)

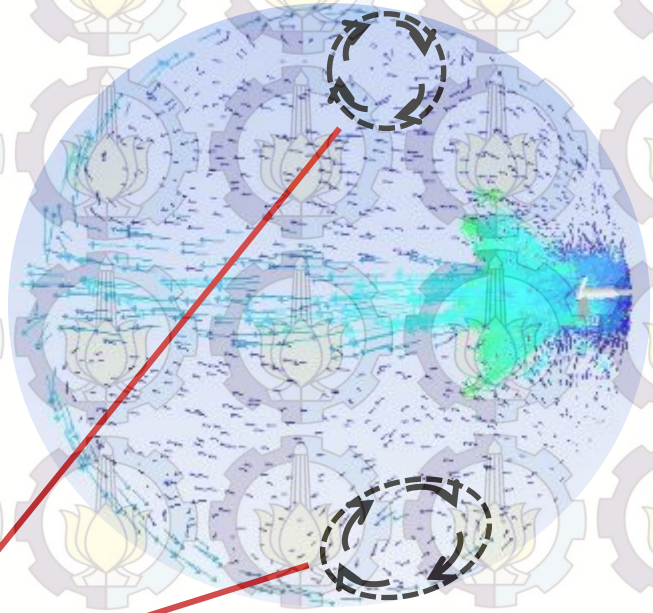
IDENTIFIKASI POLA ALIR (bidang horizontal)

Pola alir yang berbeda

Diameter impeller = 3 cm



Diameter impeller = 4 cm



Makrovortex

FENOMENA MAKRO
INSTABILITAS

Untuk diameter 3 cm 4 blade

Angular velocity	Bidang	Pola alir	life time (s)	Average life time (s)	Life time ratio	Makroistabilitas
400 RPM	vertikal	OL-OM	8,38	2,095	0,419	1
		Lain	1,62	0,400	0,080	
	horizontal	AP-TSM	9,42	4,710	0,942	1
		Lain	0,58	0,290	0,058	
500 RPM	vertikal	OL-OM	7	2,333	0,700	1
		Lain	3	3,000	0,300	
	horizontal	AP-TSM	7,15	3,575	0,715	1
		Lain	2,85	2,850	2,850	
600 RPM	vertikal	OL-OM	6,99	3,495	0,699	1
		Lain	3,01	1,505	0,301	
	horizontal	AP-TSM	8,19	4,095	0,819	2
		Lain	1,81	0,905	0,181	
700 RPM	vertikal	OL-OM	7,4	3,700	0,740	1
		Lain	2,6	2,600	0,260	
	horizontal	AP-TSM	7,99	3,995	0,799	2
		Lain	2,01	1,005	0,201	

FENOMENA MAKRO INSTABILITAS

Untuk diameter 3 cm 6 blade

Angular velocity	Bidang	Pola alir	life time (s)	Average life time (s)	Life time ratio	Makroistabilitas
400 RPM	vertikal	OL-OM	10	10	1	0
		Lain	0	0	0	
	horizontal	AP-TSM	10	10	1	0
		Lain	0	0	0	
500 RPM	vertikal	OL-OM	6,66	3,330	0,666	2
		Lain	3,34	3,340	0,334	
	horizontal	AP-TSM	5,63	2,815	0,563	4
		Lain	3,29	0,329	3,290	
600 RPM	vertikal	OL-OM	6,11	3,055	0,611	2
		Lain	3,89	1,945	0,389	
	horizontal	AP-TSM	5,87	2,935	0,587	2
		Lain	4,13	2,065	0,413	
700 RPM	vertikal	OL-OM	7,56	3,780	0,756	3
		Lain	2,44	2,440	0,244	
	horizontal	AP-TSM	6,38	2,1267	0,638	2
		Lain	3,62	0,724	0,362	

FENOMENA MAKRO
INSTABILITAS

Untuk diameter 4 cm 4 blade

Angular velocity	Bidang	Pola alir	life time (s)	Average life time (s)	Life time ratio	Makroistabilitas
400 RPM	vertikal	OL-OM	7,67	3,835	0,384	1
		Lain	2,33	0,583	0,058	
	horizontal	AP-TSM	5,82	1,455	0,146	1
		Lain	4,18	0,836	0,0836	
500 RPM	vertikal	OL-OM	7,66	2,553	0,255	3
		Lain	2,34	0,468	0,047	
	horizontal	AP-TSM	8,58	2,860	0,286	2
		Lain	1,42	0,710	0,071	
600 RPM	vertikal	OL-OM	7,82	2,607	0,261	2
		Lain	2,18	0,727	0,073	
	horizontal	AP-TSM	6,23	3,115	0,312	4
		Lain	3,77	1,885	0,1885	
700 RPM	vertikal	OL-OM	3,54	3,540	0,354	4
		Lain	6,46	1,292	0,129	
	horizontal	AP-TSM	5,34	2,670	0,267	3
		Lain	4,66	1,553	0,155	

FENOMENA MAKRO INSTABILITAS

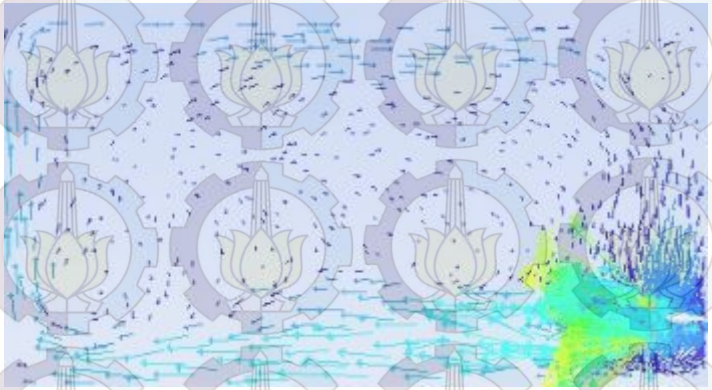
Untuk diameter 4 cm 6 blade

Angular velocity	Bidang	Pola alir	life time (s)	Average life time (s)	Life time ratio	Makroistabilitas
400 RPM	vertikal	OL-OM	3,45	3,45	0,345	1
		Lain	6,55	3,275	0,328	
	horizontal	AP-TSM	2,67	2,67	0,267	2
		Lain	7,33	2,443	0,244	
500 RPM	vertikal	OL-OM	5,64	2,820	0,282	1
		Lain	4,36	0,727	0,073	
	horizontal	AP-TSM	4,38	2,190	0,219	1
		Lain	5,62	1,873	0,187	
600 RPM	vertikal	OL-OM	3,17	3,170	0,317	3
		Lain	6,83	3,415	0,342	
	horizontal	AP-TSM	2,89	2,890	0,289	3
		Lain	7,11	2,370	0,237	
700 RPM	vertikal	OL-OM	4,67	2,335	0,234	4
		Lain	5,33	1,777	0,178	
	horizontal	AP-TSM	5,15	2,575	0,258	3
		Lain	4,85	0,808	0,081	

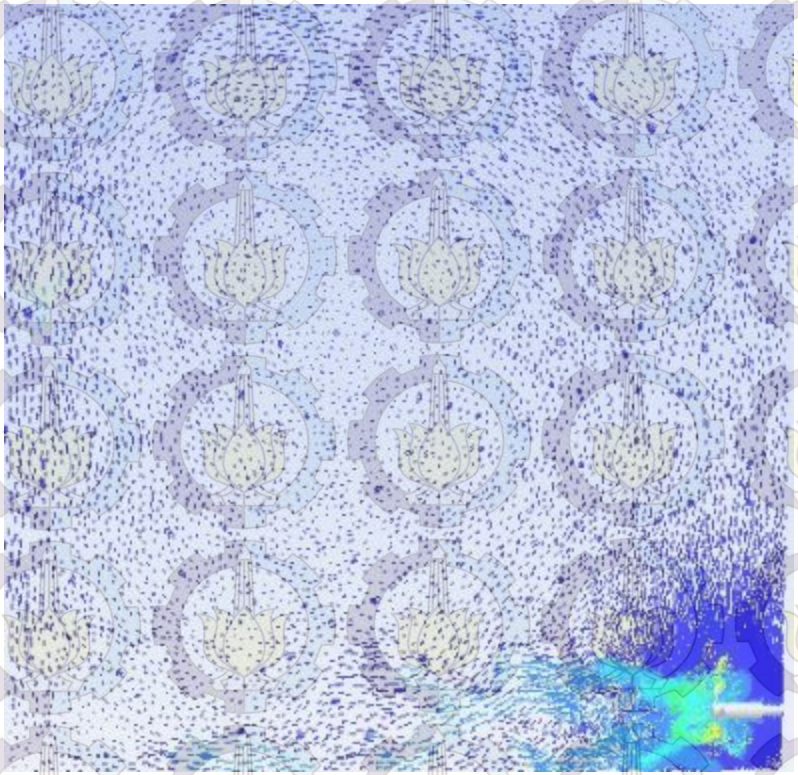
IDENTIFIKASI POLA ALIR
(pengaruh ketinggian liquid)

Pola alir pada diameter 3 cm 4 blade kecepatan 700 rpm

H/D = 0.5



H/D = 1

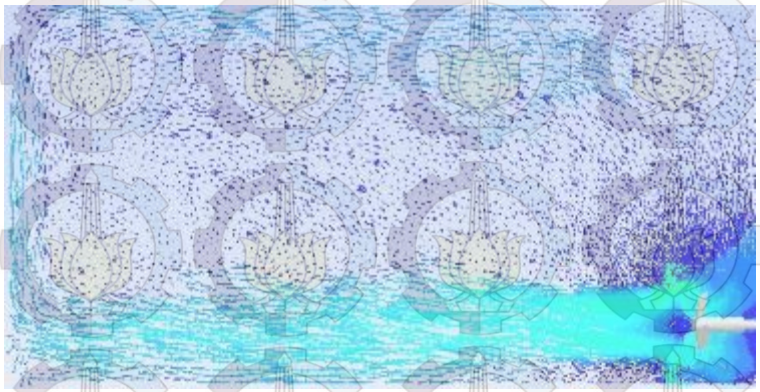


Velocity (m/s)

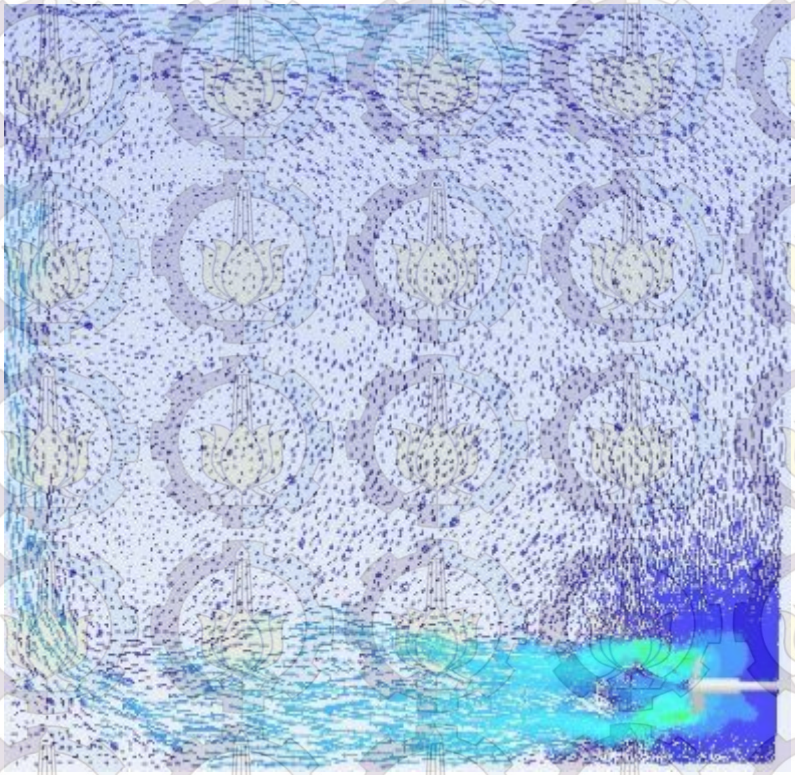
IDENTIFIKASI POLA ALIR
(pengaruh ketinggian liquid)

Pola alir pada diameter 4 cm 4 blade kecepatan 400 rpm

H/D = 0.5



H/D = 1

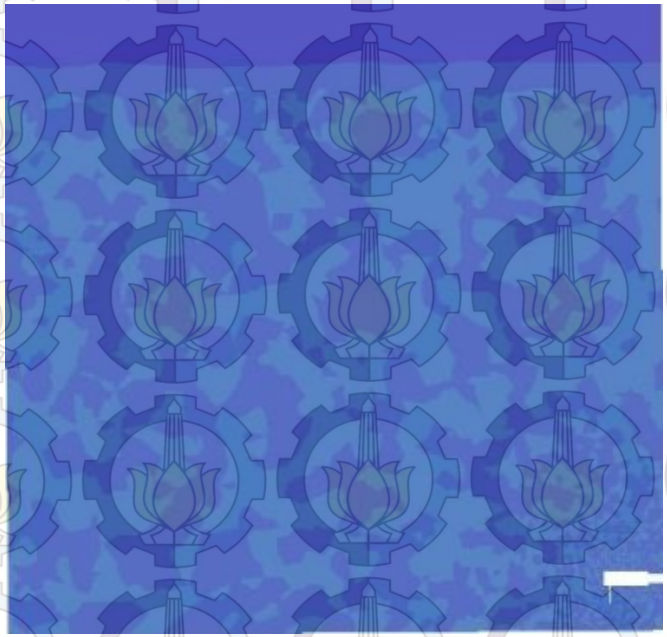


Velocity (m/s)

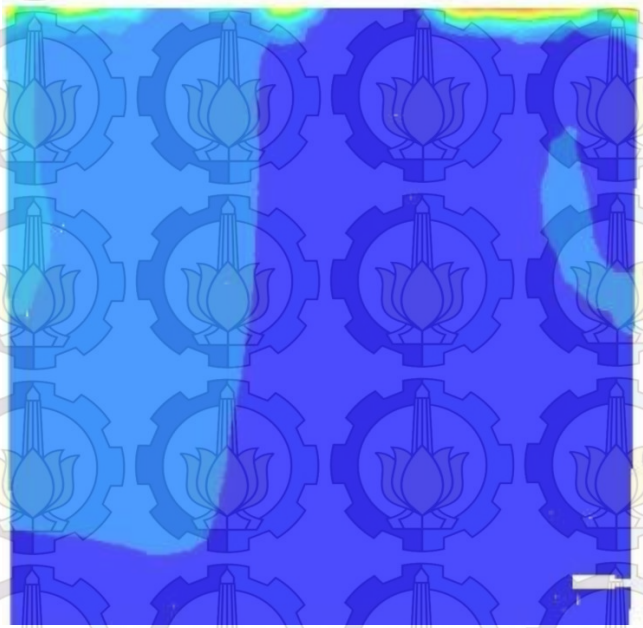
PERSEBARAN FRAKSI VOLUME GAS METANA

3 cm 4 blade – 400 rpm

(Fraksi Volume)



Contour Gas Metana Awal (t = 0 s)



Contour Gas Metana Akhir (t = 4 s)

KESIMPULAN :

1. **Pola alir dominan** yang terjadi dalam *side-entering mixer* dengan menggunakan Inclined Fan Turbine adalah ***one loop circulation***
2. **Semakin besar diameter dari impeller,** aliran yang terjadi disekitar impeller **semakin turbulen** yakni pada diameter impeller 4 cm 4 blade dengan jumlah 4 kali makrovortex
3. **Semakin cepat putaran impeller (rpm)** maka **turbulensinya meningkat** yang menyebabkan **terjadinya vortex** di beberapa bagian dalam tangki berpengaduk yakni pada kecepatan 600 rpm dan 700 rpm dengan diameter impeller 4 cm 4 blade
4. Aliran liquid pada **H/D = 1 (v = 0,1-0,15 m/s)** mencapai permukaan liquid tetapi lebih lambat dibandingkan **H/D = 0,5 (v = 0,2-0,3 m/s)**
5. **Fraksi Volum Gas Metana dalam liquid** sebesar 0,1 terlalu besar sehingga gas metana berada dalam bentuk gelembung besar.

TERIMA KASIH

おわりました、ありがとう　ございます