

# A rotary drum dryer for palm sterilization: preliminary study of flow and heat transfer using CFD

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**Abstract.** Preliminary study in this article, the flow and the heat transfer of rotary drum dryer were simulated by using Computational Fluid Dynamics (CFD). A 3D modelling of rotary drum dryer including ambient air was created by considering transient simulation. The temperature distributions on rotary drum dryer surfaces of experimental setup during heating detected by using infrared camera were given to be boundary conditions of modelling. The average temperature at the surface of the drum lids was 80°C, and the average temperature on the heated surface of the drum was 130°C. The results showed that the internal temperature of air in drum modelling was increased relating on time dependent. The final air temperature inside the drum modelling was similar to the measurement results.

## 1. Introduction

Oil palm is an edible of vegetable oil extracted from mesocarp of oil palm fruit in throughout several processing. This kind of raw material was mostly planted in Southeast Asia, such as Malaysia, Indonesia, and Thailand. After harvesting process, fresh fruit bunch must be processed directly to milling factory not more than 24 hours. Sterilization process plays important role in oil palm factory processing [1]. The purposes of sterilization process are to soften the fruit, enzyme inactivation, reduce water content in fruit and facilitate oil extraction.

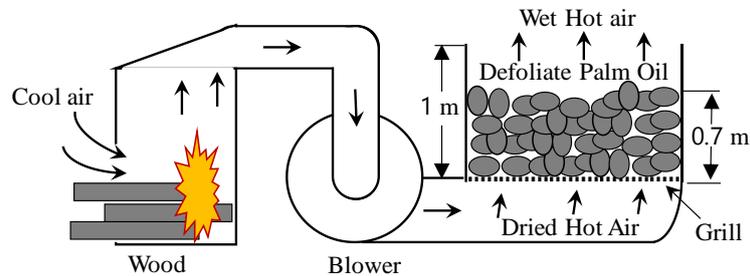
The sterilization process uses steam machines with the pressure applied at 40 psi (140°C) for 75 – 90 minutes [2]. From the process, grade A oil palm could be produced for consumption, such as pure vegetable oil. This kind of process consume a lot of water due to oil palm processing in the factory.

The second way to process oil palm is using batch dryer. This process does not require the steam as the first one. A batch dryer system can be placed in small factories. This process will heat oil palm by grilling. Hot air flow up by burning fuel, such as firewood or fuel oil. This kind of process needs much workers to flip oil palm from bottom to upper side. It resulted oil palm not cooked well and it took long time process around 30 hours (figure 1).

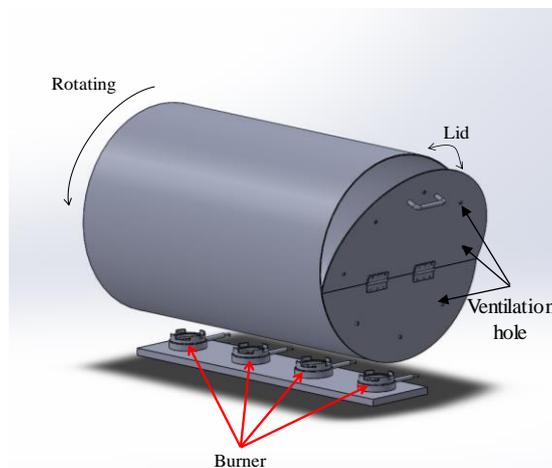
Umudee et al [3] studied about oil palm sterilization using microwave irradiation. It was found that sterilization of oil palm using microwave at 50°C is the optimum temperature for heating oil palm. But, for this kind of irradiation heating process is limited to industrial for future used. Noerhidayat et al [4]



investigated about oil palm sterilization using high pressure. It proved that at 70 psi (temperature of about 150°C) for 30 minutes showed better in sugar content, release more oil and absorb more water.



**Figure 1.** Grilling pattern of oil palm in factory



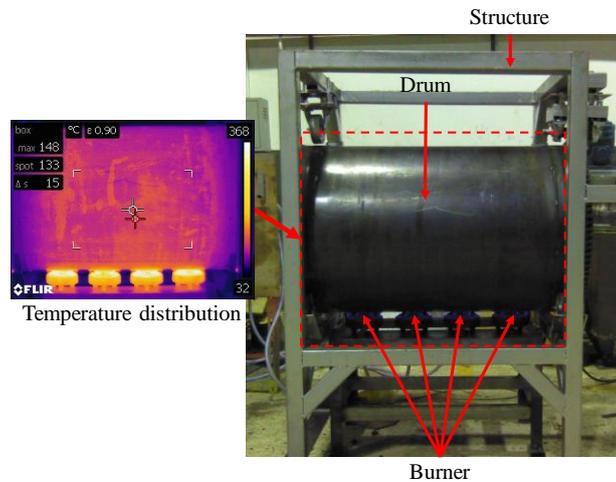
**Figure 2.** Model of rotary drum dryer.

Rotary drum dryer is being developed as a new tool for drying of medicinal and aromatic plant [5] which is to reduce specific drying energy consumption, keeping good quality and accelerating drying process. Temperature inside in rotating drum is important factor in drying, which depend on the amount of ventilation holes of rotating drum (figure 2). Therefore, the aim of this research was to understand behavior of the temperature inside the rotating drum by using CFD analysis.

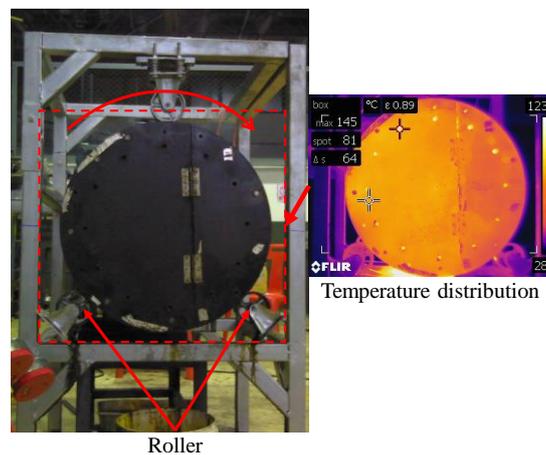
## 2. Method

### 2.1 Rotary Drum

The rotary drum dryer made of metal sheet with thickness of 3 mm. The dimensions of the drum was 90 cm in length and 57.5 cm in diameter. It is set on the structure which is supported by the bottom roller. The motor with gear that installed on the side of the drum rotates the rotary drum dryer. For the experiments, the fresh fruit palm in the drum is heated at the bottom rotary drum, which use LPG as fuel sources of thermal energy.



**Figure 3.** Appearance of temperature distribution on the drum surface using infrared camera.



**Figure 4.** Appearance of temperature distribution on the cap surface of drum using infrared camera.

The figures 3 and 4 above shows the temperature on the surface of the rotary drum dryer and the cap of the drum which in steady conditions. The temperature at the surface of the cap was about 80°C and the temperature of the drum surface was about 130°C. The rotating drum was heated from the combustion of fuel LPG by the direct contact with the drum.

### 2.2 Simulation model and grid generation

ANSYS Fluent ver. 15.0 was used to simulate the flow characteristics. A 3D numerical model based on the finite-volume method was adopted to solve governing equations with boundary conditions. The geometry of the numerical model was the same as that of the experiment and this model of the rotary drum dryer in CFD will be reduced 10 times from actual dimensions shown in figure 5.

The details of the generated grid are shown in figure 6. The cutting plane along the centerline of the drum is shown to expose the internal grid system. The majority of elements were even rectangular. The simulation was analyzed with four elements cases and 1.2 millions cases and 1.57 millions cases are in the same trend. Therefore, 1.2 millions elements case was considered in this simulation.

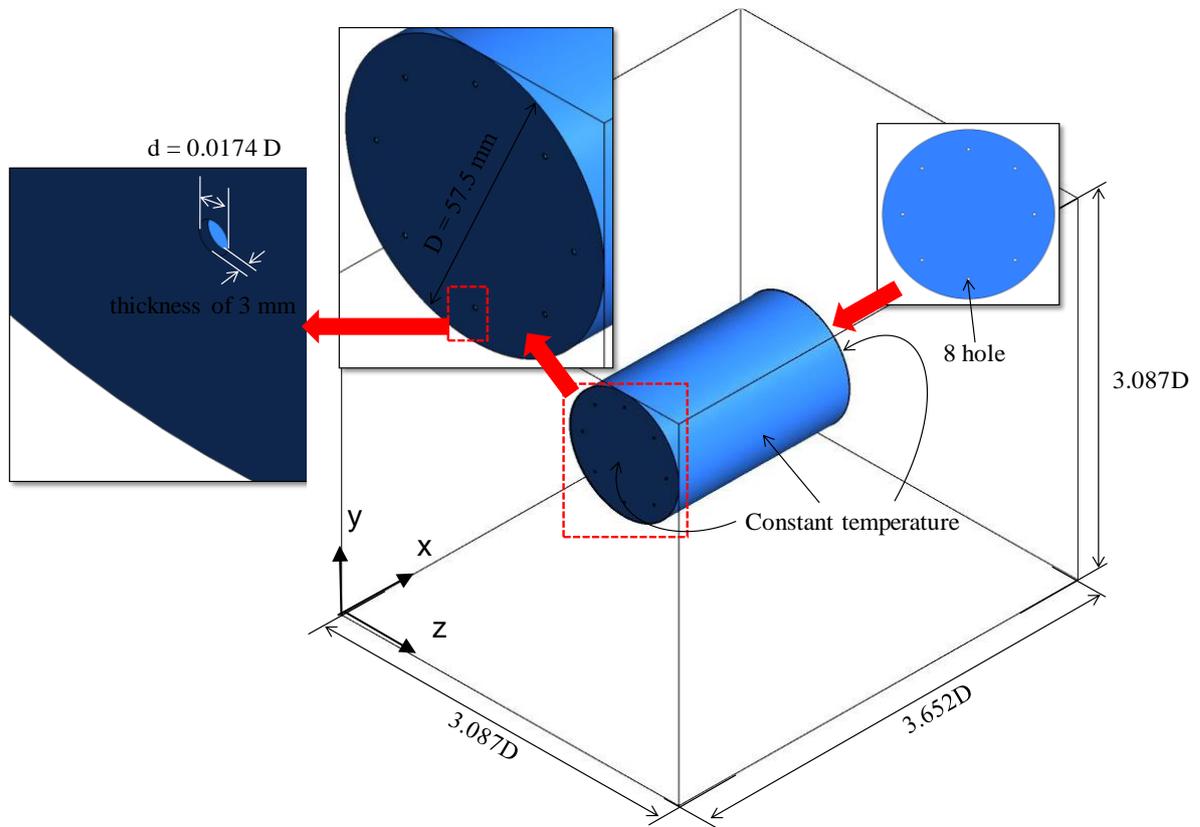


Figure 5. Model of rotary drum including surrounding air

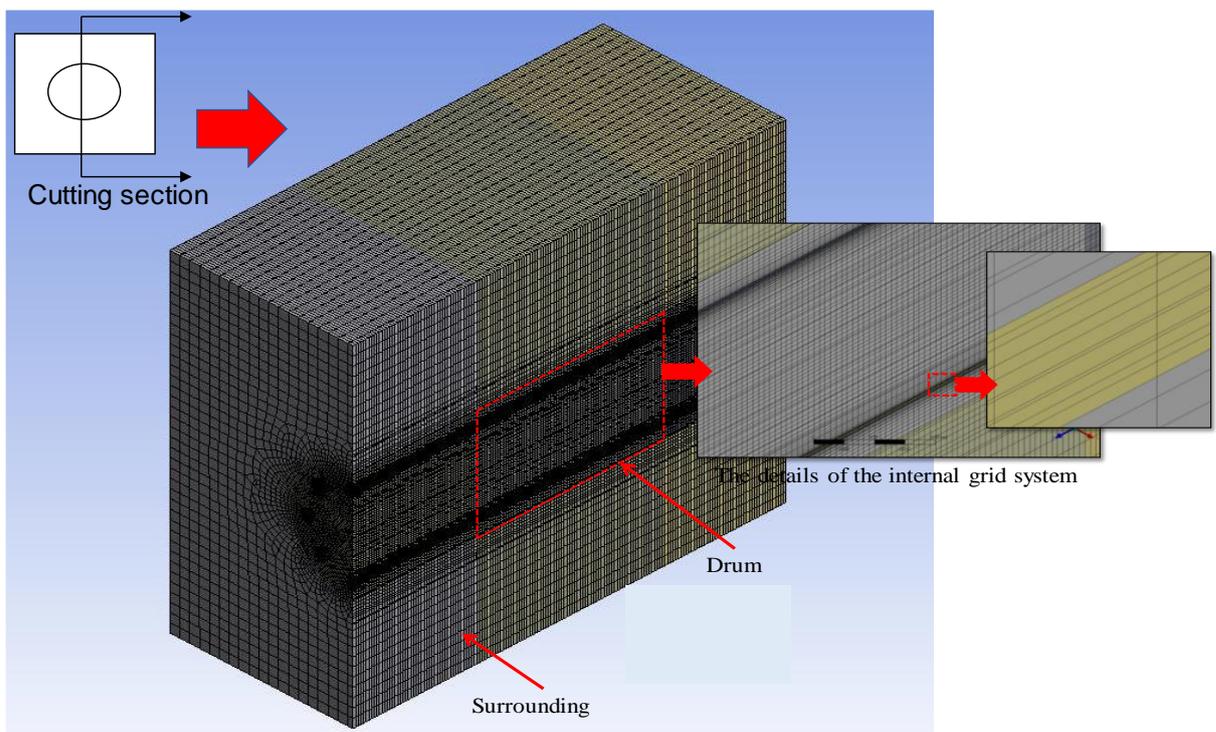
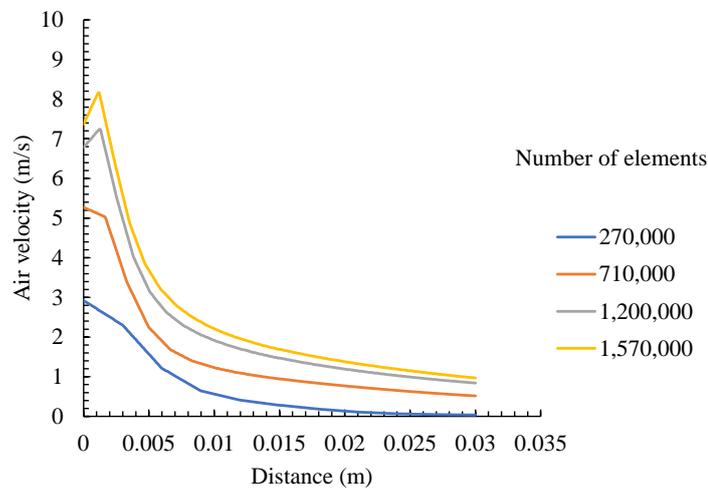


Figure 6. Internal Grid System.

The boundary conditions were identically specified to the experiment. For the rotary drum dryer, the number of hole was introduced. The details of the boundary condition are specified in table 1.

**Table 1.** Details of boundary conditions.

Conditions	Setting
The temperature of drum dryer	400 K
The temperature of drum dryer lid	353 K
The temperature of environment	303 K
The pressure of the environment	1 atm



**Figure 7.** The effect number of elements on air velocity of the centre of ventilation holes to the surrounding

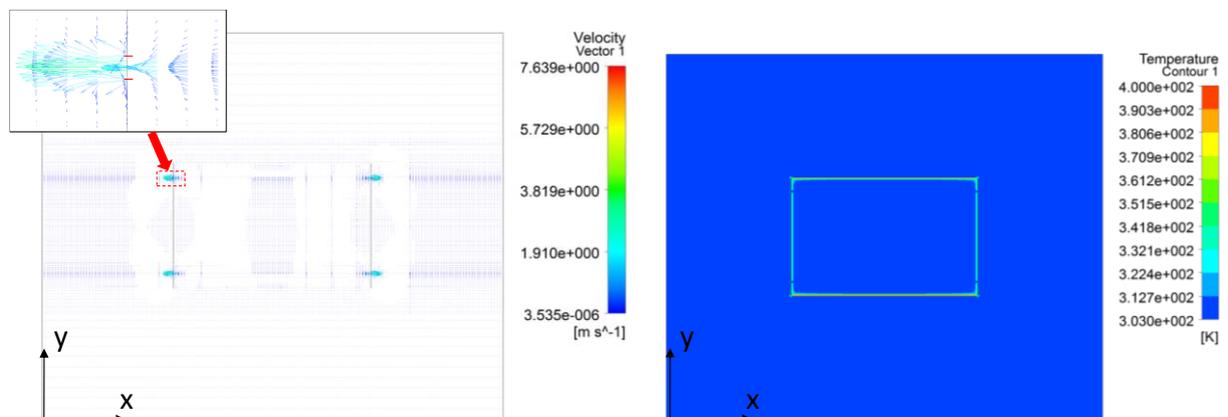
### 2.3 Calculation Method

A solution method was based on the SIMPLE algorithm with a second-order upwind for all spatial discretizations. The solution was considered to be transient. It was operated until the temperature in the middle of the drum dryer to the steady state. We set the timer to run transient which time period to calculate out as 2 seconds on each occasion, or called time step size was 2 seconds and each period will repeat it for 20 times. It has a number of calculations 1200 times or called numbers of time step is 1200. Therefore, it has the total time in 2400 seconds.

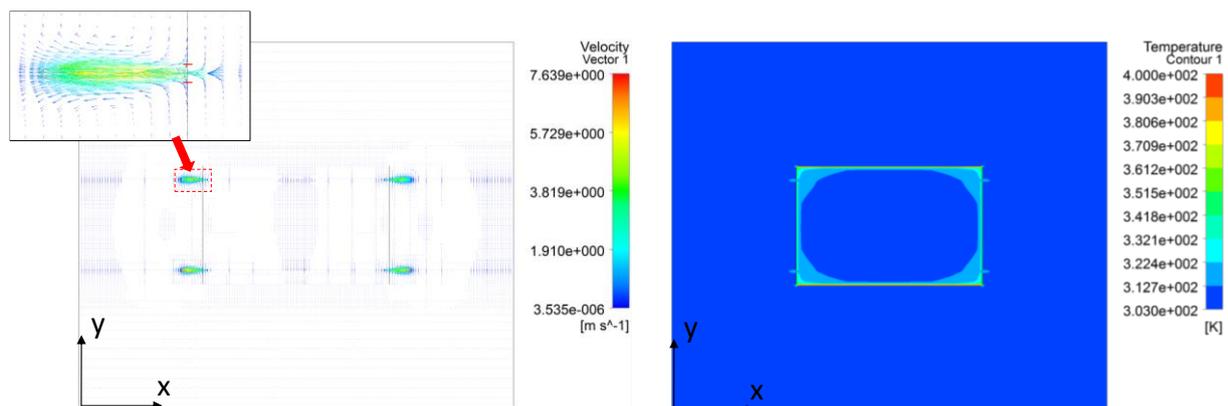
### 3. Results and Discussions

Temperature distribution and velocity vector profile was analysed with various time in xz plane at centre line cross section of rotary drum model (figure 8). At temperature 400 seconds, the temperature distribution was increase slowly from the edge side of rotary drum. At the same time, the velocity flow was also increase compare with 200 seconds case. According to the theory, volume at air is directly proportional to the temperature, so the airflow inside the rotary drum was pass through the hole. When the time become longer, the flow velocity also higher. Near outside of hole orifice the highest velocity value was found because of the pressure gradient of hole.

At 1000 second, the higher temperature distribution was found, above section of rotary drum while the bottom section was lower. For velocity, flow in above section showed stronger than below section of the rotary drum. Then for 1200 seconds, temperature distribution was the highest for whole surface of cross section of rotary drum. Near the hole of bottom section, it was showed non uniformed of temperature distribution.

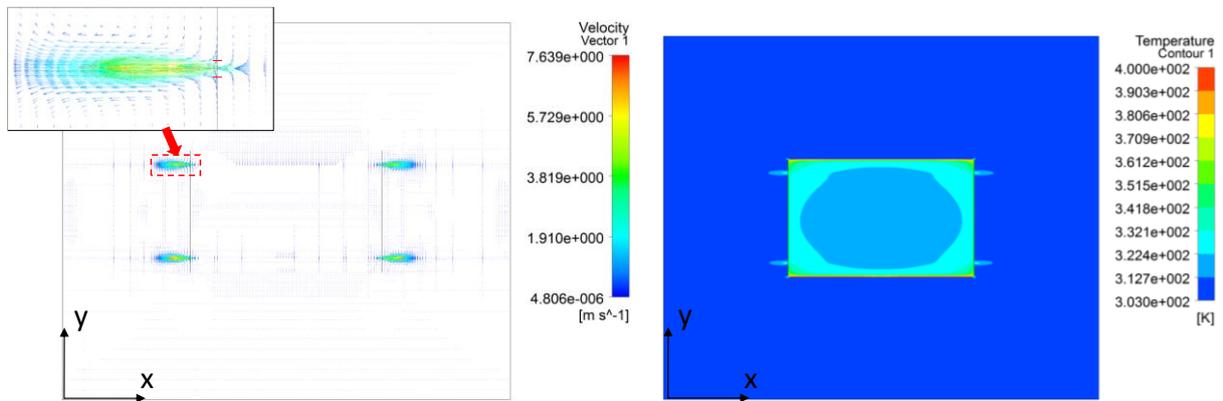


(a) Rotary drum in xy plane at 200 seconds.

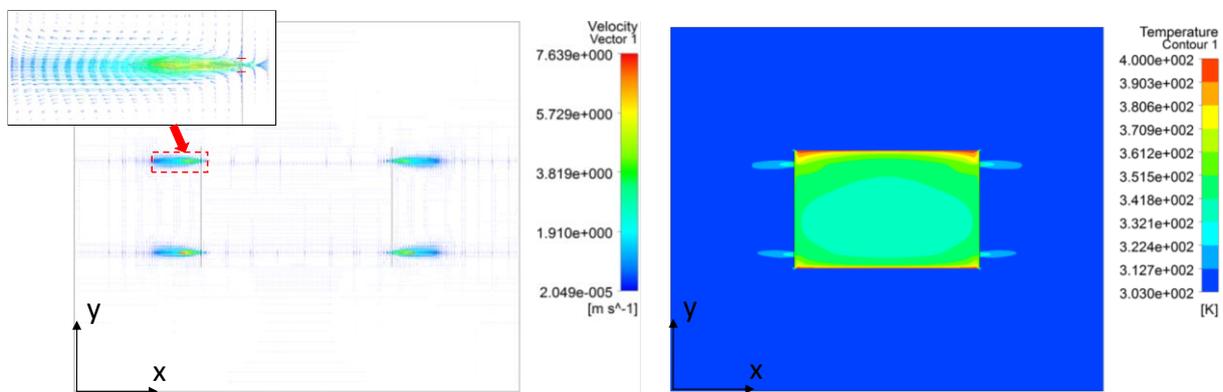


(b) Rotary drum in xy plane at 400 seconds.

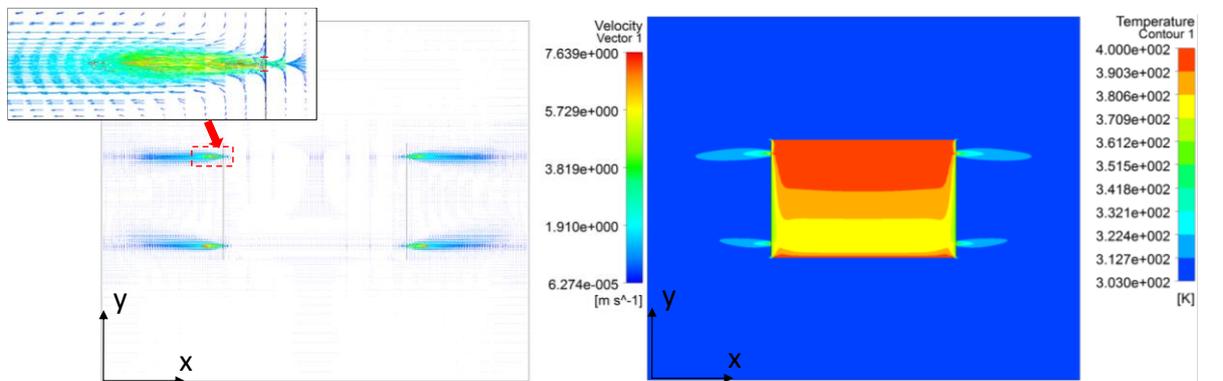
**Figure 8.** Velocity vector profile and temperature distribution of rotary drum in xz plane at various time.



(c). Rotary drum in xy plane at 600 seconds.

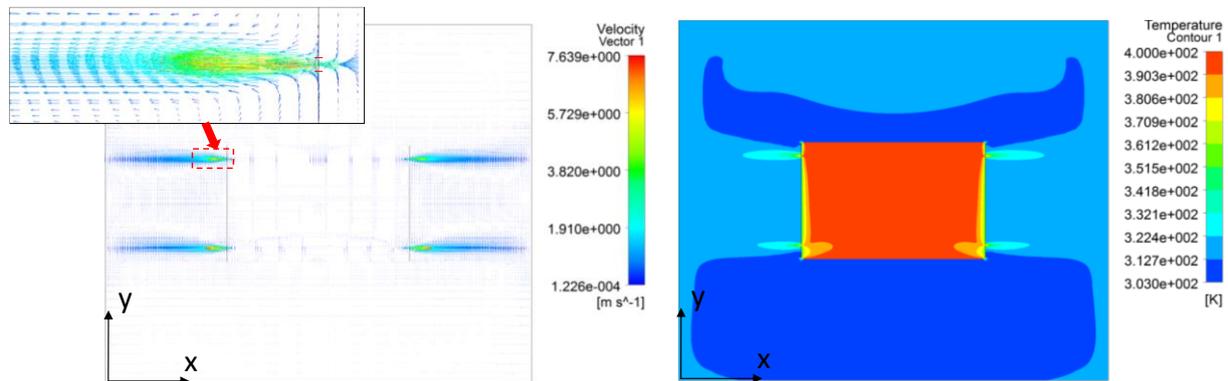


(d). Rotary drum in xy plane at 800 seconds.



(e). Rotary drum in xy plane at 1000 seconds.

**Figure 8.** Velocity vector profile and temperature distribution of rotary drum in xz plane at various time (continued)



(f). Rotary drum in xy plane at 1200 seconds.

**Figure 8.** Velocity vector profile and temperature distribution of rotary drum in xz plane at various time (continued)

#### 4. Conclusion

In this work, flow and temperature distribution of rotary drum was analyzed at various times using CFD simulations. The highest and more uniform temperature and flow velocity distribution was found in 1200 seconds for this work. The results was analyzed with fix hole and constant time range (200 to 1200 seconds). For further study about different hole and more temperature range will be analyzed for temperature and velocity flow of rotary drum.

#### Acknowledgement

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