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# Analysis of Thermal Effect in Ware House with Different Nozzle Angle to Enhance Velocity and Temperature

**Ashutosh Shukla[1], Saumitra Sharma[2]**

[1]M Tech Scholar, [2]Professor & HOD,

[1,2]Department of Mechanical Engineering, Oriental College of Technology, Bhopal, Madhya Pradesh, India

## ABSTRACT

In the current work, the CAD model of ware house has been developed by using ANSYS the model has been simulated using ANSYS software on fluent domain workbench in order to predict various parameters influencing the thermal performance of ware house. Three types of nozzle angle i.e, 3, 5 and 7 degree with constant velocity of 6m/s are considered to analyze the thermal effect. The optimum nozzle angle and velocity enhances the thermal effect in ware house.

It was analyzed that 5 degree of nozzle angle with 6 m/s of constant velocity at each position of duct enhances the thermal effect inside ware house.

***KEYWORDS**: HVAC, Nozzle Angle, Warehouse, CFD*

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## I. INTRODUCTION

A cold storage is a commercial facility where perishable food items such as fruits, vegetable, medicines, etc. are stored for a longer duration under controlled temperature to prevent them from decaying. Cold stores are an integral aspect as it minimizes the loss that can occur in the post-harvesting period. Two important factors i.e., preservation temperature and relative humidity have a great impact on the product quality. Within the cold store, in order to preserve the quality of the perishable items, there has to be homogeneity in the temperature distribution which is being directly governed by the air flow pattern. The design of air distribution system allows the air flow field to cool or warm the refrigerated enclosure in a controlled manner while keeping fixed moisture content. Other factors that affect the performance of a cold store are refrigeration system, air supply mode, air flow field distribution, frosting characteristics, heat insulation performance.

Cold stores are the place wherever biodegradable product keep under control temperatures for the purpose to maintain the quality. Protection of food item can be done beneath frozen temperatures. For many alternative merchandise conditions aside from temperature could be needed. A cold storage may be a place where the assorted things like vegetables, fruits, medicines, etc. are kept to defend them from obtaining spoiled and to increase its preservation amount.


**Figure 1: Classification of cold storage**

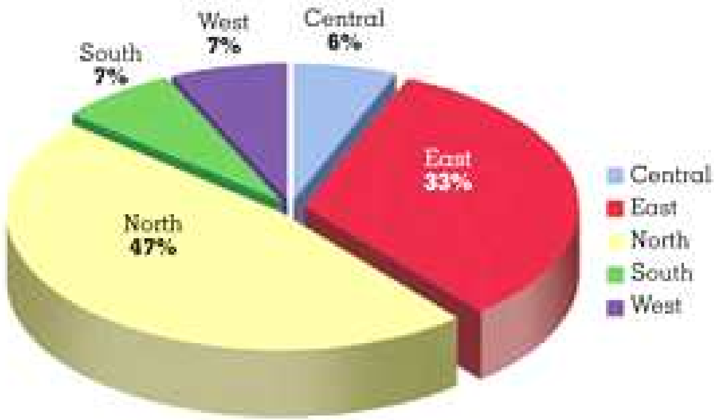



**Figure 2: State wise distribution of cold storage**

## II. Storage conditions of potato

| Fresh Potato | Temperature | Storage Period | Humidity |
|---|---|---|---|
| Early Crop | 4 – 10°C | 0 – 3 months | 95% |
| Seed Potato | 3°C | 10 months | 90 – 95% |
| Table Potato | 4°C | 10 months | 90 – 95% |

## III. METHODOLOGY

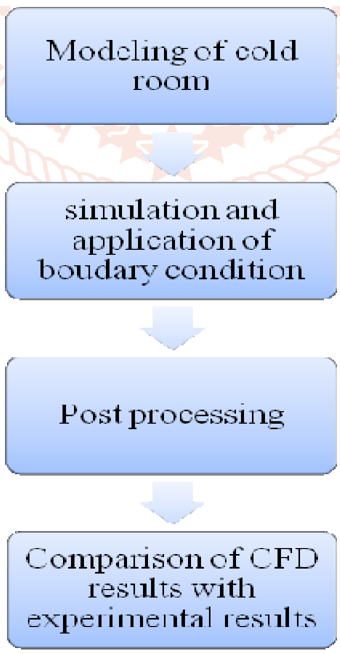



**Fig.3: Flow-chart showing the process implemented in this study**

| | |
|---|---|
| Cold room dimension | 5.9m (l) x 3.83m (h) x 3.75m (b) |
| Dimensions of inlet duct and outlet duct | Φ 0.3m x 0.4m (l) |
| Dimensions of the crates of the racks | 0.52m (l) x 0.36m (b) x 0.29m (h) |
| Air gap between the crates of racks | 0.2 m |
| Wall thickness | 0.12m |
| Nozzle angle | 3, 5, 7 degree |

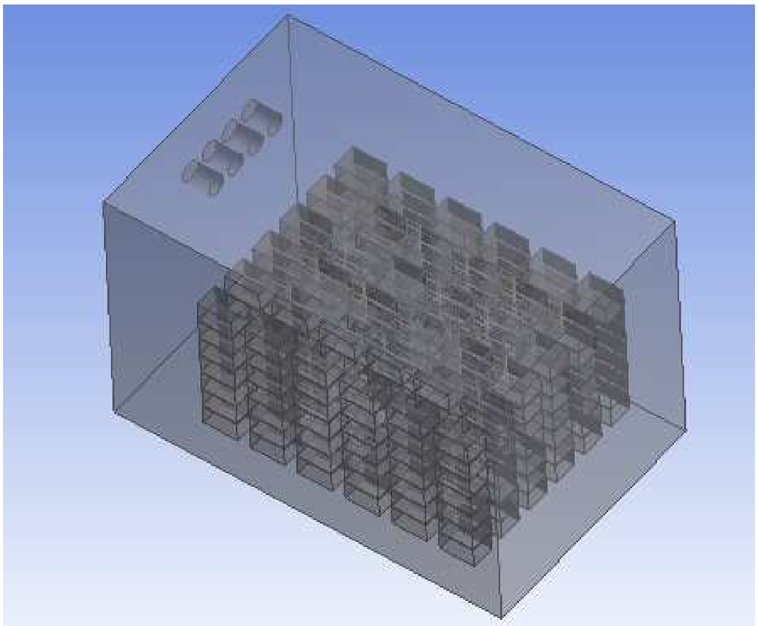


**Fig. 4: Solid geometry of the cold room**

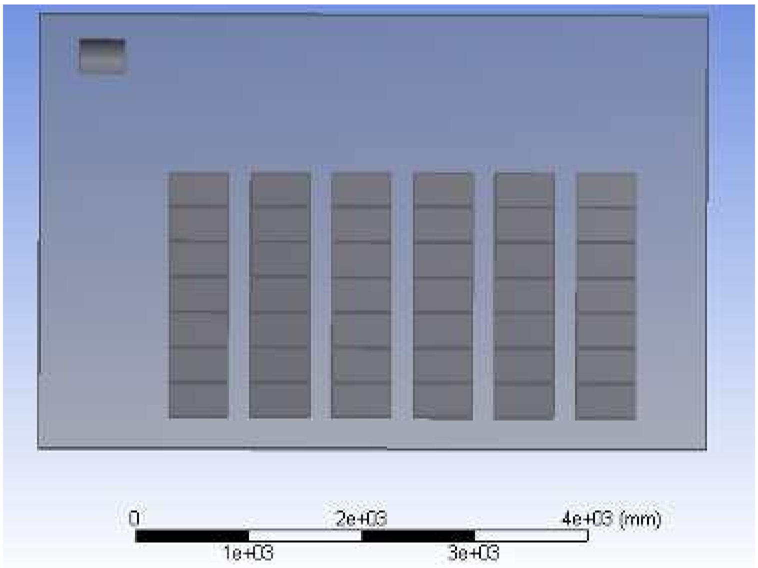
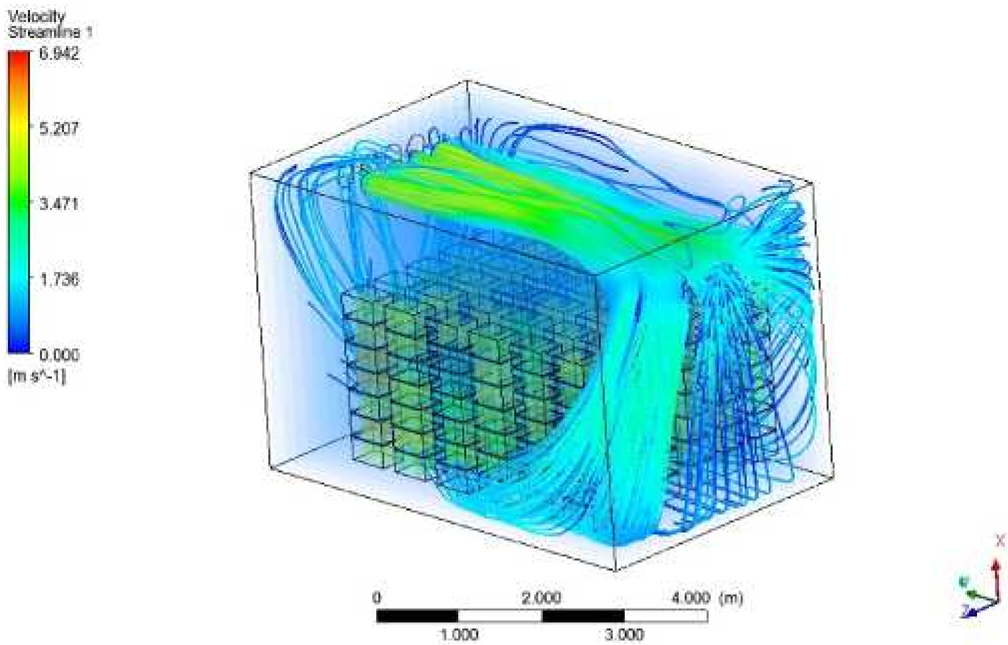



**Fig. 5: Front view of the cold room**

## IV. RESULTS
## VELOCITY DISTRIBUTION



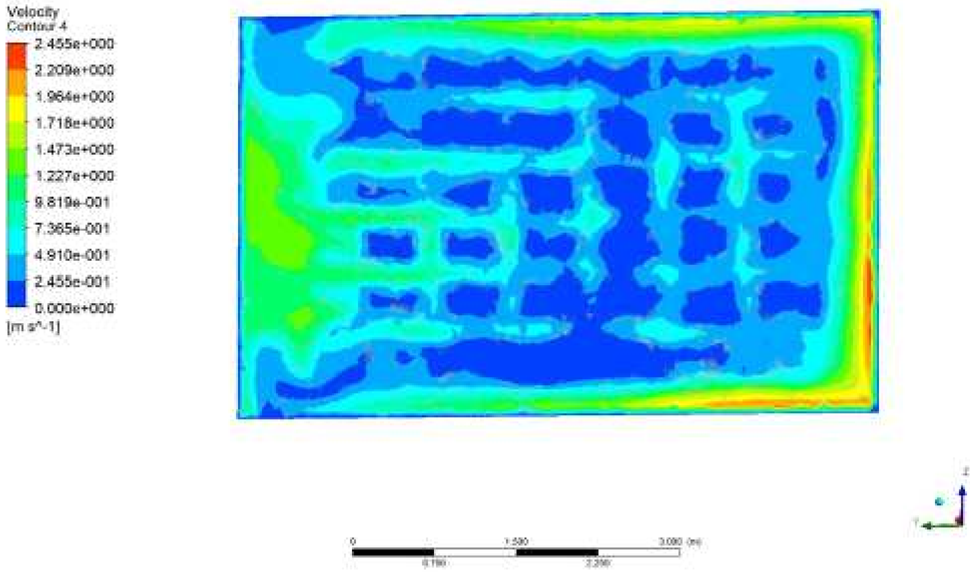



**Fig. 6: Velocity distribution along yz-plane lying at the 2.265m from bottom.**

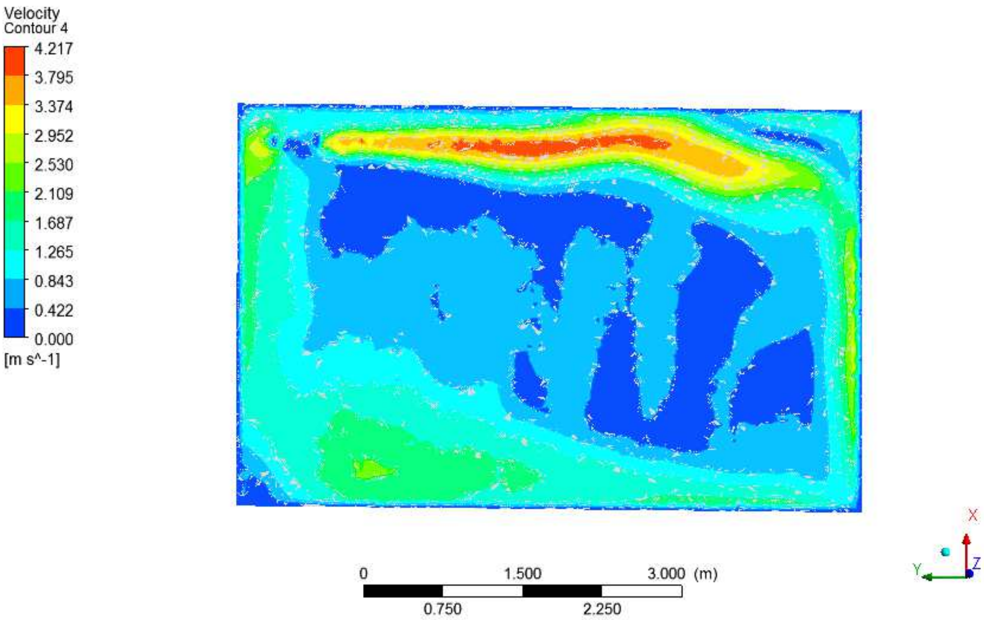



**Fig. 7: Velocity distribution along xy-plane lying at the center of the enclosure**

**Table 1: Comparison of velocity in CFD and base paper results**

| Probe Point | Velocity inside ware house at 6 m/s | |
|---|---|---|
| | CFD Result | Validation Result (Base paper experimental) |
| (2.25, 0, 0) | 0.375876 | 0.34 |
| (2.25, 1.5, 1.08) | 0.551994 | 0.57 |
| (2.25, -1.2, -0.05) | 0.129115 | 0.13 |
| (2.25, -3, -0.08) | 2.63506 | 2.3 |

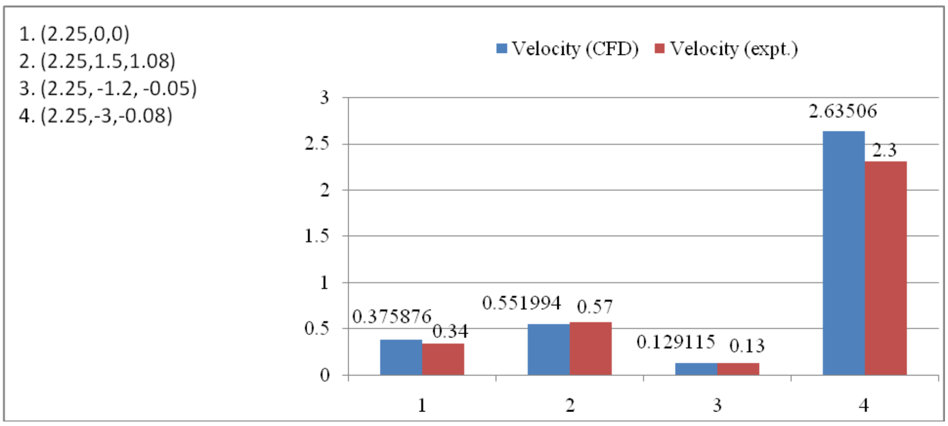



**Fig. 8: Comparison of velocity distribution of simulated and experimental results.**

**Table 2: Comparison of velocity in CFD with base paper results for 3 degree nozzle angle with constant velocity of 6 m/s**

| Nozzle angle 3 degree | | |
|---|---|---|
| Duct position | Velocity | |
| | CFD Result for velocity 6m/s with nozzle angle 3 degree | Validation Result |
| (2.25, 0, 0) | 0.38 | 0.34 |
| (2.25, 1.5, 1.08) | 0.583 | 0.57 |
| (2.25, -1.2, -0.05) | 0.159 | 0.13 |
| (2.25, -3, -0.08) | 2.56 | 2.3 |

**Table 3: Comparison of velocity in CFD with base paper results for 5 degree nozzle angle with constant velocity of 6 m/s**

| Nozzle angle 5 degree | | |
|---|---|---|
| Duct position | Velocity | |
| | CFD Result for velocity 6m/s with nozzle angle 5 degree | Validation Result |
| (2.25, 0, 0) | 0.46 | 0.34 |
| (2.25, 1.5, 1.08) | 0.62 | 0.57 |
| (2.25, -1.2, -0.05) | 0.163 | 0.13 |
| (2.25, -3, -0.08) | 2.98 | 2.3 |

**Table 4: Comparison of velocity in CFD with base paper results for 7 degree nozzle angle with constant velocity of 6 m/s**

| Nozzle angle 7 degree | | |
|---|---|---|
| Duct position | Velocity | |
| | CFD Result for velocity 6m/s with nozzle angle 7 degree | Validation Result |
| (2.25, 0, 0) | 0.42 | 0.34 |
| (2.25, 1.5, 1.08) | 0.59 | 0.57 |
| (2.25, -1.2, -0.05) | 0.154 | 0.13 |
| (2.25, -3, -0.08) | 2.63 | 2.3 |

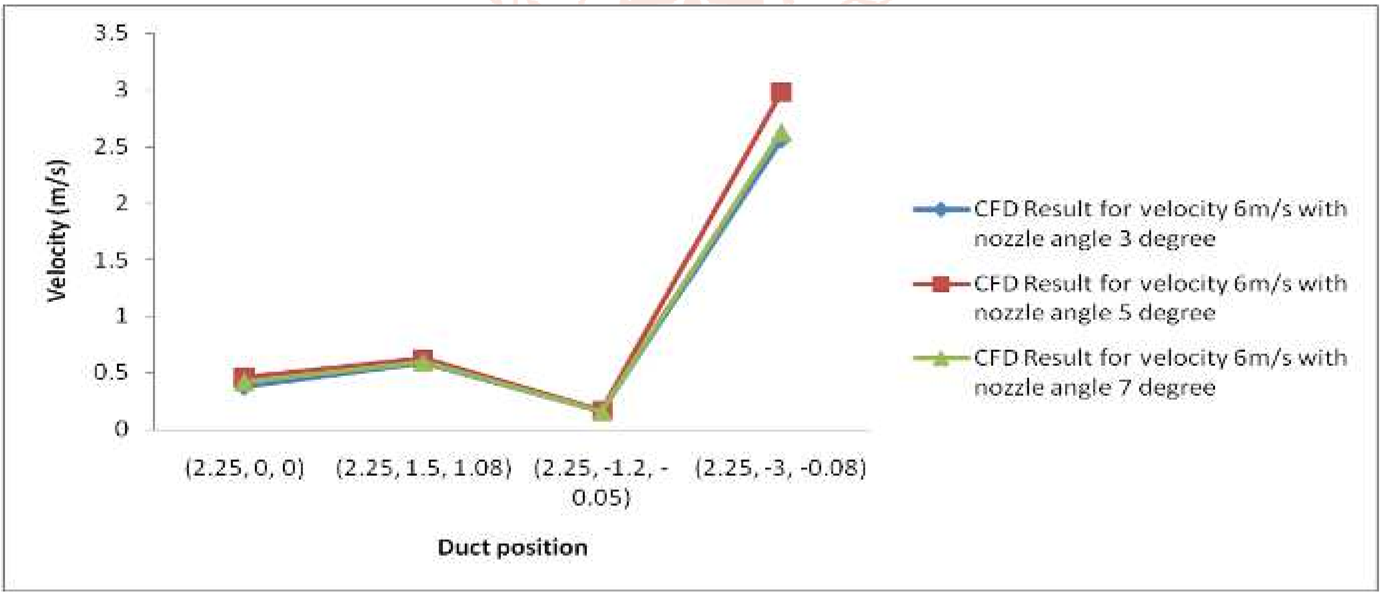



**Figure 9: Comparison of velocity in CFD with base paper results for 3, 5, 7 degree nozzle angle with constant velocity of 6 m/s**

## V. TEMPERATURE DISTRIBUTION

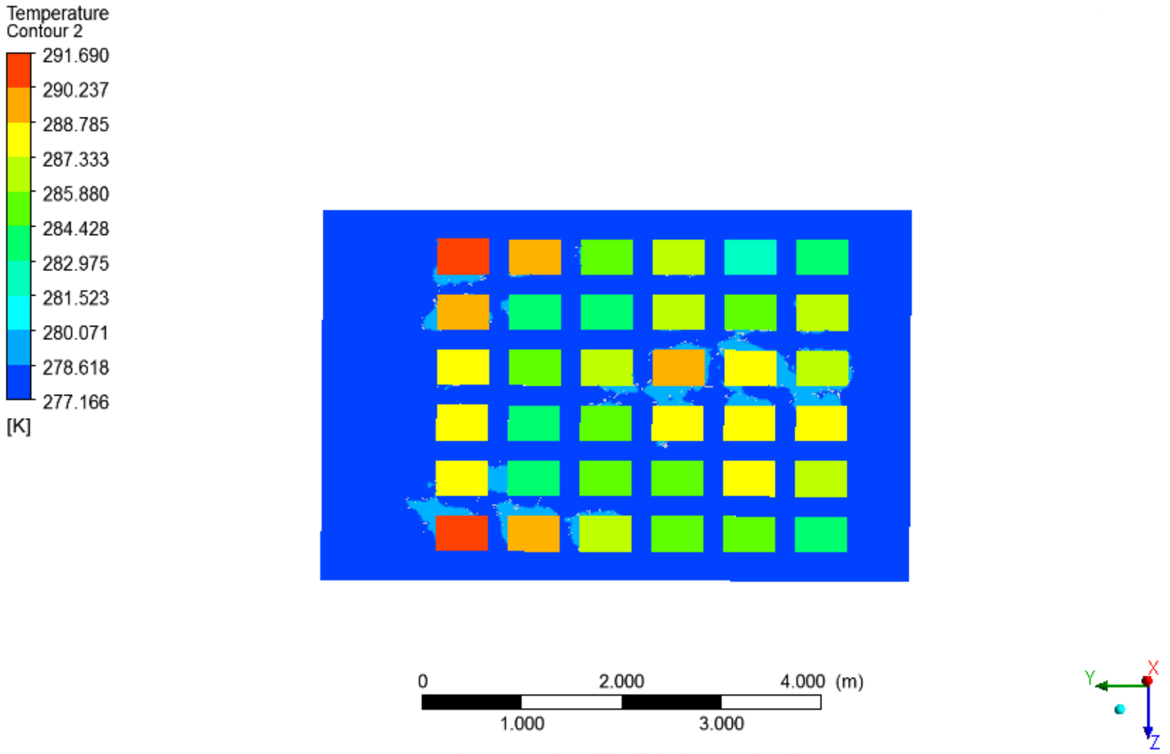



**Fig 10: Temperature distribution along yz-plane lies at middle.**

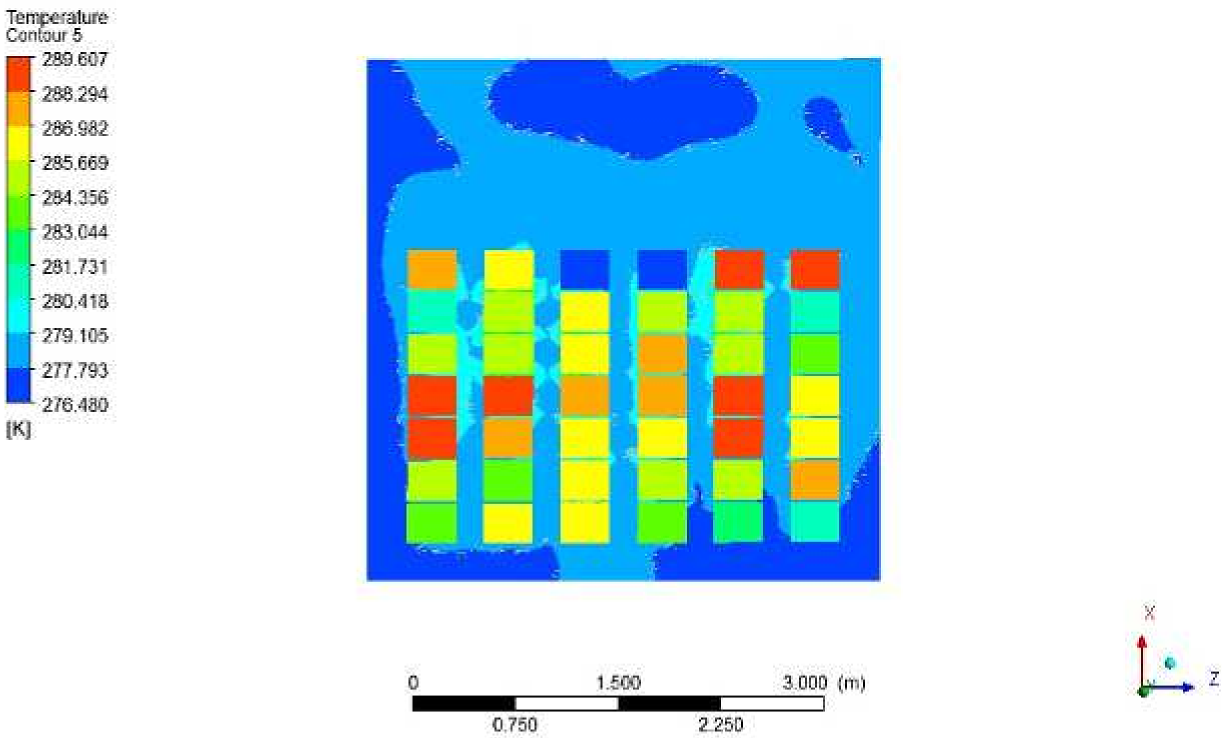



**Fig 11: Temperature distribution in zx- plane**

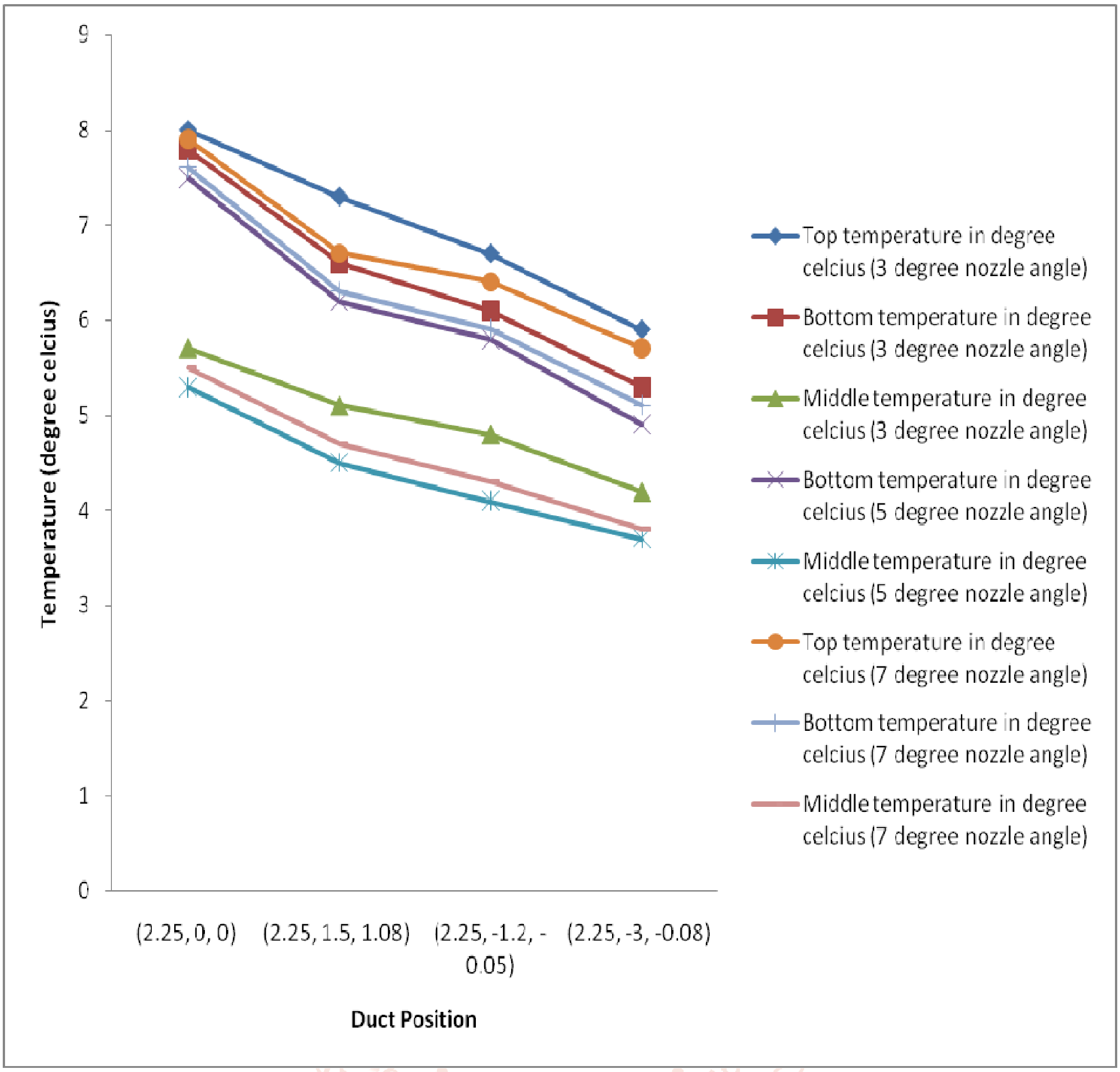



**Fig. 12: Graphical comparison of the temperature distribution at 3 different positions and nozzle angles.**

## VI. CONCLUSION

1. The 5 degree nozzle angle of duct is found effective in temperature distribution.
2. The velocity is increased in effective nozzle angle. thus, low velocity could be imparted to achieve effective thermal enhancement inside ware house.
3. Effective velocity inside the warehouse is found thus optimum temperature is achieved in less time.
4. The temperature increased in the region where the air was stationary.
5. Temperature decrement of the crates lying near the wall opposite to the evaporator was found to be faster than the other crates.
6. Crates near the evaporator cooled at a very slow rate and temperature decreasing rate was found to be very high for the crates that were away from the evaporator.
7. Hot spots were found at a region just near the evaporator and cold spots were found in the gap between the racks.

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