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Design and Performance of Under Floor Swirl Diffuser at Different Operating Angles Using FEA

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ABSTRACT:
In this thesis, the variation in temperature of conditioned air and improvement in thermal human comfort by adopting different models of floor swirl diffuser are investigated. Different models of floor swirl diffuser having different slot angles of 6^0, 8^0 and $10^0$are modeled in Creo 2.0 software. CFD analysis is performing on the models by varying velocities of fluid 0.25m/s, 0.5m/s & 0.75m/s to determine heat transfer coefficient, heat transfer rate. Thermal analysis is performing on all the models by considering materials of diffuser Copper alloy, Aluminum alloy 6061 and Nickel alloy to determine heat fluxes. Analysis is done in Ansys 14.5.

Introduction to Air Diffusers:
Air diffusers are utilized wide in air-conditioning systems and also the air diffusion is incredibly a lot of influenced by the characteristics of various diffuser styles. For air supply systems in automotive, swirl diffusers are popular. The tactic of modeling the diffuser is crucial because it has a crucial impact on the accuracy of the anticipated flow pattern within the automotive [6]. Swirl diffusers are standard devices are designed to mount into an access front panel area and "plug" into the air handling area. Installation of diffusers is done in an access front panel and may be relocated at any purpose on the base plate. This device delivers conditioned air to the area and permits the occupant to manually manage each the direction of the air and volume. The diffuser is made of a high impact, durable polycarbonate material on the market in black or grey finish [7].

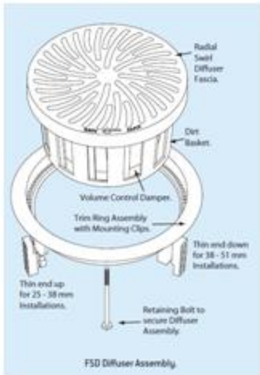

Fig 1.5: FSD Diffuser Assembly

LITERATURE REVIEW:
2.1 The work done by Suraj , In this experimental work, the author has tried to scale back the temperature variation of conditioned air and improvement in thermal human comfort by adopting totally different models of floor swirl diffuser designed on Pro-E package. Afterward author even have created example model made with mood of the floor swirl diffuser to see its performance beneath totally different operational and flow conditions by experimentation. The experiment has been performed within an acrylic sheet model space of size 4ft x 4ft x 5ft with floor swirl diffuser models put in at the roof [3]. The temperature variation of diffused air kind floor swirl diffuser at totally different altitude and therefore the impact of heat load on temperature variation is set.

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This experiment has been performed on 3 models of floor swirl diffuser having different slot angles of 7°, 8° and 9°. 2.4 In the paper by Huajun subgenus Chen, etalAs an alternate to standard Air Distribution (CAD) systems, under floor air distribution (UFAD) systems are wide employed in different countries. Though several benefits of a well-designed UFAD system will be found, there's still the next risk to styles and building house owners attributable to an absence of objective data and standardized design tips. UFAD systems style are influenced by increasing stress on indoor air quality (IAQ), energy conservation, environmental effects, safety, and economic science [4].

To research the performance of the UFAD system, a close 3-D CFD analysis on the turbulent buoyancy flow and transfer of heat within the BTLab, that locates at University of Silver State, Las Vegas, has been created during this paper. The actual interest has been focused on the flow distribution through under floor swirl diffuser. By CFD analysis with unstructured meshes related to utilizing data processing, the impact of various operational parameters on the air flow and temperature distribution has been studied very well. Usefully data has been provided on the event of high energy potency with human comfort of UFAD systems [5].

3.3 3D MODELING OF SWIRL DIFFUSER:

The reference for the modeling is taken from the journal paper "Performance and flowcharacteristics of floor swirl diffuser under different operating and flow parameters" bySuraj, International Journal of Mechanical Engineering and Technology (IJMET), ISSN0976 – 6340(Print), ISSN 0976 – 6359(Online) Volume 4, Issue 4, July - August (2013)",specified as [1] in References chapter.

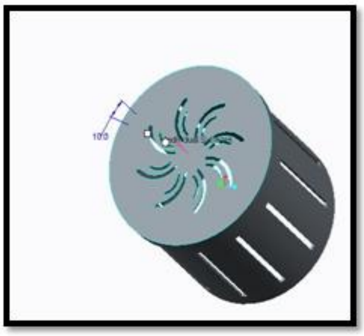

Fig: 3d model of swirl diffuser with 10^0 slot angle

ANALYSIS OF FLOOR SWIRL DIFFUSER:

The reference for the analysis is taken from the journal paper CFD modelling for swirl diffuser and its implications on air change effectiveness assessment to green star's IEQ-2 by Eddy Rusly and Mirek Piechowski, Proceedings of Building Simulation 2011:12th Conference of International Building Performance Simulation Association, Sydney, 14-16 November, specified as [2] in References chapter.

4.1 CFD ANALYSIS FOR SLOT ANGLE – 6^0

4.1.1 Velocity - 0.25m/s

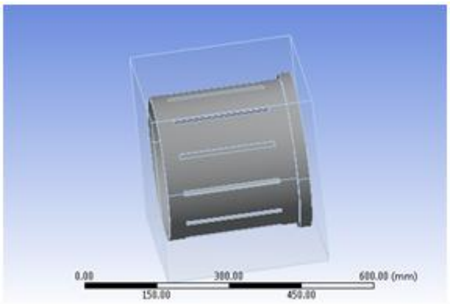

Fig: - Imported model of swirl diffuser with 6^0 slot angle

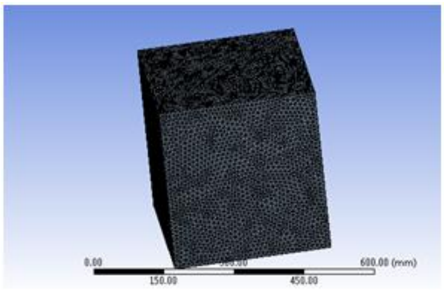

Fig: - Meshed model of swirl diffuser with 6^0 slot angle

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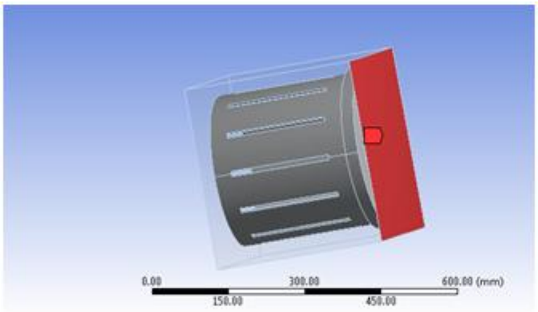

Fig: - Inlet for swirl diffuser with 6^0 slot angle

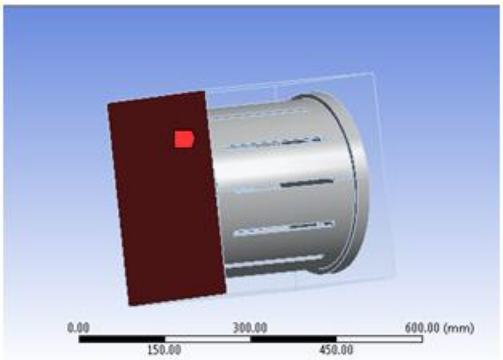

Fig: - Outlet for swirl diffuser with 6^0 slot angle

Boundary Conditions

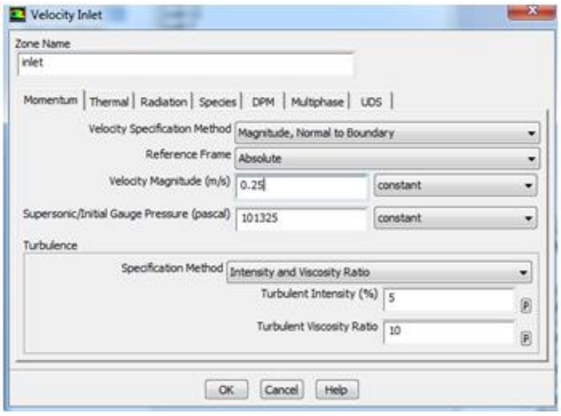

Fig: - Inlet velocity of 0.25m/s

Analysis is done with the pressure of 101.325Kpa with no of iterations of 100

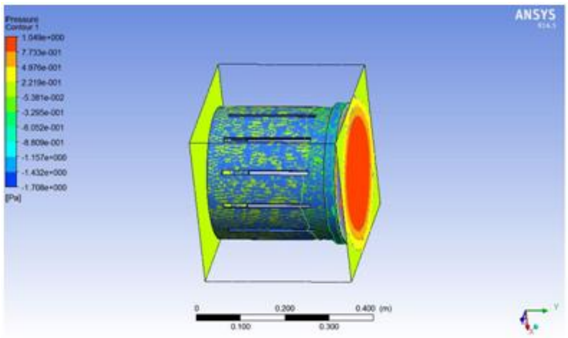

Fig 4.9: Pressure for 6^0swirl diffuser and velocity 0.25m/s

After completion of analysis we have observed the maximum pressure of 1.049e+000 Pa whichis shown in the red color and minimum pressure of -1.708e+000 Pa

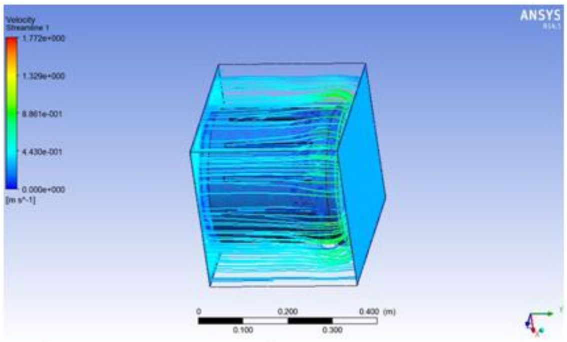

Fig 4.10 - Velocity for 6^0 swirl diffuser and velocity 0.25m/s

In the same way the analysis is done for obtaining velocity stream line which shows maximumvalue of 1.772e+000 m/s and minimum velocity of 0m/s in the below picture[8]

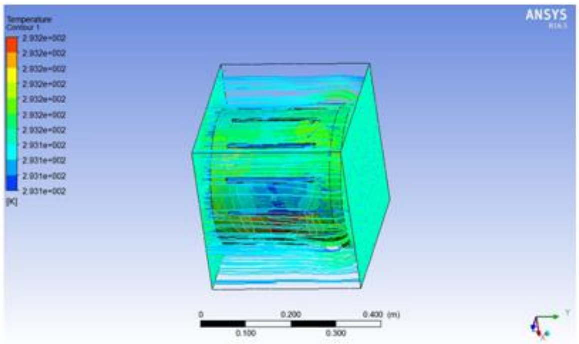

Fig: Temperature for 6^0 swirl diffuser and velocity 0.25m/s

The above picture shows the plotting of temperature contours for swirl diffuser with the maximum temperature of 2.932e+002 K and minimum temperature of 2.931e+002 K[9]

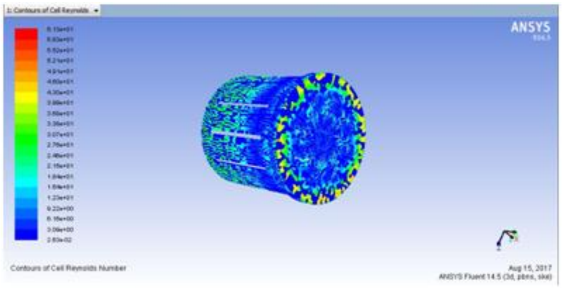

Fig: Reynolds number for 6^0 swirl diffuser and velocity 0.25m/s

The Reynolds number analysis for swirl diffuser also done and result are plotted above with maximum Reynolds number size of 6.13e+01(contours of Cell Reynolds Number) and minimum Reynolds number size of 2.63e-02(contours of Cell Reynolds Number)[10]

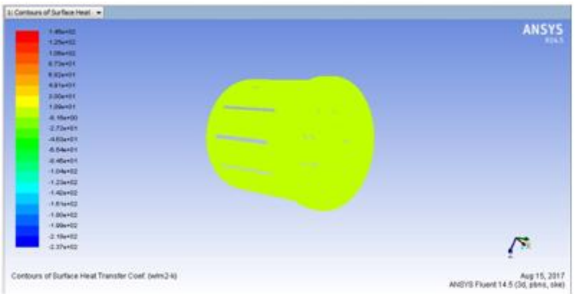

Fig: Heat transfer coefficient for 6^0 swirl diffuser and velocity 0.25m/s

The analysis for heat transfer coefficient is also done as shown in the picture above

Mass Flow Rate	(kg/s)
contact_region-src	0
contact_region-trg	0
inlet	0.039689932
interior-____msbr	0
interior-solid	0.032100268
outlet	-0.039723586
wall-12	0
wall-13	0
wall-7	0
wall-7-shadow	0
wall-solid	0
Net	-3.3654273e-05

Fig: Mass flow rates for 6^0 swirl diffuser and velocity 0.25m/s

Mass flow rate and Total heat transfer rate for 6^0swirl diffuser and velocity 0.25m/s has shown below

Total Heat Transfer Rate	(w)
contact_region-src	0
contact_region-trg	0
inlet	-199.72644
outlet	199.89352
wall-12	0
wall-13	0
wall-7	-0.0096084159
wall-7-shadow	0.0017955988
wall-solid	0
Net	0.15927092

Fig: Total heat transfer rate for 6^0 swirl diffuser and velocity 0.25m/s

THERMAL ANALYSIS

5.1 Thermal Analysis at Slot Angle – 6^0

5.1.1 Material - Copper Alloy Material properties for Copper alloy

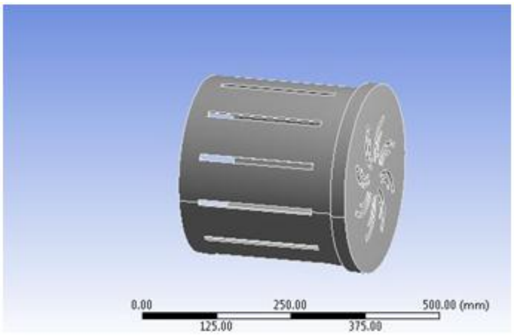

Fig: Imported model of 6^0 slot angle swirl diffuser

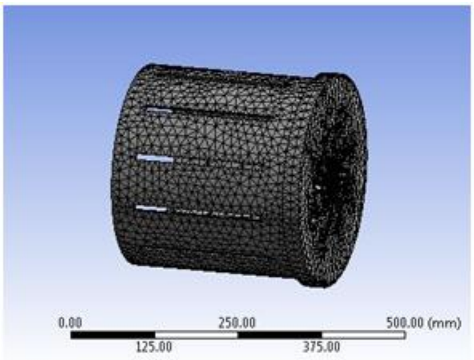

Fig: Meshed model of 6^0 slot angle swirl diffuser

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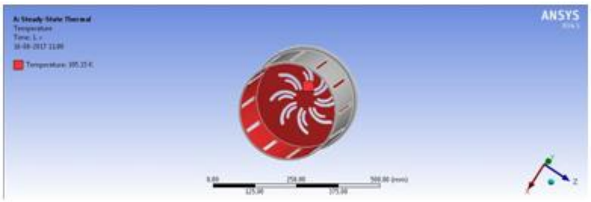

Fig: Temperature is applied inside the diffuser

Enter bulk temperature value →

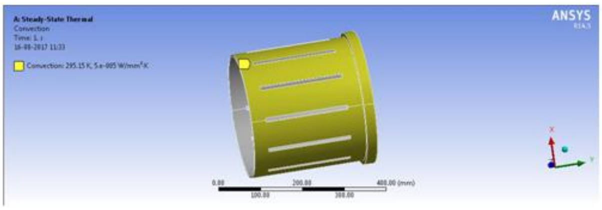

Fig: Convection is applied outside

After completion of analysis we have observed the maximum temperature of 305.12 K andminimum temperature of 305.11 K.

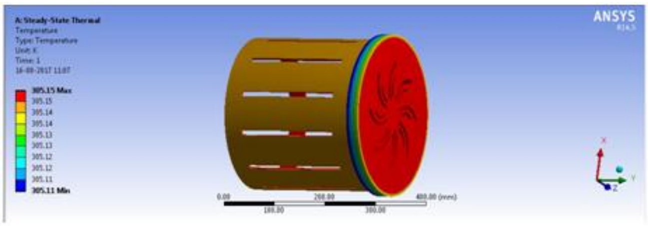

Fig: Temperature for 6^0 swirl diffuser with copper alloy

In the same way the analysis is done for obtaining total heat flux which shows maximum valueof 0.0015911 W/mm^2 and minimum velocity of 1.7502e-16 W/mm^2 in the below picture.

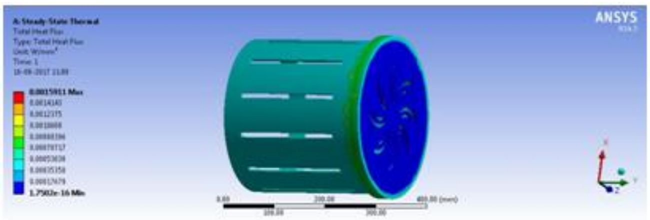

Fig: Total Heat Flux for 6^0 swirl diffuser with copper alloy

RESULTS TABLE

CFD ANALYSIS

	SLOT ANGLE								
	6^0			8^0			10^0		
Inlet Velocity (m/s)	0.25	0.5	0.75	0.25	0.5	0.75	0.25	0.5	0.75
Pressure (Pa)	1.049E +000	4.404E +000	9.545E+ 000	5.445E- 001	2.191E +000	4.962E +000	3.126E +000	1.368E +001	2.923E +001
Velocity (m/s)	1.772E +000	3.311E +000	5.316E+ 000	1.480E +001	2.956E +001	4.512E +001	8.302E +000	1.679E +001	2.573E +001
Reynolds's number	6.13E+ 01	8.40E+ 01	9.72E+0 1	5.92E+ 01	7.74E+ 01	8.90E+ 01	5.97E+ 01	7.59E+ 01	8.60E+ 01
Heat transfer coefficient(W/m²K)	1.45E+ 02	1.24E+ 02	2.40E+0 2	3.92E+ 03	1.96E+ 03	1.96E+ 03	2.68E0 1	2.61E+ 01	4.76E+ 01
Temperature(K)	2.932E +002	2.932E +002	2.932E+ 002	2.932E +002	2.932E +002	2.932E +002	2.932E +002	2.932E +002	2.932E +002
Mass flow rate(Kg/s)	3.3654 27E-05	8.8654 459E- 05	0.000133 26108	0.0396 89966	0.0793 79931	0.1190 6993	0.0396 9004	0.0793 8008	0.1190 703
Total heat transfer rate(W)	0.1527 092	0.4290 2776	0.648580 95	199.71 925	399.43 317	599.16 492	199.73 086	399.45 016	599.17 424

THERMAL ANALYSIS

SLOT ANGLE		Copper	Aluminum 6061	Nickel alloy
6^0	Temperature(K)	305.15	305.15	305.15
	Total heat flux(W/ mm²)	0.0015911	0.0015857	0.0015654
8^0	Temperature(K)	305.15	305.15	305.15
	Total heat flux(W/mm²)	0.0015884	0.001583	0.0015627
10^0	Temperature(K)	305.15	305.15	305.15
	Total heat flux(W/mm²)	0.0015886	0.0015832	0.001563

CONCLUSION:

By observing CFD analysis results, the outlet pressures are increasing for 10^0 slot angle swirl diffuser and the outlet velocity is more for 8^0 slot angle swirl diffuser. The flow pattern of air through different diffusers can be visualized with the help of smoke. The smoke is created inside the diffuser chamber and it is accelerated through the diffuser by the conditioned air coming from the air- conditioner. Heat transfer coefficient is decreasing by increasing the velocity. It is more for 8^0 slot angle swirl diffuser at 0.25m/s. The heat transfer coefficients are increasing for 8^0 slot angle swirl diffuser by about 96% when compared with that of 6^0slot angle swirls diffuser and by about 93% when compared with that of 10^0 slot angle swirl diffuser. The total heat transfer rate is more for 8^0& 10^0 slot angle swirl diffusers. Thermal analysis is performed on all the models by considering materials of diffuser Copper alloy, Aluminum alloy 6061 and Nickel alloy to determine heat fluxes.

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By observing thermal analysis results, the heat flux values are more for 6^0 slot angle swirl diffuser when compared with that of 8^0& 10^0 slot angle swirl diffusers. If the heat flux is more, heat transfer rate is more. The heat transfer rate is more when Copper is used when compared with that of Aluminum alloy 6061 and Nickel alloy.

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[3]A model for an under floor air distribution system by Y.J.P. Lin, P.F. Linden, Energy and Resources Laboratories, Industrial Technology Research Institute, Received 15 April 2004; received in revised form 30 July 2004; accepted 31 July 2004.

[4]Comparison of airflow and contaminant distributions in rooms with traditional displacement ventilation and under-floor air distribution systems by Kisup Lee, Tengfei Zhang.

[5]Thermal environment in indoor spaces with under-floor air distribution systems: by GuanqingXue, Kisup Lee, Zheng Jiang , and Qingyan Chen.

[6]Swirl Diffuser Design and Performance Characteristics for Air Flow in Air Conditioning of an Automobile-A Review by Dinesh Singh, Pankaj Mishra.

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