INVESTIGATION OF TEMPERATURE SEPARATION PHENOMENONA IN THE VORTEX CHAMBER

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ABSTRACT

The vortex chamber is a simple device with no moving parts that separates compressed gas into a high temperature region and a low temperature region. Recently, vortex chamber is being received much attention but also high industrial demand because of its structural simplicity and better performance of the temperature separation, compared with the previous vortex tubes. In the present study, both experimental and numerical analysis has been carried out to investigate the temperature separation inside a vortex chamber. Working fluid enters the chamber through four tangential inlet ports and exits through one central exit port.

To investigate the temperature separation phenomenon, static pressures and temperatures at different Reynolds number inside the vortex chamber were measured using highly sensitive pressure transducers and thermocouples. Data obtaining from experiments was used to verify the computational results.

In this thesis the CFD analysis to determine the pressure drop, velocity, heat transfer coeffient, mass flow rate and heat transfer rate at different Reynolds number 4000, 6000 &8000..

1. INTRODUCTION

The measurement of a comparatively long lifetime associated with particles containing b-quarks provided the motivation to upgrade the tracking capability of the PEP detector MAC with a Vortex Chamber (VC) of sufficient precision to measure particle flight paths of less than 1 mm. Originally, the MAC detector relied on a Central Drift (CD) Ch amber with a spatial resolution of about 180- 200pm and with the first layer of wires placed at a radius of 12 cm.

The objective of the upgrade was to add a high precision vortex chamber without modifying the existing tracking chamber. There was no space between the CD and the existing beam pipe, so the device had to be placed much closer to the circulating beams of an e + e - storage ring than had previously been attempted. Shielding studies led us to believe that this was feasible and indeed the observed radiation levels were close to expectations.

The detector had to be capable of operating in a region difficult to access and with high ambient radiation levels. Less than one year was available for production of a fully operational chamber, including prototype and design studies. This ruled out the use of solid state or other new technologies.

Because good wire chamber lifetimes have been obtained with flat cathodes:” as opposed to wire configurations, and since a broken wire would be contained within a tube, we were led to consider a “straw chamber” (i.e. a chamber of small diameter mylar tubes wire tubes) adapted from the HRS collaboration design!‘] Further considerations, described here, convinced us of the excellence of this design.

Monte Carlo and analytical studies[” based on the programs and work of Vavra14’ Jaros Is1 Boyarsky!] and others, provide general guidelines for obtaining high rl?solutioh with drift chambers.

Briefly they can be summarized as follows:

(a) The fluctuation in spacing between ionization clusters, not diffusion, provides the dominant contribution to spatial resolution for drift distances < 1 mm.

Use of high gas pressure reduces this contribution, and also reduces the effect of diffusion for larger drift distances.

(b) For all drift distances < 3.5 mm, timing on the first electron to arrive at the sense wire affords the best spatial resolution.

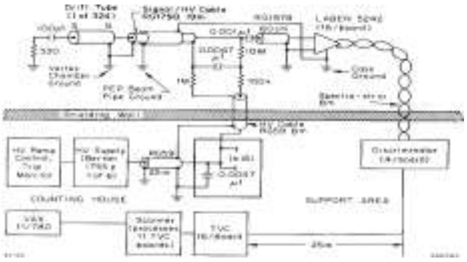
To insure one’s capability to trigger on the first electron, one should maintain the ability to operate at high gas gain, strive for the least crosstalk between neighboring channels, and use the best possible electronic signal processing.

Working of the Vortex Chamber

DESIGN

The Vortex Chamber was designed as a 'spools consisting of two aluminum endplates epoxied to either end of an extruded Beryllium tube. The straws and wires were then strung between the endplates. The radial pattern of the straws in the endplate is shown in Figure 2. There are six radial layers, arranged in three pairs. The inner member of each pair is close packed in azimuth. We took care that the sense wires of the inner members of the three pairs never align in azimuth.

The outer member of each pair is staggered one half cell with respect to the inner member, to allow resolution of the ambiguity of which side of the sense wire a track passed. There are 40 straws in the first layer pair, 54 in the second, and 68 in the third. The endplates were 1.59 mm thick; the holes in them were drilled by a computer controlled milling machine, and were placed with an accuracy of < 13~~m. In Table 1, we give an inventory of matter in the Vortex Chamber and beam pipe assembly. There was 0.8% of a radiation length between the IR and the inner VC layer, for particles exiting at 90' with respect to the beam.



2. LITERATURE REVIEW

The STAR experiment at the Relativistic Heavy Ion Collider (RHIC) has a rich physics program ranging from studies of the Quark Gluon Plasma to the exploration of the spin structure of the proton. Many measurements carried out by the STAR collaboration rely on the efficient reconstruction and precise knowledge of the position of the primary-interaction vortex. Throughout the years two main vertex finders have been predominantly utilized in event reconstruction by the experiment: MinutVF and PPV with their application domains focusing on heavy ion and proton-proton events respectively. In this work we give a brief overview and discuss recent improvements to the vertex finding algorithms implemented in the STAR software library. In our studies we focus on the finding efficiency and the quality of the reconstructed primary vortex. We examine the effect of an additional constraint, imposed by an independent measurement of the beam line position, when it is applied during the fit. We evaluate the significance of the improved primary vertex resolution on identification of the secondary decay vertices occurring inside the beam pipe. Finally, we present a method and its software implementation developed to measure the performance of the primary vertex reconstruction algorithms.Shailesh S Angalekar, Dr. A. B. Kulkarni, software package utilized towards a practical application by considering problem of natural draught hyperbolic cooling towers. The main interest is to demonstrate that the column supports to the tower could be replaced by equivalent shell elements so that the software developed could easily be utilized. Prashanth N, Sayeed sulaiman. This paper deals with study of hyperbolic cooling tower of varying dimensions and RCC shell thickness, for the purpose of comparison a existing tower is consider, for other models of cooling tower the dimensions and thickness of RCC shell is varied with respect to reference cooling tower.. N.Prabhakar (Technical Manager). The Paper describes briefly salient structural features and current practices adopted in the structural design of hyperbolic cooling towers. Cooling towers are undoubtedly exceptional structures which require special expertise both to design and construct.

3. METHODOLOGY AND PROBLEM DESCRIPTION

3. PROBLEM DESCRIPTION:

The objective of this project is to make a 3D model of the vortex chamber and study the CFD and thermal behavior of the heat exchanger by performing the finite element analysis.3D modeling software

(PRO-Engineer) was used for designing and analysis software (ANSYS) was used for thermal analysis.

4. INTRODUCTION TO CAD/CAE:

Computer-aided design (**CAD**), also known as **computer-aided design and drafting** (**CADD**), is the use of computer technology for the process of design and design-documentation.

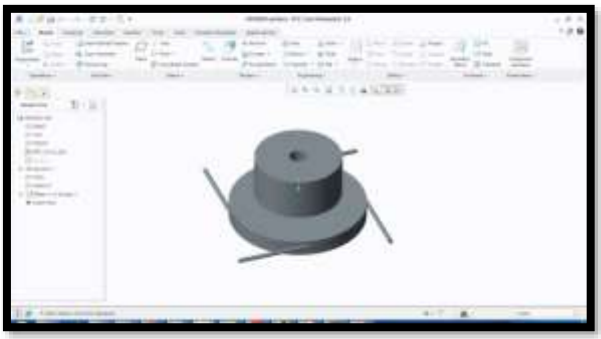
4.1. INTRODUCTION TO CREO

CREO is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design while ensuring compliance with your industry and company standards. Integrated CREO CAD/CAM/CAE solutions allow you to design faster than ever, while maximizing innovation and quality to ultimately create exceptional products.

Different modules in CREO

Part design, Assembly, Drawing& Sheet metal.

3D MODEL



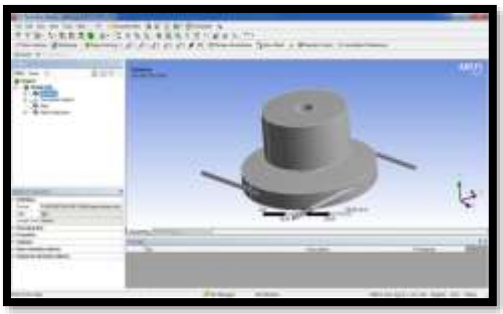
4.2. INTRODUCTION TO FINITE ELEMENT METHOD:

Finite Element Method (FEM) is also called as Finite Element Analysis (FEA). Finite Element Method is a basic analysis technique for resolving and substituting complicated problems by simpler ones, obtaining approximate solutions Finite element method being a flexible tool is used in various industries to solve several practical engineering problems. In finite element method it is feasible to generate the relative results.

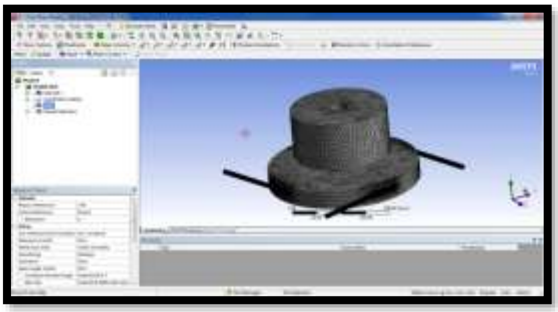
5. RESULTS AND DISCUSSIONS:

CFD ANALYSIS OF VORTEXCHAMBER

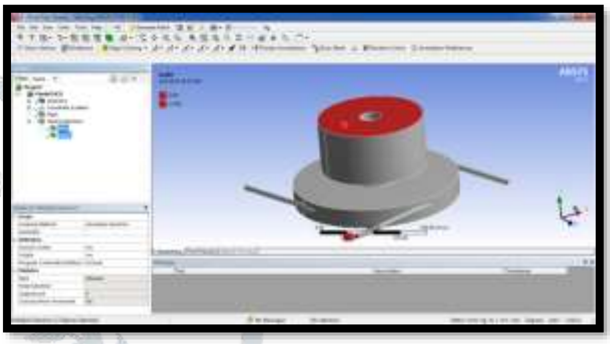
Imported model



Meshed model

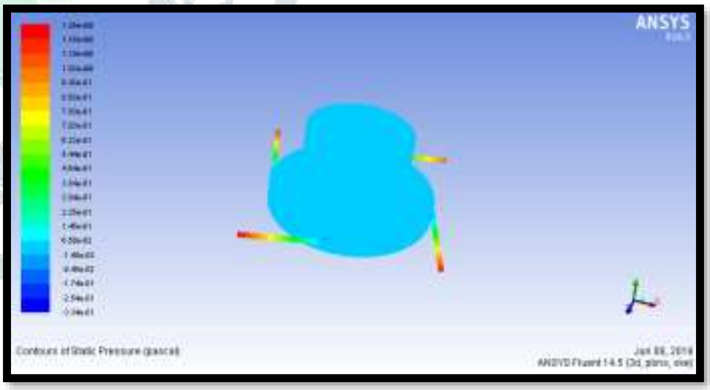


Boundary conditions

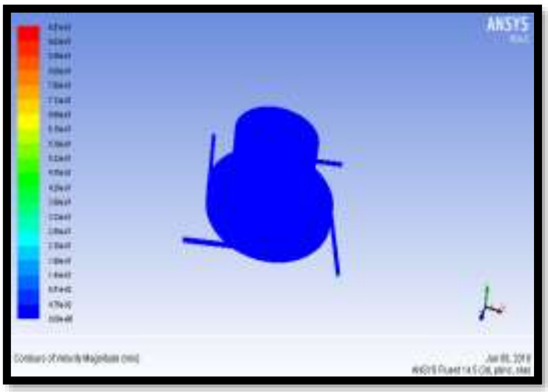


Reynolds number 8000 temperature 280K

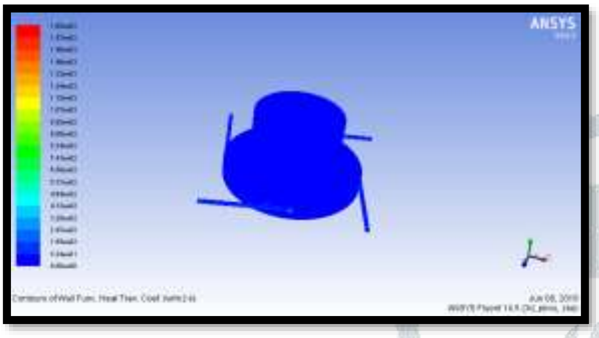
Pressure drop



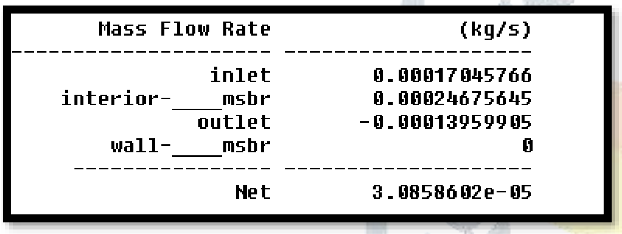
Velocity



Heat transfer coefficient

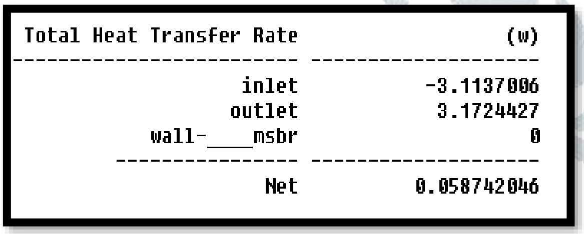


Mass flow rate



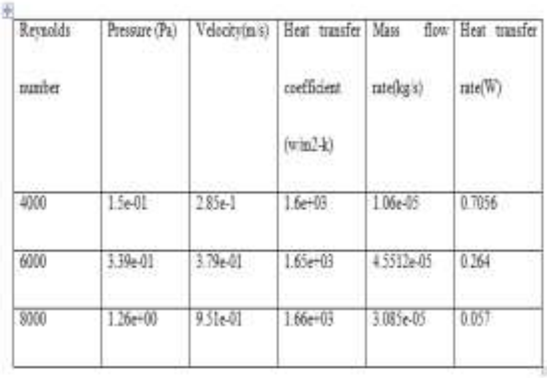
```
        Mass Flow Rate                    (kg/s)
-------------------- --------------------
                inlet         0.00017045766
      interior-____msbr        0.00024675645
               outlet        -0.00013959905
          wall-____msbr                    0
     ---------------- --------------------
                  Net          3.0858602e-05
```

Heat transfer rate



```
 Total Heat Transfer Rate                  (w)
------------------------ --------------------
                   inlet           -3.1137006
                  outlet            3.1724427
             wall-____msbr                    0
        ---------------- --------------------
                     Net          0.058742046
```

RESULTS AND DISCUSSIONS



Reynolds number	Pressure (Pa)	Velocity(m/s)	Heat transfer coefficient (w/m2-k)	Mass flow rate(kg/s)	Heat transfer rate(W)
4000	1.5e-01	2.85e-1	1.6e+03	1.06e-05	0.7056
6000	3.39e-01	3.79e-01	1.65e+03	4.5512e-05	0.264
8000	1.26e+00	9.51e-01	1.66e+03	3.085e-05	0.057

7. CONCLUSION

The possible reasons for the high and low temperature separation inside a vortex chamber are investigated in detail by the visualization of air flow. The distribution of the angular momentum indicates energy migration inside the vortex chamber. It is found that two vortices that rotate in the same direction are responsible for the low-temperature separation while counter-rotating vortices cause high-temperature separation.

By observing the CFD analysis the heat transfer coefficient, pressure drop, velocity increases by increasing the Reynolds number. The more heat transfer coefficient value at Reynolds number 8000.

REFERENCES

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[1] G. J. Ranque, Experiments on Expansion i

n a Vortex with Simultaneous Exhaust of Hot Air and Cold Air, J. Phys. Radium(Paris), Vol. 4, 1933, pp.1125-1130

[2] R. Hilsch, The use of the Expansion of Gases in a Centrifugal Field as Cooling Process, Rev. Sci. Instrum., Vol. 18, No. 2, 1947, pp.108-113

[3] Yan Beliavsky, Experimental Investigation of a Temperature Separation Effect Inside a Short Vortex Chamber, 9th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics, Malta, 2012.

[4] Yan Beliavsky, The Pressure Gradient Elastic Wave : Energy Transfer Process for Compressible Fluid with Pressure Gradient, Journal of Engineering and Automation, Vol. 3, 2013, pp. 53-64

[5] W. Frohlingsdorf and H. Unger, Numerical Investigations of the Compressible Flow and the Energy Separation in the Ranque–Hilsch Vortex Tube, Int. J. Heat Mass Transfer , Vol. 42, 1999, pp.415- 422.

[6] U. Behera, P.J. Paul, K. Dinesh and S. Jacob, Numerical Investigations on Flow Behaviour and Energy Separation in Ranque–Hilsch Vortex Tube, Int. J. Heat Mass Transfer, Vol. 51, 2008, pp.6077-6089.

[7] Y. Xue, M. Arjomandi and R. Kelso, A critical review of temperature separation in a vortex tube, Experimental Thermal and Fluid Science, Vol. 34, 2010, pp.1367-1374.

[8] C.M. Gao, K.J. Bosschaart, J.C.H. Zeegers and A. Waele, Experimental study on a simple Ranque–Hilsch vortex tube, Cryogenics, Vol. 45, No. 3, 2005, pp.173-183.

[9] K. Yokoo, S. Matsuo, Y. Matsuno, T. Setoguchi and H.D. Kim, Flow Characteristic in a Vortex Chamber, JMST, 2014 (in Japanese)