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Analysis of Convergent - Divergent Nozzle with and without Macro - Extends using ANSYS CFD

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Abstract: ***Convergent – Divergent Nozzle was designed in ANSYS design module and velocity and pressure flow was analysed from inlet to outlet. The pressure is high and velocity is low at inlet and velocity is high and pressure is low at outlet i.e. subsonic, sonic and supersonic conditions of the c-d nozzle was tested. The new c-d nozzle was designed and developed with attached macro — extends to the existed c-d nozzle for enhancing the fluid pressure and velocity flow controls. The total wall pressure distribution from inlet to the outlet too was recorded. The results indicate that the macro - extends can oblige as the effective regulators of the pressure in the base area. The duct wall pressure field is not negatively affected by the dynamic control. The fluid pressure flow was achieved for the newly developed macro-extends c-d nozzle. The convergent-divergent nozzle geometry has been modelled and simulated employing turbulence models: K-ε standard wall function turbulence model from the code was validated with the commercial com-computational fluid dynamics.***
Keywords: CFD, c-d Nozzle, ANSYS, Pressure; Mach number.

I. INTRODUCTION TO CONVERGENT AND DIVERGENT NOZZLE

A convergent-divergent nozzle or CD nozzle or de Laval nozzles is a tube that is pinched in the middle, making a carefully balanced, asymmetric hourglass shape. It is used to accelerate a hot, pressurized gas passing through it to a higher supersonic speed in the axial (thrust) direction, by converting the heat energy of the flow into kinetic energy. Because of this, the nozzle is widely used in some types of steam turbines and rocket engine nozzles. It also sees use in supersonic jet engines. The nozzle was developed (independently) by German engineer. This principle was first used in a rocket engine by Robert Goddard. Most modern rocket engines that employ hot gas combustion use de Laval nozzles.Abdul Aabid, Ambareen khan, NurulMusfirah. Mazlan, MohdAzmi. Ismail, Mohammad Nishat Akhtar, S. A. Khan [1] studied the the usefulness of base pressure control in the form of tiny jets to regulate base pressure level is adequate. These jets serve as an adequate controller, raising the base pressure magnitude adequate for the above combinations of variables. There is no negative impact of the control on the flow field in the downstream beyond the nozzle, as the flow field is identical in the presence and absence of the flow regulation mechanism.Mohammad Nishat Akhtar, Elmi Abu Bakar, Abdul Aabid, Sher Afghan Khan [2-4] present the flow-field and wall pressure distribution in a convergent-divergent nozzle and in the duct was successfully studied using finite element method. The effect of microjets control in order to control the base pressure has been achieved. In view, the jets remained over expanded the base pressure without is high due to the presence of oblique shock waves. Under these circumstances, when the control is employed results in a marginal increase in the base. As the significant gain in the base, the pressure was achieved without control. The control does not influence adversely on the wall pressure flow field. The flow remained attached with the enlarged duct even at L/D = 2; this length seems to be the minimum length needed for the flow to remain attached. G.V.R.Seshagiri Rao, U.Ramakanth and Suryaprakash [6]in this paper, two heat pipes were studied through experiment exploitation deionised water, because of the operating fluid. The wick used in the heat pipes is made of SS304 material, with 100 mesh and 200 meshes, respectively. The heat pipes were positioned at totally different angles 100, 450 , 900 with horizontal. Experiments were conducted with the natural convection, forced convection condenser cooling, with different heating fluxes. The thermal resistances of heat pipe, operating with forced convection cooling, with 200 mesh at 90o inclination is 53%, lower than the heat pipe operating at horizontal at 50W heat input. The heat transfer coefficient of heat pipe, operating at 45o angle is 71% higher than heat pipe operating at horizontal position, with forced convection cooling with 200 meshes. The effective thermal conductivity of heat pipe, operating at 45o is 47% higher, the heat pipe operating with forced convection cooling, with 200 mesh at horizontal position with 50W heat input.J. S. Anderson, T. J. Williams [7-10] the investigation described, the base pressure resulting from the abrupt expansion of an air jet from a circular nozzle into a concentric cylindrical duct or shroud has been measured. Stagnation pressure ratios of the forcing jet to atmospheric of up to six were used with shrouds of various lengths and diameters.

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II. PROBLEM DEFINITION

The parameters of the CD nozzle is modelled based on the designed Mach number 1.7 (Fig. 1.1). Macro -expands are designed above 25 mm of diameter. The main aim of this study is to analyze the flows past a CD nozzle and the computation of the flow parameters such as pressure, and velocity with the effect of different parameters proving by CFD simulation in 2D modelling with and without macro – expands.

III. DESIGN AND MESHING OF NOZZLE USING ANSYS CFD

The convergent divergent nozzle design was created as per the definition of the problem with the help of finite element analysis design module software ANSYS WORKBENCH. The design was done for the convergent divergent nozzle without macro extends.The quad mesh was crated for this model by line meshing, face meshing and surfacing technique used in ANSYS Mesh Module.

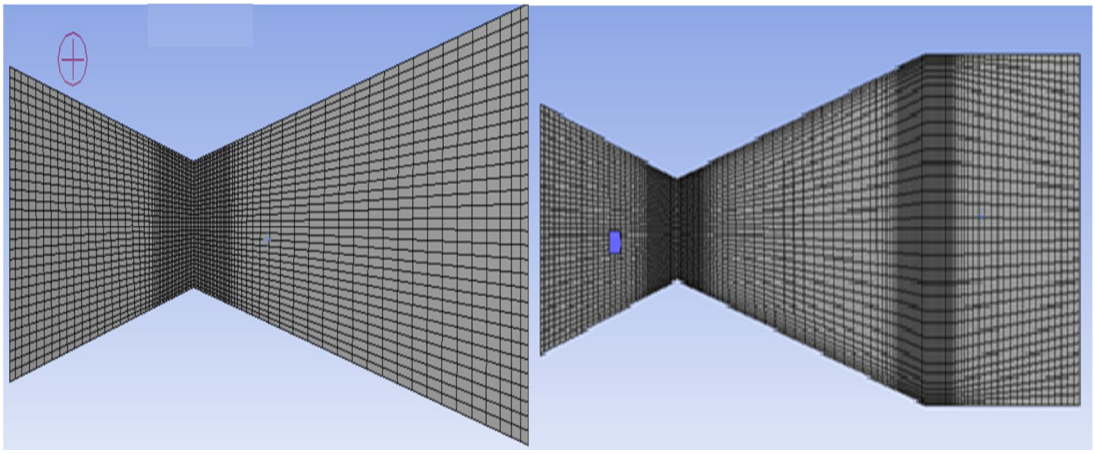


Fig1.1 show convergent- divergent nozzle with out with macro –extends

A. Analysis of Convergent And Divergent Nozzle With Out Extends

In this partto identify the fluid flow on CD nozzle without macro - extends control for a suddenly expanded duct by effect of expansion level. The velocity of the pressure to the graphs of which is attention to the Mach number of 1.23 as shown in Fig 1.2. The problem definition as simplified by observing the fluid flows for each case and identified the effect nozzle pressure ratio (NPR). The advantage of the present method is to investigate the perfect fluid flow and active control of pressure macro - extends at the base.

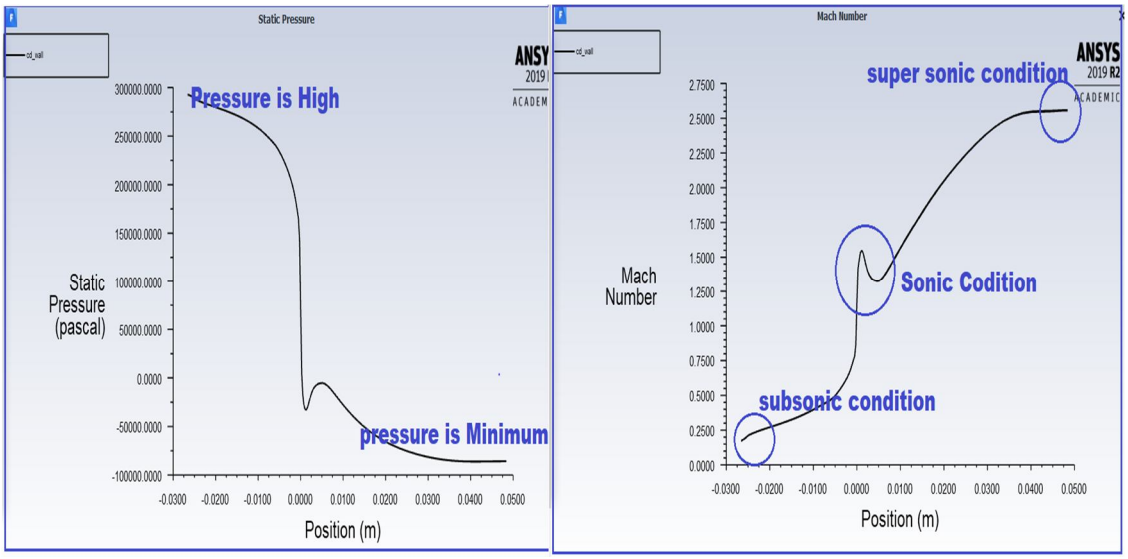


Fig 1.2 pressure and velocity plots of CD nozzle without macro extends

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B. Analysis of Convergent and Divergent Nozzle With Macro – Extends

The pressure inlet to outlet is gradually decreased i.e. 4.45e5 to -7.41e4 it was shown in contours of static pressure figure and these results are also shown.

Velocity at Inlet is Low 4.88e-2 (Subsonic Condition) and Max at Outlet 1.33e2 (Super Sonic Condition) and Middle Sonic condition (Mach number) colour changed1.23 as shown in Fig1.3.

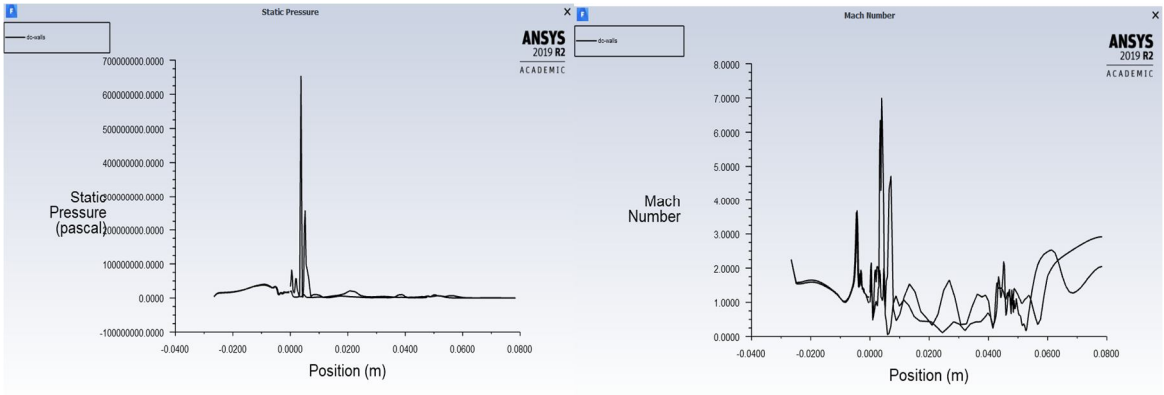


Fig 1.3 pressure and velocity plots of CD nozzle with macro extends

IV. SUMMARY & CONCLUSIONS

The Results of CD nozzle with and without macro extends are discussed. The pressure at inlet 2.91e5 for CD nozzle whereas CD nozzle with macro extends the pressure is 4.45e9 but the pressure at outlet is -7.41e4 it was greater than pressure at outlet of CD nozzle. The velocity at inlet is zero for both models whereas velocity at out let 2.166 e4 for CD nozzle macro extends is greater than CD nozzle without macro extends as shown in Fig1.4 & 1.5.

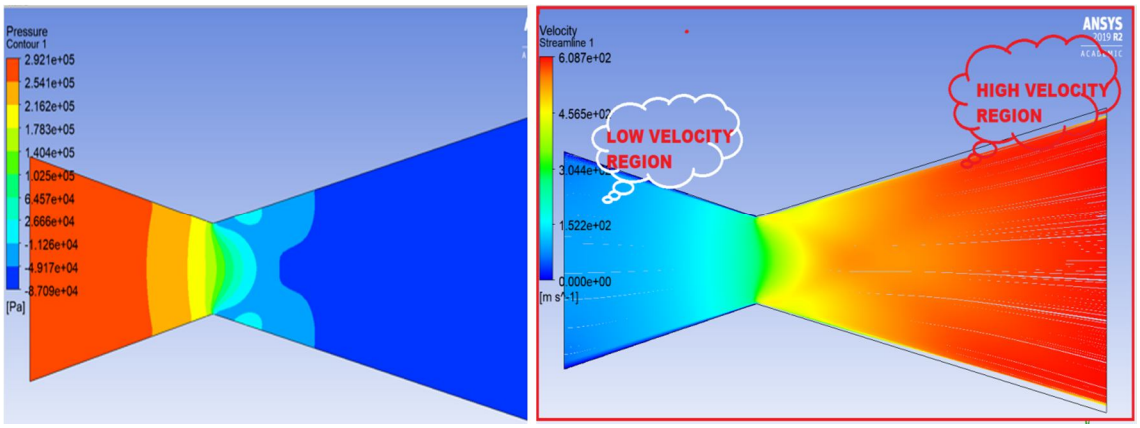


Fig 1.4 shows the contours pressure and velocity plots of CD nozzle without macro extends

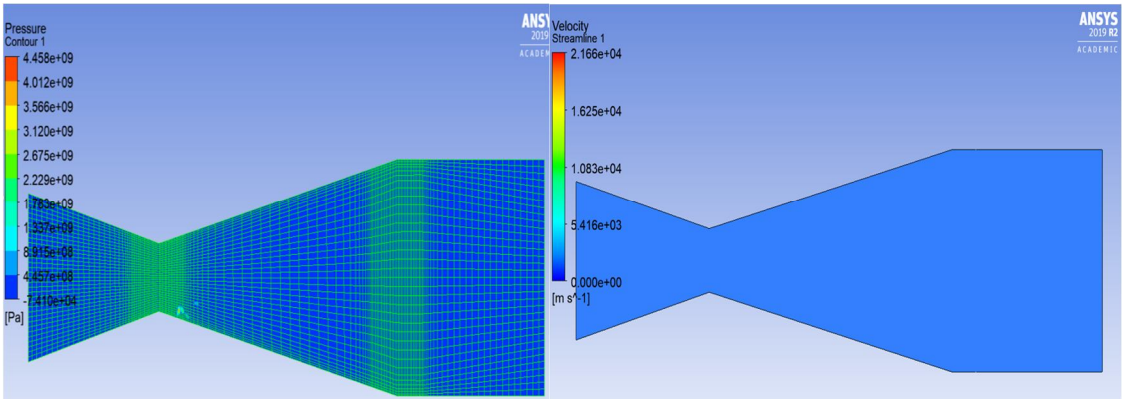


Fig 1.5 shows the contours pressure and velocity plots of CD nozzle with macro extends

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With the discussion we conclude that, total pressure dramatically varying from inlet to the outlet and value of pressure is high for cd nozzle without macro extends. As pressure decreases velocity will increase and our results proved that the velocity is high at the exit and variation of pressure inlet to the outlet is observed by considering Mach number.

V. FUTURE SCOPE

To control the pressure and velocity flow in the CD nozzle the design changes plays very important roles by introducing micro extends of regular and irregular shapes.

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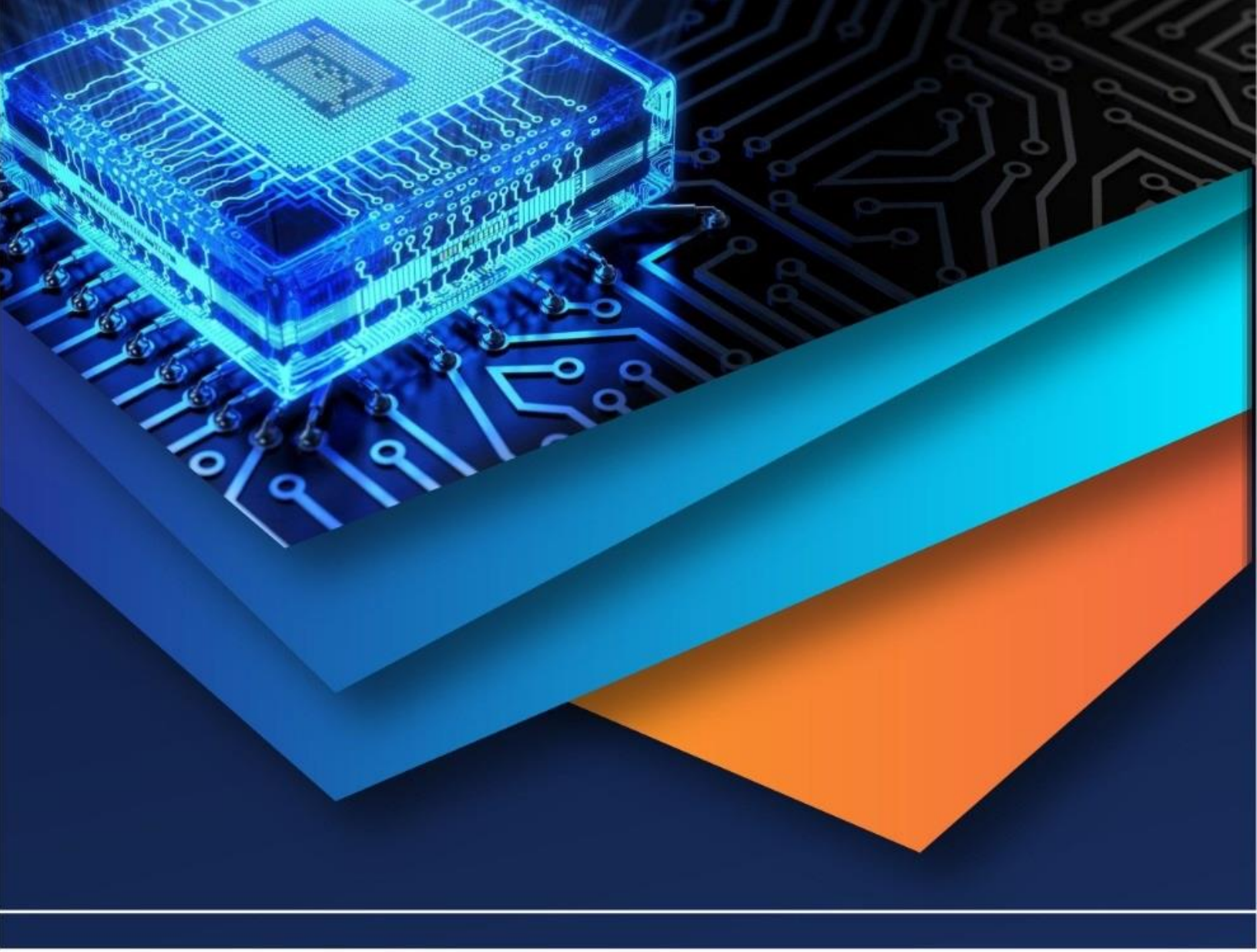
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