CFD ANALYSIS ON GRID FINS TO ENHANCE SAFE BOOSTER RELANDING SYSTEM

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ABSTRACT

In the Boosters Relanding System, the grid fins are used to slow down the boosters safely. The grid fins structure plays a major role to reduce the velocity of rocket boosters. During the boosters relanding the grid fins creating turbulence when air passing through that. Because of this effect, the reduction of velocity will happen. In this project, the grid fins structure going to change to create more turbulence to reduce the velocity of the boosters during relanding. This structure to be analyzed by ANSYS 2021 R1 (Fluent) software to choose a suitable structure for the effective landing purpose. By the natural occurrence of turbulence will reduce the additional source wastages. Through inserting a tapered kind of grid fins will be useful to generate much drag during relanding. When the area is reduced then the pressure will increase. By designing the grid fins structure with wide opening and narrow exit (convergent nozzle) will produce more pressure at exit. While achieving more pressure, the drag will be automatically generated to cause the boosters to slow down. This project also concentrates on developing rocket boosters to reland safely so that we can achieve reducing cost, reducing manufacturing, time duration, manpower that simultaneously reduces the 50% of a cost per launch currently CPL of PSLV costs 130 crores in Indian rupees, this project reduces the CPL to 60 crores. Applying this concept will achieve an effective reland and also can use the boosters at least 6 times instead of manufacturing the new boosters.

Keywords – grid fins, relanding system, analysis, fluent

I. INTRODUCTION

The recent use of advanced Lattice grid fins is in the Heavy Falcon9 rocket, in research; it appeared that the purpose use of grid fins in the rocket as an aerodynamic braking device on the re-entry of a rocket from the space to an enhanced precious landing. The fundamental part design of the lattice grid fins allows a large amount of lifting surface to be hinged along the body of the missile with a retracting movement, which can be folded to the surface in the order to reduce the space consumption compared to the conventional plane surface design. The modern grid fins is a compact design of a control surface that promises good storability for potential tube-launch and internal carriage dispenser-launched applications. The arrangement of the internal framework of grid fins merits with high strength to weight ratios, The chord dimension with the zero hinge moment and with a small center of pressure varies over a different range of Mach number with reduces the control actuator requirement In past years, since the release of the Russian book about grid fin, this topic came with intensive investigations in the scientific community working on missile technology. Several studies carried on lattice wing some NATO countries like the USA, UK, Canada, France, and Germany.

DESIGNING PROCESS

This work approaches the software that is SOLID WORKS 2015 for designing process.

DESIGN PARAMETERS

Table 2.1Geometric details grid fins

Body length	366.0 mm
Body diameter (Ref. Length)	20.32 mm
Body cross-sectional area (Ref. Area)	324.3 mm^2

Table 2.2 Geometric parameters of grid fins

Area of each cell (Standard)		25.0 mm^2
Area of total grid cell (15 cells)		375.0 mm^2
Chord length		5.0 mm
Web thickness		0.2 mm
Area of lifting surface	A: square	778.8 mm^2
	B: triangle	723.8 mm^2

	C: hexagon	604.6 mm^2

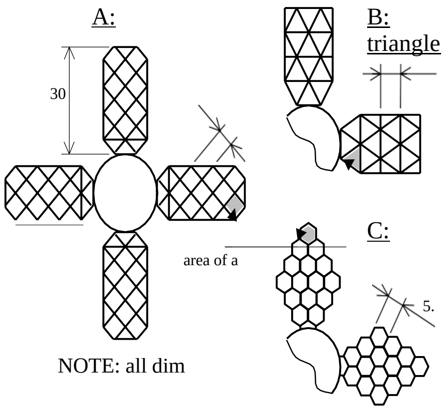


Figure 2.1 configuration of grid fins parameters

The following designs have been created based on above mentioned parameters. And the designs are generated going to be compared during analysis process.

EXSISTING MODEL

Figure 2.2 Square grid cells

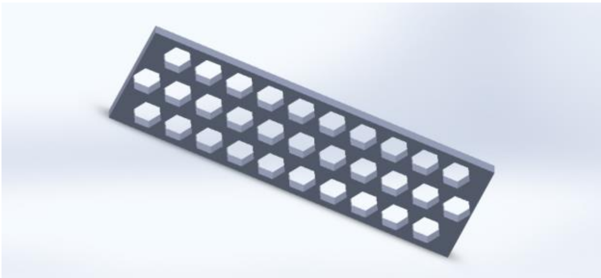


Figure 2.3Hexagon grid cells

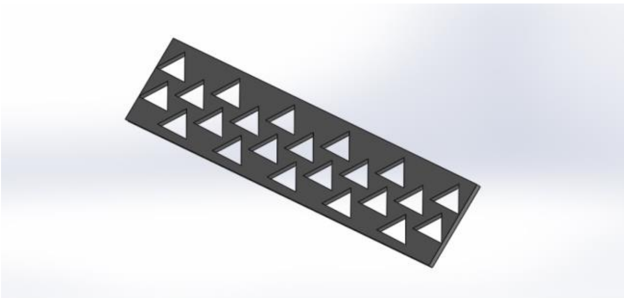


Figure 2.4 Triangle grid cells

PROPOSING MODELS

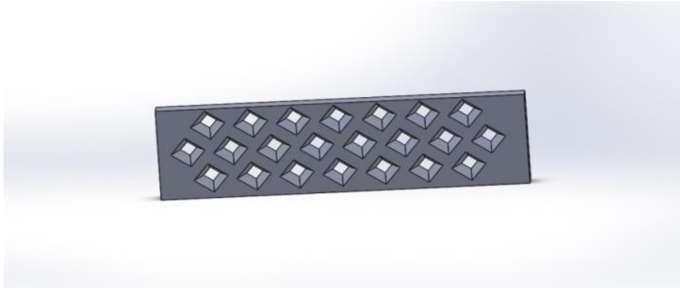


Figure 2.5 Extruded square grid cells

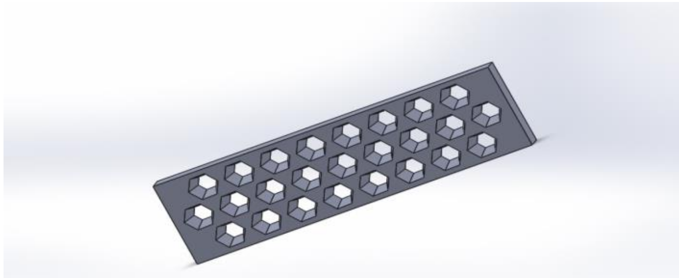


Figure 2.6 Extruded hexagon grid cells

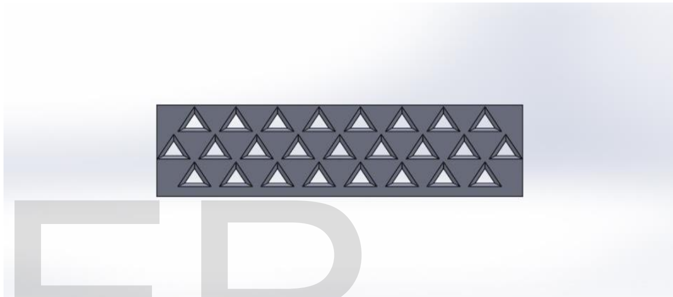


Figure 2.7 Extruded triangle grid cells

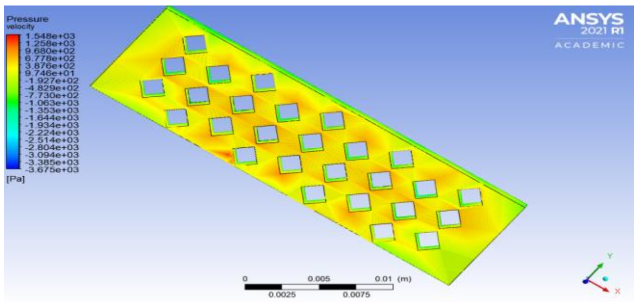
II. MESH GENERATION

Herewith, first draw the geometrical diagram which taken dimensions from the planning configuration table. And need to convert the geometrical diagram into three dimensional objects in ANSYS 2021 R1 (Fluent). Defining the domain with above mentioned dimension which surrounding the grid fins which call as air domain and inside grid fins which call as solid as shown in following figures.

III. ANALYSIS RESULTS

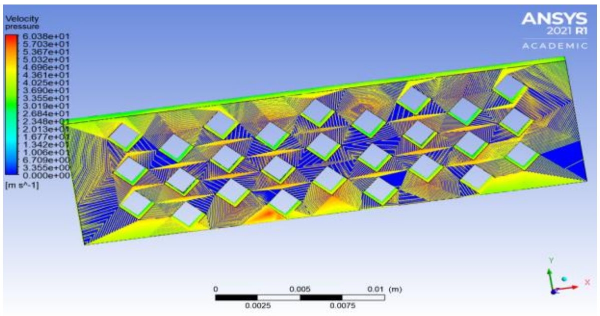
SQUARE GRID

PRESSURE



4.1 Figure pressure distribution of square grid

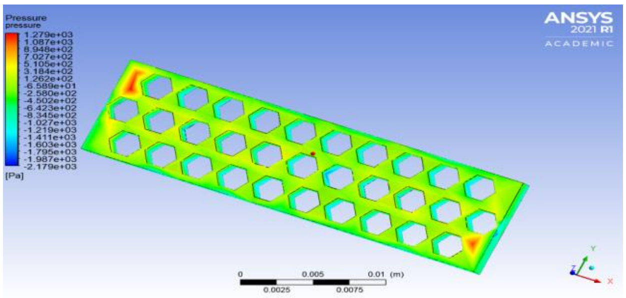
VELOCITY



4.2 Figure velocity distribution of square grid

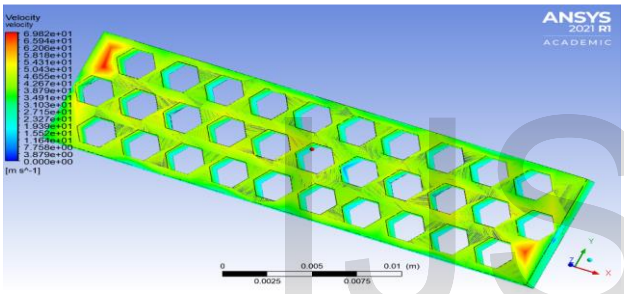
HEXAGONAL GRID

PRESSURE



4.3 Figure Pressure distribution of hexagonal grid

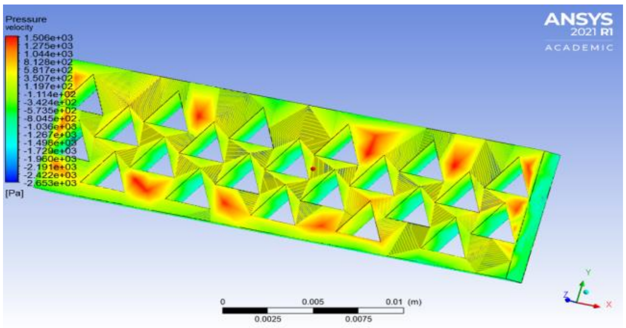
VELOCITY



4.4 Figure Velocity distribution of square grid

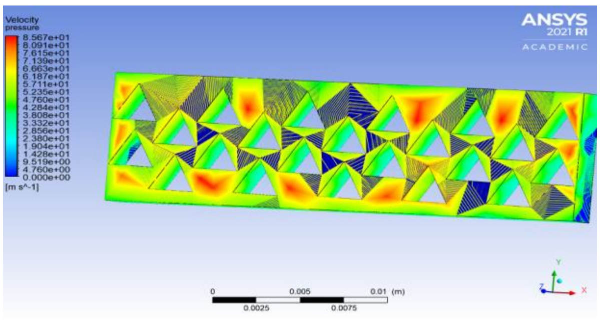
TRIANGULAR GRID

PRESSURE



4.5Figure Pressure distribution of triangular grid

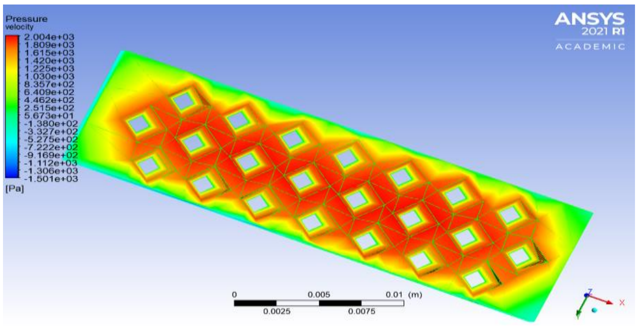
VELOCITY



4.6. Figure Velocity distribution of triangular grid

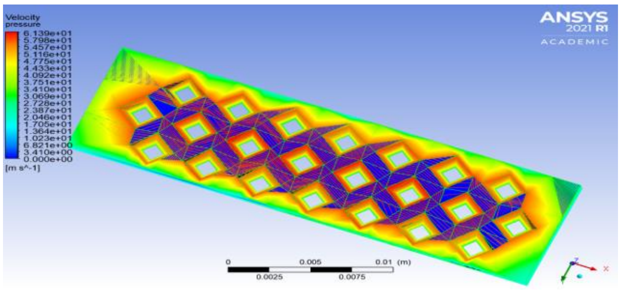
EXTRUDED SQUARE GRID

PRESSURE



4.7. Figure Pressure distribution of extruded square grid

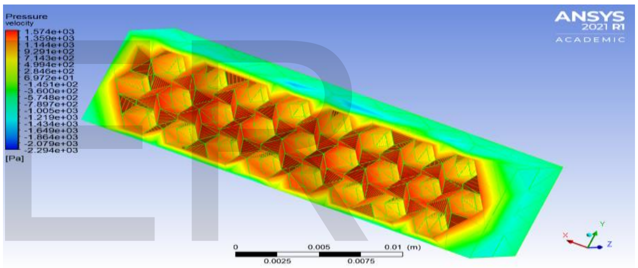
VELOCITY



4.8.Figure Velocity distribution of extruded square grid

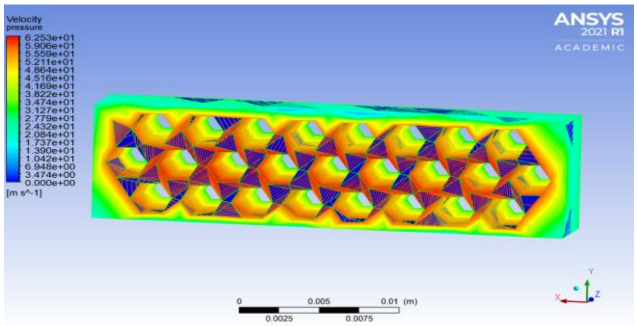
EXTRUDED HEXAGONAL GRID

PRESSURE



4.9. Figure Pressure distribution of extruded hexagonal grid

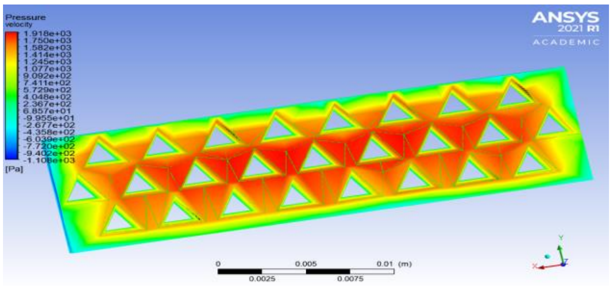
VELOCITY



4.10. Figure Velocity distribution of extruded hexagonal grid

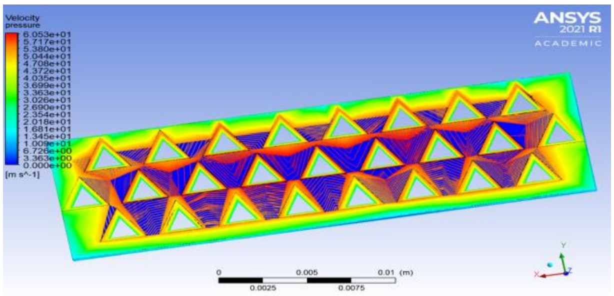
EXTRUDED TRIANGLE GRID

PRESSURE



4.11 Figure pressure distribution of extruded triangle grid

VELOCITY



4.12 Figure velocity distribution of extruded triangle grid

COMPARISONS OF RESULTS

S. no	Grid mode	Nodes	Elements	Pressure	Velocity
1	Square	19232	14231	1574.67	60.6871
2	extruded Square	42815	211302	2021.73	59.6969
3	Hexagon	17656	12201	1296.55	70.1737
4	Extruded Hexagon	63561	53392	1593.23	62.8499
5	Triangle	15113	20744	1526.87	86.1037
6	Extruded triangle	47648	232834	1933.19	60.83

IV. Conclusion

- From the study of the reference papers most the designs consisting the square grid fins and all of them done an experiment, numerical and software analysis with various angle of attack and swept and unswept designs. Some of the authors were done an analysis for triangle and hexagonal designs. This research work consisting the three designs that are triangle, square and hexagon shapes with o angle of attack and unswept type. The extruded type of these three shapes also designed here.
- The major conclusions which are extracted from the reference papers concluded the result as the hexagonal design unfits at supersonic speed. It attains a chocked effect at the speed of transonic.
- When the square grid fin and triangle grid fin angles changed from 0 to 5 it will also cause for the chocked effect.
- Here an angle has been fixed at 0 degree for the both grid fins so it doesn't cause for chocked effect.
- When the exit area of the grid fins decrease the pressure will automatically increase. This project conclude the result as, the extruded grid fins always show the better performance during relanding process.
- The normal and extruded grid fins results are compared with each other at a supersonic speed but an extruded design has been showed a better performance. It has been resulted from the analysis work.
- Finally expected results have been given by the extruded design during relanding of boosters.

REFERENCES

- Nayhel Sharma & Rakesh Kumar (2019)- Missile grid fins analysis using computational fluid dynamics: a systematic review- INCAS BULLETIN, volume 11, Issue 1
- James e, Kless, Michael & j. Aftosmis (2012)- Analysis of grid fins for launch abort vehicle using a Cartesian Euler solver – https://doi.org/10.2514/6.2011-3666
- Fumiya Hiroshima & kaoru tatsumi (2004) - Grid pattern effects on aerodynamic characteristics of grid fins - International Congress of the Aeronautical Sciences
- G.A. Faza *etal* (2018)- Study of swept angle effects on grid fins aerodynamics performance-Journal of Physics Conference Series 1005(1):012013
- Hariharan. R, Lenin Rakesh .N & Ravi .D (2019) - Reusable rockets and multi-planetary human life – (IJEAT) ISSN: 2249 – 8958, Volume-8, Issue-6S2
- Lei xie *etal* (2020)- A convex programming method for rocket powered landing with angle of attack constraint- volume 8 https://ieeexplore.ieee.org/xpl/tocresult.jsp?isnumber=8948470
- Xingu liu (2018)- Fuel-optimal rocket landing with aerodynamic controls- Aerospace research central https://doi.org/10.2514/1.G003537
- Vidya Sagar Reddy (2020)- The SpaceX effect- New space, Vol. 6, No. 2 Original Research Articles
- Henry Adrian & William Hyman (2018)-Reusable launch system: the gateway to the future of space travel - http://www.pitt.edu/~budny/papers/8226.pdf