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Design & Analysis of Multi-part Fixture for Pin Quadrant of Quadrant sub-assembly of Cultivator

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Abstract -*In Recent years we have seen remarkable development in the field of Agriculture. Big farmers are using advance machine tools now days like harvester, cultivator, and tractor. In India where 65-70% farmers are still doing farming traditionally. They also need improved agriculture tools. Pin Quadrant is very important part of quadrant sub-assembly used in cultivator. The design of a multipart fixture is a highly complex and intuitive process, which require knowledge. Fixture design plays an important role at the setup planning phase. Proper fixture design is crucial for developing product quality in different terms of accuracy, surface finish and precision of the machined parts. Fixture is required in various industries according to their application. This can be achieved by selecting the optimal location of fixturing elements such as locators and clamps. The fixture set up for component is done manually. The main objective of the report is to design the fixture for complex geometry. This geometry is having different machining operation. Major operations are Milling and Hole Drilling on different sides. These operations are to be carried out in VMC keeping the objective of minimization of the cycle time as well.*

In this project, we designed a Multi-part Fixture for Pin Quadrant of Quadrant sub-assembly of Cultivator. The CAD model of multipart fixture was generated as per the data collected, objectives of the project, references etc. After the CAD model generation, FEM and FEA was carried out and the results were discussed in order to finalize the design.

I- INTRODUCTION

A Fixture is a device/mechanism used in manufacturing to hold a work piece, position it correctly with respect to a machine tool, and support it. During manufacturing operations such as machining, inspection and assembly, fixtures provide a means to reference and align the cutting tool to the work piece but they do not guide the tool. Fixtures that have the added function of guiding the tool during manufacturing processes are called jigs. Fixtures have direct impact upon product quality, productivity and cost. Fixture devices includes various standard clamps, chucks, and vises, Metal plates containing dowel and/or tapped locating holes or key slots and dedicated fixtures with specific design and build requirements.

1.1 Types of Fixtures: Generally the fixtures are categorized into five groups:

- Plate Fixtures
- Angle Plate Fixtures
- Vice-Jaw Fixtures
- Indexing Fixtures
- Multi-Part or Multi-Station Fixtures

Plate Fixtures: Plate fixtures are constructed from a plate with a variety of locators, supports and clamps. They are the most common type of fixture because their versatility makes them adaptable to a wide range of machine tools. They are made from many different kinds of materials, which are governed only by the part being machined and the process being performed.

Fig.1.1 Plate fixture

Angle-Plate Fixtures: Angle-plate fixtures are a modification of plate fixtures. In this type a surface is set perpendicular to the mounting surface instead of parallel in the case of plate fixtures.

Fig.1.2 Angle-plate fixture

Vise-Jaw Fixtures: Vise-jaw fixtures are modified inserts for vises designed to accommodate a particular work piece. These fixtures are the least expensive and simplest to modify. The only limitations to these types of fixtures are size of the part and capacities of available vises.

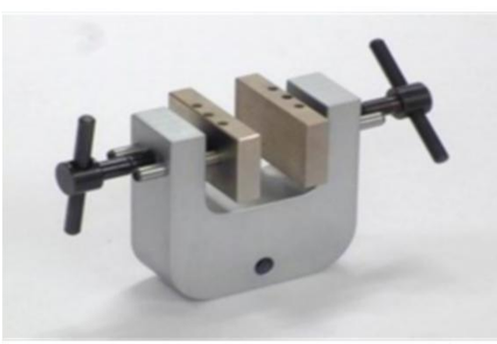

Fig. 1.3 Vise- Jaw fixture

Indexing Fixtures: Indexing fixtures are used to reference work pieces that need machining details set at prescribed spacing. Indexing fixtures must have a positive means to accurately locate and maintain the indexed position of the part.

Multi-Part or Multi-Station Fixtures: Multi-part or multi-station fixtures are normally used for either machining multiple parts in a single setup, or machining individual parts in sequence with the performing different operations at each station.

Fig: Indexing Fixture and multipart fixture

2. Data Accumulation:

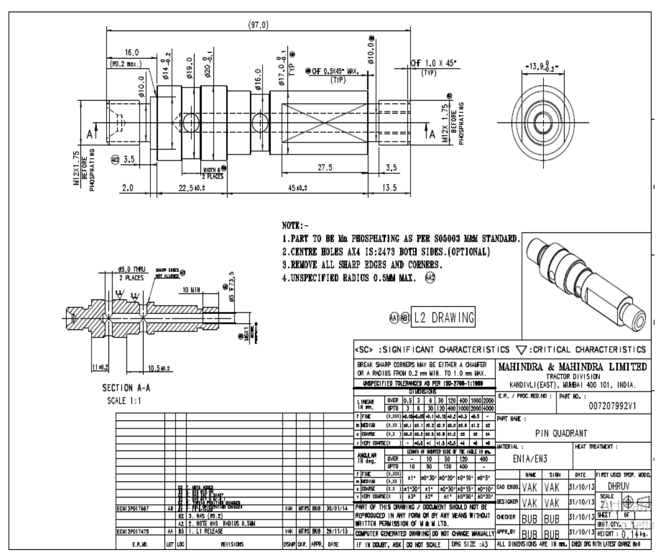

Fig 2.1: Existing Data of Pin Quadrant

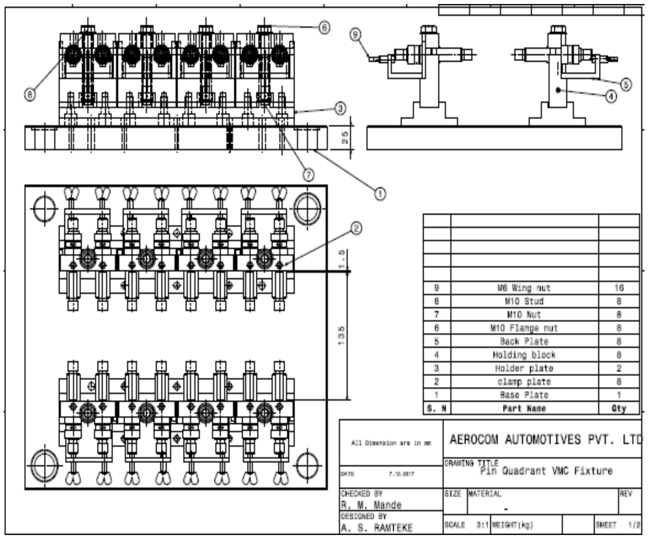

Fig 2.2: Existing Data of Pin Quadrant VMC Fixture

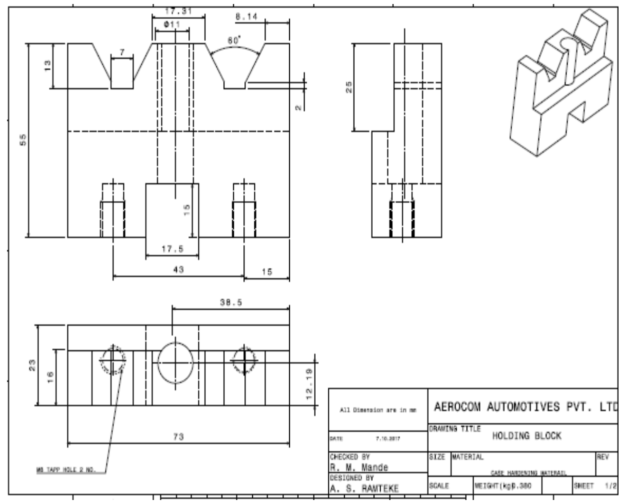

Fig 2.4: Existing Data of Holding Block

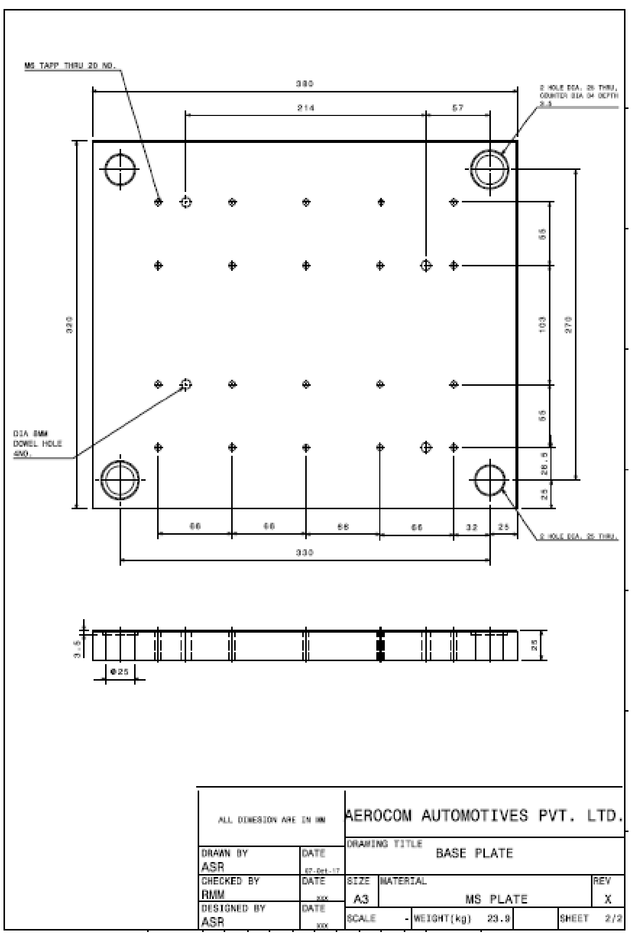

Fig 2.3: Existing Data of Base Plate

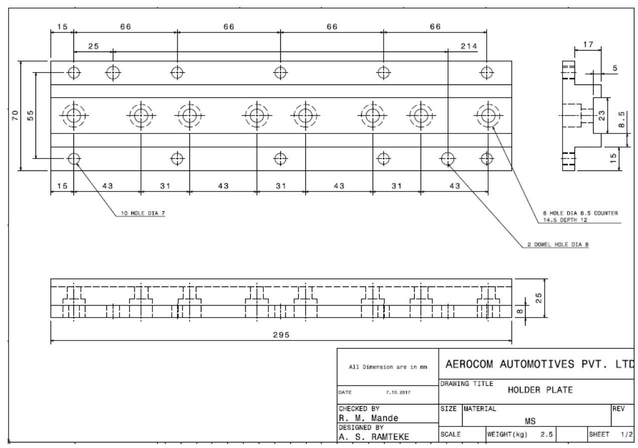

Fig 2.5: Existing Data of Holder Plate

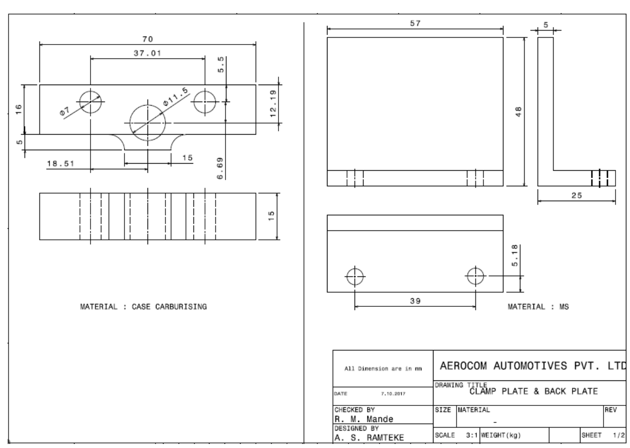

Fig 2.6: Existing Data of Clamp Plate and Back Plate

3. CAD Modeling:

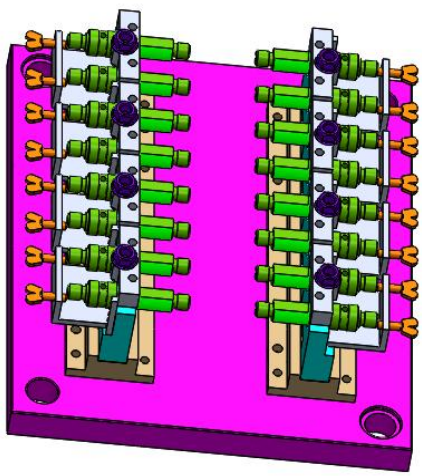

Fig 3.1: Isometric view of Cad Model

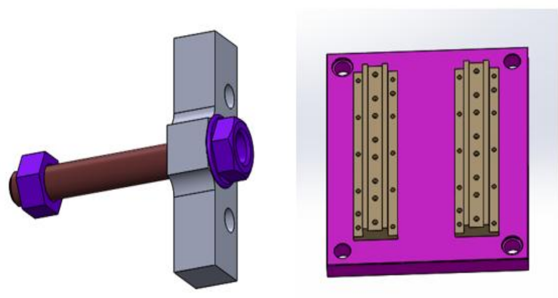

Fig 3.2: Isometric view of Clamp and sub-assembly

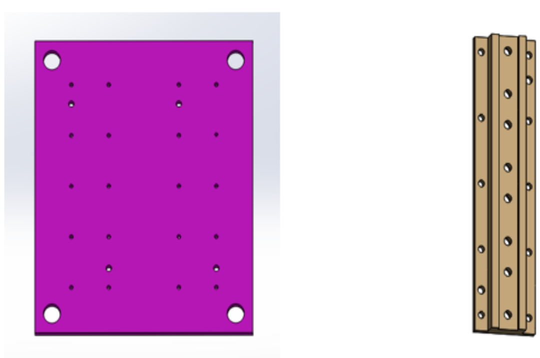

Fig 3.3: CAD Model of F plate and Holder plate

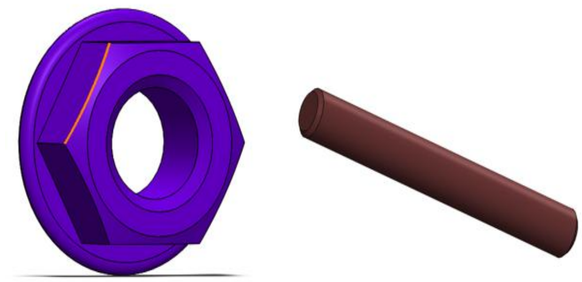

Fig 3.4: CAD Model of M10 Flang Nut and M10 stud

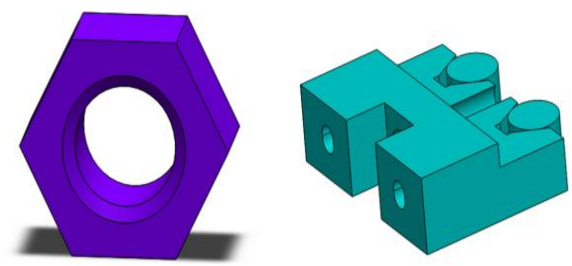

Fig 3.5: CAD Model of Nut and Holding Block

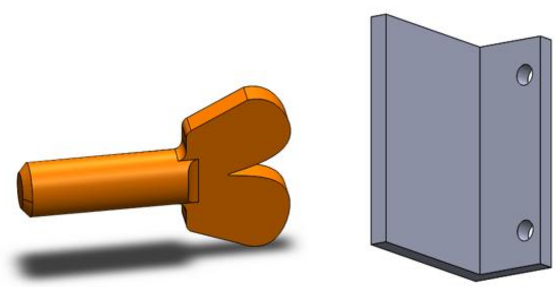

Fig 3.6: CAD Model of Wing Bolt and Back Support

4. Finite Element Analysis:

4.1 Structural Analysis of Clamp Assembly

Equivalent stress:

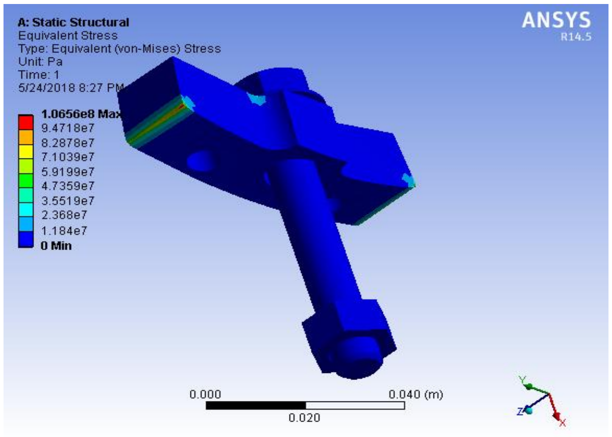

Fig 4.1: Max Stress is 106.56 MPa

Normal stress:

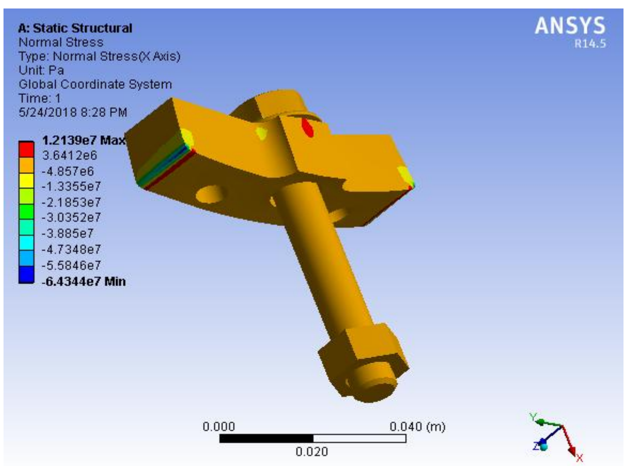

Fig 4.2: Max Stress is 12.139MPa

Shear stress:

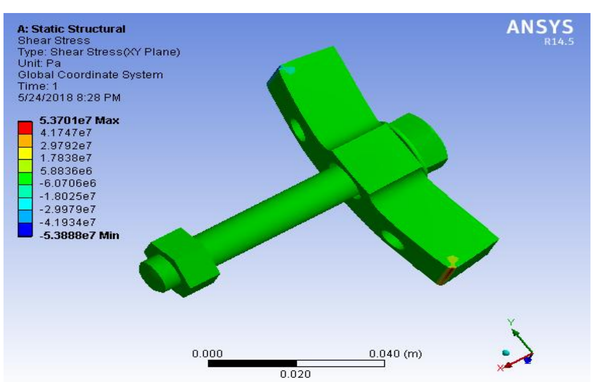

Fig 4.3: Max Stress is 53.701 MPa

Stress Intensity:

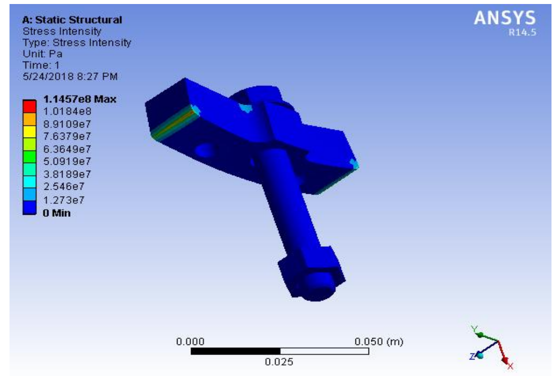

Fig 4.4: Max Stress is 114.57 MPa

Total Deformation:

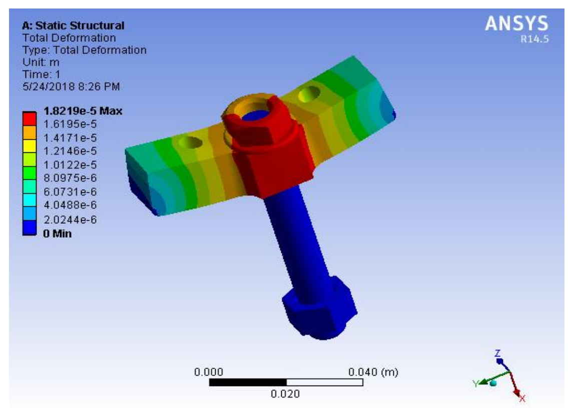

Fig 4.5: Max Displacement is 0.018219 mm

4.2 Structural Analysis of Clamp

Equivalent Stress:

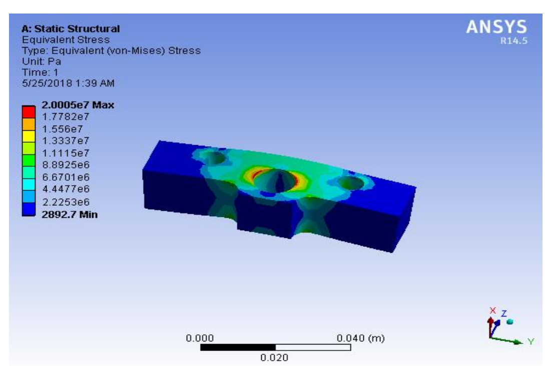

Fig 4.6: Max Stress is 20.005MPa

Normal Stress:

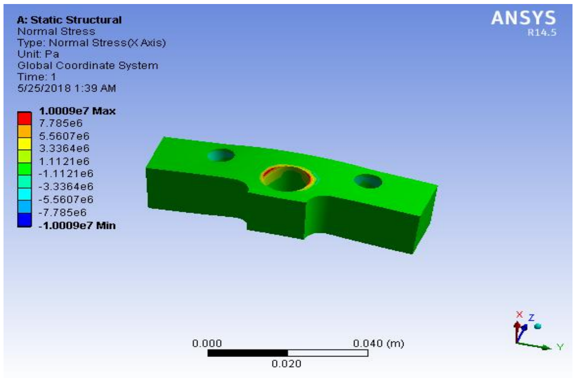

Fig 4.7: Max Stress is 10.009MPa

Shear Stress:

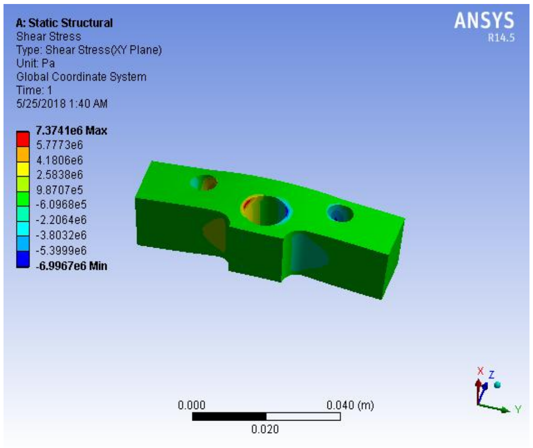

Fig 4.8:Max Stress is 7.3741MPa

Stress Intensity:

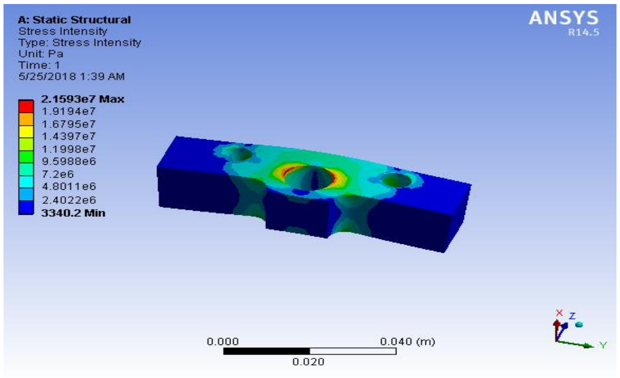

Fig 4.9: Max Stress is 21.593MPa

Total Deformation:

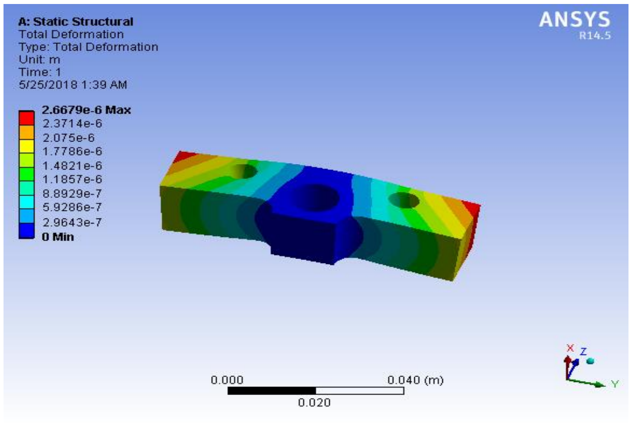

Fig 4.10: Max Displacement is 0.0026679mm

4.3 Structural Analysis of F Plate

Equivalent Stress:

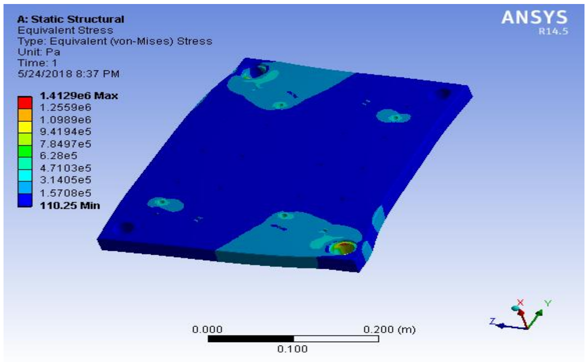

Fig 4.11: Max Stress is 1.4129 MPa

Normal Stress:

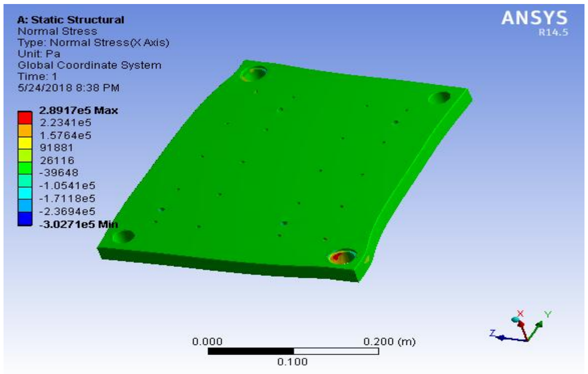

Fig 4.12: Max Stress is 0.28917MPa

Shear Stress:

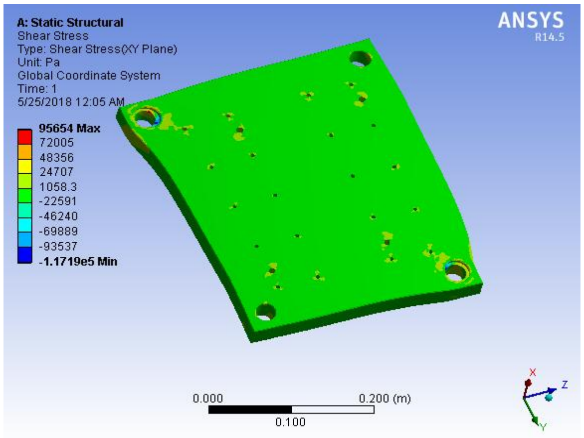

Fig 4.13: Max Stress is 0.095654MPa

Stress Intensity:

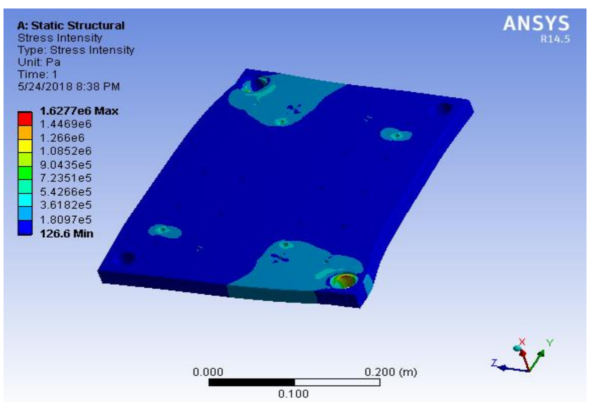

Fig 4.14: Max Stress is 1.6277MPa

Total Deformation:

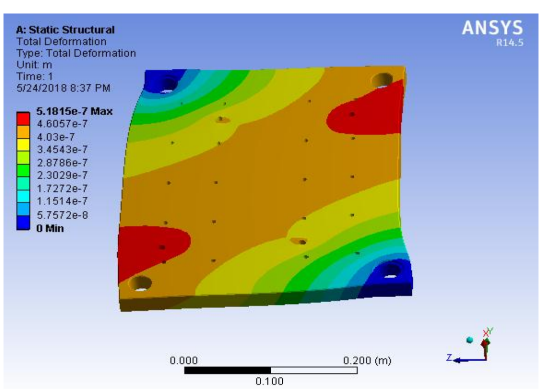

Fig 4.15: Max Displacement is 0.00051815 mm

4.4 Structural Analysis of Holder Plate

Equivalent stress:

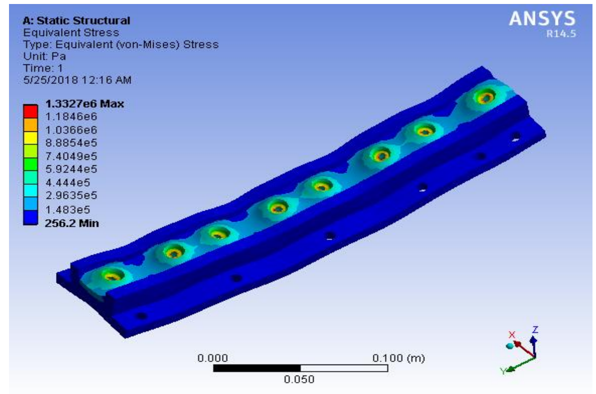

Fig 4.16: Max Stress is 1.3327MPa

Normal stress:

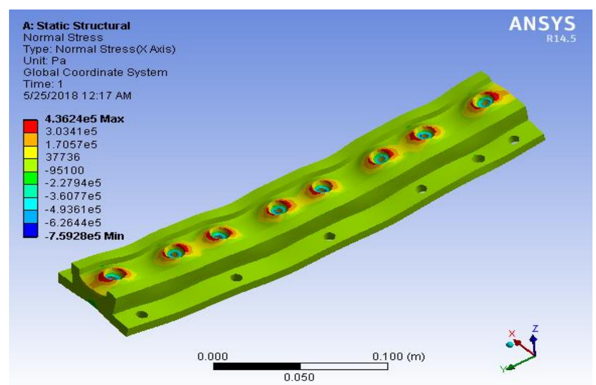

Fig 4.17: Max Stress is 0.43624MPa

Shear stress:

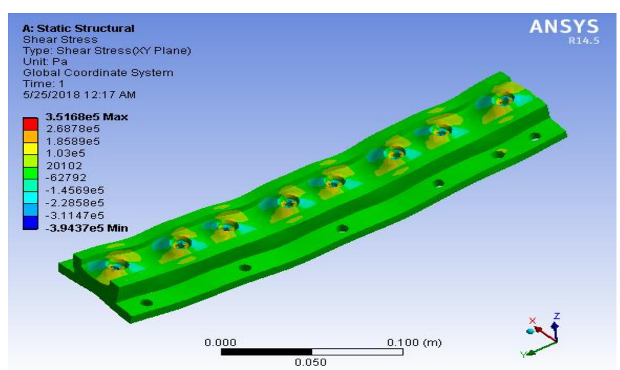

Fig 4.18: Max Stress is 0.35168MPa

Stress Intensity:

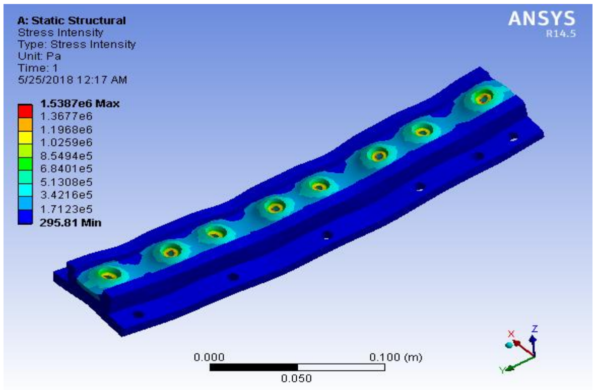

Fig 4.19: Max Stress is 1.5387MPa

Total Deformation:

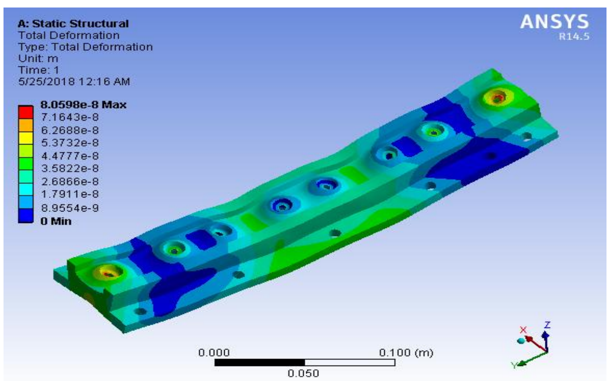

Fig 4.20: Max Displacement is 0.000080598mm

4.5 Structural Analysis of Back Support

Equivalent stress:

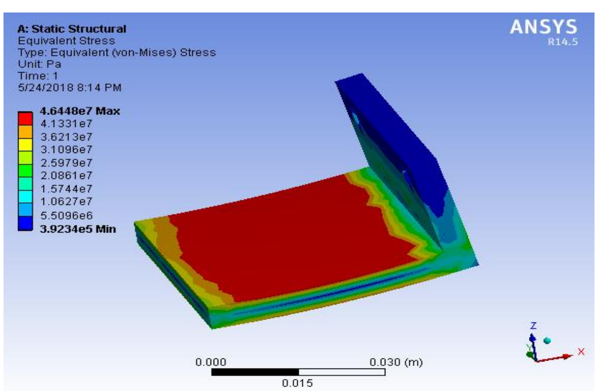

Fig 4.21: Max Stress is 46.448MPa

Normal stress:

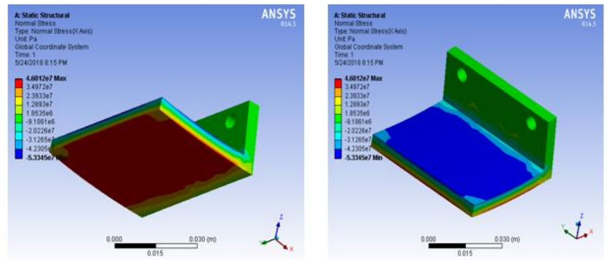

Fig 4.22:Max Stress is 46.012MPa

Shear stress:

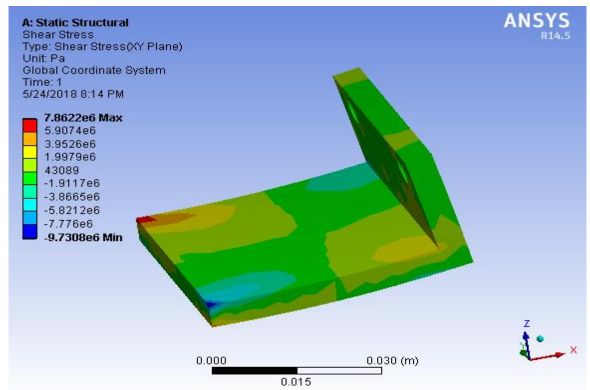

Fig 4.23: Max Stress is 7.8622MPa

Stress Intensity:

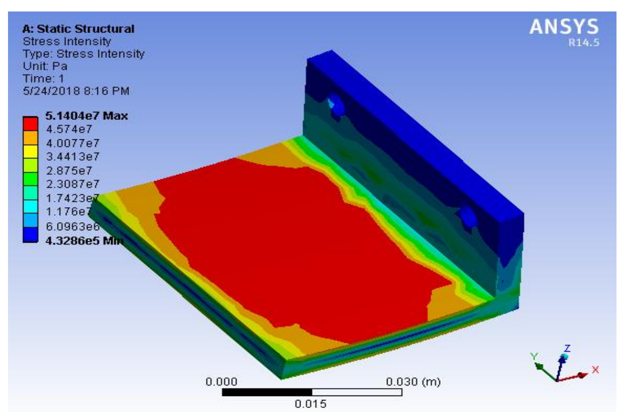

Fig 4.24: Max Stress is 51.404 MPa

Total deformation:

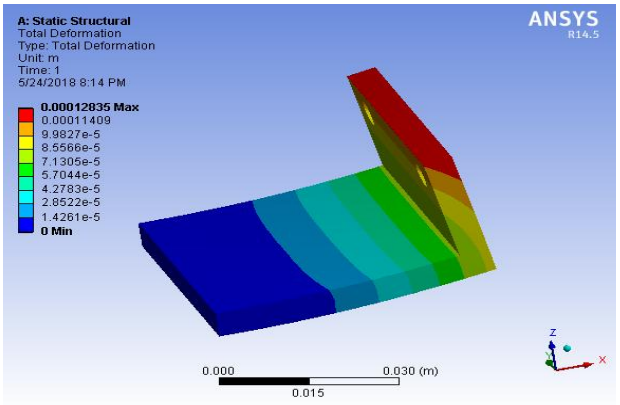

Fig 4.25: Max Displacement is 0.12835mm

4.6 Structural Analysis of Holding Block

Equivalent stress:

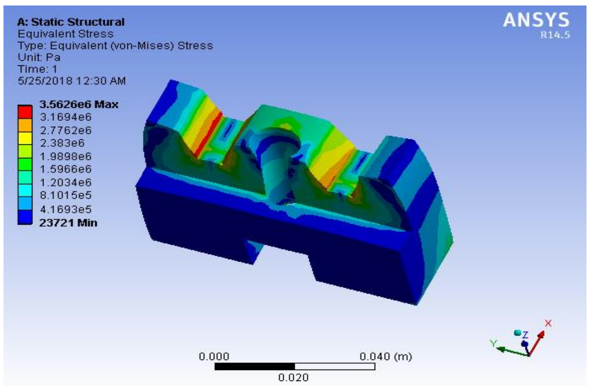

Fig 4.26: Max Stress is 3.5626MPa

Normal stress:

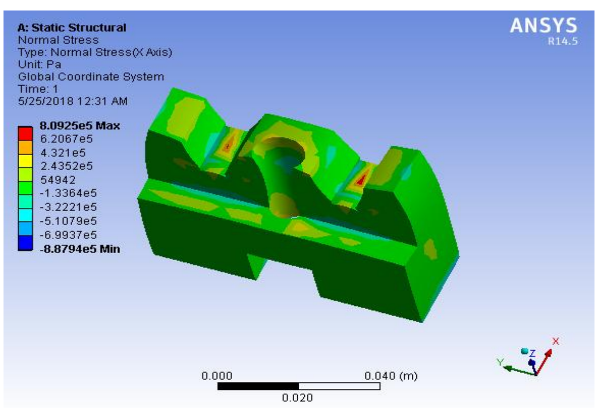

Fig 4.27: Max Stress is 0.80925MPa

Shear stress:

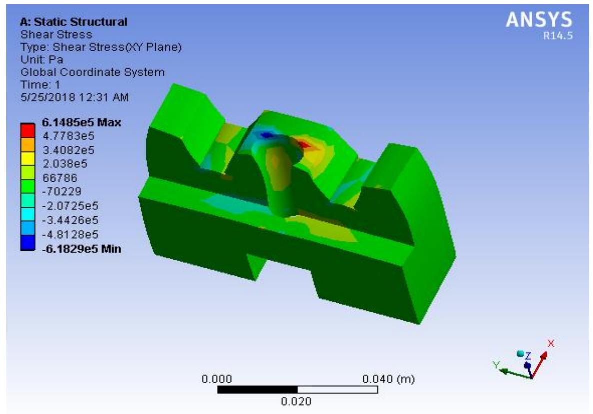

Fig 4.28: Max Stress is 0.61485MPa

Stress Intensity:

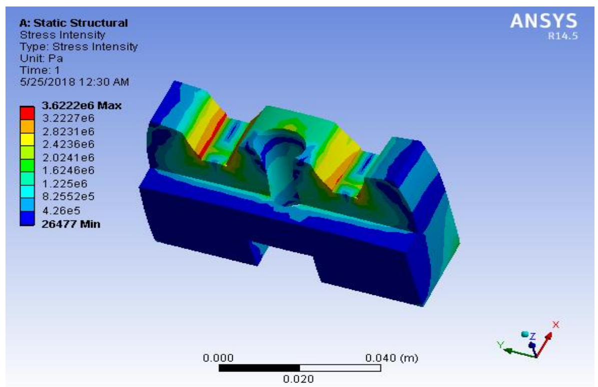

Fig 4.29: Max Stress is 3.6222MPa

Total Deformation:

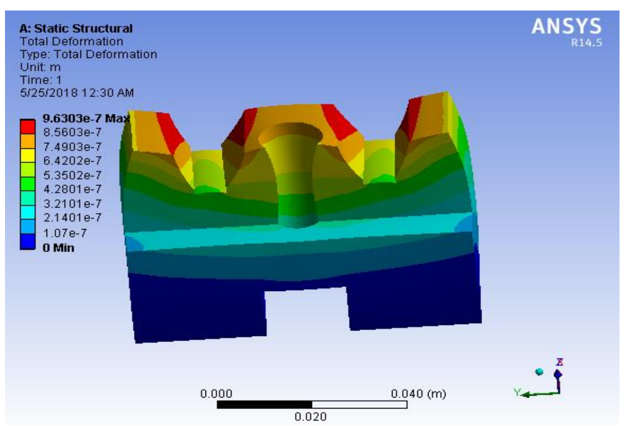

Fig 4.30: Max Displacement is 0.00096303 mm

4.7 Structural Analysis of Wing Bolt

Equivalent Stress:

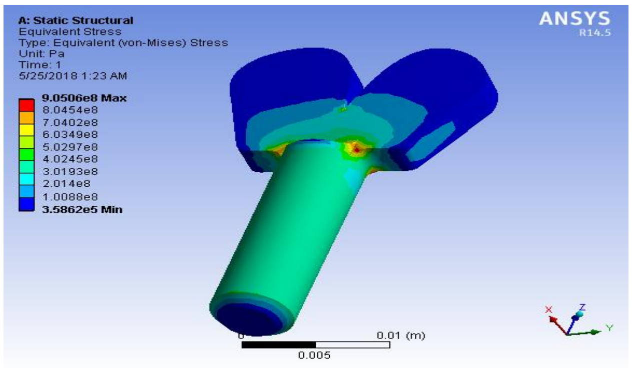

Fig 4.31: Max Stress is 905.06MPa

Normal Stress:

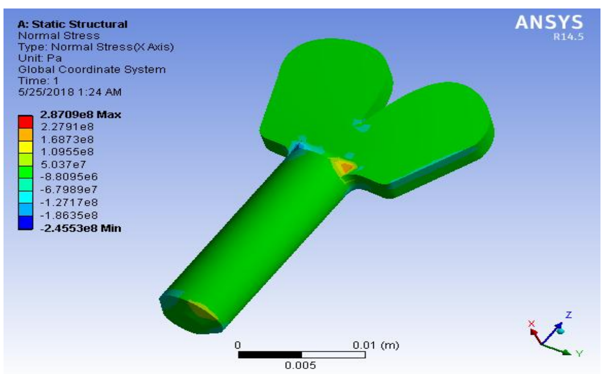

Fig 4.32: Max Stress is 287.91MPa

Shear Stress:

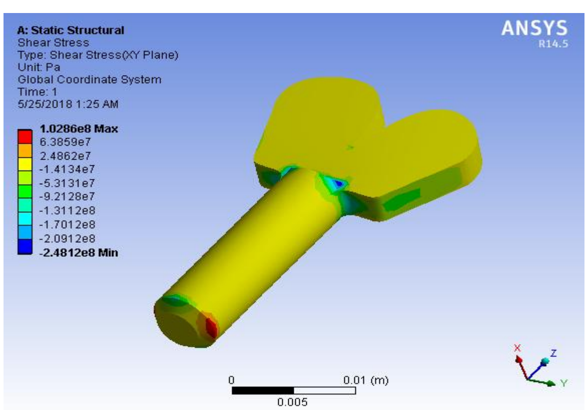

Fig 4.33: Max Stress is 102.86MPa

Stress Intensity:

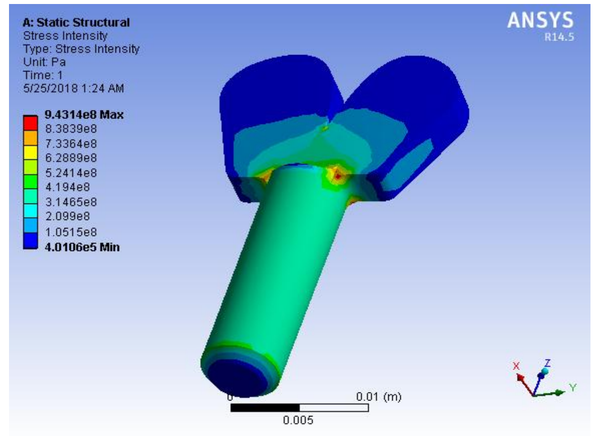

Fig 4.34: Max Stress is 943.14 MPa

Total Deformation:

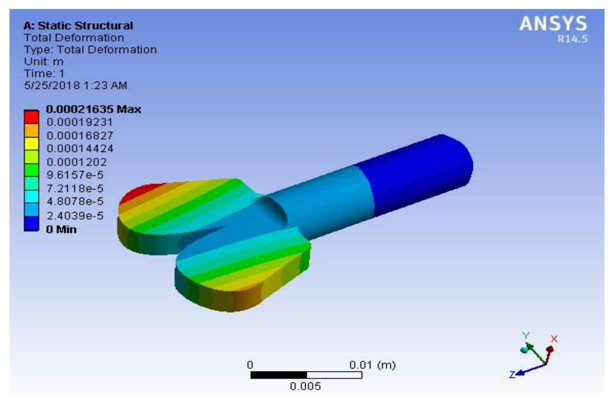

Fig 4.35: Max Displacement is 0.21635mm

5. RESULT DISCUSSION

As per the requirement and concept of special fixture for, Design & Analysis of Multi-part Fixture for Pin Quadrant of Quadrant sub-assembly of Cultivator is carried out by using CAD software Solidworks, and CAE packages Ansys. Concept design, literature study and data gathered led the CAD model generation with reference to design requirements.

Vibration Dynamic analysis is carried out to observe the behaviour of the fixture to the excitation frequencies and to understand the natural frequencies of the structure material

A Linear static analysis is carried out to validate the design for maximum loading conditions. From the Linear static Analysis performed in Finite Element Analysis Technique, Maximum displacement of 0.21635mm and maximum Stresses of 943.14 MPa obtained.

Design is said to be safe if Developed stresses are well within the Material Yield stress. For the fixture structure a structural steel with grade S275 is used.

As the displacement obtained in the assembly are very less, maximum stresses should be considered for the result comparison.

Yield stress of Structural steel is 275 Mpa, where the stresses developed in structure is well within the yield stress limit of frame material.

6. CONCLUSION

Pin Quadrant is very important part of quadrant sub-assembly used in cultivator. The design of a multipart fixture is a highly complex and intuitive process, which require knowledge. Fixture design plays an important role at the setup planning phase. Proper fixture design is crucial for developing product quality in different terms of accuracy, surface finish and precision of the machined parts. Fixture is required in various industries according to their application.

The main objective of the report is to design the fixture for complex geometry. This geometry is having different machining operation. Major operations are Milling and Hole Drilling on different sides. These operations are to be carried out in VMC keeping the objective of minimization of the cycle time as well. To overcome this problem a concept design of fixture mechanism is carried out. As per requirement a concept design is carried out. With the help of existing data a cad model of fixture is generated using Solidworks. To validate the design with extreme loadings a Finite Element Analysis is carried out using Ansys. From the Linear static Analysis performed in Finite Element Analysis Technique, Maximum displacement of 1.76 mm and maximum Stresses of 205 MPa obtained. Yield stress of Structural steel is 275 Mpa, where the stresses developed in structure is well within the yield stress limit of frame material.

Hence design is safe for the given loading conditions.

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