



Additive Manufacturing / 3D Printing Technology

Expertise and Facility at Pyrodynamics

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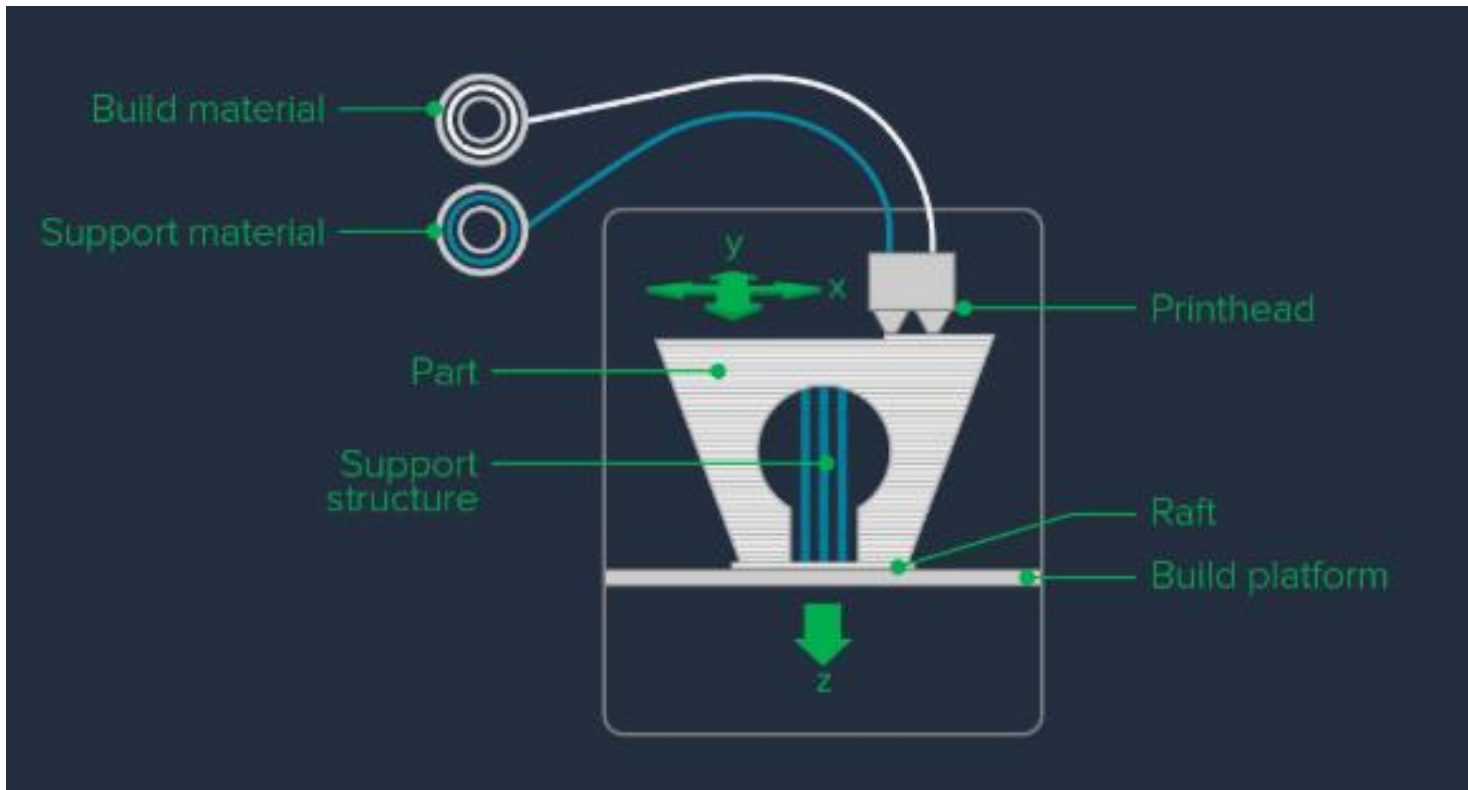
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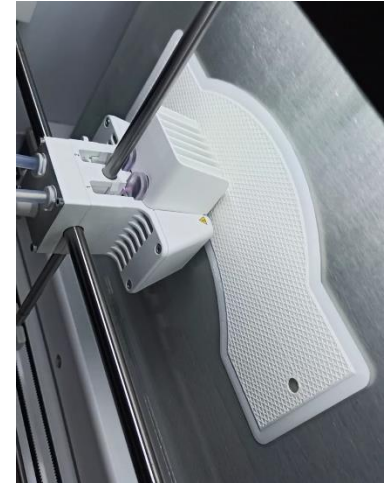
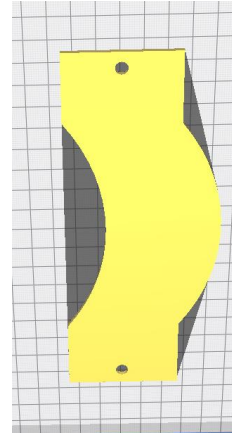
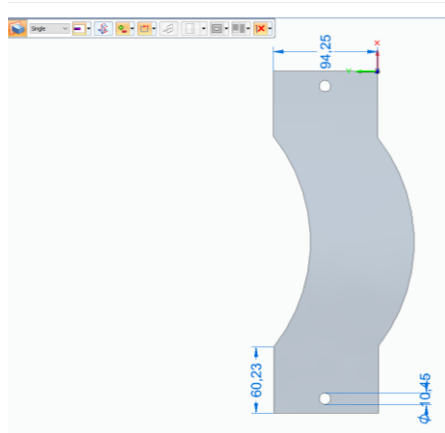
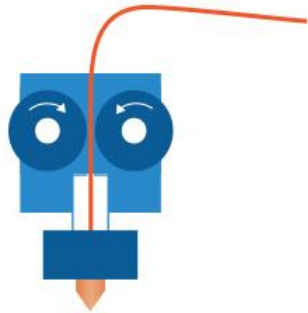
- Additive Manufacturing or 3D Printing is a process of making three dimensional solid objects from a digital file (CAD File).
- The creation of a 3D printed object is achieved using additive processes.
- Additive process is a process where successive layers of material are deposited down layer by layer to create unique shapes and sizes.
- Objects can be modelled of almost any shape, size or geometry and are produced from a CAD Modelling Software such as AutoCAD, Solid Edge, Solid Works, etc.
- The CAD model is then sliced in the CAD Software and converted to an STL/3MF/OBJ File that is ready for 3D Printing.

There are three major ways which is used in Additive Manufacturing:-

1. Fused Deposition Modeling (FDM)
2. Stereo Lithography (SLA)
3. Selective Laser Sintering (SLS)



Fused Deposition Modeling (FDM) uses a filament (spool) as the input material which is fed to an extrusion nozzle. The nozzle is heated to a certain temperature and this melts the filament, and the nozzle moves in horizontal and/or vertical directions as per the geometry of the CAD Model. The filament is then deposited layer by layer upon which the initial layer hardens immediately after extrusion from the nozzle. This process of layer-by-layer deposition is repeated to achieve the 3D Model.



1.

2.

3.

1

A 3D Model of an object is created using a computer-aided design (CAD) software program.

2

The CAD File is sliced, and an STL file is generated which is programmed to the printer.

3

The printer deposits the material layer by layer, starting from the bottom layer, onto a build platform. This process is repeated to achieve the final 3D Model.

Materials that can be Printed

1. PLA (Polylactic Acid)
2. Tough PLA (Tough Polylactic Acid)
3. ABS (Acrylonitrile Butadiene Styrene)
4. Nylon
5. CPE (Co-Polyester)
6. CPE+ (Tough Co-Polyester)
7. PC (Polycarbonate)
8. PP (Polypropylene)
9. TPU
10. PVA (Poly Vinyl Alcohol)
11. Glass Fibre
12. Carbon Fibre

Dimension of the specimen that can be printed:-

Maximum – 330 x 240 x 300 mm

Minimum – 0.5 x 0.5 x 0.5 mm

Technology	Fused Deposition Modeling (FDM)
Filament Used	PLA White
Filament Diameter	2.85 mm
Nozzle Diameter	0.4 mm
Printing Speed	50 mm/sec
Layer Resolution	0.2 mm
Infill	50% Infill



PYRO DYNAMICS DIC Measurement on a 3D Printed Specimen – 50% Infill

A Test Specimen who Photoelastic Fringe Pattern (Stress Pattern) is available from literature was 3D Printed.

The tool path is clearly seen on the test specimen and was not smoothed out





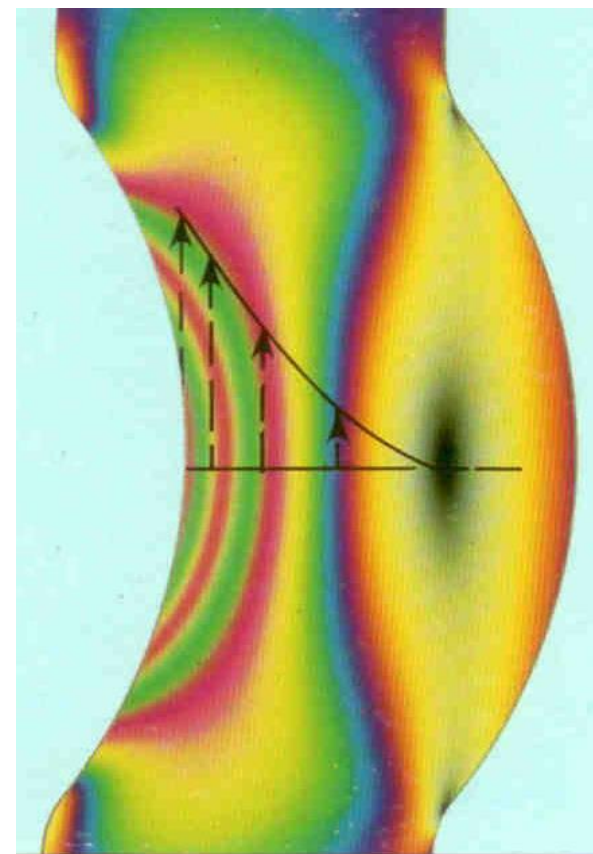
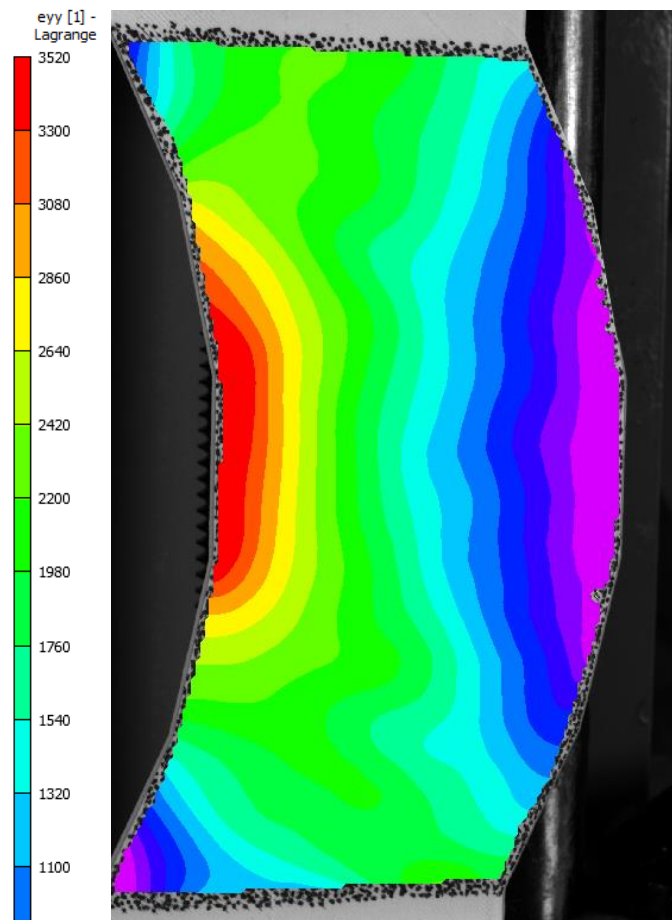
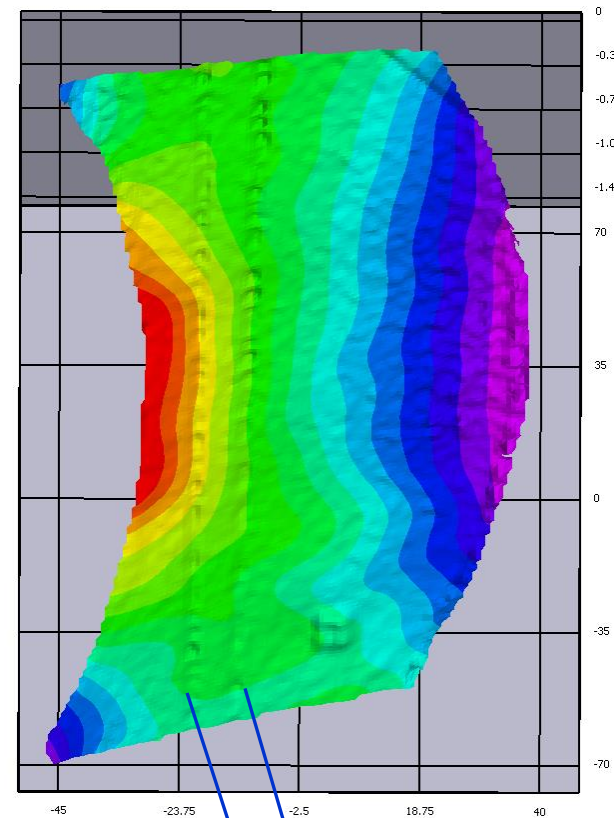


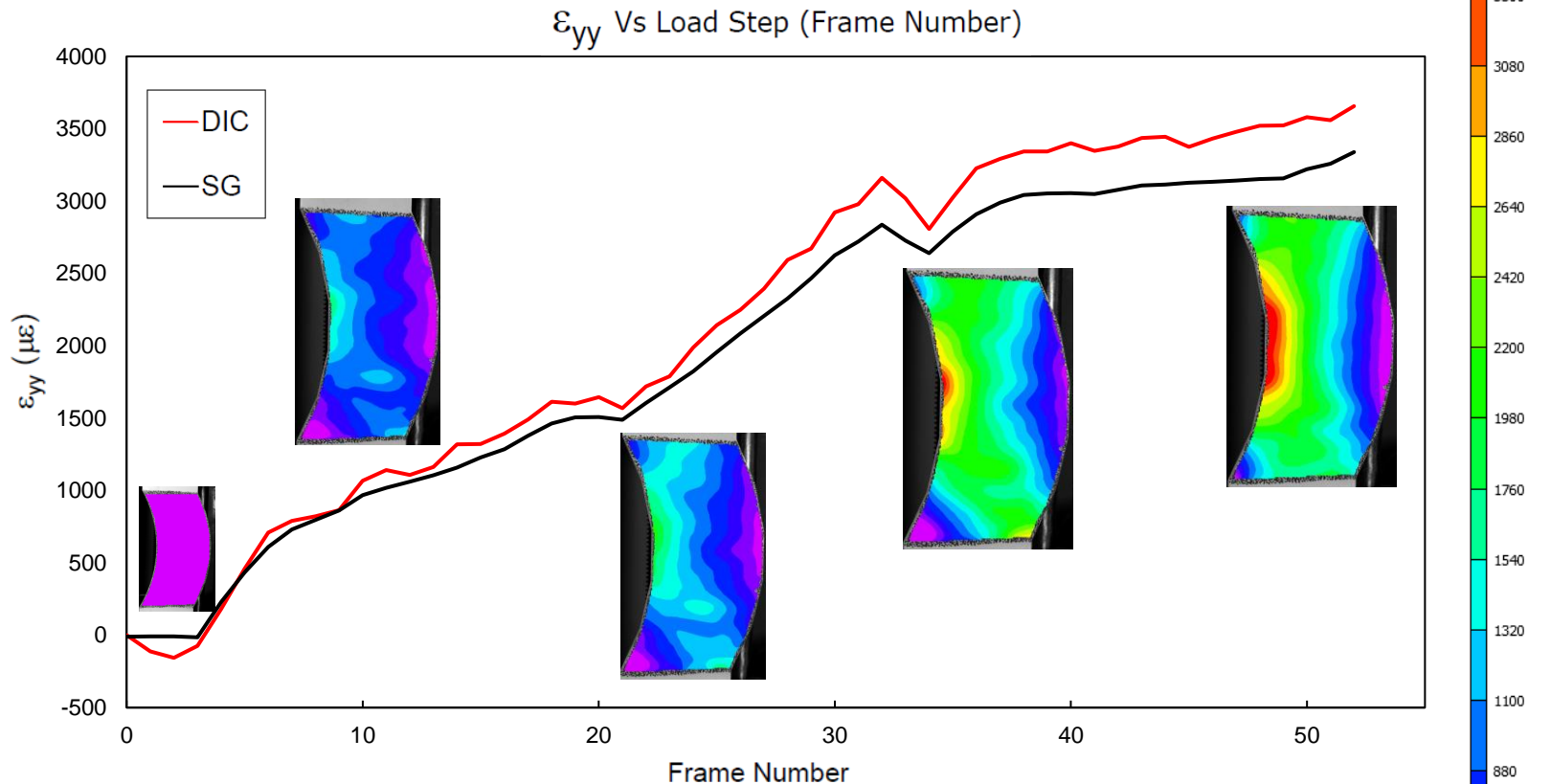
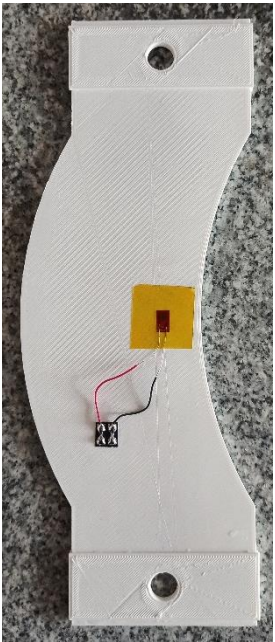
Photo Elastic Fringe Pattern



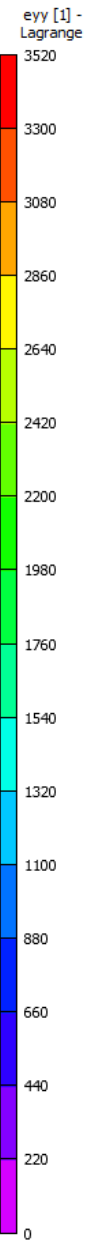
Plot of ϵ_{yy} obtained from VIC-3D

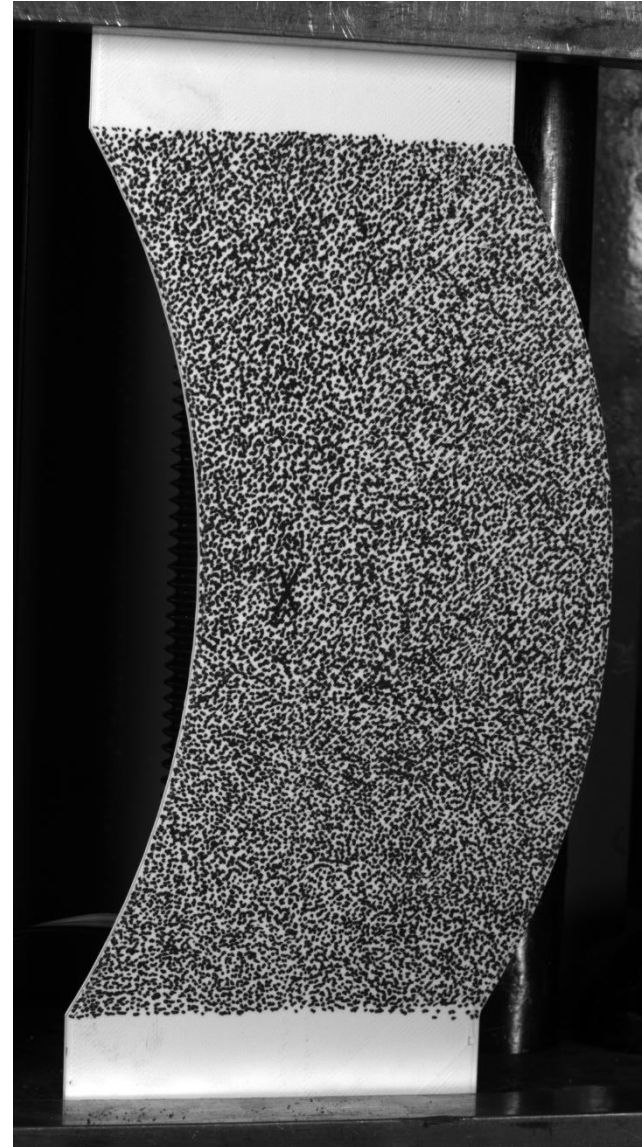


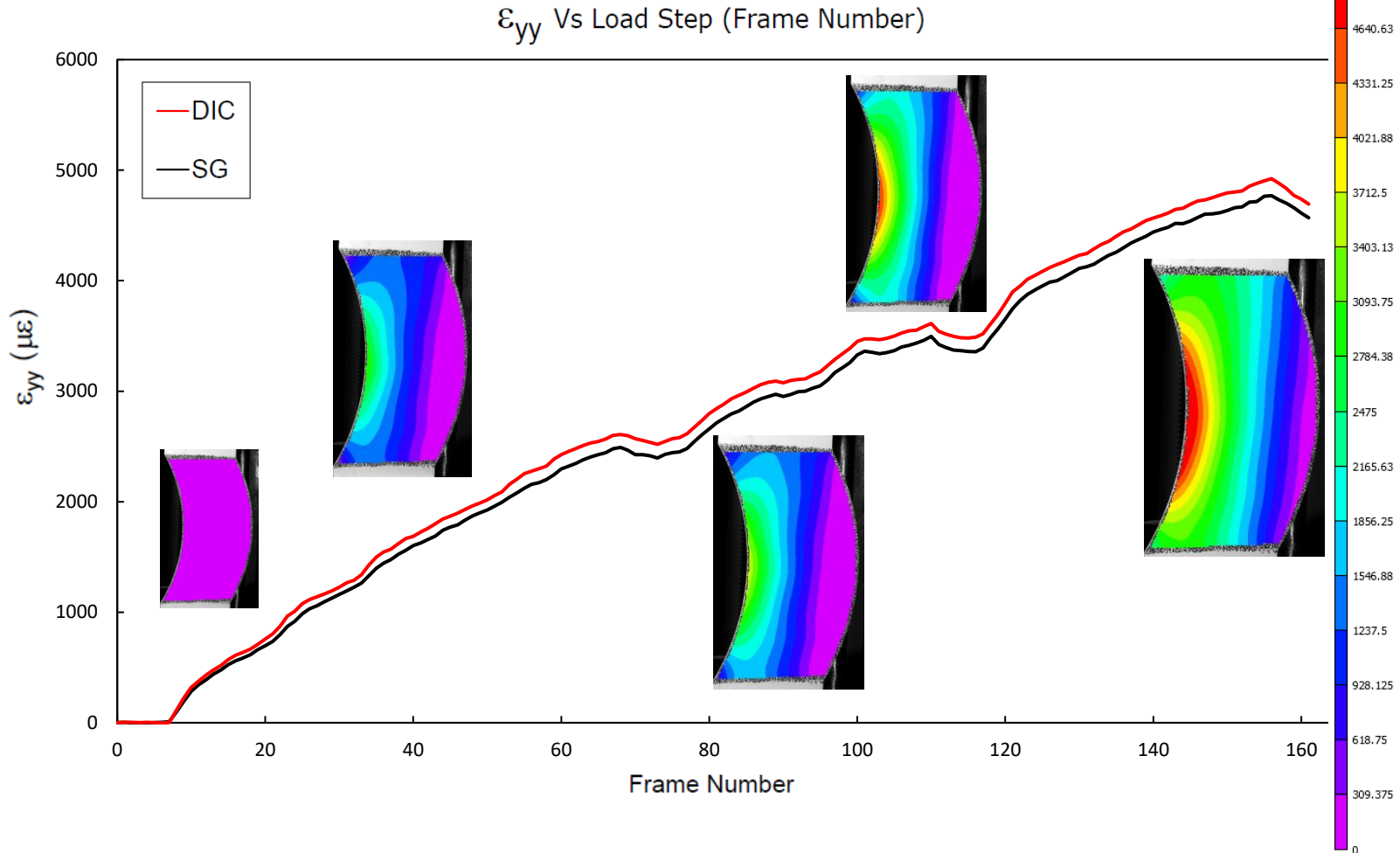
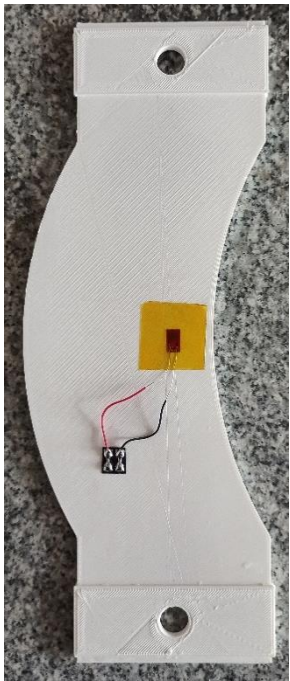
The tool path of the nozzle is clearly visible in the DIC Plot. The tool path has not created any strain gradient. The data over the tool path can be smoothed using the SMOOTH option of VIC-3D.



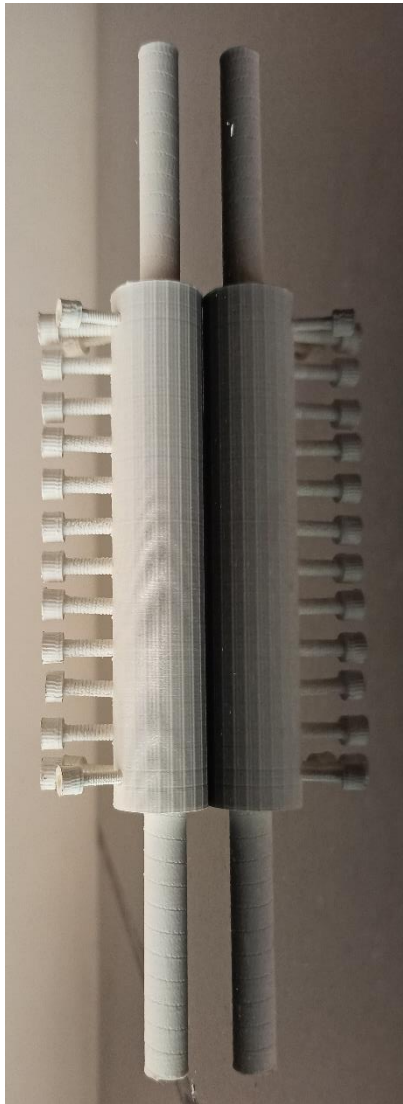
A strain gage was bonded on the back of the specimen. There is approximately a 10% difference in the data obtained from DIC and Strain Gage. The 3D Printed Test Specimen has only 50% infill, due to which the material properties in the front and back are not the same. So they behave differently under load.







A strain gage was bonded on the back of the specimen. There is a close match of the data obtained from DIC and Strain Gage.

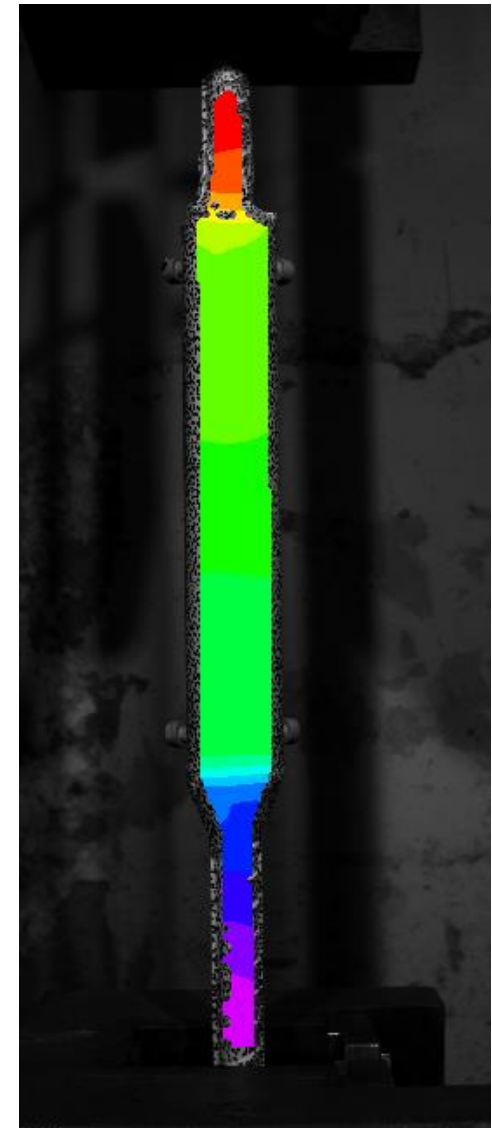


3D Printed Coupler

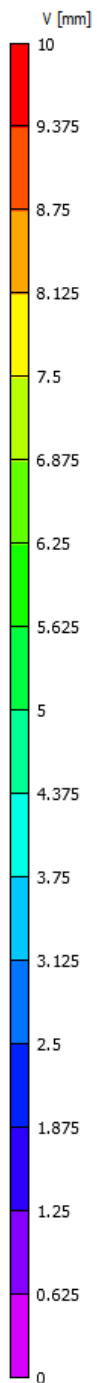


Speckle image

An Actual Coupler under test – At IIT-Roorkee – Department of Earthquake Engineering.



V - Displacement Data





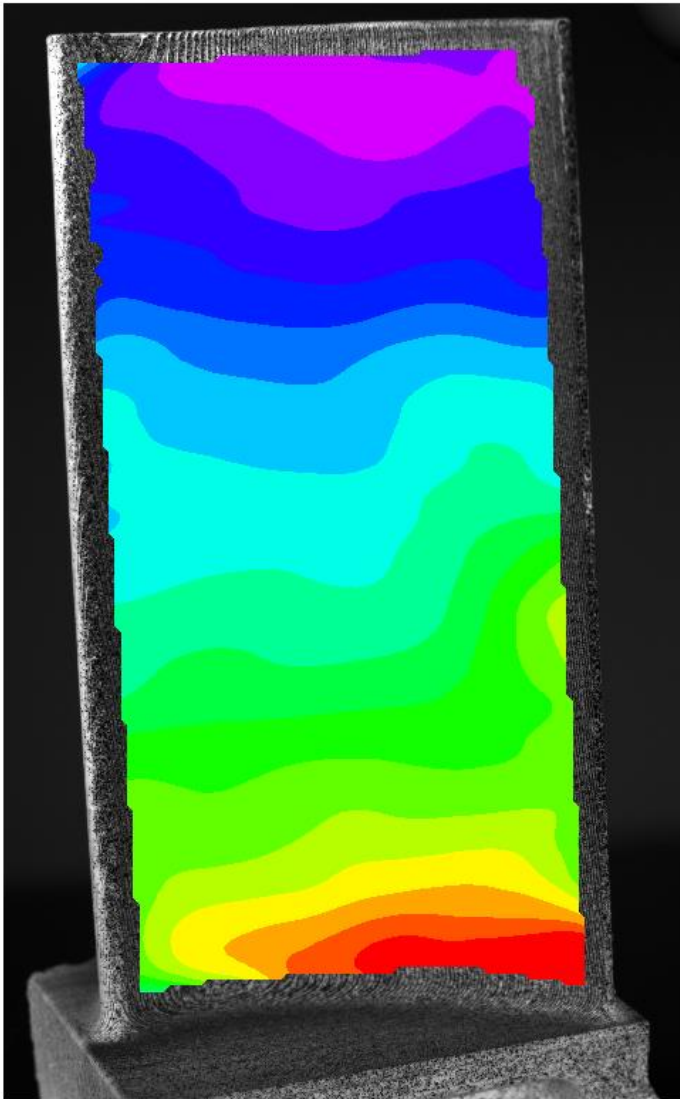
3D Printed
Gas Turbine Blade



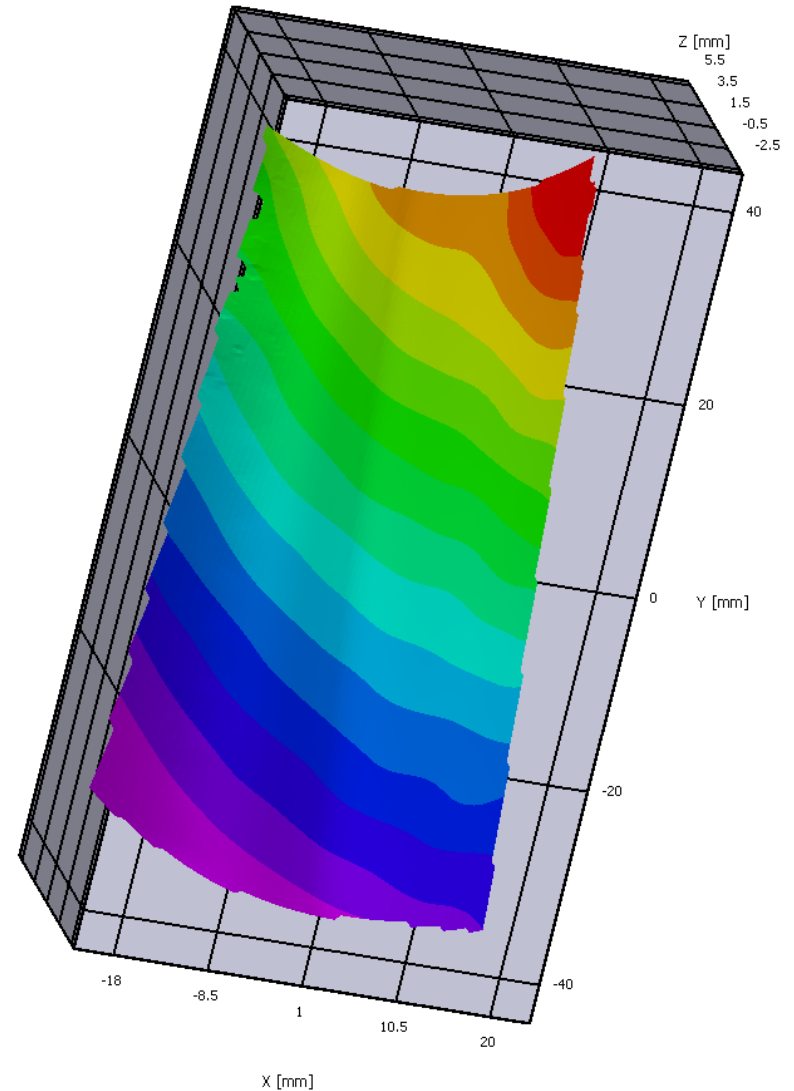
Speckle pattern applied on
the Gas Turbine Blade using
an Air Brush.



Speckle image



Plot of ϵ_{yy} obtained from VIC-3D



W - Displacement Data



Images of the Turbine Blade from Literature (for description purpose only) and not from The test site.

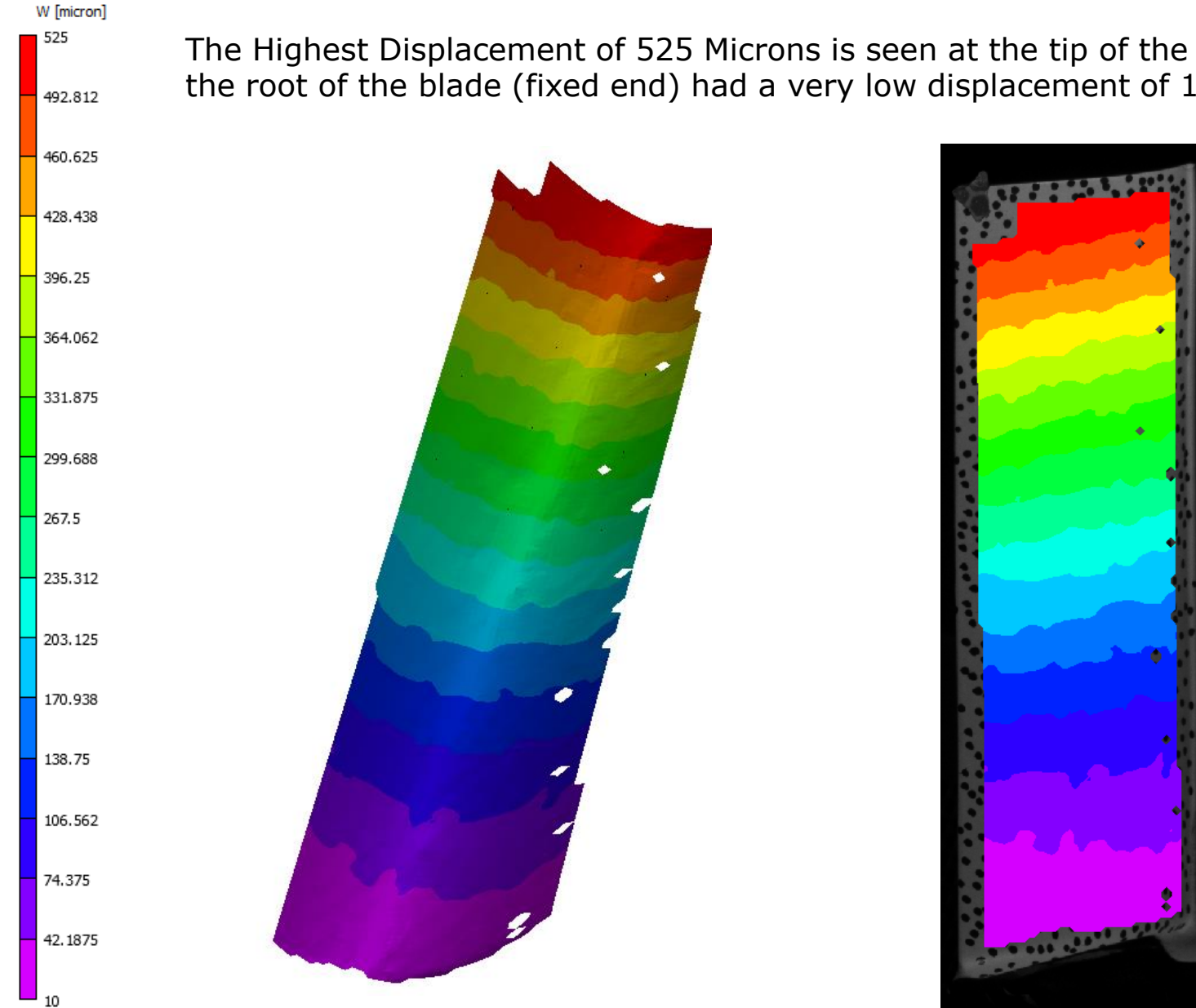
DIC Measurements were carried on 3 components under steady state vibration:-

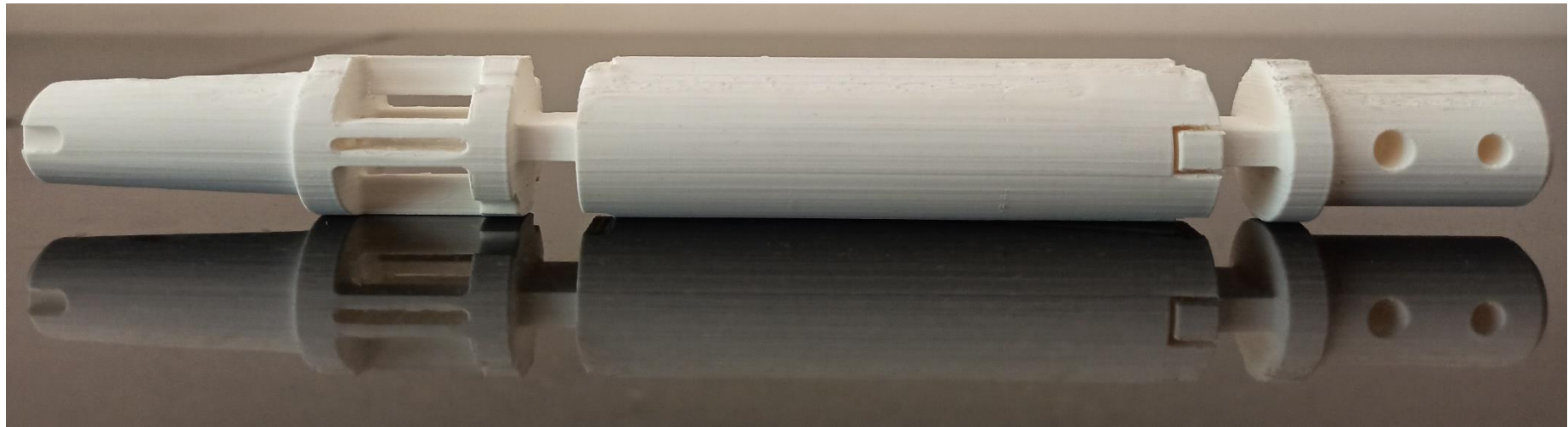
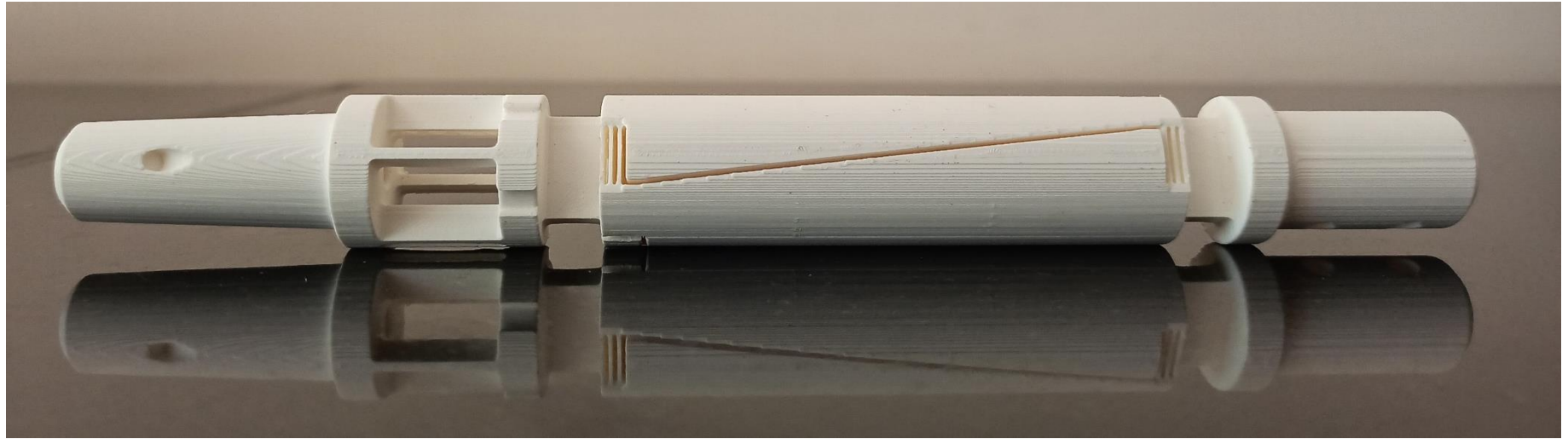
1. Flat Plate.
2. Turbine Blade.
3. Cracked Turbine Blade.

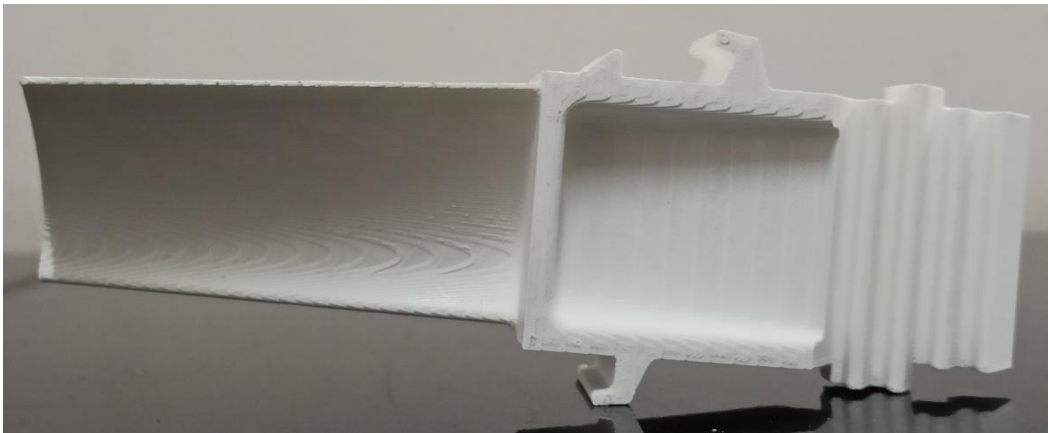
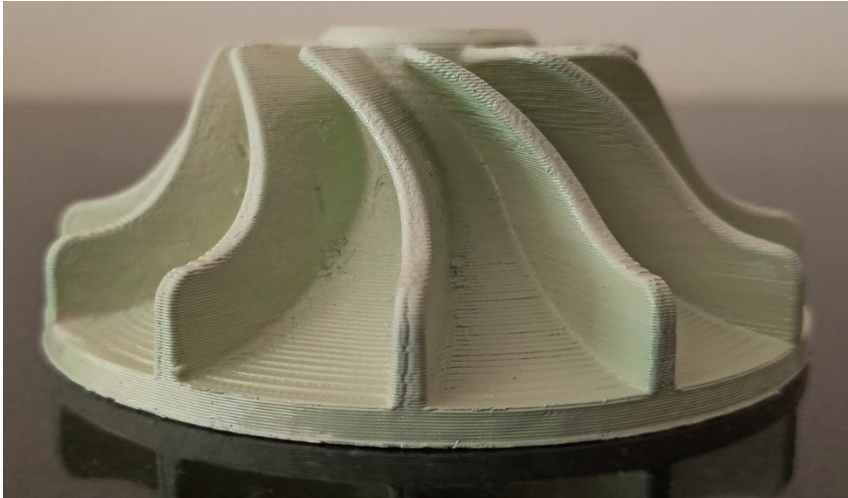
Mode Shapes of these components were obtained at different frequencies.

The Turbine blade is very stiff, and the levels of Displacement and Strain are very low. VIC-3D captured these low levels of displacements and strain.

The Highest Displacement of 525 Microns is seen at the tip of the blade (free end) and the root of the blade (fixed end) had a very low displacement of 10 Microns.







Lets Think Collectively

Thank You

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**Moto of
Pyrodynamics**

**“A Company of
Value Rather
than a Company
of Success”**