In our systematic approach, a representative material volume (RMV) was considered for a ductile reinforcement embedded with a spherical hole. For simplicity and symmetry, one eight models of RMV were considered for the simulations. Copper (Cu) single crystal properties with face cementer cubic (FCC) structure were used as reinforcement properties. The material constraint is captured through stain triaxiality. Strain triaxiality of values ranging from 1 to -0.45 was considered for loading. These loading conditions can replicate most of the loading scenarios on the reinforcement (1 representing high constrain, 0 representing uniaxial loading, -0.45 representing least constraint). The void volume fraction values were used. To understand the effect of crystallographic orientation, several orientations such as [100], [110], and [111] were considered.

Two types of failure mechanisms were observed: first, the material is failed by void growth with an increase in remote strain. In this case, the softening of the material is dominant than the material hardening. Second, the Material is failed by void growth at nearly constant remote strain (cavitation instability). While the void volume fraction is approaching zero, the cavitation instability stress is converging to constant values, called critical stress. Our work provided the procedure to estimate the critical stress values for a given orientation and reported the critical stress values for different orientations, as shown in Fig. 2. We have also reported that fracture energy and energy absorbed by metal reinforcement vary significantly with material anisotropy.

The void shape is observed to have a strong dependence on the initial crystallographic orientation. Both spheroidal and non-spheroidal voids are observed during cavitation (as shown in Fig. 3). The non-spheroidal voids are attributed to material anisotropy and void spin.

In our group, we are extending our investigation on ductile fracture to understand the complex failure mechanism such as void coalescence and void sheeting.

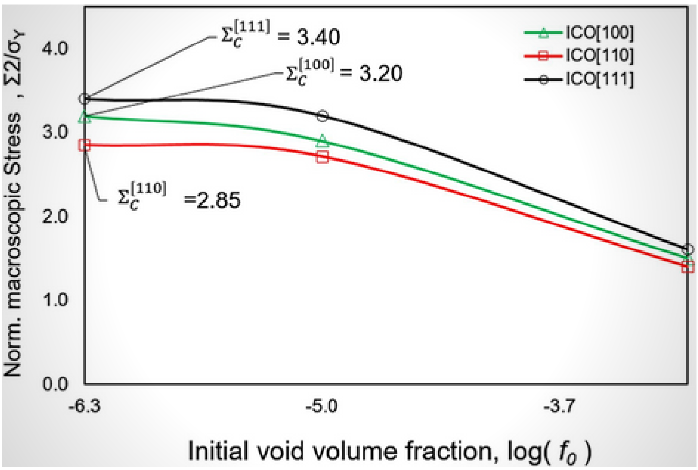

Fig. 2: Effect of material anisotropy on the cavitation limit

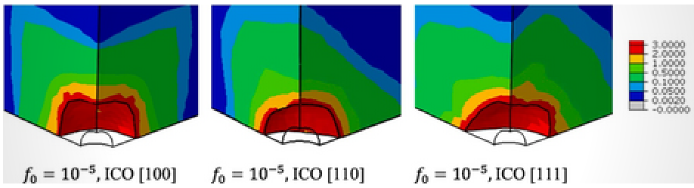

Fig. 3: Deformed void shape for different initial crystallographic orientation (ICO)

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1. MK Karanam, G Gulivindala, VR Chinthapenta, Effect of anisotropy on the ductile fracture in metal reinforcements of brittle matrix composites, Theoretical and Applied Fracture Mechanics, 112, 10293, 2021
2. MK Karanam, VR Chinthapenta, Void growth, and morphology evolution during ductile failure in an FCC single crystal, Continuum Mechanics and Thermodynamics, 33(2), 497-513, 2021

A new perspective on the law of the wall

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Turbulent flows are common in natural and industrial environments. A few examples include atmospheric circulation, a fast-flowing river, flow around an aircraft, and a pipeline. The law of the wall is one of the major accomplishments in turbulence research and is widely used in computational models of fluid dynamics. The law accurately predicts the flow velocity, specifically in the near-wall shear layer that accounts for the substantial fraction of the aerodynamic (or hydrodynamic) drag on the wall, e.g., aircraft surface or inner-wall of a pipe. The mean-velocity profile (MVP) can be obtained by averaging the local mean-velocity u at a wall-normal distance z over a long duration (see Fig. 1). Three distinct layers exist at an infinitely large Reynolds number Re: near-wall layer (viscous sublayer and buffer layer), overlap layer, and the wake layer.

The law of the wall stems from the imagery of turbulent eddies arising from the fluid mixing that gives rise to the turbulent shear stress. German aerodynamicist Prandtl proposed the mixing-length hypothesis, drawing an analogy between the motions of turbulent eddy and random gas molecules, in order to quantify the turbulent shear stress. Despite magnificent advances, Prandtl's classical work and recent theories fall short to find the origin of the law of the wall.

In a recent attempt, Ali and Dey found the origin of the law of the wall with the aid of a new hypothesis, called the mixing-instability hypothesis. It states:

At a large Reynolds number, the turbulent mixing at a location in a wall-bound flow produces disturbances that transmit in the form of waves, causing a continuous stretching and shrinking of turbulent eddies to produce the turbulent stress.

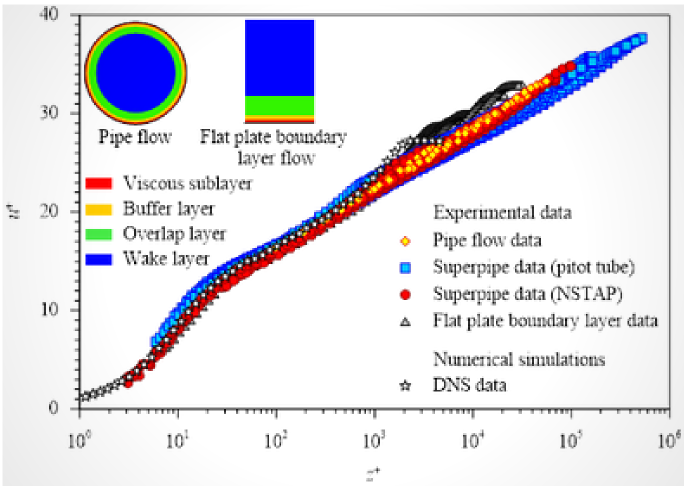

Fig. 1: MVPs comprising data of experimental observations and numerical simulations. Here, u+ = u/u*, u* is the shear velocity, z+ = zu*/n and n is the coefficient of kinematic viscosity of fluid.

The mixing instability hypothesis revealed an unprecedented link between the law of the wall and the mixing instability. The hypothesis recovers the classical logarithmic law within the overlap layer. Particularly, the amplitude of waves within the overlap layer was found to obey a unique law with the wall-normal distance. More broadly, the mixing instability hypothesis explains the law of the wall in near-wall, overlap, and wake layers. Rigorous testing of the computational MVPs with the experimental observations over a broad range of Reynolds numbers supports the mixing-instability hypothesis (see Fig. 2).

In essence, the mixing-instability hypothesis offers a new mechanism of the momentum exchange in a turbulent flow, calling for a revision of the traditional mixing-length hypothesis, which has persisted in standard textbooks of turbulence for about nine decades.

Reference:

Ali SZ, Dey S. The law of the wall: A new perspective. Physics of Fluids, American Institute of Physics, 32, 121401 (2020).

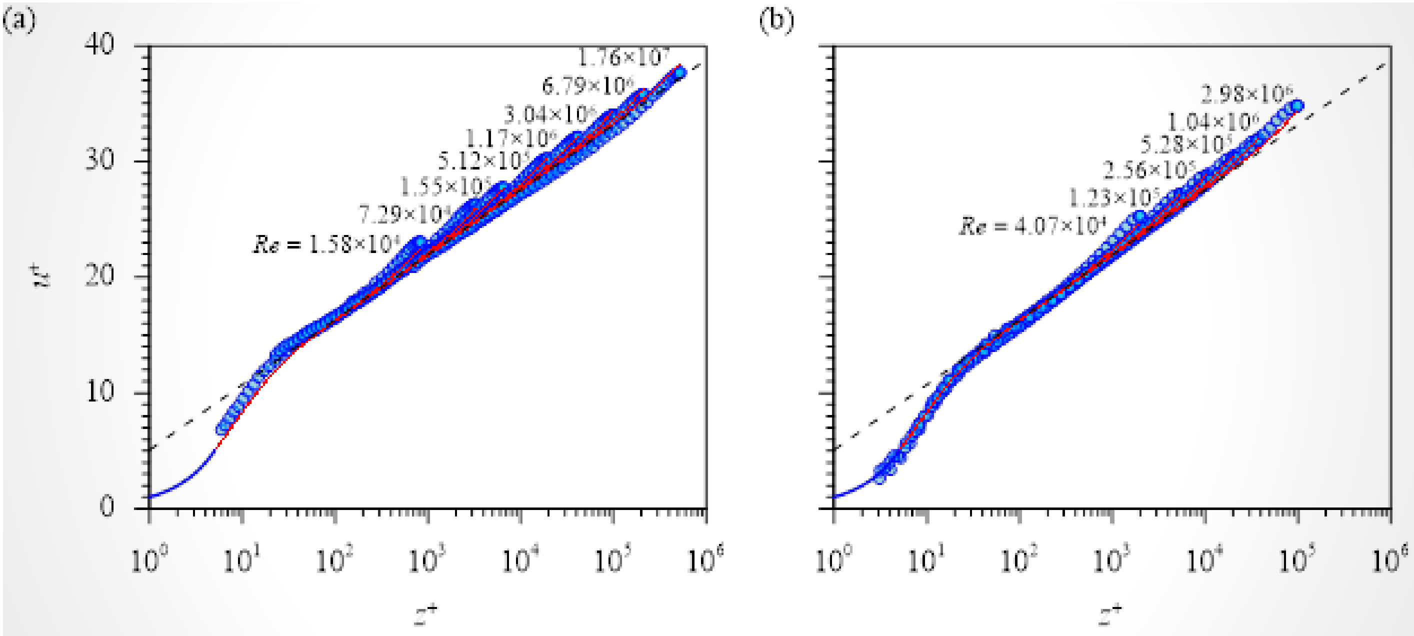

Fig. 2: Comparison of the computational MVPs with the experimental data obtained in a superpipe facility using (a) pitot probe and (b) nano-scale thermal anemometry probe.

Research & Innovations - Q4
Preserving 'Dhokra Craft', an IIT Hyderabad endeavor

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Department of Design

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The Design Intervention workshop by the Department of Design, aimed at safeguarding the Dhokra crafts of Ojha Gonds Community in Telangana.

Highlights:
- Community building and peer learning for the Ojha craftsmen.
- Creating Sustainable livelihood opportunities for the Ojha craftsmen.
- Documenting the traditional process of the metallurgy and regional artifacts of the Raj Gonds of Adilabad district.
- Create a digital repository of the traditional artifacts to trace the design evolution in the Ojha Craft.
- Encourage younger generations of the Ojha families to adapt and safeguard their ancestorial crafts practices.
- Generate awareness of the traditional craft practices of the Ojhas' among the common people of the region.

Professor Deepak John Mathew, Department of Design, IIT Hyderabad, along with his team has conducted a design intervention workshop on Dhokra crafts of Ojha Gonds of Adilabad as a part of an ongoing project under his supervision "Tangible and Intangible Cultural Heritage of Telangana" supported by Science and Heritage Research Initiative Programme, Design Innovation Centre, and Institutional Innovation Centre IIT Hyderabad.

Read More: https://tinyurl.com/yc7k6j6x

View Video Abstract:
Part-1 (Workshop Objectives):
https://youtu.be/g19qrmdOTzI
Part-2 (Brief on Dhokra Casting):
https://youtu.be/GEnaazvezf4

The workshop was focusing on training the younger generations of the Ojha community in the traditional Dhokra Crafts under the supervision and training of the Master Craftsman. Traditionally the artifacts were majorly created for the ritualistic purposes of the Raj Gonds, which is a part of the Intangible cultural heritage of the Raj Gonds of Telangana. The workshop aimed at retaining and sustaining the traditional craft practices of the Ojha's and to provide them opportunities to generate livelihood from their ancestorial occupation of Dhokra crafts. The workshop also had an objective of community building, and peer learning, skill development, and training. Thus, the Master Craftsman was chosen from Ojha Community itself.

Snapshot from the workshop