Fluid Structure Interactions Research Group

UNIVERSITY OF Southampton
School of Engineering Sciences

Improvements to experimental approach for application of optical methods to high-speed testing of composites

Dr Duncan A. Crump, Professor Janice M. Dulieu-Barton and Dr Stephen W. Boyd

Motivation

- The military use composite materials in land, sea and air vehicles in high performance applications, to assist with speed and maneuverability.
- Collisions or blast loads cause high strain rate events to occur, that may cause the composite structure to fail completely or to suffer damage that reduce service life – possibly leading to sudden unexpected failure.
- To reduce the risk of catastrophic failure after a high strain rate event it is important to fully understand the structural performance of polymer composite materials and structures under such loading.
- It is known that the behaviour of composite materials is dependent upon the strain rate, and that during the formation of damage a temperature change occurs within the material.

Objectives

- to develop digital image correlation (DIC) procedures for capturing deformations at high velocity based on the use of high speed digital cameras which would lead to an ability to produce a full-field high resolution map of the strains during the high strain rate events.
- to obtain a full field picture of the temperature evolution during the high strain event using infra-red thermography (IRT)
- to provide a thermomechanical characterisation of the material performance using experimental data to validate existing measured data and models.
- to use full-field techniques to assess the performance and damage tolerance of materials after experiencing high strain rate events.

High strain-rate testing

- Servo-hydraulic VHS Instron machine capable of strain rates up to 100 s^{-1}
- Test fixtures designed to improve consistency and use with composites (Figure 1)
- Improved protective enclosure to allow optical access for camera systems (Figure 2)

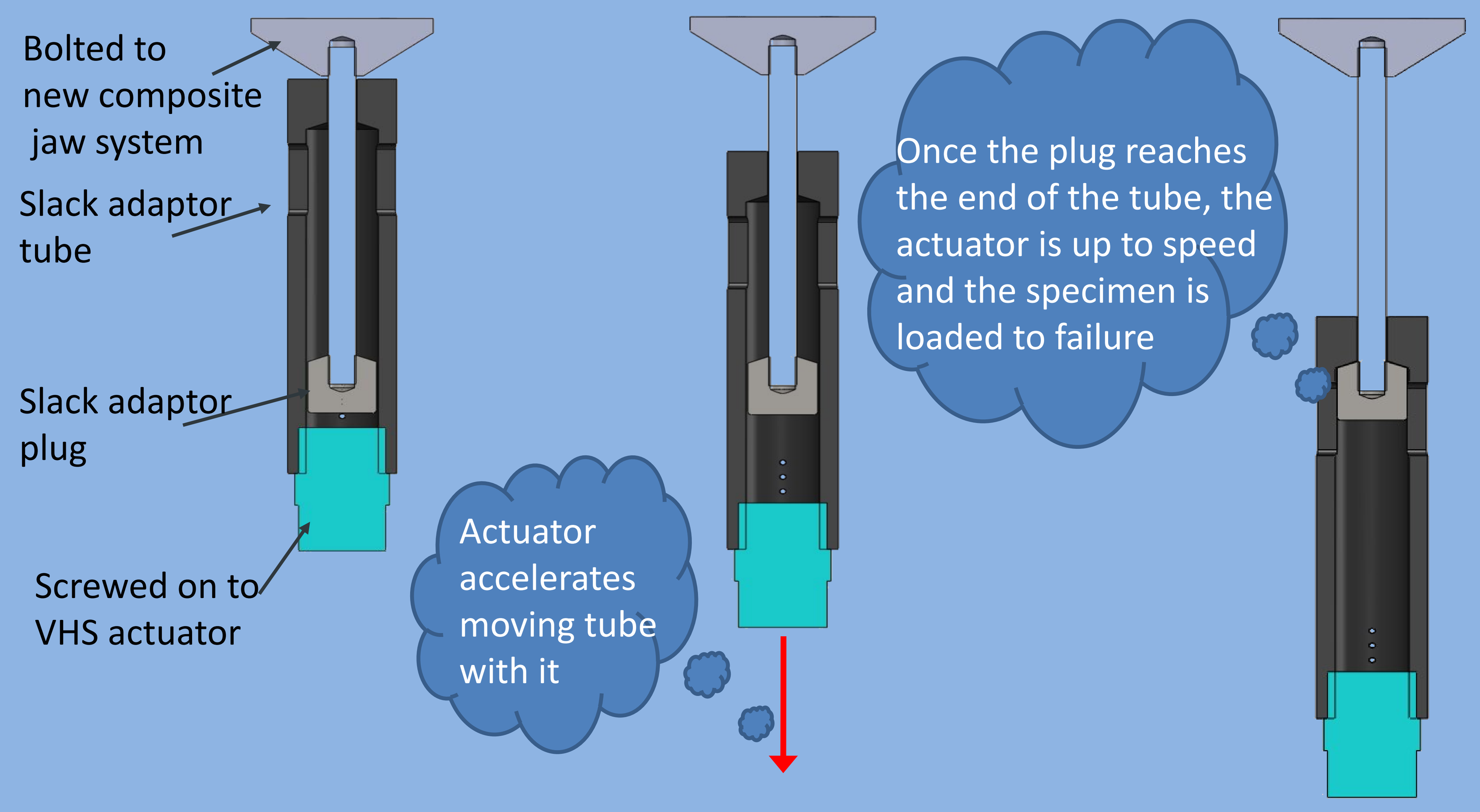


Figure 1: Slack adaptor for VHS machine to improve test consistency

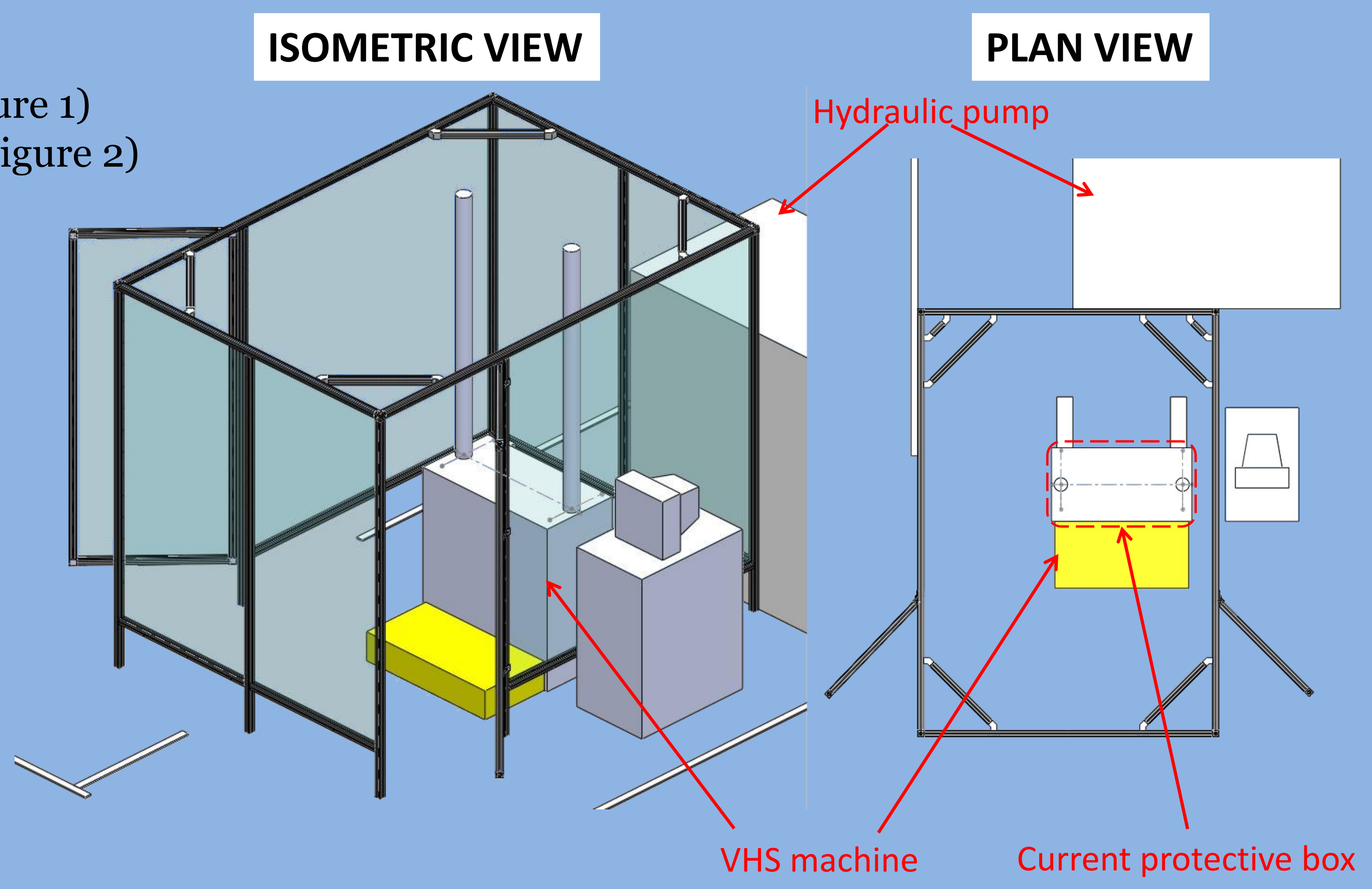
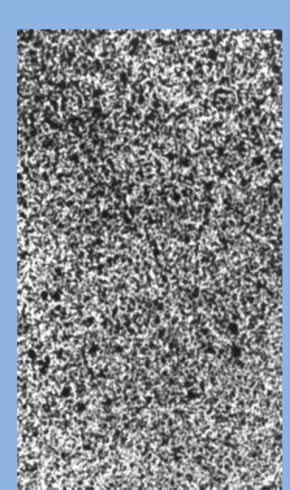
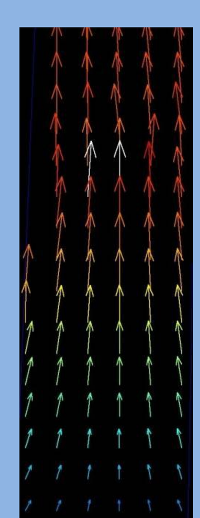


Figure 2: Improved protective enclosure allowing optical access

Challenges for application of optical techniques

- High speed DIC – paint coating, illumination, reduction in camera resolution required for higher frame rates, accuracy
- High speed IRT – Acquisition frequency, integration time, calibration
- Sampling rate of other data acquisition hardware for comparison
- Synchronisation of optical data with test machine etc.
- Use of hardware at its limits, therefore a strong knowledge of sources of errors is required i.e.

Errors =  **+**  **+** 

Loading **Speckle** **Correlation**

- Loading – misalignment, parasitic, slippage (especially in current jaw)
- Speckle pattern – Surface preparation, speckle size, contrast (lighting)
- Correlation – Use of LaVision's DaVis software, uses a fast fourier transform algorithm to track the displacement and hence strain with two important user controlled parameters cell size and cell overlap

Future work

- Commissioning improvements to high speed test facility
- Using National Instruments Compaq Rio with LabView software to produce a high sampling rate data acquisition system
- Combine the Compaq Rio system to send synchronisation signals to DIC and IRT systems
- An investigation into error sources, and accuracy of testing/ measurement systems to produce a calibrated system
- Use of calibrated/synchronised system to measure strains and temperature evolution during high strain rate tests of glass and carbon fibre composites

- An MSc project student has designed a Split Hopkinson pressure bar rig (see Figure 3) to extend the strain rates for composite testing up to the order of 1000 s^{-1}
- This rig has been manufactured and now needs calibrating and proving before use for a continuation of the project

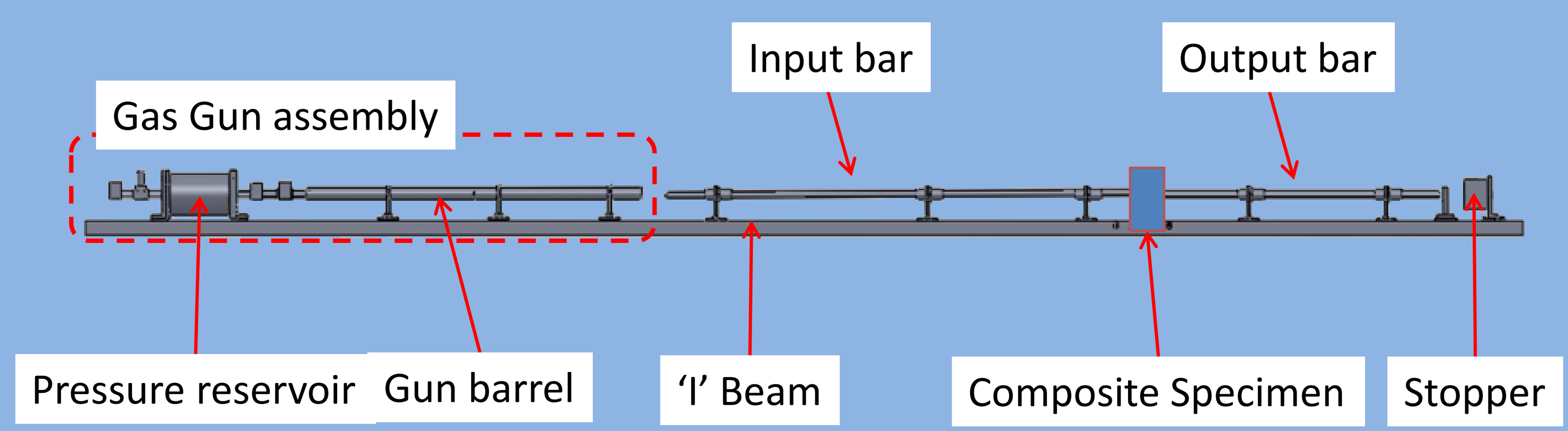


Figure 3: Split Hopkinson pressure bar test rig for strain rates 1000 s^{-1}

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