GISSMO Based Material Characterization
Using Workflows in d3VIEW

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Abstract

In times when the automotive industry is trying ways to reduce the R&D time for a new vehicle, material characterization using Workflows provide a structured way to develop a material card quickly and efficiently. GISSMO Material Development workflow greatly reduces the time required to generate and edit LS-DYNA® input files, visualize the results and automate decision-making aimed for optimization. The workflow is divided into sections as hardening curve optimization, Triaxiality curve optimization, mesh regularization, evaluation runs and result generation to make the challenging and complicate process of developing material model seem easy and user-friendly. Advantages of the workflow are timesaving, ease of use, efficient and flexible to adapt to the requirements of different materials
Keywords: d3VIEW, Workflow, Worker, Optimization

Introduction

Steel and Aluminum are amongst the most common crash critical materials, which makes characterizing them as accurately as possible of paramount importance. CAE material models are sensitive to many parameters like mesh size, strain rates, triaxiality, etc. The MAT_ADD_EROSION card provides a way to make the material card independent of these parameters using the **G**eneralized **I**ncremental **S**tress-**S**tate dependent damage **MO**del (GISSMO)

Developing a GISSMO card is a lengthy and tedious process. Workflows streamline this process into easy steps and automate the repetitive part to generate material card within days instead of weeks.

Workflows

Workflow can be defined as a flow chart of multiple workers linked to each other, where each worker performs a specific operation such as data cleaning, decision making, job submissions etc. Workflows aim to simplify complex CAE process in segments like data extraction, data processing and data visualization to enable quick decisions.

Each workflow comprises of series of 'Workers' that follow a single responsibility principle. For example, a Worker named 'Curves Overlay' overlays curve on top of each other to compare. The worker will only accept curves as input. In d3VIEW, there are 600+ workers each capable on a single pre-defined task. Figure 1 shows demonstration of Curves Overlay worker.
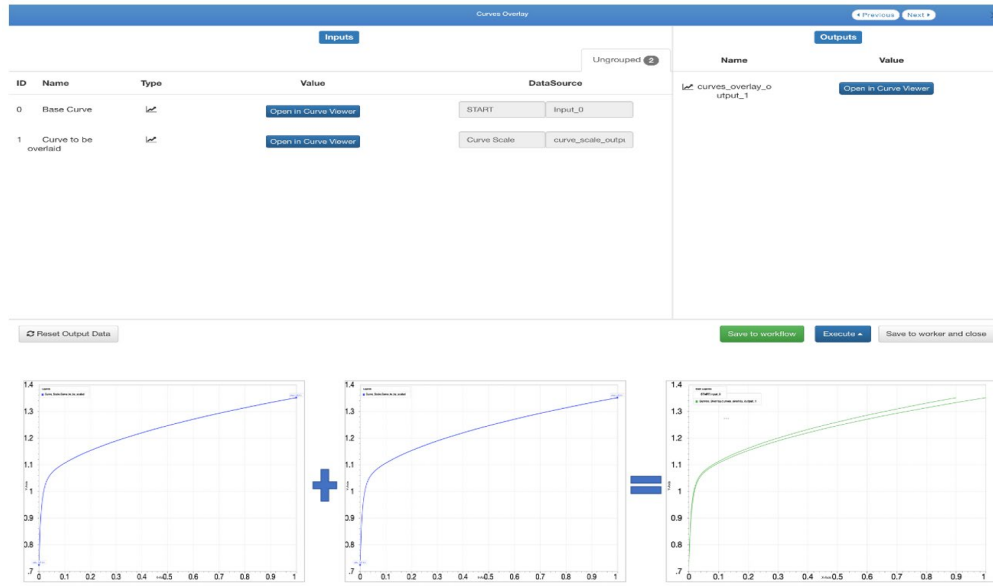
Figure 1: Curve Overlay Worker Example

Material Characterization using Workflows

This is a schematic of the general Workflow. Each segment of workflow performs a specific task. Let us look at sections of the GISSMO Material Development workflow separately:
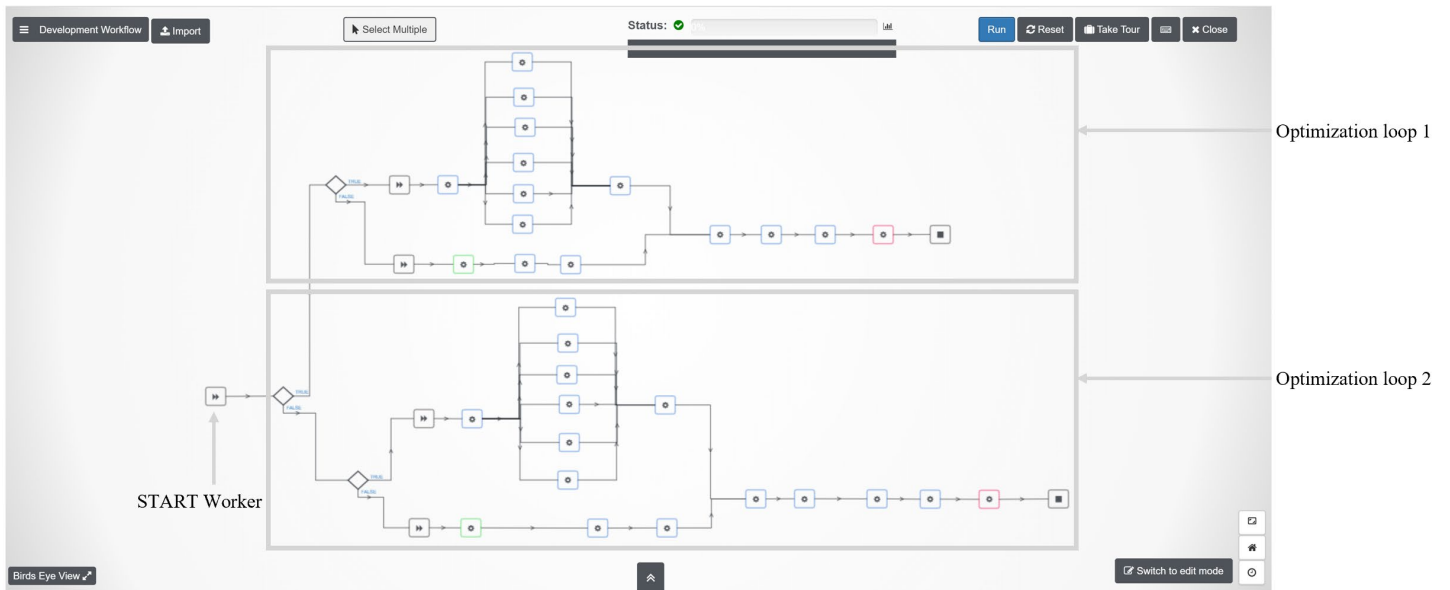

Figure 2: GISSMO Material Development Workflow

1. **Data collection and Cleaning:**

All the inputs required to run the generate the material card like LS-DYNA keyword files, Test data from laboratories, DIC images etc. are stored in a worker called 'START worker'. This data is then passed onto other workers as required.

The raw curves generated from physical testing are usually noisy and need to be smoothened out before feeding it to the LS-DYNA input deck. This operation is done using data cleaning workers like curve_smooth, curve_digitize and curve_monotonic. The cleaned Engineering SS curve is then converted to Effective SS curve worker using hardening laws.
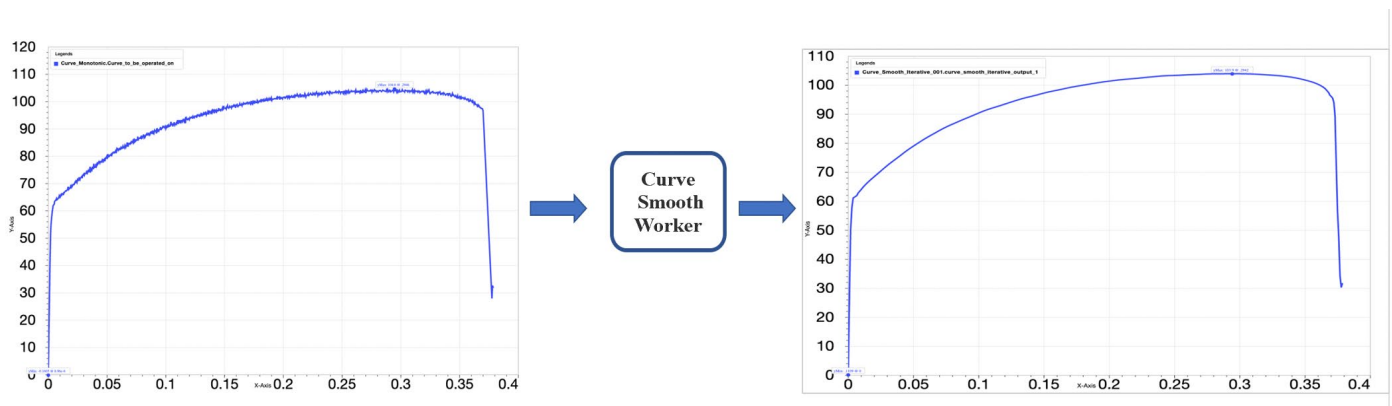
Figure 4: Curve Smooth Worker

2. **Uniaxial Hardening Curve Optimization:**

The post-necking hardening curve is optimized by setting up DOE simulations to match the stress-strain profile experienced in the test.

3. **Triaxiality Curve Optimization:**

Effective Plastic Strain to failure with respect to Triaxiaity for every specimen is calculated by minimizing the Curves_Match_Error between the simulation and test. The optimized value from individual specimens is combined to create a Triaxiality v/s Equivalent Plastic Strain to Failure curve

4. **Mesh Regularization**

Like Triaxiality Curve Optimization, optimum scale factor for all the mesh sizes are obtained using regression workers and these optimum values are combined to generate a mesh regularization scale factor curve

5. **Evaluation Runs and Results:**

After all the important parameters are optimized, the generated material card is tested by running an evaluation run for all the specimens to see how well the material card calibrates against the test results. The reporter worker then generates final output in PPT/PDF format comparing CAE results with the test.

Workflows Highlights

1. Decision Worker

Decision worker is one of the most powerful features of Workflows. The decision worker makes decision like which path to take, how many simulations to run, if the results are optimized or not, etc. based on the decision matrix you provide. It is heavily used in the GISSMO Optimization workflow to auto optimize curves and store history of previous results
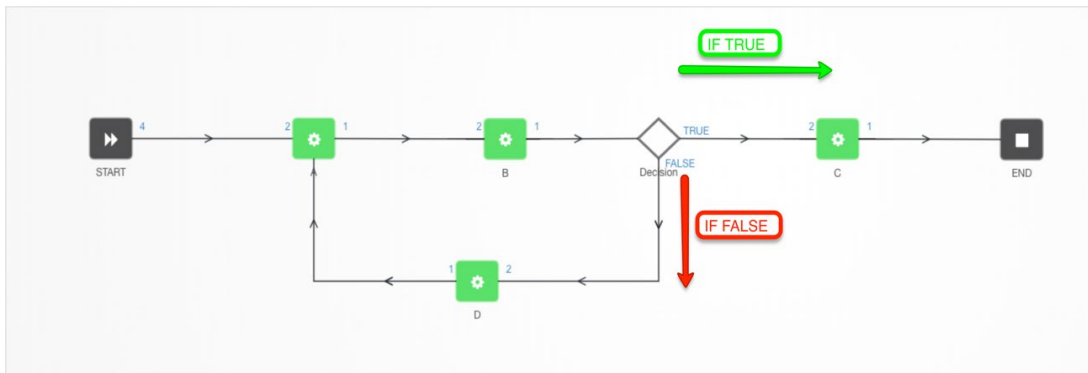

Figure 9: Decision Worker

2. Curves Match Error Worker:

Computes difference between two curves using options like root mean square, dynamic time warping, etc. Generates input for LS-OPT® worker
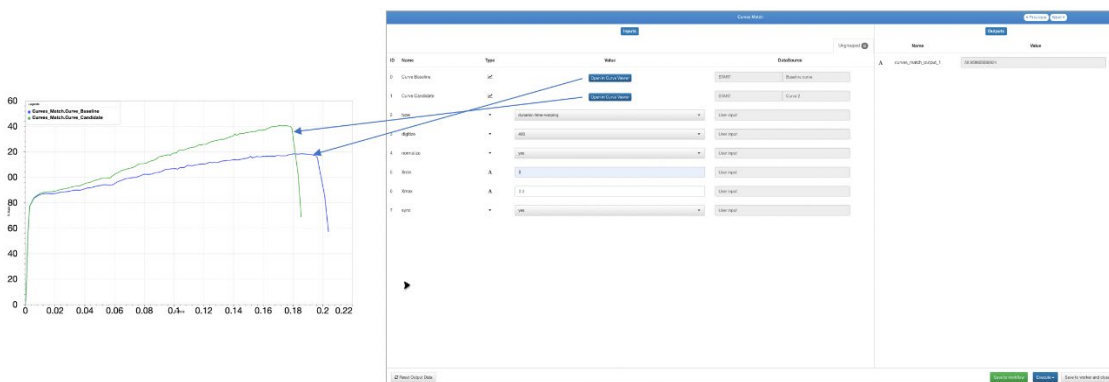
Figure 10: Curves_Match_Error Worker

3. LS-OPT Worker

Generates optimal values after running the input parameters and results through LS-OPT. Important worker tp get optimized values.

Results and Conclusions

Workflows is an essential part of d3VIEW. The GISSMO Material Development Workflow has helped us and our customers develop many crash critical materials in time sensitive environment efficiently and accurately

References

- LS-DYNA Keyword User's Manual
- LS-DYNA Theory Manual
- LS-OPT Support Site