SWEATING THE ASSETS - USING MATLAB TO IMPROVE RELIABILITY AND PRODUCTIVITY OF MATERIALS HANDLING MACHINES

MATLAB Conference
May 2018
Adam Mayers
Material Handling Machines
Simulation Tools

Description: This is a reclaim simulation test.

Volumetric Throughput vs Time

Time [Hrs]
Using SCADA Data to Compare Real Loads with Design Loads

Luff cylinder forces:
- Dead load balance
- Slew brg loads
- Combined live loads
- Collisions

Belt weigher tonnes/hr:
- Conveyor live load
- Flooded belt

Slew drive power and angle:
- Lateral digging
- Lateral collision
- No. Slew cuts for fatigue

BW drive power:
- Normal digging
- Abnormal digging

Counterweight
Bucketwheel boom
Control system "set and forget" information.

- Large volumes of data.
- Difficult to post-process.
- Poor visualisation tools.
- Inconsistent time stamps.
- Different "types" of data.
- Challenge is to turn this data into useful information for optimisation.

Data available to optimise performance within design envelope of machine.
Data Processing Using Matlab

Data Import and Pre-Processing
- Automated input of numerous data files (TBs).
- Use “Tall Arrays”
- Data conditioning
- Pre-processing of units / conversions etc.
- Filtering (if required)
- Live scripts

Post Process
- Vector calculations
- Signal processing
- Rainflow counting

Visualisation & Analysis
- Plotting
- Statistical analysis
- 3D Contour plots
- Export to other programs (e.g. FEA packages)

Applications
- Asset management
- Production improvements
- Capital planning
- Improving design rules
Example – Troubleshooting to Improve Productivity

- Colour scale shows SCADA parameter as a function of 3D boom tip position e.g. BW current, throughput, slew torque. Individual stockpiles are visible.
- Black dots are logged alarms/trips which represent production delays (lost revenue)
- Concise way of finding patterns using very large data sets e.g. ~5 million data points in picture below. Not easy to look at these patterns using normal “trend” software

1 month of 1Hz data
Example – Troubleshooting to Improve Productivity

Brakes applying too early leading to trips
Example – Health Checking

Coloured lines represent strength and design load assumptions

Conclusion: Digging load is higher than assumed in the fatigue design which may reduce the life of certain areas of the structure. The loads are generally within the strength design envelope. Machine is more bucketwheel boom heavy than originally designed (out of balance).
Example – Capital Planning for Remaining Fatigue Life

- Fatigue is caused by stress fluctuations at the welds. The magnitude of the stress range and the number of cycles are important.

- Primary limitation on life of machine structure is accumulated steel fatigue damage which results in cracking, at which point, machine replacement is often required (sustaining capital). Machines specifications typically require 20-30 years of operation.

- Matlab used to process data from structural analysis software (Finite Element Analysis) and measured loads (SCADA). Results then passed back to FEA software for plotting of “Damage Ratio”.

- Useful for capital planning, maintenance, productivity and reliability improvements.
Example – Capital Planning for Remaining Fatigue Life

3D PDF Enables Site Personnel to Plan Inspections and Maintenance

Some areas of high fatigue utilisation
Example – Structural Reliability to Improve Designs

- Machine design based on providing sufficient strength or “resistance” for a statistically rare load event (e.g. 1:500 year event).

- For a number of operating loads, machine design codes assume a distribution of loading which is not based on actual measurements.

- Matlab statistical analysis used to assess “structural reliability”.

- Analysis has shown that generally design standards are over-conservative compared with actual operations. By using measured load statistics, the design can be optimised. Lighter, faster, cheaper!
Key Outcomes

- Successfully used SCADA analysis to assist in asset management.
- Understanding of whether machine is operating within design envelope.
- Estimate when machine may need to be replaced based on remaining fatigue life.
- Improvements in production by reducing trips and by identifying under-utilisation of the machine.
- Highly cost effective method of “sweating the assets” for maximum productivity.

How has Matlab been useful?

- Many existing functions for handling “big data”
- Visualisation tools.
- Re-usability of code – ASPEC has now completed this analysis on over 25 machines.
- Next steps – potentially use more advanced Matlab tools for further optimisation.