Materials Fatigue Tutorial

An Introductory course to help engineers understand the fundamentals of metal fatigue and the computational methods used to by engineers to design components and structures subjected to repeated loading.

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Dedicated to the many colleagues who have helped teach me the intricacies of fatigue testing and design.

A Fatigue Fracture

Fracture surface of a beam in bending. Note multiple initiation sites along the line of the weld.
(Source: F.D.E. Comm. of SAE
https://fde.uwaterloo.ca/Fde/CaseStudies/TotalLife1/1_SAE_Current_Effort_30Oct12i.pptx)

Chapter 1: Introduction: Where is fatigue testing and design needed?

Railroads: Engines, wagons, rails, sleepers, bridges, turntables
An early case:
https://en.wikipedia.org/wiki/Versailles_rail_accident

As an exercise make a list of the above components that you think require fatigue design.

Solutions

Bridges: Main cyclic loads attributed to heavy trucks or trains.

For this bridge, at Windsor, the main loads are trucks. When traffic is heavy the bridge is lined with trucks, end to end.

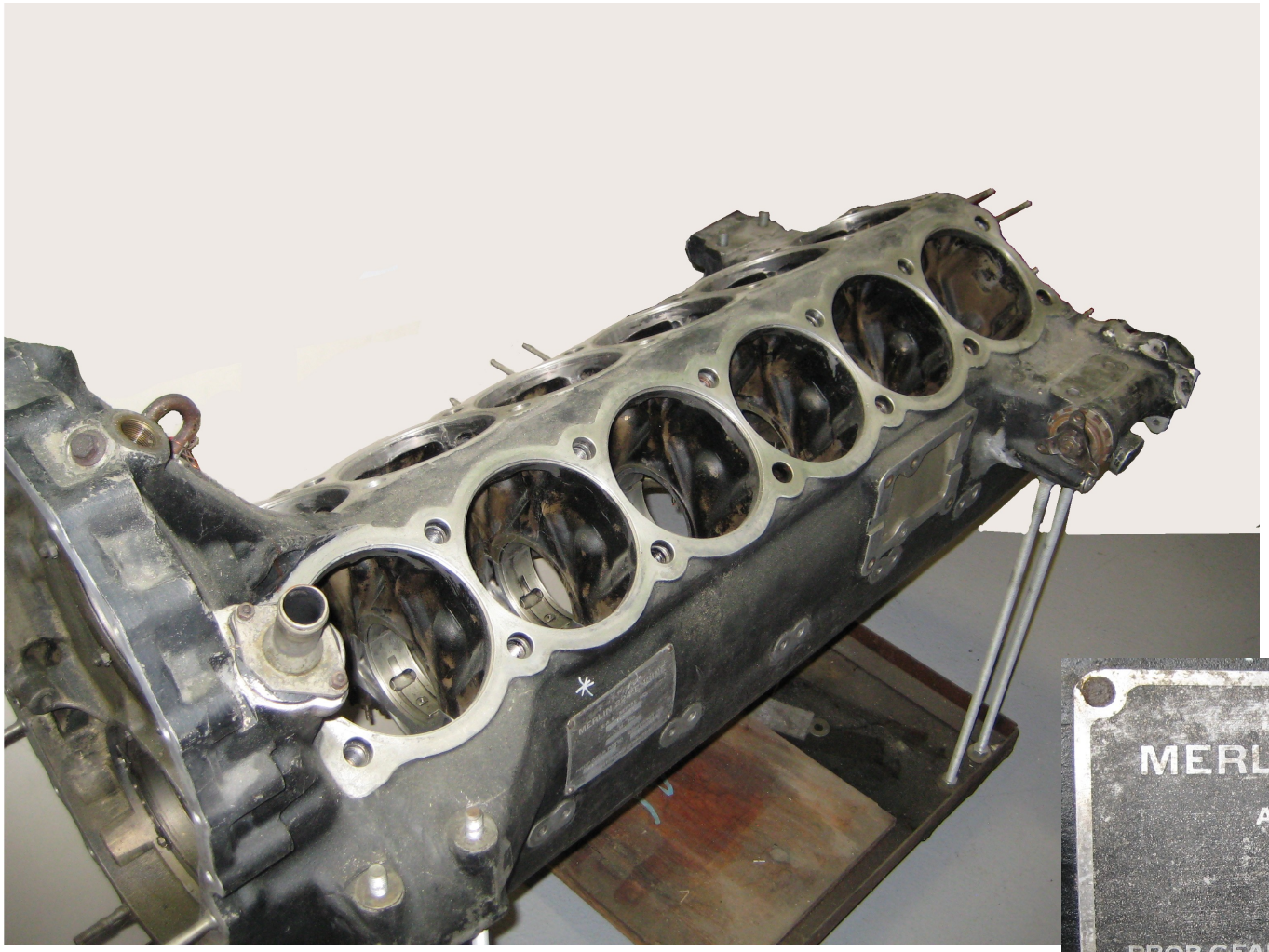
Typical suspension bridge cable ends

Vehicles: Cars, trucks, buses, motorcycles, bicycles: all require design against fatigue

Airplanes: Most airplanes have a finite life due to the need for low weight.

Each component of the structure and engine must be designed and tested.

Many engine components are designed for infinite life due to the many load cycles of the rotating components. “Infinite life” implies that the stresses are below the Fatigue Limit



Earth moving and construction equipment - design dominated by fatigue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Road surfaces of asphalt or cement also fatigue and settle with vehicle loads. This machine is a surface grinder used to flatten irregularities or prepare for a re-surfacing.

An older drag-line bucket excavator used in open-pit coal mining.

- with an interesting method of movement…..

Engineering exercise:
Figure out how this moves across the ground.

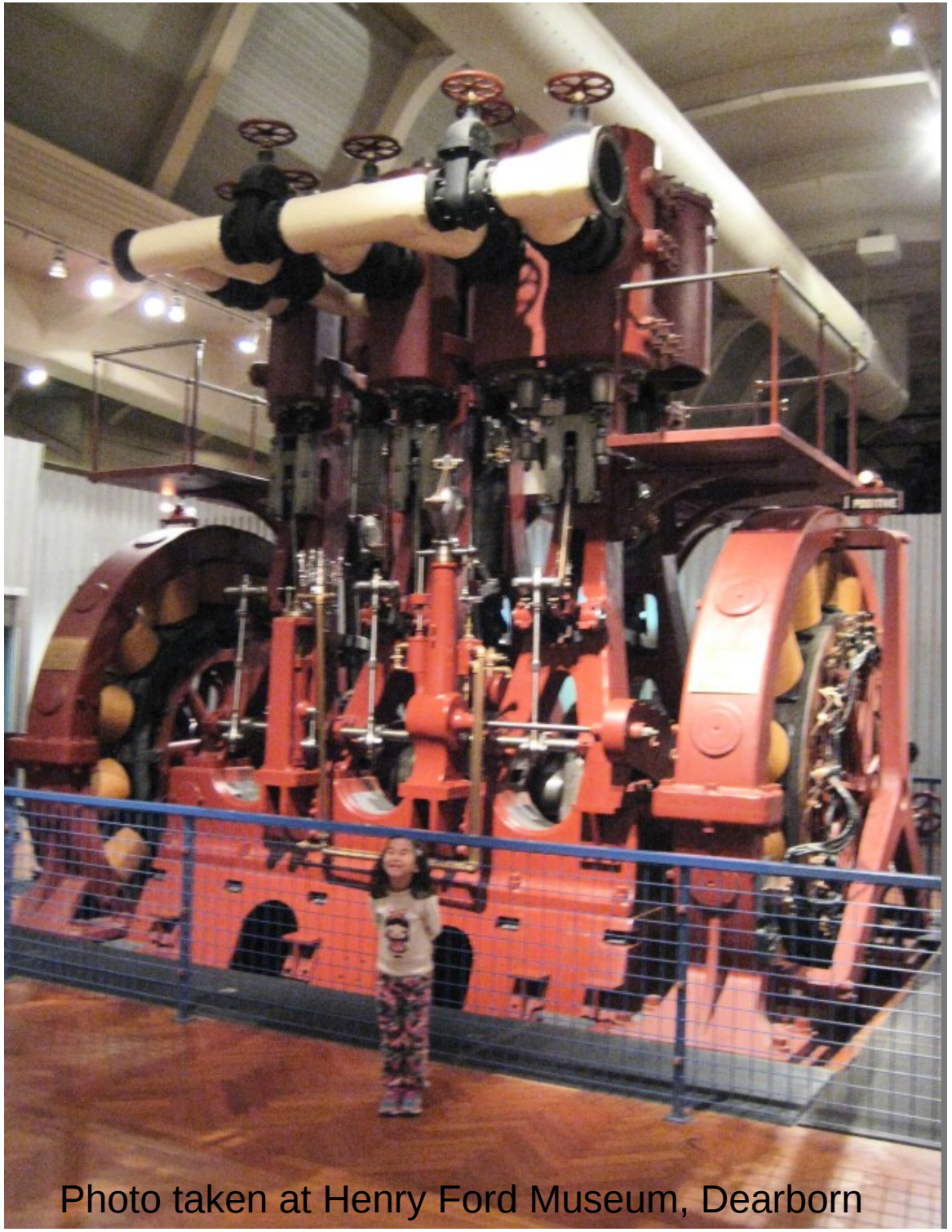

Photo taken at Henry Ford Museum, Dearborn

Power generation

Some of the early generators were steam powered and piston driven.

Turbines are used in the hydro or nuclear industries. Often the large load/stress fatigue cycles are due to the

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duty cycles and not so much due to the spinning of the turbines.

It may be green but it still fatigues.

Fluctuating wind pressure and rotation stresses cause fatigue of the often composite blades.

At predetermined intervals of use, inspectors hanging from a rope bang on the blades with a small hammer to listen for sound differences that indicate sub-surface delaminations which require repair.

Other items of fatigue design are the control and generation equipment at the top, the pole, bolts at the bottom and the foundation.