Measurement of metal creep in vertical attenuation cantilever blades

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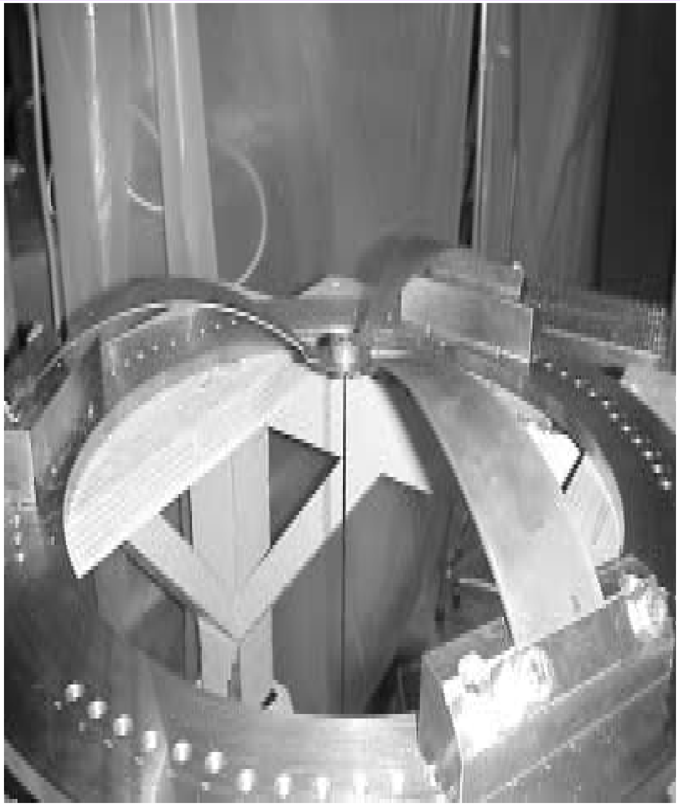
Contents

- Purpose of my experiment
- What does metal creep mean
- Experimental setup
  - » Mechanics
  - » electronics
- Data acquisition software
- Data Analysis
- Results

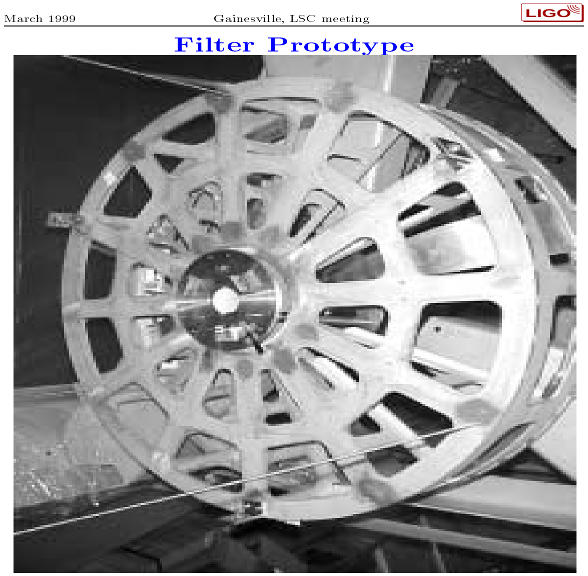


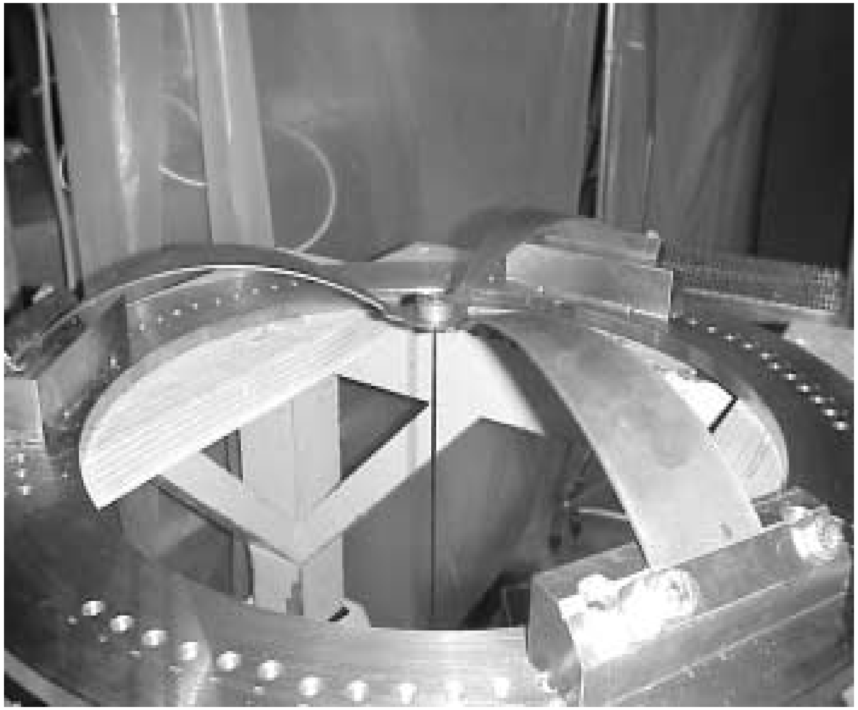
Purpose of my experiment

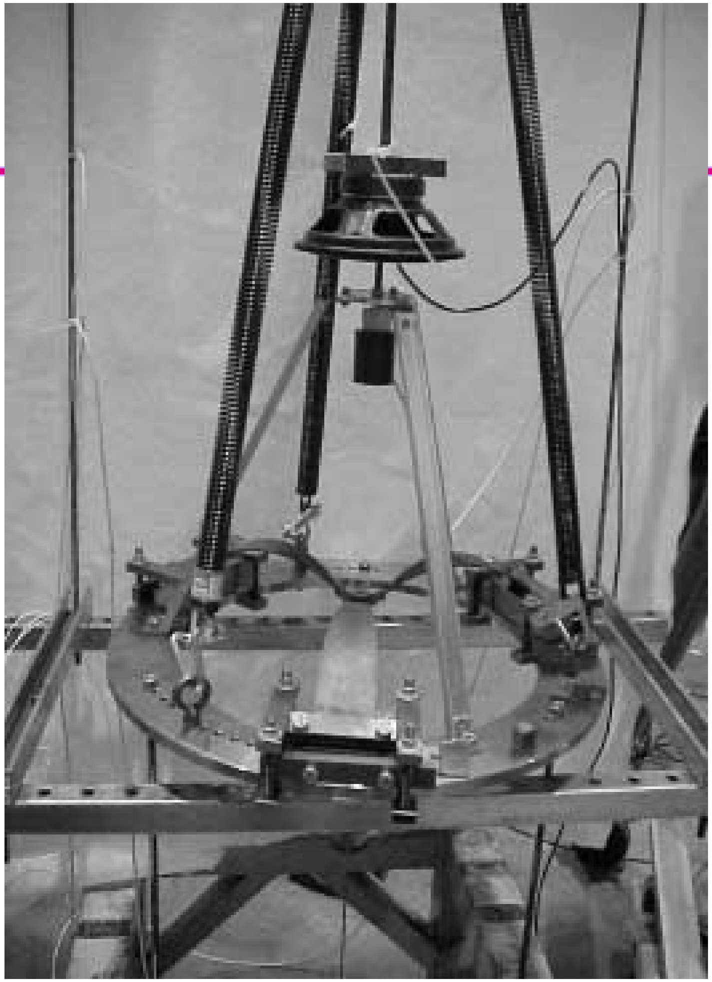
- Soft suspensions provide vertical isolation for the mirrors
- Stress can produce creep
- Must select material and treatment to minimize creep

  (require about 1 micron/day)

Test Tower







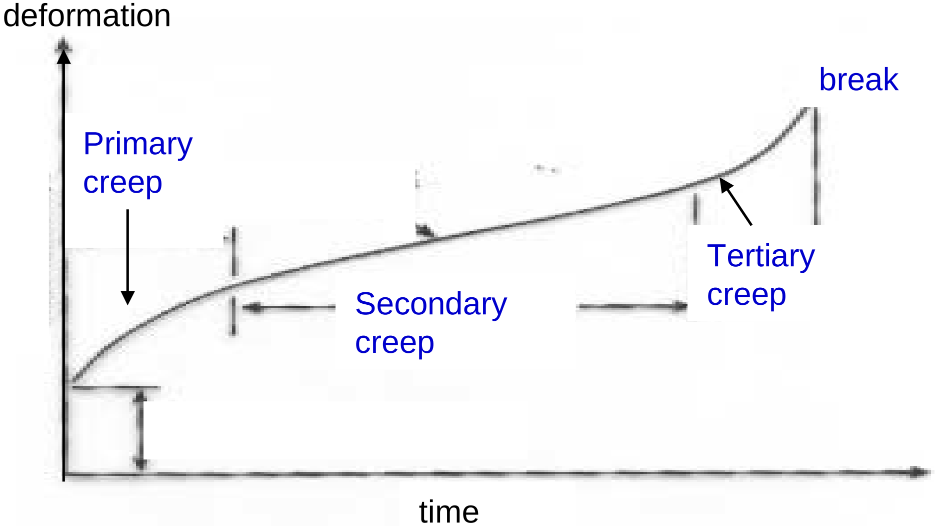
Metal springs under high stress

What does metal creep mean

- **Metallic material subjected to constant stress undergoes progressive deformation**

The typical curve of metallic creep

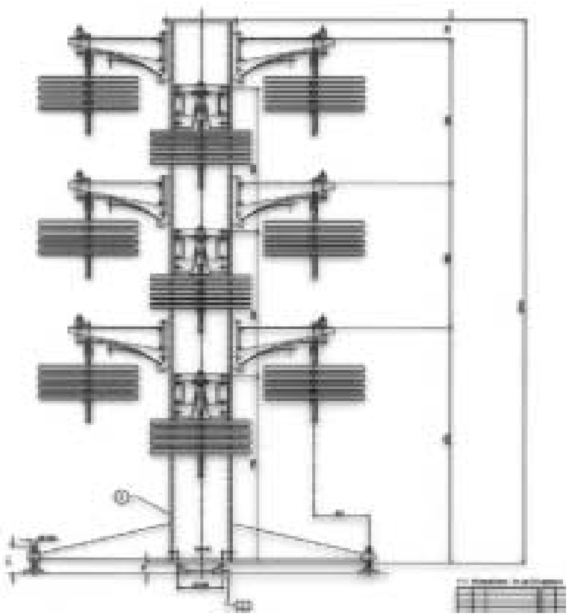
- **Maraging steel ONLY has PRIMARY CREEP**



- Treatment can be devised to limit creep levels (extended heating, ecc)
- Design parameters for blades can be defined to minimize creep

Experimental Setup

Mechanics



Eight metal springs have been loaded on the "totem" tower with different blade parameters

blade	thickness(mm)	length(cm)	load(kg)
4	3.4	29.2	51.06
9	2	29.2	76.2
7	4	20.8	115
6	3.1	20.8	48.66
5	3	20.8	48.5
2	3	29.2	34.5
0	3.8	29.2	71
8	4	20.8	115.5

Data Acquisition

- ***Linear Variable differential transducer (LVDT)***

  Sensitive to small displacements

  5 V/mm

- ***Multichannel data acquisition***

  - lvdt drivers

  - lvdt readout

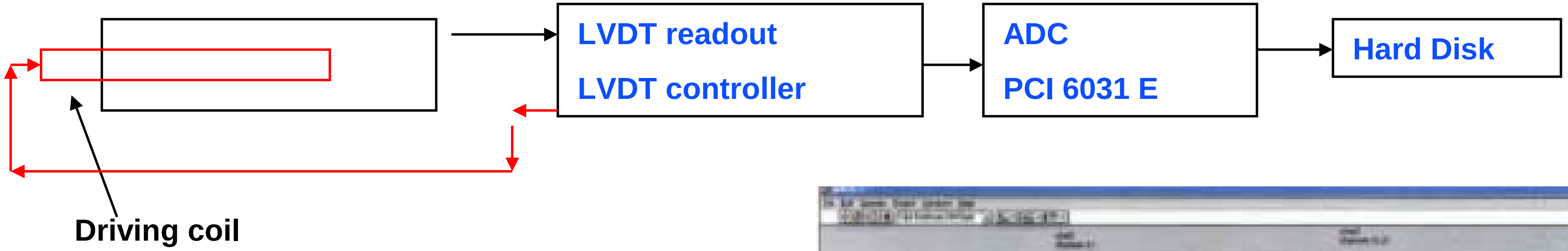
  - lvdt controls signals

  - thermally stabilized readout

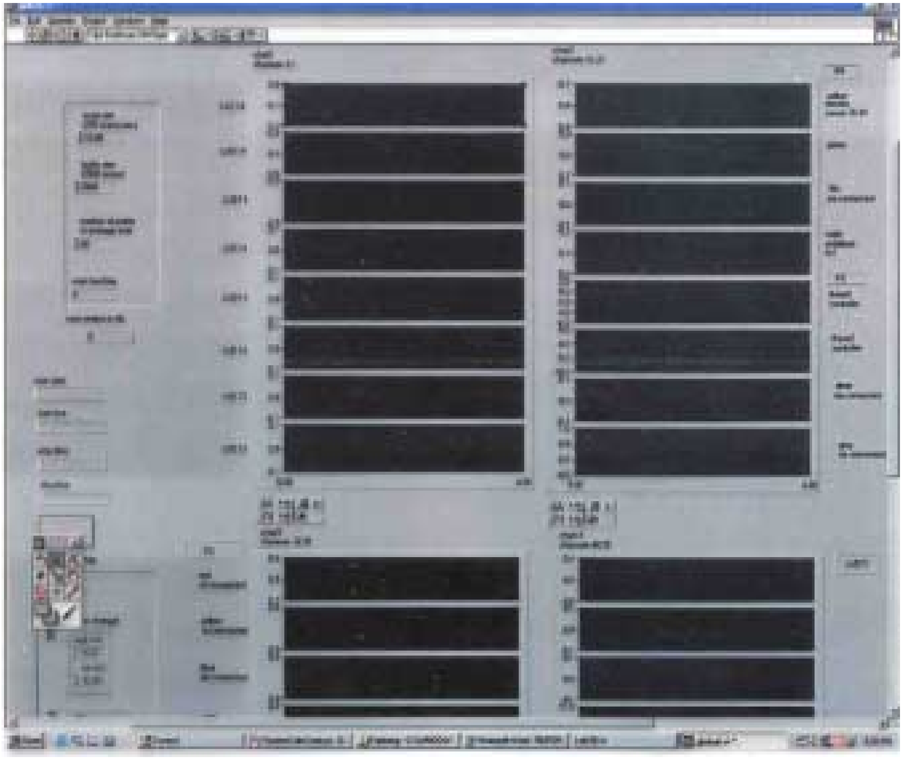
  stability= 10mK

  -other esternal channels for environmental controls

Data Acquisition



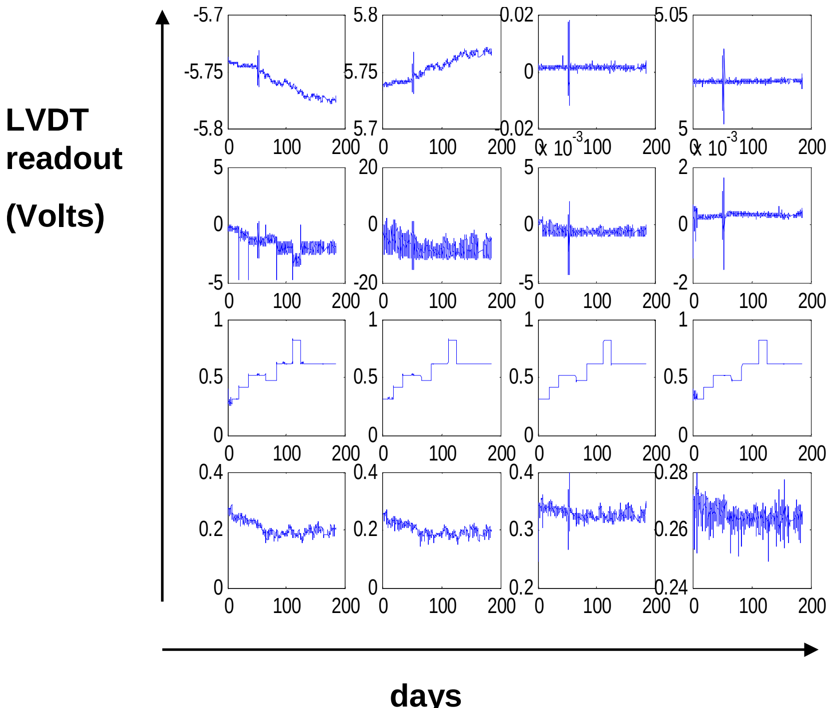
- PCI 6301 E
  Labview data acquisition
- ACQ 250 Hz averages 10,000 samples
- Text file conteins average readout (every 40 sec.)

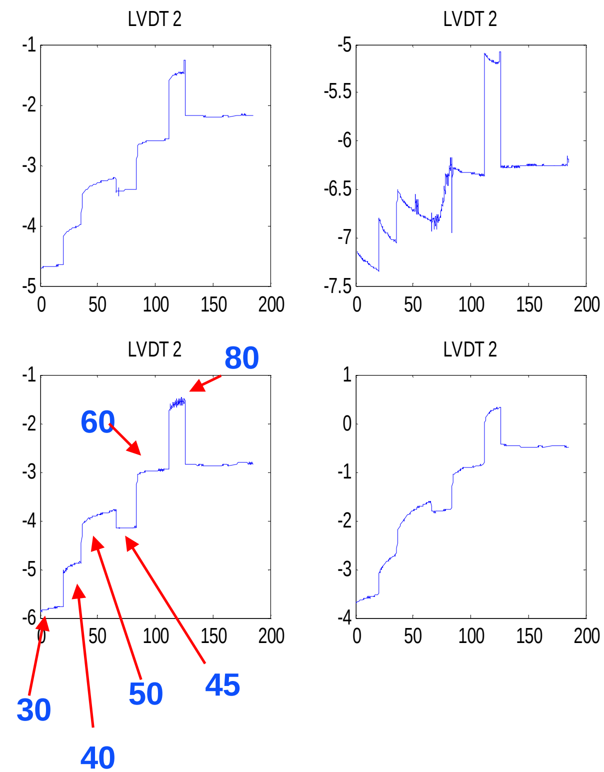


Data analysis steps

One year of acquisition data at different temperatures

1. Plotting the blade deformation as a function of time





Data analysis steps

2. Separation of data for every blade and every temperature

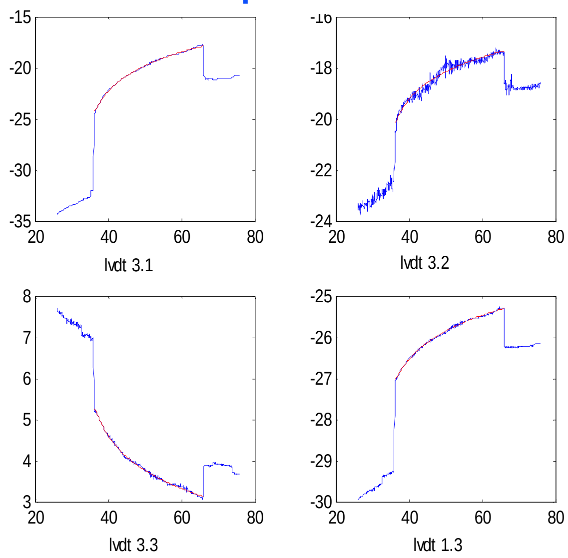
The primary creep follows a logarithmic behavior during the time

$$Y(t)= y_0+\alpha \log (t-t_0)$$

Temp 50 C

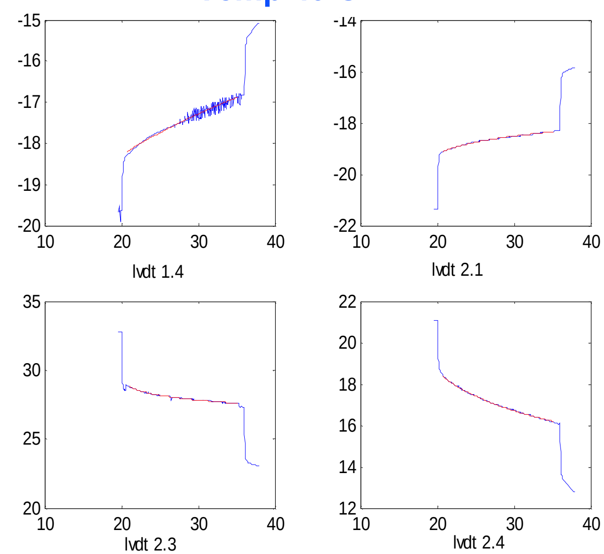
LVDT readout

(V)



days

Temp 40 C



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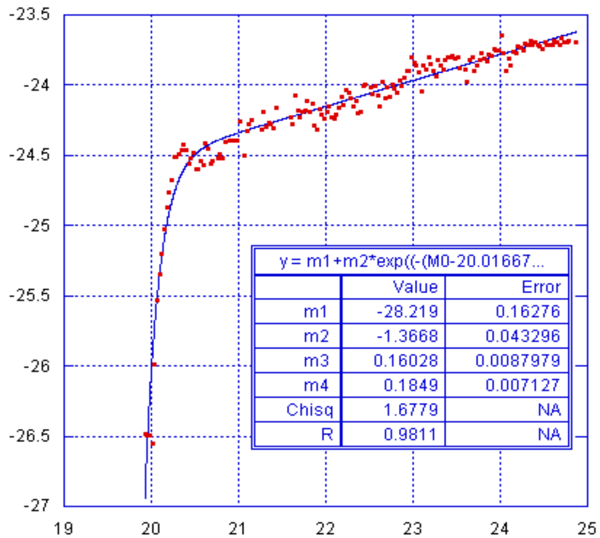
Data analysis steps

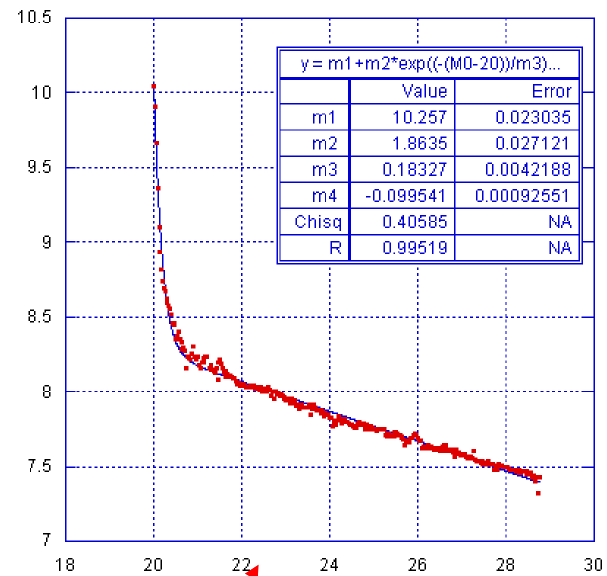
3. Fits of jumps between different temperatures

Typical exponential behavior of creep with temperature change.

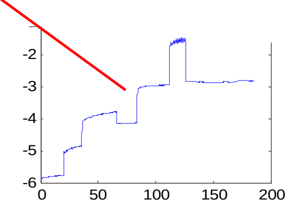
$$R= \beta * \exp(\Delta E/ kT)$$

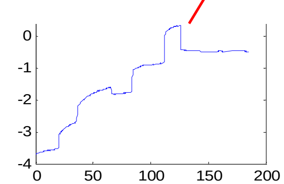
LVDT readout (V)





days





Conclusions

Achieved:

- Good agreement with literature for data analysis
- Stable data acquisition
- Most noise sources identified
- Formulation of exponential design for creep study

Verified:

- Typical logarithmic and exponential behaviors of in creep in Maraging Steel
- Time scales nedeed for creep stability
- Effects of temperature on creep