Ecole Polytechnique Fédérale de Lausanne

Module 1

Determining theoretical speed for setting oscilloscope triggering

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Introduction

The goal is to set a triggering time capable of catching our signal properly. It is therefore important to account for the maximum crack speed.

Oscilloscope trigger system allows us to set a point in the signal and begin the capture at that point. It is important to notice that the oscilloscope has a buffer. Meaning that the signal just before the chosen point is also being recorded.

Theory and expected signal characteristics

0.1 Crack speed

Crack dynamics depends on various material parameters that are beyond the scope of this project. Nevertheless, having a boundary on its value is essential for setting the oscilloscope triggering system. In fact, if we don't set a measuring frequency high enough, we might loose the signal.

The crack speed is limited by the Rayleigh wave's speed C_R[1]. Which is found using 1

$$C_R = C_S \frac{0.862 + 1.14\mu}{1+\mu} \tag{1}$$

where C_S is found by eq 2 and corresponds to the speed of sound in the material.

$$C_S = \sqrt{\frac{G}{\rho}} \tag{2}$$

The shear modulus G is found using eq 3

$$G = \frac{E}{2(1+\mu)} \tag{3}$$

Density of the material	ρ
Poisson's ratio	μ
Elasticity modulus	E
Shear modulus	G
Shear wave speed	C_S
Rayleigh wave speed	C_R

Taking $E = 3000 \quad MPa$, $\mu = 0.4$ and $\rho = 1.18 \cdot 10^3 \quad Kg/m^3$ we find that $C_R = 900 m/s$

0.2 Signal frequency

The goal is to be able to catch up the largest frequency reached by the setup. The maximum velocity reached by a crack is defined by its Rayleigh wave speed and rarely exceeds 60% of this limit [**Fineberg**]. Rayleigh's velocity is calculated to be 900 m/s in this experiment (975m/s in Finberg's paper). Therefore, considering a velocity of 540m/s, the sample width of 50mm, the maximum observable frequency is computed according to Eq. 4

$$f_0 = \frac{540}{50 \cdot 10^{-3}} = 10.8 kHz \tag{4}$$

References

[1] Ariel Livne Tamar Goldman and Jay Fineberg. "Acquisition of Inertia by a Moving Crack". In: *Racah Institute of Physics, Hebrew University of Jerusalem, Jerusalem 91904, Israel* (2010).