Detection and analysis of loosening in jointed structures using acoustic emission sensors and smart bolts

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In aeronautic, automotive or civil engineering structures, the parts are assembled together by means of rivets welding points or bolted joints. The bolted joints are likely to self-loosen when the structure is subjected to vibrations [4]. As loosening can lead to serious accidents, our project focuses on the early detection of self-loosening. To achieve this goal, it is possible to integrate a sensor in a screw to monitor it, but it is impossible to instrument the thousands of screws that contains a structure. Our project therefore aims to try to overload all links with a network of some Acoustic Emission sensors well chosen and well positioned. The setup ORION has been firstly developed to perform research activity about **damping** and **nonlinear vibrations** [2]. It is made with two plates linked with three bolted joints. To facilitate the understanding of the physical phenomena, the contact between the plates is made by patches machined on the surfaces. A piezo-electric actuator (CEDRAT) has been especially developed in order to cause the loosening. A sensor (TEXYS) has been embedded into a M4 bolt head to measure the tightening loads. Acoustic Emission sensors (MISTRAS) are used to measure acoustic activity, see figure 1.

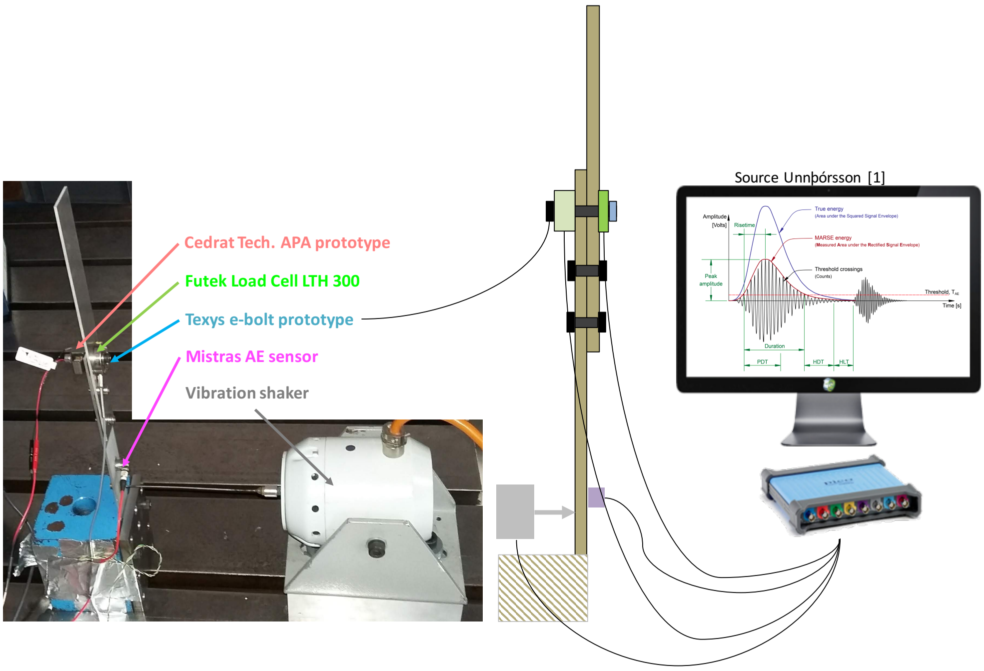


Fig. 1: Studied structure

Loosening is monitored under a 100Hz harmonic vibration test. During this vibration loading measured and controlled with a laser velocimeter, three Acoustic Emission sensor are used to record hits induced by stick slip transitions or shocks in the interface, see Figure 2. Two hit patterns are mainly interesting. According to the sensor, their frequency content, amplitude, start and stop are varying. The SE 25 has been finally chosen as it is the most selective one in term of frequency content. It allows to filter all the frequency except a narrow frequency bandwidth around 30kHz.

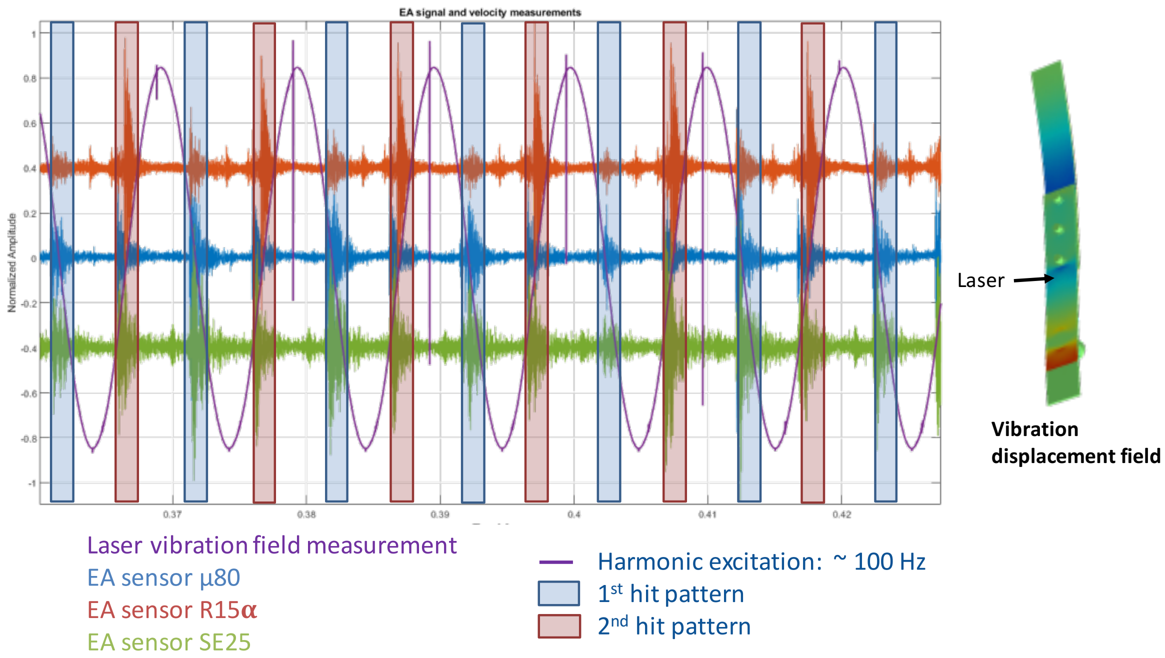


Fig. 2: Harmonic vibration tests and raw observations

Next studies are about detection. Only the SE25 sensor has been used. The parametric study shows that a vibration amplitude change is visible analyzing the acoustic peak amplitude, see fig. 3 where as a loosening is visible analyzing the hit starts, se fig. 4.

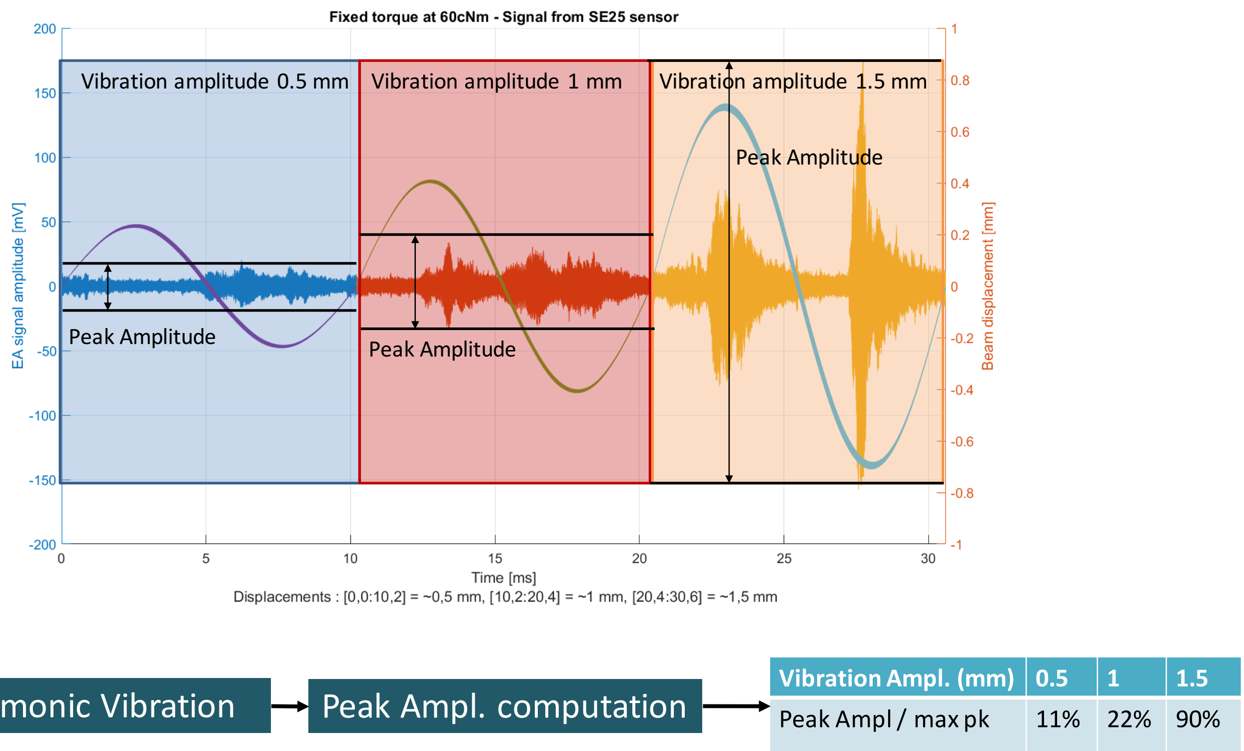
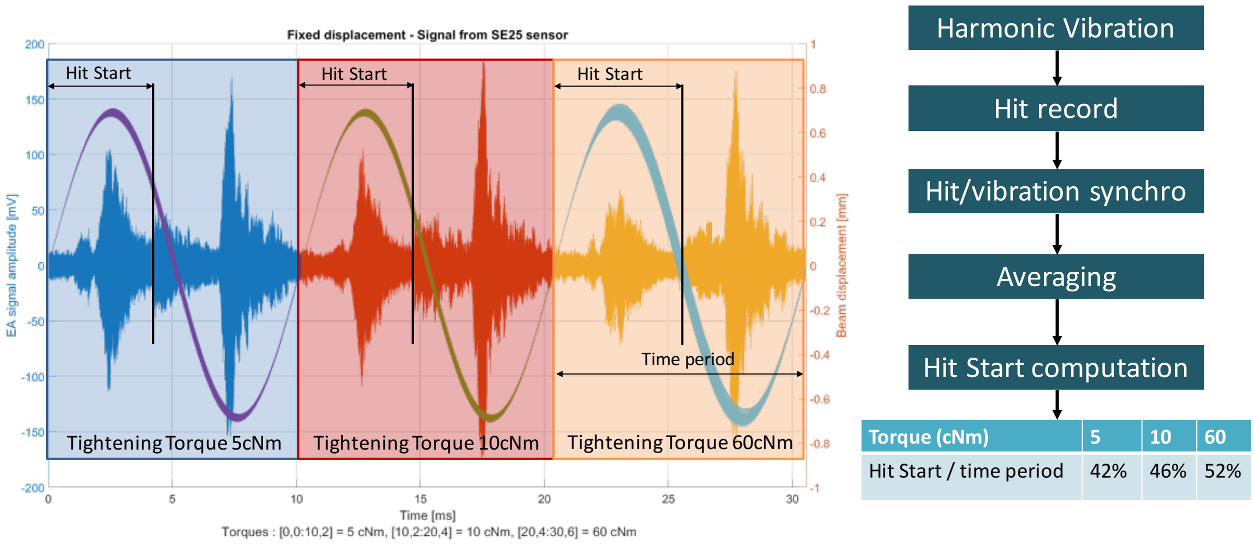


Fig. 3: AE according to vibration amplitude



Torque (cNm)	5	10	60
Hit Start / time period	42%	46%	52%

Fig. 4: AE according to tightening

AE techniques are able to detect friction and contact induced waves. The « Hit start » seems to be a good descriptor for loosening detection. The « Amplitude » is a good descriptor to measure the joint loading amplitude. Future work will focus on stick slip transition and contact separation simulation and self loosening simulation. Better understanding the physics involved in order to perform smart description of the AE datas

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