The Story of Knock in SI Engines
A concise tutorial

By

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Knock is technically defined as an audible noise associated with "autoignition" of a region of the fuel-air mixture ahead of the moving flame front inside the engine. The term autoignotion in combustion terminology refers to spontaneous ignition of a mixture of fuel and air with no external means such as a spark , hot spot, or even a high power laser. If you form a mixture of fuel and air in a constant volume box at a given pressure and temperature with no ignition sources, chemical reactions start as soon as the fuel and air are mixed, but, it may or may not autoignite. If these reactions are extremely rapid, most likely you will have autoignition. Only for certain combinations of initial temperature and pressure in the box (mathematically speaking, a region in a temperature-versus-pressure plane) one experiences autoignition. That is, the mixture will explode by itself after a delay period from the start of the above box experiment. Mixtures of the same fuel but at different fuel-air proportions will autoignite in a larger or smaller regions in the aforementioned plane.

Imagine yourself as a member of the police bomb squad and know that there is a time-bomb ticking at a distance from you. As a last resort, not recommended of course, you run to catch it for neutralization before explosion. If you arrive on time explosion can be prevented. The autoignition of the unburned fuel–air mixture far ahead of the flame is like a time bomb (with no external ignition source) and the running flame is the member of the bomb squad. This simple picture is our current understanding of the basic knock in spark ignited engine. There are of course variety of this basic picture with different names in use that we will not engage in this brief tutorial. Note that the flame itself is initiated by an external ignition source (i.e. spark plug) which after its initial development phase advances in an attempt to consume the entire unburned fuel-air mixture. If before having the opportunity to burn all the trapped charge an autoignition occurs somewhere within the unburned mixture, we say that knock happens.

When knock occurs it is followed by a very high local heat release, causing localized high temperature zones, and very high local pressures leading to formation of shock wave with its mechanical impact as it travels and reflects from the chamber walls. The shock wave along with its accompanied expansion wave are bounced off the walls of combustion chamber numerous times causing oscillations seen when chamber pressure is measured. The mechanical damage can be material erosion and thermal adverse effects are localized melt down of the chamber walls. Heavy knock that becomes progressively stronger can easily cause piston and ring seizer in the bore leading to engine failure in a short time. Tendency of a fuel to knock is measured by what is called as "octane number" of the fuel. It is evaluated by a standardized test on a specially-designed single-cylinder engine. Knock is also an inherent constraint on both engine performance (since it usually happens at wide open throttle) and efficiency (since it limits the maximum compression ratio). For all of the above reasons, knock prevention and design of engines to lower the so-called "octane requirement of an engine" are critical. This writing should be considered as a brief introduction to the subject of knock. For more details interested readers are referred to Internal Combustion Engine Fundamentals by J. B. Heywood as a good starting point.