Evolution of P/S limit for short and long tokamak shots

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The analysis of the tokamak “high performance regimes” for the past 55 years from 1962 up to today showed that the maximum allowable total heating power $P$ for each separate tokamak changes approximately linearly with $S$-area of the chamber facing to the plasma [1]. This indicates on the existence of some kind of limit (P/S limit 0.2+/−0.1 MW/m$^2$) which excess leads to the degradation of the plasma confinement. The maximum allowable heating power increases with increase of the magnetic field, increases with decreasing $Z$ of the material of the first wall and progressively reduces with the elongation of the plasma shot duration $t \sim 1/(P/S)^{1.7}$ as shown the experiments on superconductor tokamaks and stellarator LHD (Figure).

![Figure. Diagram P/S - $t$ shots for number of fusion devices](image)

If we suppose that the reason of the P/S restrictions is the breakdown of the plasma sheet [2], we can explain the visible P/S reduce by the gradual collection of erosion products of limiters and divertor on the chamber wall that can assist the plasma-wall breakdown. That means that the steady state plasma process, which needs for the industrial fusion reactor, will require the constant removal of erosion products from the tokamak chamber during plasma operations. The use of lithium circulation between the wall and the plasma in the form of the closed loop can be one of the solutions of this problem. These questions will discuss in the communication.
