Target power loads during disruptions in ASDEX Upgrade

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on behalf of G. Pautasso, A. Herrmann and C. Fuchs

• database on power load in ASDEX Upgrade lower div II and div IIb
• temporal evolution of the disruption
• spatial distribution of power
• role of radiation on power load
bolometers and thermography for power balance

100 bolometer chords
time resolution 1 ms

2 IR cameras for the lower target
time resolution 0.12 - 1 ms
spatial resolution 1-2 mm
the power deposition on the lower divertor (Div. II and Div. II-b) is analysed in this work.
the power deposition on the divertor plates during the thermal quench lasts 2-3 ms.

there is no one typical power deposition time history during disruption but a variety of them.
disruption database for Divertor II and II-b


Divertor II-lyra configuration: 30 discharges
(shot # < 14200)

Divertor II-b configuration: 14 discharges
(shot # > 14200)

Parameters:

- plasma current (I_p) = 0.6 - 1 MA
- q_95 = 2.5 - 6
- thermal energy (E_th) = 50 - 500 kJ
- magnetic energy (E_mag) = 0.7 - 1.8 MJ
- disruption duration = 10 - 30 ms

different disruption causes, not yet analysed
\[ \Delta E_{\text{mag}} + \Delta E_{\text{th}} + \Delta E_{\text{in}} = \Delta E_{\text{rad}} + (\Delta E_{\text{div}} - \Delta E_{\text{div\_rad}}) + \Delta E_{\text{em}} \]

Energy balance is consistent within uncertainties
The amount of energy deposited on the divertor plates during the whole disruption is 30% in average (up to 45%).

During the 4 ms about the thermal quench $E_{\text{div}}$ is:

1. In average 90% of pre-disruptive $E_{\text{th}}$.
   - Part of the magnetic energy is already dissipated in this phase.

2. In average 50% of $(E_{\text{th}} + 0.1 \times E_{\text{mag}})$.

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A. Kallenbach, 3rd ITPA SOL and Divertor Topical Group meeting, St. Petersburg, July 2003
time evolution of power load

s-coordinate along target

0 m  1.5 m

A. Kallenbach, 3rd ITPA SOL and Divertor Topical Group meeting, St. Petersburg, July 2003
Halo currents distribution

- Moderate currents flow outside divertor
- Quite symmetric in toroidal direction on time scales > 1 ms
- Toroidal asymmetries by factor 4 observed on very short time scales (0.2 ms)
most of the disruption power is radiated in divertor region

☐ Most of the energy deposited on the divertor plates during thermal quench is conducted/convected.

☐ Most of the energy deposited on the divertor plates during current quench is radiated.
Langmuir probes measure strong ion flux during current quench

- largest ion fluxes on top end of divertor
- quiet phase in lower part of divertor between thermal and final quench
- strong ion fluxes during current quench suggest convective/conductive load

![Graph showing ion flux measurements](image-url)
comparison of Isat and thermography during energy and current quench

- absence of ion flux in upper div suggests dominant radiation there during this phase
- clear correlation of ion flux and power footprint in lower part
- strong ion fluxes in upper part during current quench - not all radiative load

outer strike point moves downward

#13540 ; time - 4.518 s

#13540 ; time - 4.526 s
Conclusions on disruptions in ASDEX Upgrade divertors II + II-b

- The time history of the power deposition on the lower divertor plate may change from shot to shot.

- The thermal quench phase lasts 2-3 ms.

- The power profile is broad and extends outside of the divertor plates.

- The energy balance is consistent within the uncertainties.

- An amount of energy equivalent and larger than the thermal energy of the pre-disruptive plasma is found on the divertor during the thermal quench. This energy is mostly deposited by convection and conduction.

- Up to 45% of the total energy of the plasma is found on the divertor plates. Most of it is deposited as radiation.

- The divertor plates are rather uniformly loaded with power (on a time scale ≥ 4 ms).