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Plsma heating on MHz θ Pinch Bp Fuel Engine

MHz θ ピンチエンジンにおけるプラズマ加熱

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Tokamaku type fusion heating is difficullt. For primary coil magnetic flux Φ, $e=-\partial\Phi/\partial t$ is not sufficient to produce enogh Jule heating.

New coil MHz magnetic field make $J \times B$ acceleration every cycle. High temperature plasma ions could be accelerrated by the MHz magnetic field of the new coil. Jule heat at accleration place of snowplow is small.
For electron velocity v_e and ion velocity v_i, $u=v_i-v_e=3\times10^7$m/s is easy. In this condition, electron resistance is small.

Energy increase rate for one ion

$$\langle d\varepsilon/dt\rangle = \{-u^*(qq^*)^2 \ln\Lambda/4\pi\varepsilon_0{}^2 m_r u^3\}(V\cdot n)=2\times10^{-12}\mathrm{J/s}$$

is very small, where $m_r=m_e m_i/(m_e+m_i)$, $V=(m_e v_e+m_i v_i)/(m_e+m_i)$.

Accelerated ions and electrons are pinched eachother at center of plasma container.

The coil is the bundle of electric resonance elements. The element is a capacity and a all coated fine wire one loop. The bundle has first mode when excited with MHz current of resonance frequency. The excited mode current of each element is almost same amplitude. And the current phases of the element is preciesly same between each other so that strong stable MHz field is obtained.

0.1m plasma cylinder container rasius, 0.1m cylinder width, with 0.2m rudius systemmagnetic field shield coil or sheat metal, is considered.

Snowploud lasma of 1×10^{16}/m^3 density is accelerated to 2,699,510m/s.

Snowploud plasma Is compressed graduarlly at center,so that plasma is compressed adiabatically. And it is assumed that the plasma is ideal gas.
Plasma is compressed with constant pressure by pinch magnetic field pressure and reversible adiavatic change.
Snowplow plasma temp 0.0047ev,temperatre before pinch:T_{gc}=0.1ev,density before pinch:n_{gc}=1.38/m^3,max density:n_2=200,000/337.5$\times n_{gc}$=5.75$\times10^{30}$/m^3.
Mean free path of pinch plasma is

$$\lambda_{ii2}=1.2\times10^{-4}Z^{-4}T_2{}^2/(n_2 10^{-20})=1.33\times10^{-7}\mathrm{m}$$

Z:boron ion electrons charge number:5, T_2:200,000ev.

Out put efficiency is

$$\eta_s=(P_{out}-W_b-W_c-W_v-W_j-W_c)P_{out}=0.698$$

where output power is

$P_{out}=n_B n_p\langle v*\sigma\rangle E\times1.6\times10^{-19}\Delta t f_s(\varepsilon V)/1000=276.2$kw

where n_B:boron density and n_p:hydrogen $n_B=n_p=n_2$, v:ion velocity at pinch, σ:nuclear fusion cross section, E:fusion release energy 8.7Mev, Δt:pinch time which is determined plasma acceralation from expanded state to required plasma speed to produce fusion heat, f_s:pinch repitition per sec, V:expanded plasma volume, ε:compression rate.

Bramaatrahlung radiation

$$W_b=1.7\times10^{-38}Zn_e^2T_e^{1/2}V_2\Delta t_p f_0=12\text{kw}$$

synchrotron radiation

$$W_c=e^4v_\perp^2B_{p2}^2/\{6\pi\varepsilon_0c^2m^2(1-v^2/c^2)\}\times V_2\Delta t_p f_0=11.7\text{kw}$$

Where n_e:pinch plasma electron density $7.4\times10^{26}/\text{m}^3$, T_e:pinch plasma temperature 200,000ev. V_2:pinch plasma volume $=5.45\times10^{-18}\text{m}^3$, Δt_p:pinch time 3.08×10^{-13}sec, f_0:MHz θ pinch cycle 5.921,034cycle.

Coil Jule loss $W_J=0.2$kw, coil fine wire voltex loss $W_v=3.9$kw. Capacity part loss W_c is made of fine wires array sheets and air gaps.

Ref.1 and 2 shows example for torus type plasma vessel. The vessels are changed to the combination of linear cylinder plasma vessel so that the MHz θ are made compleatly as shown in Fig.1.

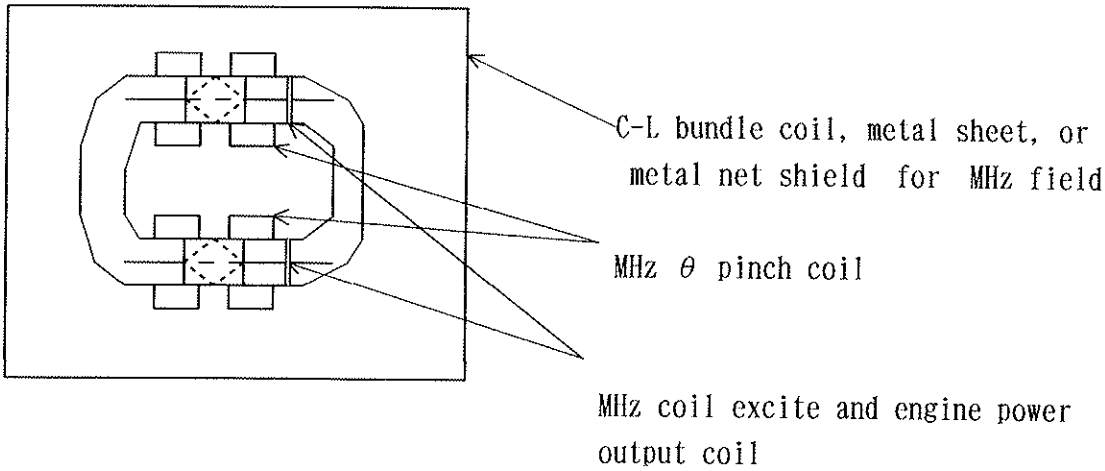

Fig.1

Ref.1; 電学論B、110巻12号p1013, ELECTRICAL ENGINEERING IN JAPANJ, Vol11, No.4, 1991, p52

Ref.2; JPFR, Vol60, No9(1993), pp.1062-107

Ref.3; 先の予稿集