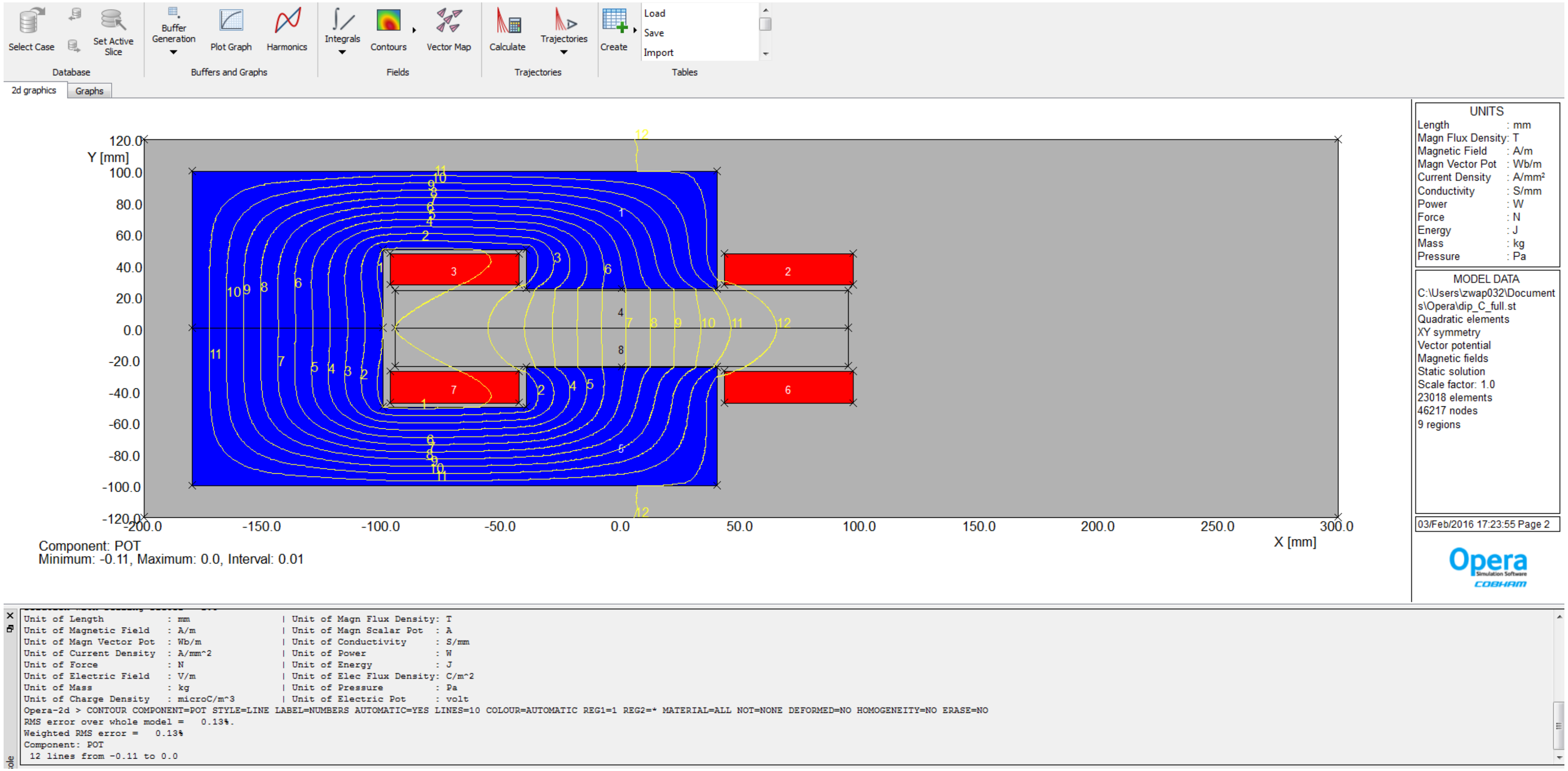
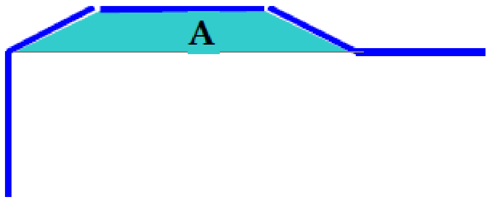

Select Case
Set Active Slice
Database
Buffer Generation
Plot Graph
Harmonics
Buffers and Graphs
Integrals
Contours
Vector Map
Fields
Calculate
Trajectories
Trajectories
Create
Load
Save
Import
Tables
2d graphics
Graphs
Y [mm]
X [mm]
Component: POT
Minimum: -0.11, Maximum: 0.0, Interval: 0.01
UNITS
Length : mm
Magn Flux Density: T
Magnetic Field : A/m
Magn Vector Pot : Wb/m
Current Density : A/mm²
Conductivity : S/mm
Power : W
Force : N
Energy : J
Mass : kg
Pressure : Pa
MODEL DATA
C:\Users\zwap032\Documents\Opera\dip_C_full.st
Quadratic elements
XY symmetry
Vector potential
Magnetic fields
Static solution
Scale factor: 1.0
23018 elements
46217 nodes
9 regions
03/Feb/2016 17:23:55 Page 2
Opera
COBHAM
Unit of Length : mm | Unit of Magn Flux Density: T
Unit of Magnetic Field : A/m | Unit of Magn Scalar Pot : A
Unit of Magn Vector Pot : Wb/m | Unit of Conductivity : S/mm
Unit of Current Density : A/mm^2 | Unit of Power : W
Unit of Force : N | Unit of Energy : J
Unit of Electric Field : V/m | Unit of Elec Flux Density: C/m^2
Unit of Mass : kg | Unit of Pressure : Pa
Unit of Charge Density : microC/m^3 | Unit of Electric Pot : volt
Opera-2d > CONTOUR COMPONENT=POT STYLE=LINE LABEL=NUMBERS AUTOMATIC=YES LINES=10 COLOUR=AUTOMATIC REG1=1 REG2=* MATERIAL=ALL NOT=NONE DEFORMED=NO HOMOGENEITY=NO ERASE=NO
RMS error over whole model = 0.13%.
Weighted RMS error = 0.13%
Component: POT
12 lines from -0.11 to 0.0

Typical pole designs

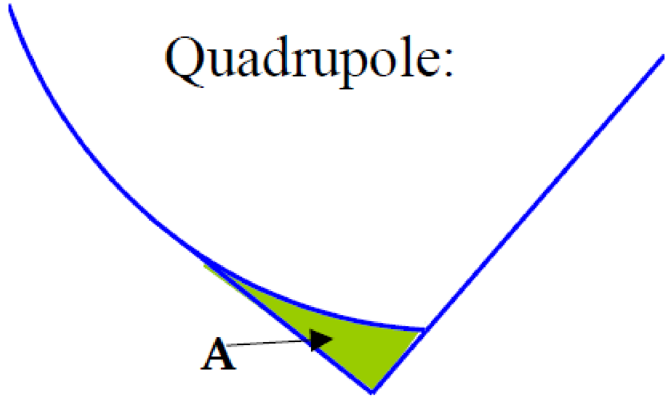
To compensate for the non-infinite pole, shims are added at the pole edges. The area and shape of the shims determine the amplitude of error harmonics which will be present.

Dipole:



The designer optimises the pole by 'predicting' the field resulting from a given pole geometry and then adjusting it to give the required quality.

Quadrupole:



When high fields are present, chamfer angles must be small, and tapering of poles may be necessary

Magnet geometry

Dipoles can be ‘C core’ ‘H core’ or ‘Window frame’

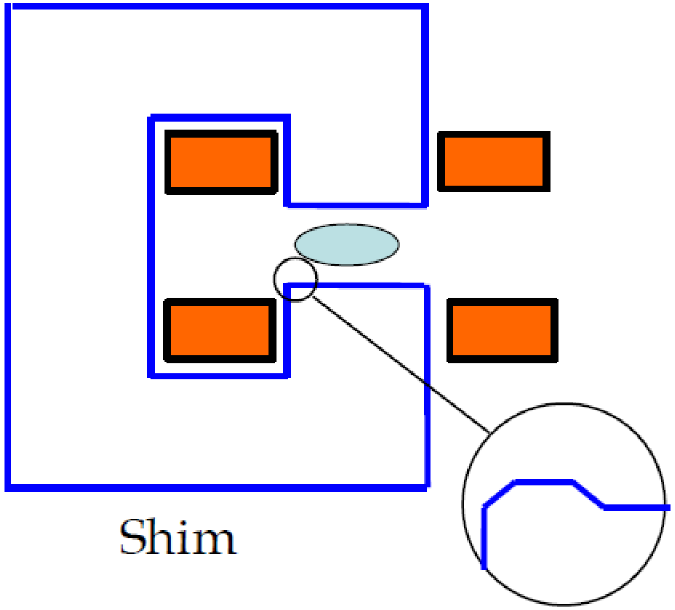
"C' Core:

Advantages:

- Easy access;
- Classic design;

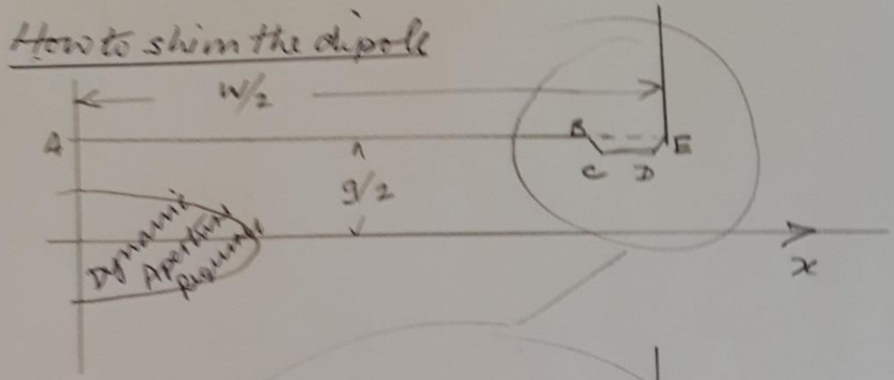
Disadvantages:

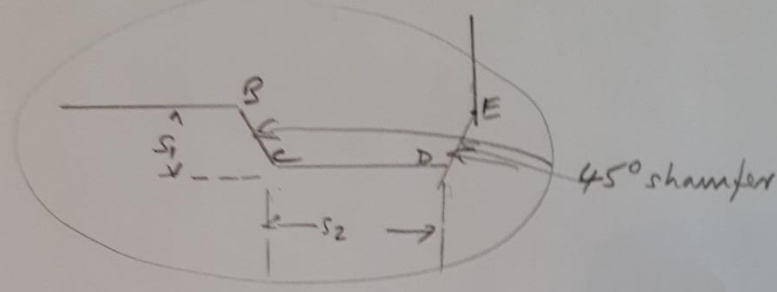
- Pole shims needed;
- Asymmetric (small);
- Less rigid;

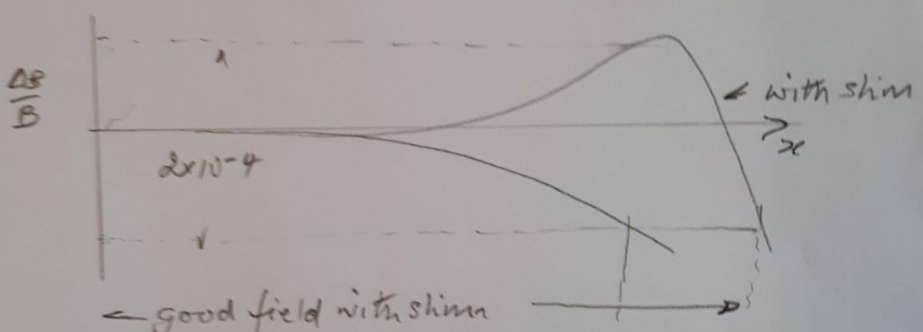


The ‘shim’ is a small, additional piece of fero-magnetic material added on each side of the two poles – it compensates for the finite cut-off of the pole, and is optimised to reduce the 6, 10, 14...... pole error harmonics.

How to shim the dipole







① Write small program to give coordinates of B, C, D, E as a function of S_1 and S_2. (also include W and g in the calculation)

② Input BCDE coords in to Opera and calculate $\Delta B/x$.

③ Optimise BCDE ie S_1, S_2 to get max good field

④ reduce W so good field matches Dynamic Aperture

⑤ Reduce g and repeat ① to ④

The Cockcroft Institute
of Accelerator Science and Technology

'Residual' fields

Residual field - the flux density in a gap at $I = 0$;

Remnant field B_R - value of B at $H = 0$;

Coercive force H_C - negative value of field at $B = 0$;

I = 0: $\int H.ds = 0$;

So: $(H_{steel})\,\lambda + (H_{gap})g = 0$;

$B_{gap} = (\mu_0)(-H_{steel})(\lambda/g)$;

$B_{gap} \approx (\mu_0)\,(H_C)(\lambda/g)$;

Where: λ is path length in steel;

g is gap height.

Because of presence of gap, residual field i
determined by coercive force H_C (A/m)
and <u>not</u> remnant flux density B_R (Tesla).