

FIRE
TF
Parametric
Analysis

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5/31/00

Objective

- Quantify TF performance with BeCu and Cu using simple model to guide choice of conductor material and peak field

Method

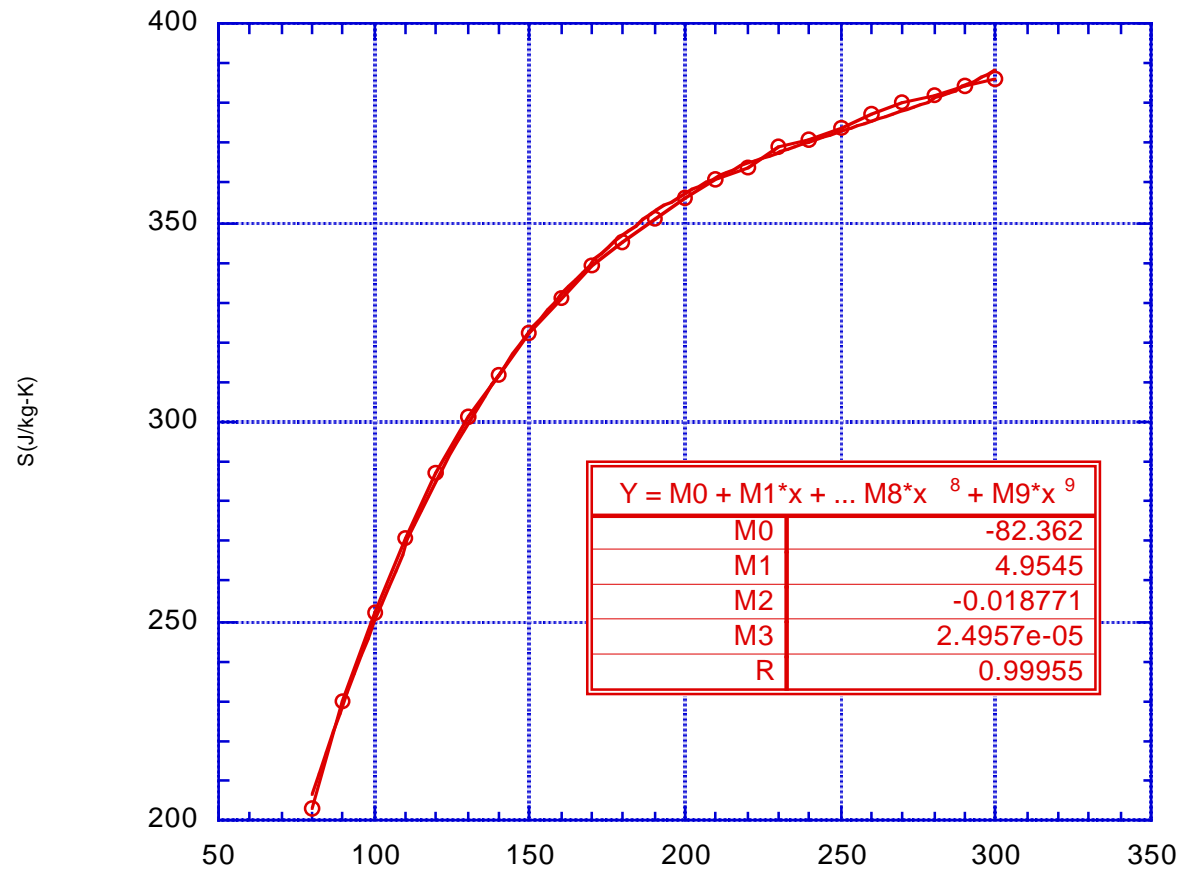
- Spreadsheet model
 - Include BeCu and Cu specific heat and resistance variation with T
 - Include nuclear heating
 - Neglect non-uniform current density effects

Modeling

- Coil dimensions from T Brown
- Inductance from R Woolley (TFCUR model) but confirmed by spreadsheet calculation
- BeCu (C17510) and Cu (pure) specific heat and resistivity data from NIST Monograph 177, “Properties of Copper and Copper Alloys at Cryogenic Temperatures”

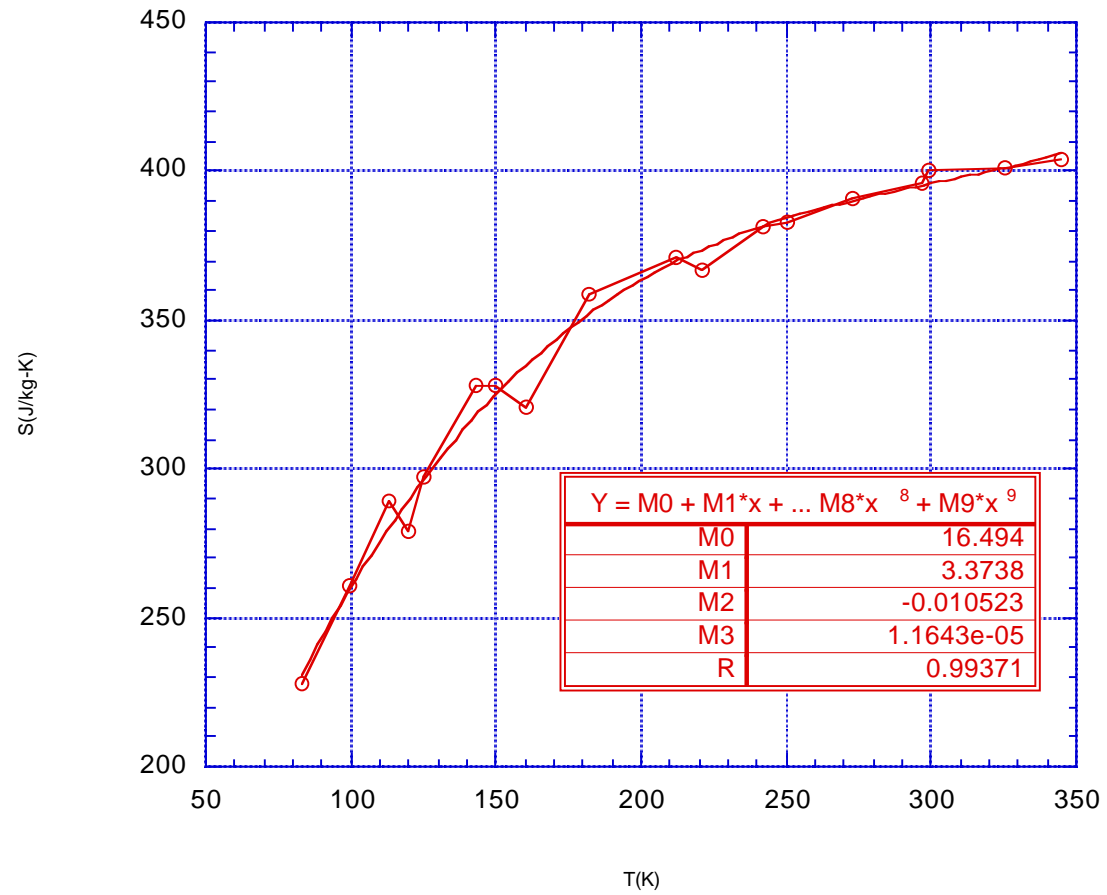
—○— S(J/kg-K)

Cu Specific Heat

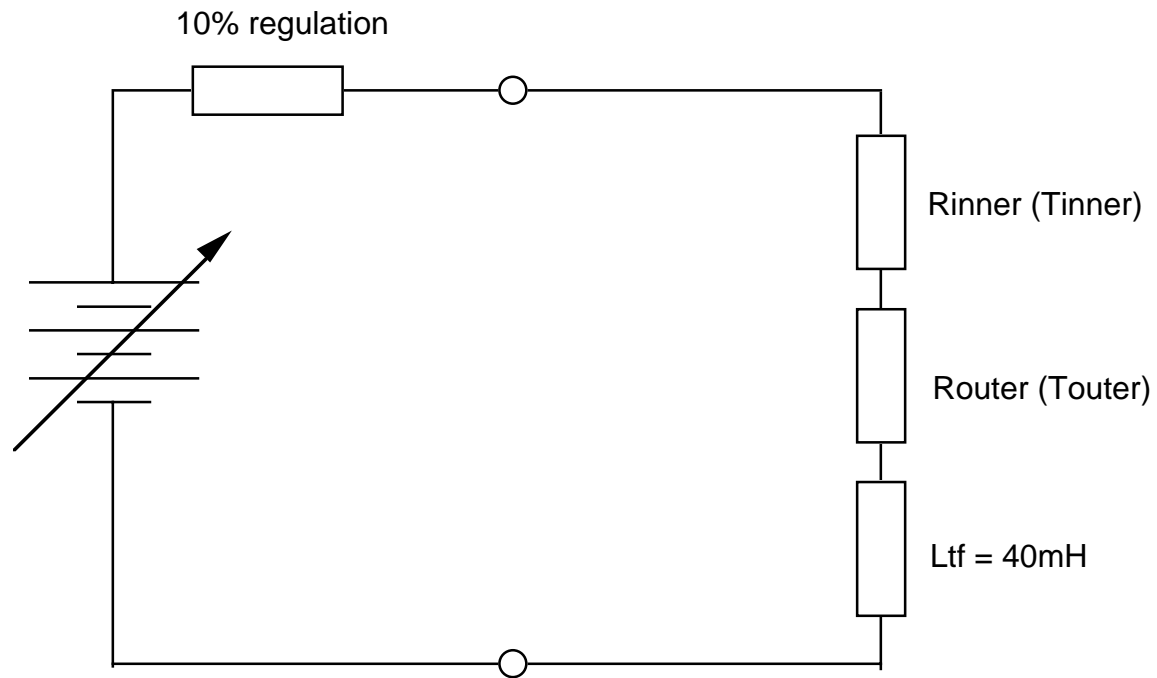


—○— S(J/kg-K)

BeCu Specific Heat



ELECTRICAL CIRCUIT



Calculation

- Simple Euler integration $\Delta I_i = (V_i - I_{i-1} * R_{i-1}) * \Delta t / L$ with $R(T)$ and ΔT (dissipation, specific heat (T_i))
- PS Voltage set to full during current rise, set to $V = IR$ during flat top, set to 0 during current fall
- EOFT declared when inner leg T and stored magnetic energy such that L/R decay will lead to max allowable T (assumed 370C)
- Nuclear heating set to 30MW, applied to inner legs
- Added PF and Heating power to TF power, $PF(Bt(I_p))$

SPREADSHEET I/O

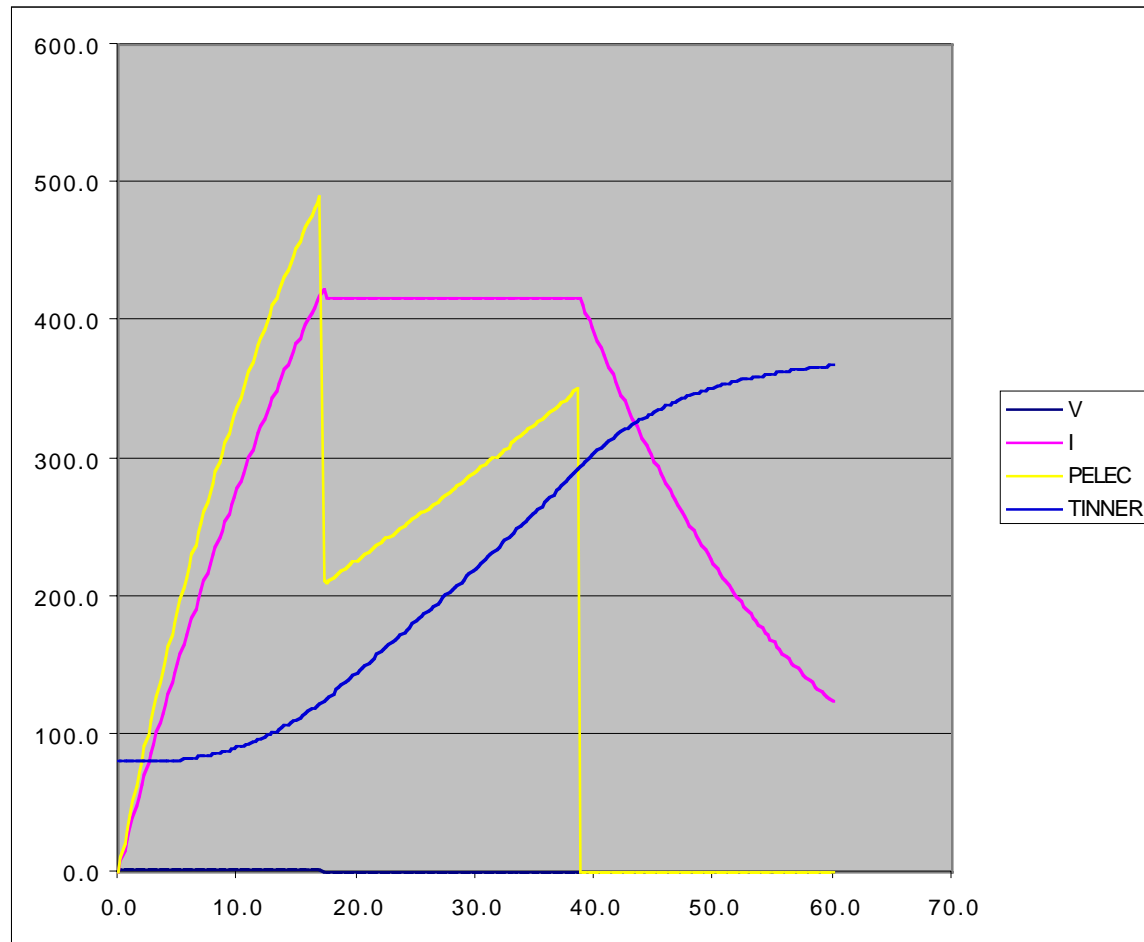
LINNER	3.74806	m
AINNER	0.012419	m ²
VINNER	0.046547157	m ³
DINNER	8750	kg/m ³
MINNER	407.287625	kg
RES293INNER	2.53E-08	ohm-m
COEFFINNER	0.0025	1/degK
M0INNER	16.4940	
M1INNER	3.3738	
M2INNER	-0.0105	
M3INNER	1.1643E-05	
RINNER293	7.6338E-06	ohm
LOUTER	5.8261	m
AOUTER	0.0218	m ²
VOUTER	0.1272	m ³
DOUTER	8940.0000	kg/m ³
MOUTER	1137.1498	kg
RES293OUTER	1.7200E-08	ohm-m
COEFFOUTER	0.0041	1/degK
M0OUTER	-82.3620	
M1OUTER	4.9545	
M2OUTER	-0.0188	
M3OUTER	2.4957E-05	
ROUTER293	4.5899E-06	ohm

URNS/COIL	15.0000	
COILS	16.0000	
TURNS	240.0000	
R0	2.0000	m

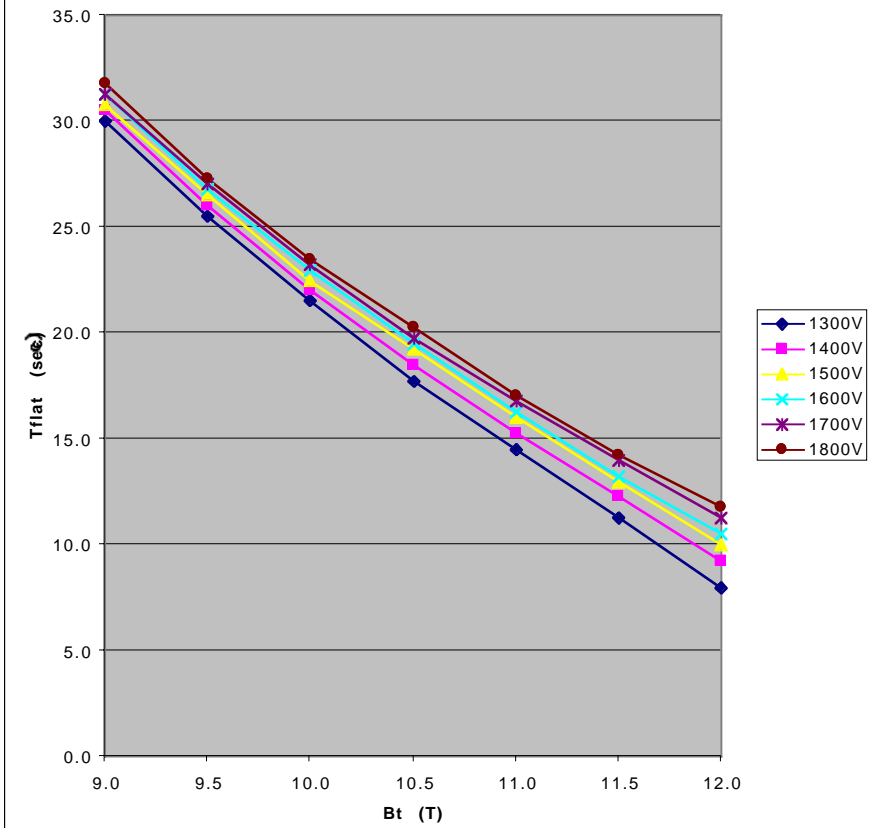
%IACSINNER	68	%
TMAX	370	degK
B(R0)	10	T
VNL	1300	volt
REG	10	%
PNUCINNER	30.0	MW
PPF@10T/6.4MA	250.0	MW
PAUX	60.0	MW

PMAXTF=	489.8	MW
PPEAKTOT	799.8	MW
DTRAMP=	17.3	sec
DTFLAT=	21.5	sec
WDISS=	11.1	GJ

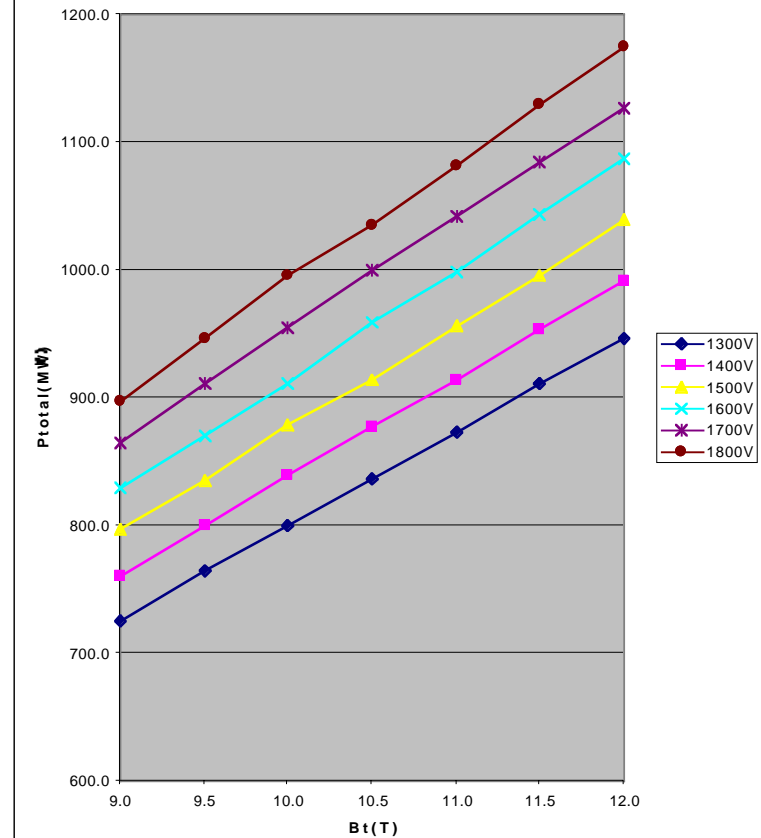
BeCu Coil (1.3kV, 10T w/NH)



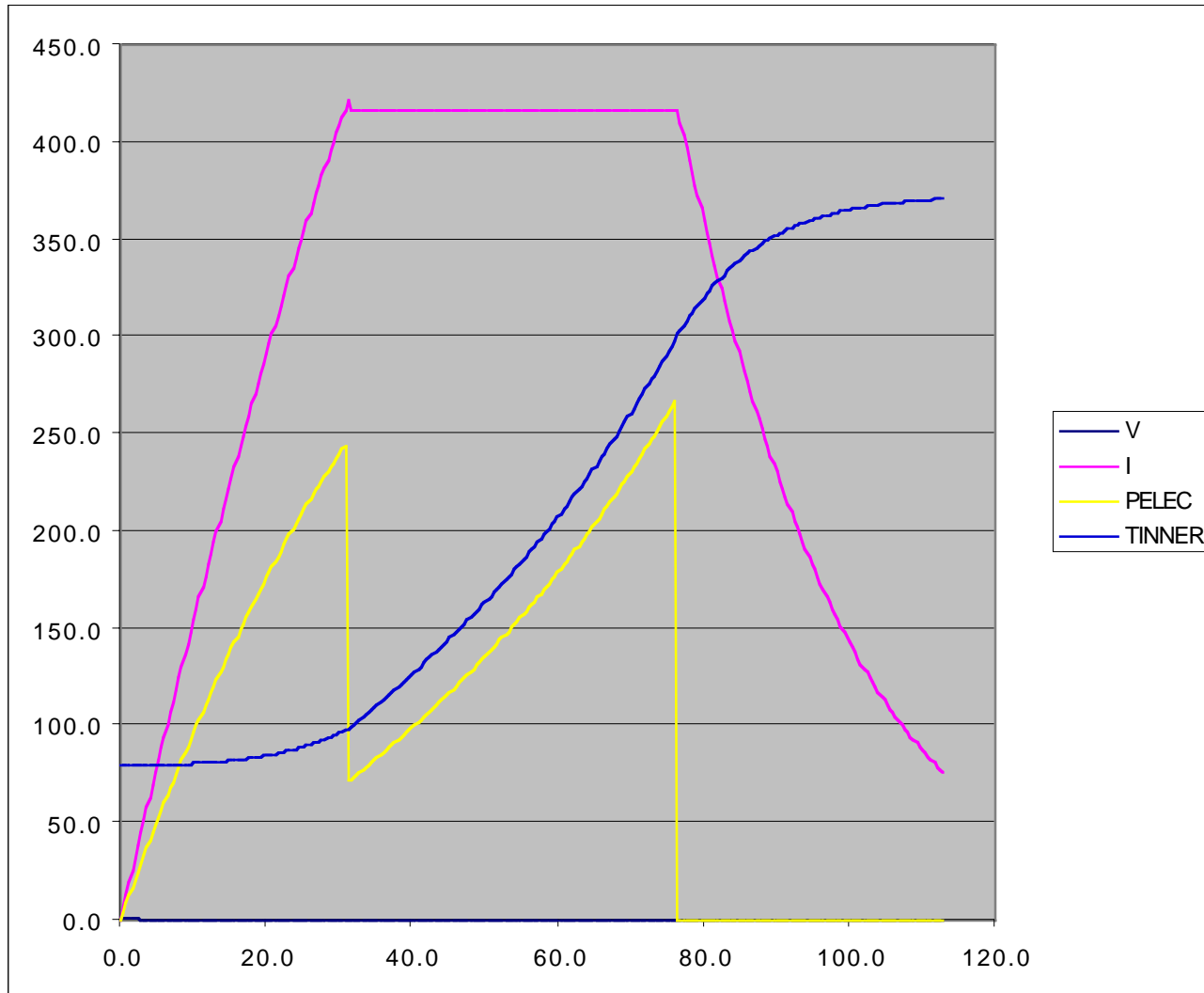
BeCu Tflat vs. Bt vs. Vnl



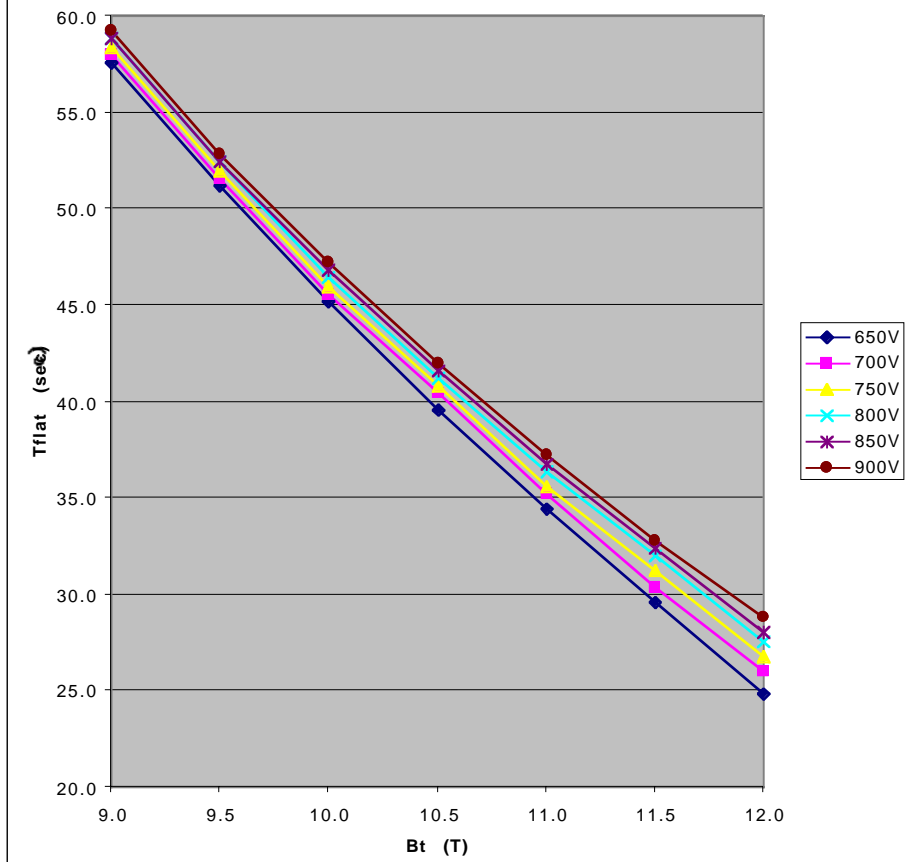
BeCu Ptot vs. Bt vs. Vnl



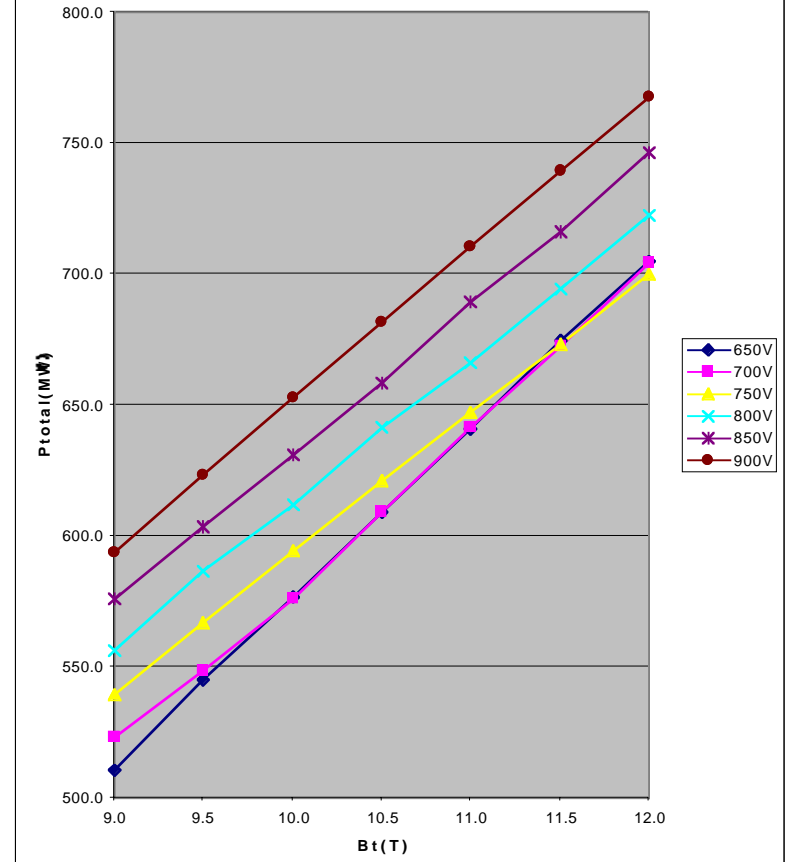
Cu Coil (0.65kV, 10T w/NH)



Cu Tflat vs. Bt vs. Vnl



Cu Ptot vs. Bt vs. Vnl



Summary of Data

	BeCu						Cu			
Conductivity	77	77	68	68	68	68	100	100	100	100
Bt	10	10	10	10	12	12	10	10	11.5	11.5
Nuc Heat	0	30	0	30	0	30	0	30	0	30
PT Flat top	31	21		18.5		12				
CN Flat top	29	25	24	21	8	9	60	45	36	30
Ptf	490	490	490	490	587	587	276	266	334	327

Conclusions

- All Cu design improves performance, reducing peak TF power requirement by ~ factor of 2 while increasing flat top ~ factor of 2 @ 10T, factor of 3 @ upgrade level (~ 12T)
- All Cu design would reduce AC/DC converter cost by ~ \$25M
- All Cu design would improve chances of powering FIRE exclusively from grid, and then saving another ~ \$30M