

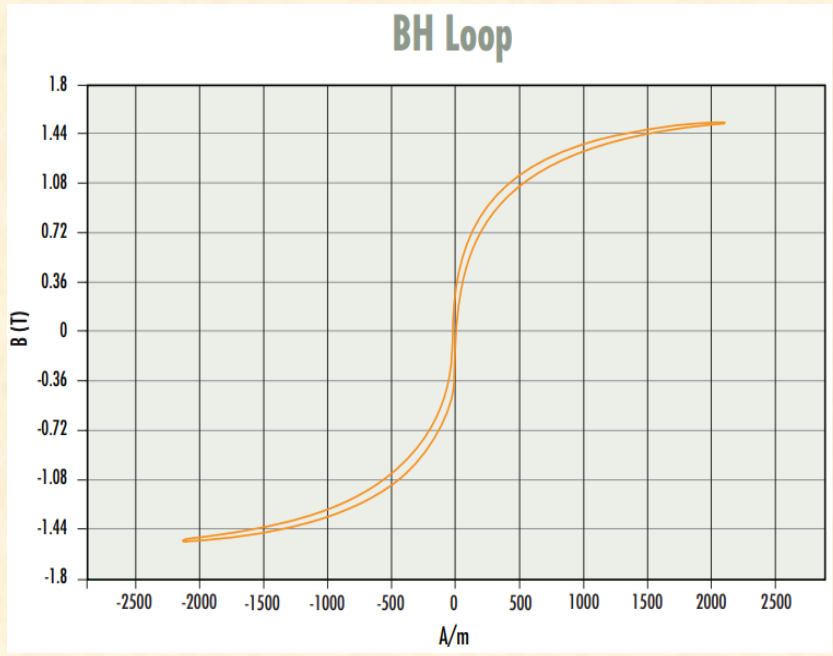
ANALYSIS OF SATURATION FLUX DENSITY AND MAXIMUM CURRENT IN DC INDUCTOR WITH GAPPED CORE

1. INITIAL DATA

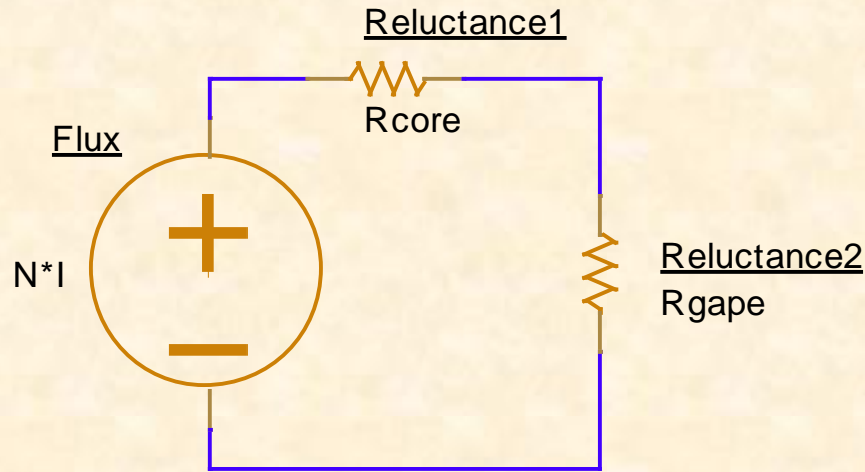
- Core: Metglas amorphous core AMCC25
- BH curve and derived permeability table:
- Number of turns N: 40
- Gap length l_g : $1.5 \cdot 10^{-3}$ meter
- Mean magnetic path l_m : 0.196 meter
- Core area: A_e : $2.7 \cdot 10^{-4}$ sq. meter
- $\mu_{gap} = \mu_o = 1.26 \cdot 10^{-6}$ H/m

2. DERIVE B(T), H(A/M) AND PERMEABILITY VALUES FROM BH CURVE GIVEN IN MANUFACTURER DATA

| B, T | H, A/M | μ_{core} , H/m |
|-------|--------|--------------------|
| 0.58 | 100 | 0.0058 |
| 0.7 | 165 | 0.004242 |
| 0.75 | 200 | 0.00375 |
| 0.87 | 300 | 0.0029 |
| 0.98 | 400 | 0.00245 |
| 1.075 | 500 | 0.00215 |
| 1.145 | 600 | 0.001908 |
| 1.19 | 700 | 0.0017 |
| 1.23 | 800 | 0.001538 |
| 1.285 | 900 | 0.001428 |
| 1.33 | 1000 | 0.00133 |
| 1.37 | 1100 | 0.001245 |
| 1.39 | 1200 | 0.001158 |
| 1.415 | 1300 | 0.001088 |
| 1.44 | 1400 | 0.001029 |
| 1.46 | 1500 | 0.000973 |
| 1.48 | 1600 | 0.000925 |
| 1.5 | 1700 | 0.000882 |



3. EQUIVALENT MAGNETIC CIRCUIT OF THIS GAPPED CORE



3.1. CALCULATE CORE AND GAP RELUCTANCES

$$R_{core} = l_m / (\mu_{core} * A_e)$$

Core reluctance change following permeability values from the table above.

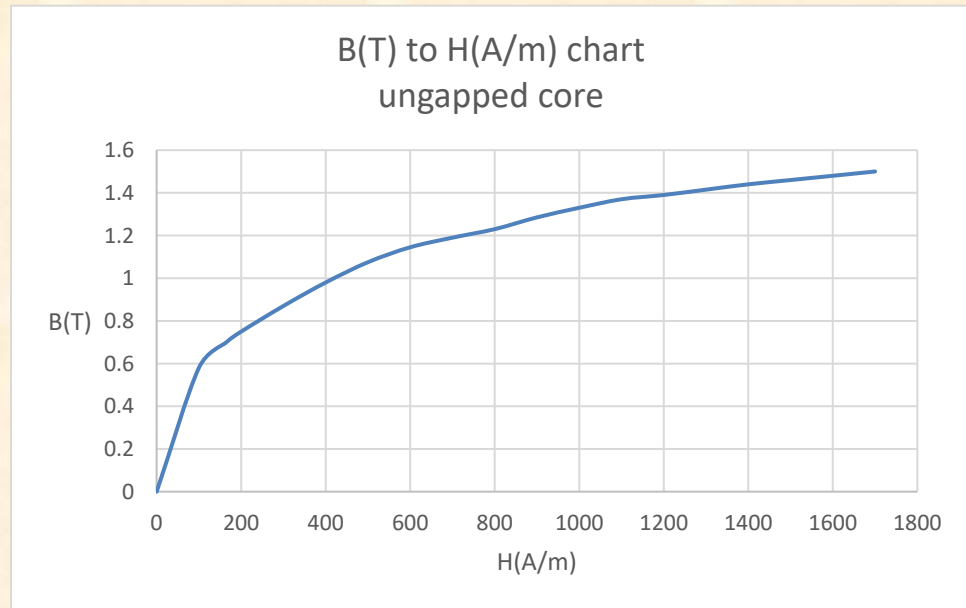
$$R_{gap} = l_g / (\mu_{gap} * A_e) = 1.5 * 10^{-3} / (1.26 * 10^{-6} * 2.7 * 10^{-4}) = 4.42 * 10^6 \text{ H}^{-1}$$

| B, T | H, A/M | μ_{core} | μ_{rel} | R_{core} | $R_{core} + R_{gap}$ |
|-------|--------|--------------|-------------|------------|----------------------|
| 0.58 | 100 | 0.0058 | 4614 | 125160 | 4544854 |
| 0.7 | 165 | 0.004242 | 3375 | 171111 | 4590805 |
| 0.75 | 200 | 0.00375 | 2983 | 193580 | 4613274 |
| 0.87 | 300 | 0.0029 | 2307 | 250319 | 4670013 |
| 0.98 | 400 | 0.00245 | 1949 | 296296 | 4715990 |
| 1.075 | 500 | 0.00215 | 1710 | 337640 | 4757334 |
| 1.145 | 600 | 0.001908 | 1518 | 380398 | 4800092 |
| 1.19 | 700 | 0.0017 | 1352 | 427015 | 4846709 |
| 1.23 | 800 | 0.001538 | 1223 | 472147 | 4891841 |
| 1.285 | 900 | 0.001428 | 1136 | 508431 | 4928125 |
| 1.33 | 1000 | 0.00133 | 1058 | 545809 | 4965503 |
| 1.37 | 1100 | 0.001245 | 991 | 582860 | 5002554 |
| 1.39 | 1200 | 0.001158 | 922 | 626699 | 5046393 |
| 1.415 | 1300 | 0.001088 | 866 | 666928 | 5086623 |
| 1.44 | 1400 | 0.001029 | 818 | 705761 | 5125455 |
| 1.46 | 1500 | 0.000973 | 774 | 745814 | 5165508 |
| 1.48 | 1600 | 0.000925 | 736 | 784785 | 5204479 |
| 1.5 | 1700 | 0.000882 | 702 | 822716 | 5242410 |

4. BH CURVES, UNGAPPED AND GAPPED

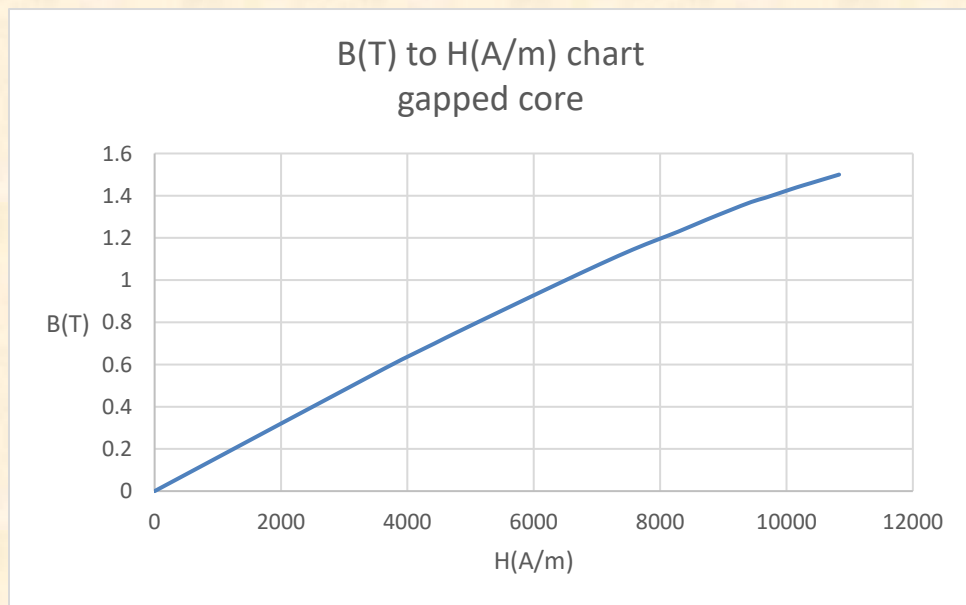
4.1. UNGAPPED BH CURVE

| H, A/M | B, T |
|--------|-------|
| 0 | 0 |
| 100 | 0.58 |
| 165 | 0.7 |
| 200 | 0.75 |
| 300 | 0.87 |
| 400 | 0.98 |
| 500 | 1.075 |
| 600 | 1.145 |
| 700 | 1.19 |
| 800 | 1.23 |
| 900 | 1.285 |
| 1000 | 1.33 |
| 1100 | 1.37 |
| 1200 | 1.39 |
| 1300 | 1.415 |
| 1400 | 1.44 |
| 1500 | 1.46 |
| 1600 | 1.48 |
| 1700 | 1.5 |



4.2. GAPPED BH CURVE, 1.5MM GAP

| H, A/M | B, T |
|--------|-------|
| 0 | 0 |
| 3631 | 0.58 |
| 4432 | 0.7 |
| 4766 | 0.75 |
| 5597 | 0.87 |
| 6367 | 0.98 |
| 7045 | 1.075 |
| 7571 | 1.145 |
| 7945 | 1.19 |
| 8289 | 1.23 |
| 8724 | 1.285 |
| 9098 | 1.33 |
| 9441 | 1.37 |
| 9663 | 1.39 |
| 9915 | 1.415 |
| 10167 | 1.44 |
| 10389 | 1.46 |
| 10611 | 1.48 |
| 10833 | 1.5 |



5. MAXIMUM MAGNETIZING CURRENT TO FLUX DENSITY CURVES

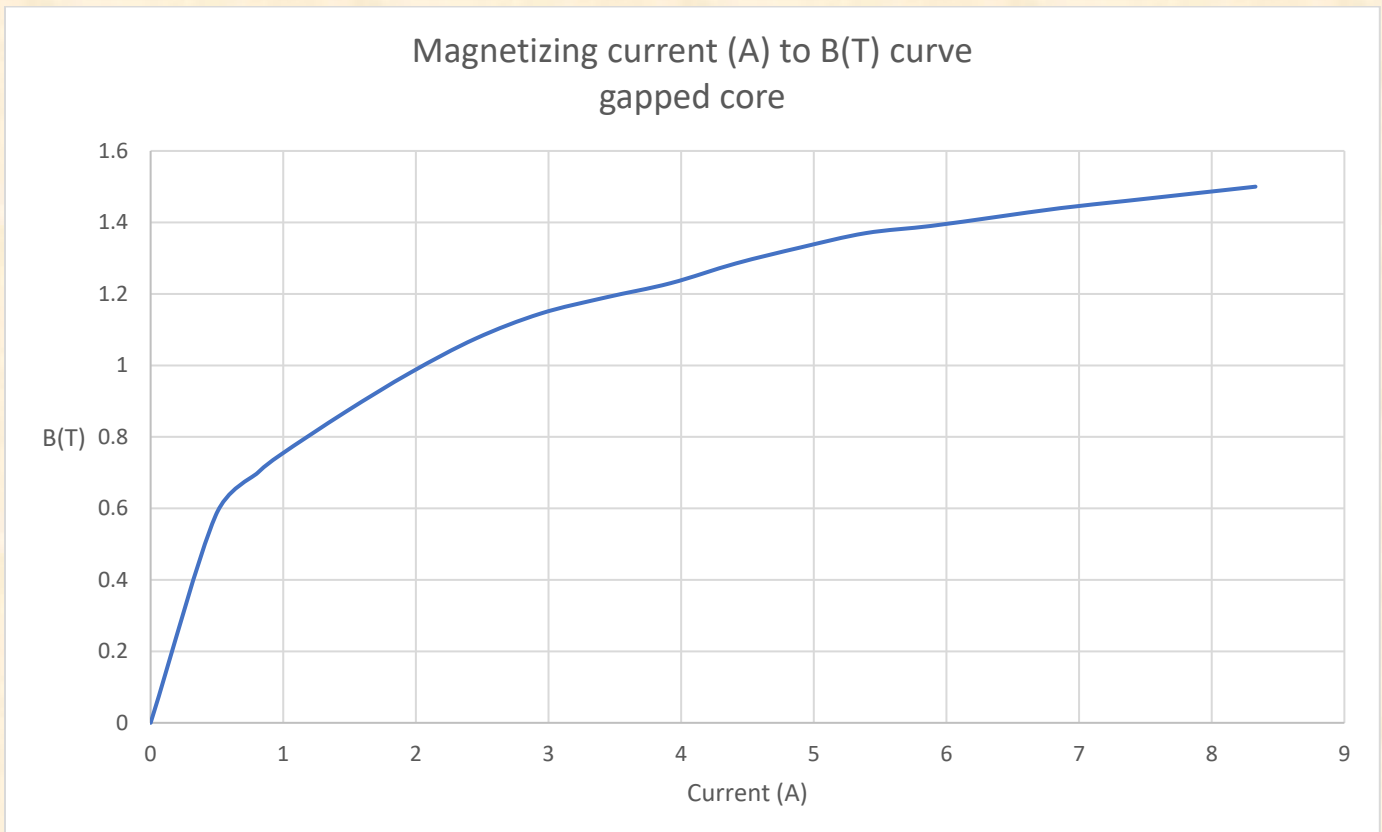
From the circuit model above:

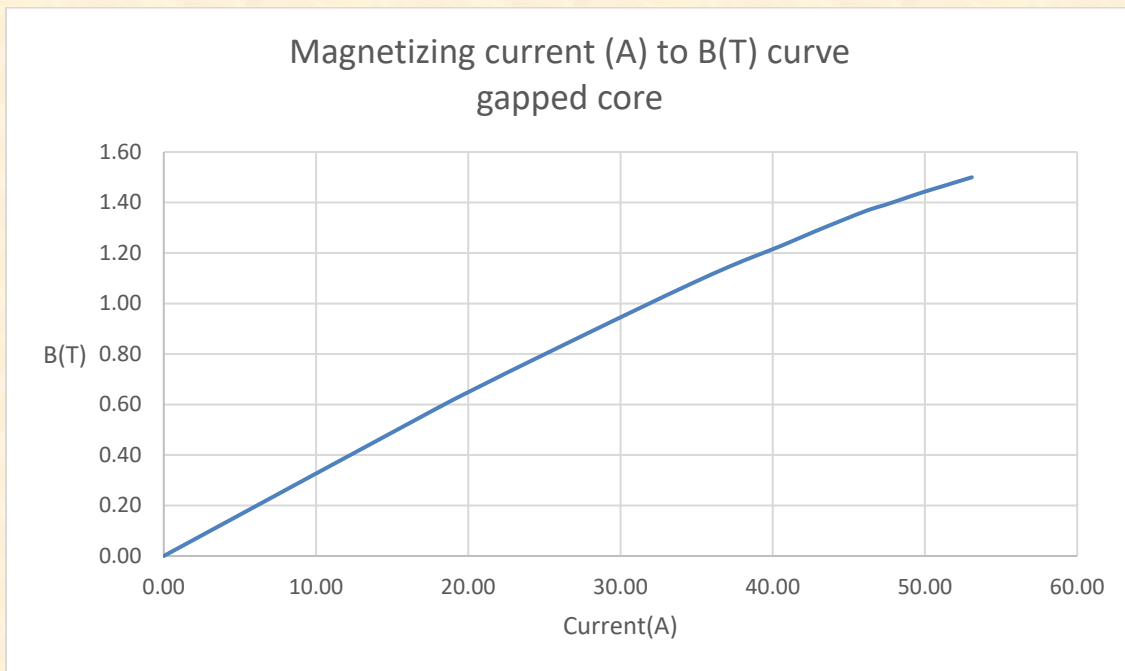
$$N \cdot I = \text{Flux} \cdot (R_{\text{core}} + R_{\text{gap}}) = B \cdot A \cdot (R_{\text{core}} + R_{\text{gap}})$$

$$R_{\text{gap}} = 4.42 \cdot 10^6 \text{ H}^{-1}$$

$$I = B \cdot A \cdot (R_{\text{core}} + R_{\text{gap}}) / N$$

| B, T | H, A/M | R _{core} | R _{core} +R _{gap} | I, A |
|------|--------|-------------------|-------------------------------------|------|
| 0.58 | 100 | 125160 | 4544853.8 | 17.8 |
| 0.70 | 165 | 171111 | 4590805.3 | 21.7 |
| 0.75 | 200 | 193580 | 4613274.4 | 23.4 |
| 0.87 | 300 | 250319 | 4670013.4 | 27.4 |
| 0.98 | 400 | 296296 | 4715990.5 | 31.2 |
| 1.08 | 500 | 337640 | 4757334.1 | 34.5 |
| 1.15 | 600 | 380398 | 4800092 | 37.1 |
| 1.19 | 700 | 427015 | 4846709.4 | 38.9 |
| 1.23 | 800 | 472147 | 4891841.1 | 40.6 |
| 1.29 | 900 | 508431 | 4928124.8 | 42.7 |
| 1.33 | 1000 | 545809 | 4965503.1 | 44.6 |
| 1.37 | 1100 | 582860 | 5002554.4 | 46.3 |
| 1.39 | 1200 | 626699 | 5046392.8 | 47.3 |
| 1.42 | 1300 | 666928 | 5086622.6 | 48.6 |
| 1.44 | 1400 | 705761 | 5125455.5 | 49.8 |
| 1.46 | 1500 | 745814 | 5165508.5 | 50.9 |
| 1.48 | 1600 | 784785 | 5204478.9 | 52.0 |
| 1.50 | 1700 | 822716 | 5242410.2 | 53.1 |





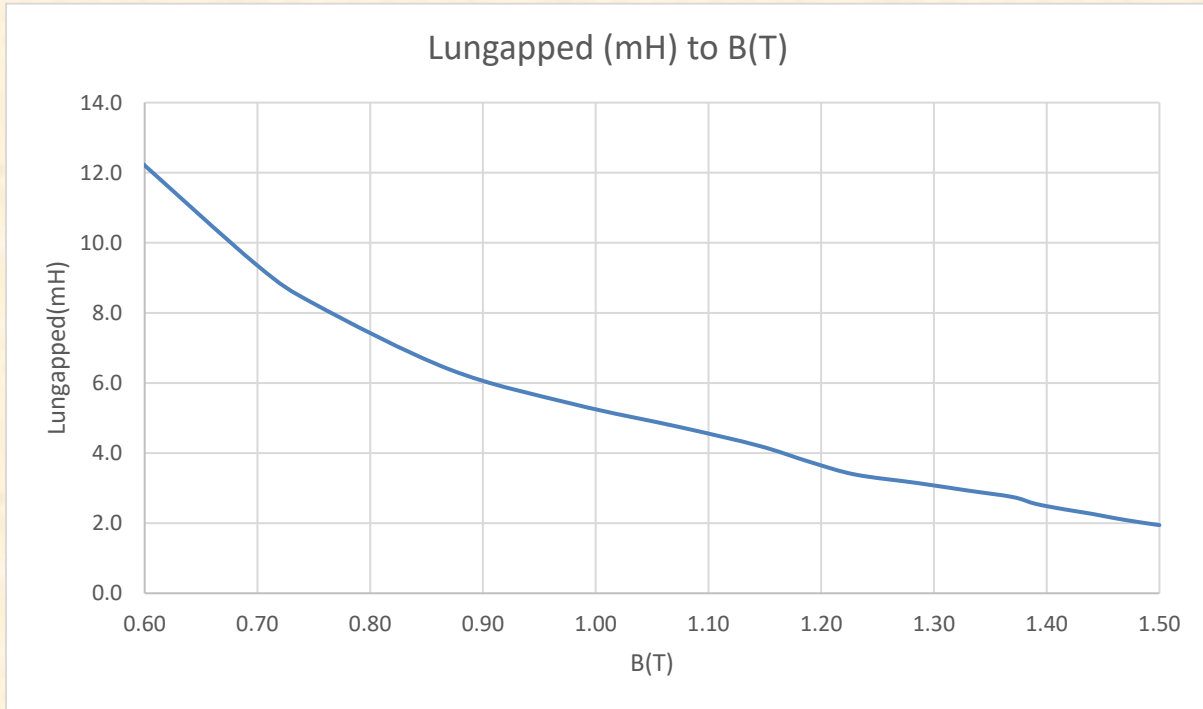
6. INDUCTANCE OF UNGAPPED AND GAPPED CORES CALCULATIONS

Inductance $L_{ungapped} = N^2 / R(\text{reluctance}) = N^2 / R_{core}$

Inductance $L_{gapped} = N^2 / R(\text{reluctance}) = N^2 / (R_{core} + R_{gap})$

| B, T | H, A/M | R _{core} | R _{core} +R _{gap} | I, A | L _{ungapped} (mH) | L _{gapped} (uH) |
|------|--------|-------------------|-------------------------------------|------|----------------------------|--------------------------|
| 0.58 | 100 | 125160 | 4544853.8 | 17.8 | 12.8 | 352 |
| 0.70 | 165 | 171111 | 4590805.3 | 21.7 | 9.4 | 349 |
| 0.75 | 200 | 193580 | 4613274.4 | 23.4 | 8.3 | 347 |
| 0.87 | 300 | 250319 | 4670013.4 | 27.4 | 6.4 | 343 |
| 0.98 | 400 | 296296 | 4715990.5 | 31.2 | 5.4 | 339 |
| 1.08 | 500 | 337640 | 4757334.1 | 34.5 | 4.7 | 336 |
| 1.15 | 600 | 380398 | 4800092 | 37.1 | 4.2 | 333 |
| 1.19 | 700 | 427015 | 4846709.4 | 38.9 | 3.7 | 330 |
| 1.23 | 800 | 472147 | 4891841.1 | 40.6 | 3.4 | 327 |
| 1.29 | 900 | 508431 | 4928124.8 | 42.7 | 3.1 | 325 |
| 1.33 | 1000 | 545809 | 4965503.1 | 44.6 | 2.9 | 322 |
| 1.37 | 1100 | 582860 | 5002554.4 | 46.3 | 2.7 | 320 |
| 1.39 | 1200 | 626699 | 5046392.8 | 47.3 | 2.6 | 317 |
| 1.42 | 1300 | 666928 | 5086622.6 | 48.6 | 2.4 | 315 |
| 1.44 | 1400 | 705761 | 5125455.5 | 49.8 | 2.3 | 312 |
| 1.46 | 1500 | 745814 | 5165508.5 | 50.9 | 2.1 | 310 |
| 1.48 | 1600 | 784785 | 5204478.9 | 52.0 | 2.0 | 307 |
| 1.50 | 1700 | 822716 | 5242410.2 | 53.1 | 1.9 | 305 |

6.1. INDUCTANCE TO FLUX DENSITY CURVE, UNGAPPED CORE, MH



6.2. INDUCTANCE TO FLUX DENSITY CURVE, GAPPED CORE, UH

