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Evaluation of Constants K_0,K_1,K_2,K_3, K_4, K_5, K_6,K_7, K_8, K_9 for Ferromagnetic Crystal Magnetocrystalline Anisotropy Energy Balance and Continuum Analysis of Pure Iron and Electrical Steels based on Electrical Properties and Texture of α,α*,η,Random ideal fibers & Magnetic Susceptibility of YBCO Super Conductor,Young's Modulus and Texture Factor of Inconel 718,OFHC,Beryllium Copper,Ti-6Al-4V,304 SS

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Abstract:

Texture Factor, A* and Magneto-Crystalline Anisotropy Energy Density K_0,K_1,K_2,K_3, K_4, K_5, K_6,K_7, K_8, K_9 Constants are important parameters for Pure Iron and Electrical Steels. While the former indicates volume density ofcrystals having preferred Orientation, latter indicates the easy and hard magnetization directions.Evaluation of these parameters for Pure Iron and Electrical Steel enables in reduction of core lossesand improving the electrical energy efficiency in Transformers, Rotating Machines. In this Research Article,Magnetic Anisotropy Constants of Pure Iron and Electrical Steels, Magnetic Susceptibility of YBCO Super Conductor,Young's Modulus & Texture Factor of Inconel 718.OFHC Copper,Beryllium Copper,Ti-6Al-4V,304SS.

Keywords: Texture Factor, Magnetic Crystalline Anisotropy Energy Density, Core losses

I NTRODUCTION:

In case of Pure Iron and Electrical Steels the Magneto Crystalline Anisotropy constants K_0,K_1,K_2,K_3, K_4, K_5, K_6,K_7, K_8, K_9 values determine the extent towhich a material is easily magnetizable. Their value depends on Chemical Composition, CrystalStructure, and Thermo-Mechanical Processing history of the given material. Texture factor constantsK_0,K_1,K_2,K_3, K_4, K_5, K_6,K_7, K_8, K_9 values determines the preferred orientations of grains, the Overall TextureFactor is quantitative measurement of texture. Texture Factor is an important microstructuralparameter which directly determines the anisotropy degree of most physical properties of apolycrystalline material at the macro scale. Its characterization is thus of fundamental and appliedimportance, and should ideally be performed prior to any physical property measurement or modeling.Neutron diffraction is a tool of choice for characterizing crystallographic textureS. The obtainedinformation The obtainedinformation is representative of a large number of grains, leading to a better accuracy of the statisticaldescription of texture.Texture factor constants K_0,K_1,K_2,K_3, K_4, K_5, K_6,K_7, K_8, K_9 values determines the preferredorientations of grains, the Overall Texture Factor is quantitative measurement of texture. The valuesignifies extent of presence of standard texture viz. Alpha Texture (T.F = 30.06), Alpha* Texture (T.F =30.77), EtaTexture (T.F =27.88) in the given material. Magnetic Susceptability of YBCO Super Conductor,Young's Modulus & Texture Factor of Inconel 718.OFHC Copper,Beryllium Copper,Ti-6Al-4V,304 SS K_0,K_1,K_2,K_3, K_4, K_5, K_6,K_7, K_8, K_9 Constants are determined

Standard Equations:

$$E^*=K_0 + K_1(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+K_2(\alpha_1^2+\alpha_2^2+\alpha_3^2)+K_3(\alpha_1\alpha_2\alpha_3)+K_4(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)++K_5(\alpha_1^3+\alpha_2^3+\alpha_3^3)+K_6(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+K_7(\alpha_1^4+\alpha_2^4+\alpha_3^4)+K_8(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+K_9(\alpha_1^6+\alpha_2^6+\alpha_3^6)$$

$$E^*=K_+K_1(\sum\alpha_1\alpha_2)+K_2(\sum\alpha_1^2)+K_3(\prod\alpha_1)+K_4(\sum\alpha_1^2\alpha_2^2)++K_5(\sum\alpha_1^3)+K_6(\sum\alpha_1^2\alpha_2\alpha_3)+K_7(\sum\alpha_1^4)+K_8(\sum\alpha_1^4\alpha_2^2)+K_9(\sum\alpha_1^6)$$

$$A^*=K_0 + K_1(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+K_2(\alpha_1^2+\alpha_2^2+\alpha_3^2)+K_3(\alpha_1\alpha_2\alpha_3)+K_4(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)++K_5(\alpha_1^3+\alpha_2^3+\alpha_3^3)+K_6(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+K_7(\alpha_1^4+\alpha_2^4+\alpha_3^4)+K_8(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+K_9(\alpha_1^6+\alpha_2^6+\alpha_3^6)$$

$$A^*=K_+K_1(\sum\alpha_1\alpha_2)+K_2(\sum\alpha_1^2)+K_3(\prod\alpha_1)+K_4(\sum\alpha_1^2\alpha_2^2)++K_5(\sum\alpha_1^3)+K_6(\sum\alpha_1^2\alpha_2\alpha_3)+K_7(\sum\alpha_1^4)+K_8(\sum\alpha_1^4\alpha_2^2)+K_9(\sum\alpha_1^6)$$

[uvw]	a	b	c	α_1	α_2	α_3	E
[100]	0	90^0	90^0	1	0	0	K_0
[110]	45^0	45^0	90^0	$1/\sqrt{2}$	$1/\sqrt{2}$	$1/\sqrt{2}$	$K_0 + K_1/4$
[111]	54.7^0	54.7^0	54.7^0	$1/\sqrt{3}$	$1/\sqrt{3}$	$1/\sqrt{3}$	$K_0 + K_1/3+ K_2/27$

From REF1,we have $E^* = 0.355A^* +(0.163 – 0.013A^*)[wt\%Si] -1.898$

For Pure Iron, $E^* = 0.355A^* -1.898$

II. Calculate Manetic Anisotropy Constants E* of PURE IRON K_0,K_1,K_2,K_3, K_4, K_5, K_6,K_7, K_8, K_9 of Iron [α,α*,η Fibres] and [α,α*,η , Random Fibres]

2.1 Calculate Manetic Anisotropy Constants E* of Pure Iron K_0,K_1,K_2,K_3, K_4, K_5, K_6,K_7, K_8, K_9 of Iron α,α*,η Fibres

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$E^{*}=K_0+K_1(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+K_2(\alpha_1^2+\alpha_2^2+\alpha_3^2)+K_3(\alpha_1\alpha_2\alpha_3)+K_4(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)++K_5(\alpha_1^3+\alpha_2^3+\alpha_3^3)+K_6(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+K_7(\alpha_1^4+\alpha_2^4+\alpha_3^4)+K_8(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+K_9(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

$E^{*}=K_{+}K_1(\sum\alpha_1\alpha_2)+K_2(\sum\alpha_1^2)+K_3(\prod\alpha_1)+K_4(\sum\alpha_1^2\alpha_2^2)++K_5(\sum\alpha_1^3)+K_6(\sum\alpha_1^2\alpha_2\alpha_3)+K_7(\sum\alpha_1^4)+K_8(\sum\alpha_1^4\alpha_2^2)+K_9(\sum\alpha_1^6)$

FOR E* for **η** fiber <100>//RD => E*=7.9994

FOR E* for **α** fiber <110>//RD => E*=8.7733

FOR E* for **α***fibre <112>//RD => E*=9.02535

CASE 1: $7.9994= K_0 + K_2 + K_5 + K_7 +K_9$

CASE 2: $8.7733= K_0+0.5K_1 + K_2+0.25K_4+0.708K_5+0.5K_7 +0.125K_8+0.25K_9$

CASE 3: $9.02535= K_0+0.833K_1+K_2+0.136K_3+0.25K_4+0.6804K_5 +0.222K_6+0.5K_7+0.0959K_8 +0.30684K_9$

Doing Computational procedure below,

$p1=k0+k2+k5+k7+k9$

$p2=k0+0.5k1+k2+0.25k4+0.706k5+0.5k7+0.125k8+0.25k9$

$p3=k0+0.833k1+k2+0.136k3+0.25k4+0.6804k5+0.222k6+0.5k7+0.09567k8+0.3084k9$

$k0=k2=k5=k7=k9$ =p1/5;$k4$=2,$k8$=1;

$k1$=2*(p2 -$k0$-$k2$-0.706$k5$-0.5$k7$-0.25$k9$)-1.25;$k3$=3;

k6=4.5(p3-$k0$-0.833$k1$-$k2$-0.136$k3$-0.25$k4$ -0.6804$k5$-0.5$k7$-0.09567$k8$-0.3084$k9$)

p1=7.9994;p2=8.7733;p3=9.02535 we haves dataset of k1,...k9

$k0$=**0.159;**$k1$=**5.236;**$k2$=**0.159;**$k3$=3;$k4$ =2;$k5$=**0.159;**$k6$=$k7$=**0.159;**$k8$=1;$k9$ =**0.159;**

On Substitution in Main Equation,We Have

$E^{*}=K_{+}K_1(\sum\alpha_1\alpha_2)+K_2(\sum\alpha_1^2)+K_3(\prod\alpha_1)+K_4(\sum\alpha_1^2\alpha_2^2)++K_5(\sum\alpha_1^3)+K_6(\sum\alpha_1^2\alpha_2\alpha_3)+K_7(\sum\alpha_1^4)+K_8(\sum\alpha_1^4\alpha_2^2)+K_9(\sum\alpha_1^6)$

$E^{*}=0.159+5.236(\sum\alpha_1\alpha_2)+0.159(\sum\alpha_1^2)+3(\prod\alpha_1)+2(\sum\alpha_1^2\alpha_2^2)+0.159(\sum\alpha_1^3)-8.641(\sum\alpha_1^2\alpha_2\alpha_3)+0.159(\sum\alpha_1^4)-1(\sum\alpha_1^4\alpha_2^2)+0.159(\sum\alpha_1^6)$

CRYSTAL DIRECTION	MAGNETOCRYSTALLINE ALL ANISOTROPY ENERGY DENSITY FOR PURE IRON
[100] $\alpha_1 =1,\alpha_2 =0, \alpha_3=0$	$E^{*}_{[100]} = 7.9994$

[110] $\alpha_1 = 1/\sqrt{2}, \alpha_2 = 1/\sqrt{2}, \alpha_3 = 0$	$E^*_{[110]} = 8.7733$
[112] $\alpha_1 = 0.408248, \alpha 2 = 0.408248, \alpha 3 = 0.816496$	$E^*_{[112]} = 9.02535$

DISCUSSION:

<100>//RD fibers have the lowest anisotropic strength because the flux lines are uniformly distributed in the plane of the rotated laminate, have a simple magnetization direction, and also have a α texture component rotated into a plane. In contrast, the α* and <011>//RD ,<112>//RD fiber orientations have relatively high anisotropy properties and therefore the presence of particles is undesirable in electrical steels.

2.2 Calculate Texture Factor constants $K_0, K_1, K_2, K_3, K_4, K_5, K_6, K_7, K_8, K_9$ of PureIron for α,α*,η Fibres

For Electrical Steels, E* = 0.355A* +(0.163 – 0.013A*)[wt%Si] -1.898

For Pure Iron,

$E^*_{PURE\ IRON} = 0.355A^*_{PURE\ IRON} - 1.898$ [Si%=0]

$\Rightarrow 0.355A^*_{PURE\ IRON} = [E^*_{PURE\ IRON} + 1.898]$

$\Rightarrow A^*_{PURE\ IRON} = [E^*_{PURE\ IRON} + 1.898]/0.355$

=>Substuting $E^*_{PURE\ IRON} = 0.159 + 5.236(\sum\alpha_1\alpha_2) + 0.159(\sum\alpha_1^2) + 3(\prod\alpha_1) + 2(\sum\alpha_1^2\alpha_2^2) + 0.159(\sum\alpha_1^3) - 8.641(\sum\alpha_1^2\alpha_2\alpha_3) + 0.159(\sum\alpha_1^4) - 1(\sum\alpha_1^4\alpha_2^2) + 0.159(\sum\alpha_1^6)$

=> We have $A^*_{PURE\ IRON} = 5.79437 + 14.747(\sum\alpha_1\alpha_2) + 4.507(\sum\alpha_1^2) + 8.451(\prod\alpha_1^4) + (4.507)(\sum\alpha_1^2\alpha_2^2) + 4.507(\sum\alpha_1^3) + (-24.345)(\sum\alpha_1^2\alpha_2\alpha_3) + 4.507(\sum\alpha_1^4) + 2.817(\sum\alpha_1^4\alpha_2^2) + 4.507(\sum\alpha_1^6)$

CRYSTAL DIRECTION	TEXTURE FACTOR FOR PURE IRON
[100] $\alpha_1 = 1, \alpha_2 = 0, \alpha_3 = 0$	$A^*_{[100]} = 27.88$
[110] $\alpha_1 = 1/\sqrt{2}, \alpha_2 = 1/\sqrt{2}, \alpha_3 = 0$	$A^*_{[110]} = 30.06$
[112] $\alpha_1 = 0.408248, \alpha 2 = 0.408248, \alpha 3 = 0.816496$	$A^*_{[111]} = 30.77$

2.3 Calculate Texture Factor constants $K_0, K_1, K_2, K_3, K_4, K_5, K_6, K_7, K_8, K_9$ of PureIron for α,α*,η Fibres by General Method

$A^* = K_0 + K_1(\alpha_1\alpha_2 + \alpha_2\alpha_3 + \alpha_3\alpha_1) + K_2(\alpha_1^2 + \alpha_2^2 + \alpha_3^2) + K_3(\alpha_1\alpha_2\alpha_3) + K_4(\alpha_1^2\alpha_2^2 + \alpha_2^2\alpha_3^2 + \alpha_3^2\alpha_1^2) + +K_5(\alpha_1^3 + \alpha_2^3 + \alpha_3^3) + K_6(\alpha_1^2\alpha_2\alpha_3 + \alpha_2^2\alpha_3\alpha_1 + \alpha_3^2\alpha_1\alpha_2) + K_7(\alpha_1^4 + \alpha_2^4 + \alpha_3^4) + K_8(\alpha_1^4\alpha_2^2 + \alpha_2^4\alpha_3^2 + \alpha_3^4\alpha_1^2) + K_9(\alpha_1^6 + \alpha_2^6 + \alpha_3^6)$

$A^{*}=K_{+}K_1(\sum\alpha_1\alpha_2)+K_2(\sum\alpha_1^2)+K_3(\prod\alpha_1)+K_4(\sum\alpha_1^2\alpha_2^2)++K_5(\sum\alpha_1^3)+K_6(\sum\alpha_1^2\alpha_2\alpha_3)+K_7(\sum\alpha_1^4)+K_8(\sum\alpha_1^4\alpha_2^2)+K_9(\sum\alpha_1^6)$

FOR A* for **η** fiber <100>//RD => A*=27.88

FOR A* for **α** fiber <110>//RD => A*=30.06

FOR A* for **α***fibre <112>//RD => A*=30.77

CASE 1: 27.88= $K_0 + K_2 + K_5 + K_7 + K_9$

CASE 2: 30.06= $K_0+0.5K_1 + K_2+0.25K_4+0.708K_5+0.5K_7 +0.125K_8+0.25K_9$

CASE 3: 30.77= $K_0+0.833K_1+K_2+0.136K_3+0.25K_4+0.6804K_5 +0.222K_6+0.5K_7+0.0959K_8 +0.30684K_9$

Doing Computational procedure below,

p1=$k0+k2+k5+k7+k9$

p2=$k0+0.5k1+k2+0.25k4+0.706k5+0.5k7+0.125k8+0.25k9$

p3=$k0+0.833k1+k2+0.136k3+0.25k4+0.6804k5+0.222k6+0.5k7+0.09567k8+0.3084k9$

$k0=k2=k5=k7=k9$ =p1/5;$k4$=2,$k8$=1;

$k1$=2*(p2 -$k0$-$k2$-0.706$k5$-0.5$k7$-0.25$k9$)-1.25;$k3$=3;

k6=4.5(p3-$k0$-0.833$k1$-$k2$-0.136$k3$-0.25$k4$ -0.6804$k5$-0.5$k7$-0.09567$k8$-0.3084$k9$)

p1=27.88;p2=30.06;p3=30.77 we haves dataset of k1,...k9

$k0$=**5.576;**$k1$=**20.322;**$k2$=**5.576;**$k3$=3;$k4$ =2;$k5$=**5.576;**$k6$=-25.588,$k7$=**5.576;**$k8$=1;$k9$ =**5.576;**

On Substitution in Main Equation,We Have

$A^{*}=K_{+}K_1(\sum\alpha_1\alpha_2)+K_2(\sum\alpha_1^2)+K_3(\prod\alpha_1)+K_4(\sum\alpha_1^2\alpha_2^2)++K_5(\sum\alpha_1^3)+K_6(\sum\alpha_1^2\alpha_2\alpha_3)+K_7(\sum\alpha_1^4)+K_8(\sum\alpha_1^4\alpha_2^2)+K_9(\sum\alpha_1^6)$

$\mathbf{A^{*}=5.576+20.322(\sum\alpha_1\alpha_2)+5.576(\sum\alpha_1^2)+3(\prod\alpha_1)+2(\sum\alpha_1^2\alpha_2^2)(\sum\alpha_1^3)+5.576(\sum\alpha_1^2\alpha_2\alpha_3)+5.576-25.588(\sum\alpha_1^4)+1(\sum\alpha_1^4\alpha_2^2)+5.576(\sum\alpha_1^6)}$

CRYSTAL DIRECTION	TEXTURE FACTOR FOR PURE IRON
[100] α_1 =1,α_2 =0, α_3=0	$A^*_{[100]}$ = 27.88
[110] α_1 =1/√2,α_2 =1/√2, α_3=0	$A^*_{[110]}$ = 30.06
[112] α_1 =0.408248,α2 =0.408248, α3=0.816496	$A^*_{[111]}$ =30.77

2.4 **Calculate Magnetic Anisotropy Constants E* of Pure Iron K_0,K_1,K_2,K_3, K_4, K_5, K_6,K_7, K_8, K_9 of Iron ϴ ,α, ϒand random Fibres**

$E^*=K_0 + K_1(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+K_2(\alpha_1^2+\alpha_2^2+\alpha_3^2)+K_3(\alpha_1\alpha_2\alpha_3)+K_4(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)++K_5(\alpha_1^3+\alpha_2^3+\alpha_3^3)+K_6(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+K_7(\alpha_1^4+\alpha_2^4+\alpha_3^4)+K_8(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+K_9(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

$E^*=K_+K_1(\sum\alpha_1\alpha_2)+K_2(\sum\alpha_1^2)+K_3(\prod\alpha_1)+K_4(\sum\alpha_1^2\alpha_2^2)++K_5(\sum\alpha_1^3)+K_6(\sum\alpha_1^2\alpha_2\alpha_3)+K_7(\sum\alpha_1^4)+K_8(\sum\alpha_1^4\alpha_2^2)+K_9(\sum\alpha_1^6)$

FOR E* for **η** fiber <100>//RD => E*=7.9994

FOR E* for **α** fiber <110>//RD => E*=8.7733

FOR E* for **α***fibre <112>//RD => E*=9.02535

FOR E* for **Random** fibre => E*=9.4194

$7.9994 = K_0 + K_2 + K_5 + K_7 +K_9$

$8.7733= K_0+0.5K_1 + K_2+0.25K_4+0.7074K_5+0.5003K_7 +0.125K_8+0.25K_9$

$9.02535 = K_0+0.833K_1+K_2+0.136K_3+0.25K_4+0.6804K_5 +0.222K_6+0.5K_7+0.0959K_8 +0.30684K_9$

$9.4194=K_0+K_3+3(K_1+K_2+K_4 + K_5+K_6+K_7 ++K_8+K_9)$

case 1: $K_0 + K_2 + K_5 + K_7 +K_9 = 7.9994$;considering equal values for all constants we have

$K_0 = K_2 = K_5 = K_7= K_9 = 1.6$;.....(I)

case 2: $8.7733= K_0+0.5K_1 + K_2+0.25K_4+0.7074K_5+0.5003K_7 +0.125K_8+0.25K_9$

$2K_1 +K_4+0.5K_8 = 16.166$...(V)

2*6 +2+0.5*4.332 =16.166

$K_1 = 6;K_4 = 2;K_8 = 4.332$ .....(II)

Case 3: $30.77= K_0+0.833K_1+K_2+0.136K_3+0.25K_4+0.6804K_5 +0.222K_6+0.5K_7+0.0959K_8 +0.30684K_9$

On Substitution of $K_0,K_1,K_2,K_4,K_5,K_7,K_8.K_9$

$0.136K_3 +.222K_6 =20.876544$ ....(VI)

Case 4: $K_0+K_3+3(K_1+K_2+K_4 + K_5+K_6+K_7 +K_8+K_9)=9.4194$

$K_3+3K_6 = -48.3766$ .....(VII)

Solving ....Equations (VI) and (VII)

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We have K_3=2.977;K_6= 24;

K_0=1.6;K_1=6;K_2=1.6;K_3=2.977;K_4=2; K_5=1.6;K_6=24;K_7 =1.6;K_8=4.332;K_9=1.6;

$E^*_{PURE\ IRON}=(1.6)+6(\sum\alpha_1\alpha_2)+1.6(\sum\alpha_1^2)+2.977(\prod\alpha_1^4)+(2)(\sum\alpha_1^2\alpha_2^2)+1.6(\sum\alpha_1^3)+(24)(\sum\alpha_1^2\alpha_2\alpha_3)+1.6(\sum\alpha_1^4)+4.332(\sum\alpha_1^4\alpha_2^2)+1.6(\sum\alpha_1^6)$

FOR E* for **η** fiber <100>//RD => E*=7.9994

FOR E* for **α** fiber <110>//RD => E*=8.7733

FOR E* for **α***fibre <112>//RD => E*=9.02535

FOR E* for Random fibre => E*=9.4194

CRYSTAL DIRECTION	MAGNETOCRYSTALLINE ALL ANISOTROPY ENERGY DENSITY FOR PURE IRON
[100] α_1 =1,α_2 =0, α_3=0	$E^*_{[100]}$ = 7.9994
[110] $\alpha_1 =1/\sqrt{2}$,$\alpha_2 =1/\sqrt{2}$, α_3=0	$E^*_{[110]}$ = 8.7733
[112] α_1 =0.408248,α2 =0.408248, α3=0.816496	$E^*_{[112]}$ =9.02535
Random α_1 =1,α_2 =1, α_3=1	$E^*_{[Random]}$ =9.4194

DISCUSSION:

<100>//RD fibers have the lowest anisotropic strength because the flux lines are uniformly distributed in the plane of the rotated laminate, have a simple magnetization direction, and also have a α texture component rotated into a plane. In contrast, the α* and <011>//RD ,<112>//RD fiber orientations have relatively high anisotropy properties and therefore the presence of particles is undesirable in electrical steels.

2.4 Calculate Texture Factor constants K_0,K_1,K_2,K_3, K_4, K_5, K_6,K_7, K_8, K_9 of PureIron for ϴ ,α, ϒ,Random Fibres

For Electrical Steels, E* = 0.355A* +(0.163 – 0.013A*)[wt%Si] -1.898

For Pure Iron,

$E^*_{PURE\ IRON}$= 0.355$A^*_{PURE\ IRON}$ -1.898 [Si%=0]

=>0.355$A^*_{PURE\ IRON}$ = [$E^*_{PURE\ IRON}$+1.898]

=>$A^*_{PURE\ IRON}$ = [$E^*_{PURE\ IRON}$+1.898]/0.355

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=>Substituting $E^*_{PURE\ IRON}=(1.6)+6(\sum\alpha_1\alpha_2)+1.6(\sum\alpha_1^2)+2.977(\prod\alpha_1^4)+(2)(\sum\alpha_1^2\alpha_2^2)+1.6(\sum\alpha_1^3)+(24)(\sum\alpha_1^2\alpha_2\alpha_3)+1.6(\sum\alpha_1^4)+4.332(\sum\alpha_1^4\alpha_2^2)+1.6(\sum\alpha_1^6)$

=> We have $A^*_{PURE\ IRON}=$
$9.85+16.9014(\sum\alpha_1\alpha_2)+4.507(\sum\alpha_1^2)+2.977(\prod\alpha_1^4)+(5.6338)(\sum\alpha_1^2\alpha_2^2)+4.507(\sum\alpha_1^3)+(67.6056)(\sum\alpha_1^2\alpha_2\alpha_3)+4.507(\sum\alpha_1^4)+0.6625(\sum\alpha_1^4\alpha_2^2)+4.507(\sum\alpha_1^6)$

CRYSTAL DIRECTION	TEXTURE FACTOR FOR PURE IRON
[100] $\alpha_1=1, \alpha_2=0, \alpha_3=0$	$A^*_{[100]} = 27.88$
[110] $\alpha_1=1/\sqrt{2}, \alpha_2=1/\sqrt{2}, \alpha_3=0$	$A^*_{[110]} = 30.06$
[112] $\alpha_1=0.408248, \alpha2=0.408248, \alpha3=0.816496$	$A^*_{[111]} =30.77$
Random $\alpha_1=1, \alpha_2=1, \alpha_3=1$	$A^*_{[111]} =31.88$

2.5 Calculate Texture Factor constants $K_0, K_1, K_2, K_3, K_4, K_5, K_6, K_7, K_8, K_9$ of PureIron for ϴ ,α, ϒ,Random Fibres By General Approach

$A^*=K_0+K_1(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+K_2(\alpha_1^2+\alpha_2^2+\alpha_3^2)+K_3(\alpha_1\alpha_2\alpha_3)+K_4(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)++K_5(\alpha_1^3+\alpha_2^3+\alpha_3^3)+K_6(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+K_7(\alpha_1^4+\alpha_2^4+\alpha_3^4)+K_8(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+K_9(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

$A^*=K_+K_1(\sum\alpha_1\alpha_2)+K_2(\sum\alpha_1^2)+K_3(\prod\alpha_1)+K_4(\sum\alpha_1^2\alpha_2^2)++K_5(\sum\alpha_1^3)+K_6(\sum\alpha_1^2\alpha_2\alpha_3)+K_7(\sum\alpha_1^4)+K_8(\sum\alpha_1^4\alpha_2^2)+K_9(\sum\alpha_1^6)$

OR A*=27.88 for **η** fiber <100>//ND

FOR A* =30.06 for **α**for fiber <110>//ND

FOR A*=30.77 for **α*** fibre <111>//ND

FOR A*=31.88 for Random Fibre

$27.88= K_0 + K_2 + K_5 + K_7 +K_9$

$30.06= K_0+0.5K_1 + K_2+0.25K_4+0.7074K_5+0.5003K_7 +0.125K_8+0.25K_9$

$30.77= K_0+K_1+K_2+0.192K_3+0.333K_4+0.5772K_5+0.333K_6+0.333K_7+0.111K_8 +0.111K_9$

$31.88=K_0+K_3+3(K_1+K_2+K_4+K_5+K_6+K_7++K_8+K_9)$

case 1: $K_0 + K_2 + K_5 + K_7 +K_9 = 27.88$;considering equal values for all constants we have

$K_0 = K_2 = K_5 = K_7= K_9 =5.576$ .....(I)

case 2: $8.7733= K_0+0.5K_1 + K_2+0.25K_4+0.7074K_5+0.5003K_7 +0.125K_8+0.25K_9$

$2K_1 +K_4+0.5K_8 = -30.87$...(V)

2*-14 -2-0.5*1.74 = -30.87

K_1 = -14;K_4 = -2;K_8 = -1.74 .....(II)

Case 3: 30.77= K_0+0.833K_1+K_2+0.136K_3+0.25K_4+0.6804K_5 +0.222K_6+0.5K_7+0.0959K_8 +0.30684K_9
On Substitution of K_0,K_1,K_2,K_4,K_5,K_7,K_8.K_9

0.136K_3 +.222K_6 =30.627....(VI)

Case 4: K_0+K_3+3(K_1+K_2+K_4 + K_5+K_6+K_7 +K_8+K_9)=9.4194

K_3+3K_6 = -9.8486 .....(VII)

0.864K_3+2.778K_6 = 40.4756

Solving ....Equations (VI) and (VII)

We have K_3=0.66;K_6= 14.57;

K_0=5.576;K_1=-14;K_2=5.576;K_3=0.66;K_4= -2; K_5=5.576;K_6=14.57;K_7 =5.576;K_8=-1.74;K_9=5.576;

$A^*_{PURE\ IRON}=(5.576)-14(\sum\alpha_1\alpha_2)+5.576(\sum\alpha_1^2)+0.66(\prod\alpha_1^4)+(-2)(\sum\alpha_1^2\alpha_2^2)+5.576(\sum\alpha_1^3)+(14.57)(\sum\alpha_1^2\alpha_2\alpha_3)+5.576(\sum\alpha_1^4)-1.74(\sum\alpha_1^4\alpha_2^2)+5.576(\sum\alpha_1^6)$

CRYSTAL DIRECTION	TEXTURE FACTOR FOR PURE IRON
[100] α_1 =1,α_2 =0, α_3=0	$A^*_{[100]}$ = 27.88
[110] α_1 =1/√2,α_2 =1/√2, α_3=0	$A^*_{[110]}$ = 30.06
[112] α_1 =0.408248,α2 =0.408248, α3=0.816496	$A^*_{[111]}$ =30.77
Random α_1 =1,α_2 =1, α_3=1	$A^*_{[111]}$ =31.88

III. Calculate Magnetic Anisotropy ConstantsK_0,K_1,K_2,K_3, K_4, K_5, K_6,K_7, K_8, K_9 of E* of ELECTRICAL STEELS K_0,K_1,K_2,K_3, K_4, K_5, K_6,K_7, K_8, K_9 [ϴ ,α, ϒ, RandomFibres] and [ϴ ,α, ϒ Fibres]

3.1 Calculate Manetic Anisotropy Constants E* of Electrical Steels K_0,K_1,K_2,K_3, K_4, K_5, K_6,K_7, K_8, K_9 of Iron ϴ ,α, ϒ ,Random Fibres

$E^*=K_0+K_1(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+K_2(\alpha_1^2+\alpha_2^2+\alpha_3^2)+K_3(\alpha_1\alpha_2\alpha_3)+K_4(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)++K_5(\alpha_1^3+\alpha_2^3+\alpha_3^3)+K_6(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+K_7(\alpha_1^4+\alpha_2^4+\alpha_3^4)+K_8(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+K_9(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

$E^*=K_++K_1(\sum\alpha_1\alpha_2)+K_2(\sum\alpha_1^2)+K_3(\prod\alpha_1)+K_4(\sum\alpha_1^2\alpha_2^2)++K_5(\sum\alpha_1^3)+K_6(\sum\alpha_1^2\alpha_2\alpha_3)+K_7(\sum\alpha_1^4)+K_8(\sum\alpha_1^4\alpha_2^2)+K_9(\sum\alpha_1^6)$

FOR E* for η fiber <100>//RD => E*=7.9994-0.19944[wt%Si]

FOR E* for α fiber <110>//RD => E*=8.7733 -0.22778[wt%Si]

FOR E* for α*fibre <112>//RD => E*=9.02535-0.23701[wt%Si]

FOR E* for Random fibre => E*=9.4194 - 0.25144Si[wt%Si]

7.9994 -0.19944[wt%Si] = $K_0 + K_2 + K_5 + K_7 + K_9$

8.7733-0.22778[wt%Si]= $K_0+0.5K_1 + K_2+0.25K_4+0.7074K_5+0.5003K_7 +0.125K_8+0.25K_9$

9.02535-0.23701[wt%Si] = $K_0+0.833K_1+K_2+0.136K_3+0.25K_4+0.6804K_5 +0.222K_6+0.5K_7+0.0959K_8 +0.30684K_9$

9.4194-0.25144[wt%Si]=$K_0+K_3+3(K_1+K_2+K_4+K_5+K_6+K_7+$

$K_8+K_9)$

Calculating without Silicon Content and Only Silicon Content Seperately, we have

$7.9994 = K_0 + K_2 + K_5 + K_7 + K_9$

$8.7733= K_0+0.5K_1 + K_2+0.25K_4+0.7074K_5+0.5003K_7 +0.125K_8+0.25K_9$

$9.02535 = K_0+0.833K_1+K_2+0.136K_3+0.25K_4+0.6804K_5 +0.222K_6+0.5K_7+0.0959K_8 +0.30684K_9$

$9.4194=K_0+K_3+3(K_1+K_2+K_4+K_5+K_6+K_7++K_8+K_9)$

case 1: $K_0 + K_2 + K_5 + K_7 + K_9 = 7.9994$;considering equal values for all constants we have

$K_0 = K_2 = K_5 = K_7= K_9 = 1.6$;.....(I)

case 2: $8.7733= K_0+0.5K_1 + K_2+0.25K_4+0.7074K_5+0.5003K_7 +0.125K_8+0.25K_9$

$2K_1 +K_4+0.5K_8 = 16.166$...(V)

2*6 +2+0.5*4.332 =16.166

$K_1 = 6;K_4 = 2;K_8 = 4.332$ .....(II)

Case 3: $30.77= K_0+0.833K_1+K_2+0.136K_3+0.25K_4+0.6804K_5 +0.222K_6+0.5K_7+0.0959K_8 +0.30684K_9$

On Substitution of $K_0,K_1,K_2,K_4,K_5,K_7,K_8.K_9$

$0.136K_3 +.222K_6 =20.876544$ ....(VI)

Case 4: $K_0+K_3+3(K_1+K_2+K_4+K_5+K_6+K_7 +K_8+K_9)=9.4194$

$K_3+3K_6 = -48.3766$ .....(VII)

Solving ....Equations (VI) and (VII)

We have $K_3=2.977;K_6= 24;$

K_0=1.6;K_1=6;K_2=1.6;K_3=2.977;K_4=2; K_5=1.6;K_6=24;K_7 =1.6;K_8=4.332;K_9=1.6;

Calculation With Silicon Content Only,

K_0 = -0.19944Si;

K_0 +0.25K_4 = -0.22778Si;

K_0+3(K_4+K_6+K_8) = -0.25144Si;

K_0+0.25K_4+0.222K_6+0.0959K_8 = -0.23701;

Final Values of K_0=-0.19944Si;K_4=-0.11336Si;K_6=-0.146224Si;K_8=0.24225

FOR E* for **η** fiber <100>//RD => E*=7.9994-0.19944[wt%Si]

FOR E* for **α** fiber <110>//RD => E*=8.7733 -0.22778[wt%Si]

FOR E* for **α***fibre <112>//RD => E*=9.02535-0.23701[wt%Si]

FOR E* for **Random** fibre => E*=9.4194 - 0.25144[wt%Si]

$E^*_{ELECTRICAL\ STEEls}$=(1.6-0.19944Si)+6($\sum\alpha_1\alpha_2$)+1.6($\sum\alpha_1^2$)+2.977($\prod\alpha_1^4$)+(2-0.11336Si)($\sum\alpha_1^2\alpha_2^2$)+1.6($\sum\alpha_1^3$)+ (24-0.146224Si)($\sum\alpha_1^2\alpha_2\alpha_3$)+1.6($\sum\alpha_1^4$)+(4.332-0.24225Si)($\sum\alpha_1^4\alpha_2^2$)+1.6($\sum\alpha_1^6$)

CRYSTAL DIRECTION	MAGNETOCRYSTALLINE ALL ANISOTROPY ENERGY DENSITY FOR PURE IRON
[100] α_1 =1,α_2 =0, α_3=0	$E^*_{[100]}$ = 7.9994 -0.19944[wt%Si]
[110] α_1 =1/√2,α_2 =1/√2, α_3=0	$E^*_{[110]}$ = 8.7733-0.22778[wt%Si]
[112] α_1 =0.408248,α2 =0.408248, α3=0.816496	$E^*_{[112]}$ =9.02535 -0.23701[wt%Si]
Random α_1 =1,α_2 =1, α_3=1	$E^*_{[Random]}$ =9.4194 -0.25144[wt%Si]

S.NO.	Standard Crystallographic Directions	Magneto-Crystalline Anisotropy Value E* For	Magneto-Crystalline Anisotropy Value E*	Magneto-Crystalline Anisotropy Value E* for Fe-	Magneto-Crystalline Anisotropy Value E* for Fe-	Magneto-Crystalline Anisotropy Value E* for Fe-	Magneto-Crystalline Anisotropy Value E* for Fe-

		Pure Iron		0.51%Si	1.38%Si	2.8%Si	3.2%Si
1	[100]	$E^*_{[100]}$ = 7.9994	$E^*_{[100]}$ = 7.9994 - 0.19944[wt%Si]	7.8957	7.724	7.4409	7.3612
2	[110]	$E^*_{[110]}$ = 8.7733	$E^*_{[110]}$ = 8.7733- 0.22778[wt%Si]	8.6571	8.459	8.1355	8.0444
3	[112]	$E^*_{[112]}$ = 9.02535	$E^*_{[112]}$ = 9.02535 - 0.23701[wt%Si]	8.9044	8.6982	8.3617	8.2667
4.	Random	$E_{[Random*]}$ = +9.4194	$E^*_{[111]}$ = -0.25144 [wt%Si] + 9.4194	9.29116	9.0724	8.7153	8.6148

DISCUSSION:

<100>//RD fibers have the lowest anisotropic strength because the flux lines are uniformly distributed in the plane of the rotated laminate, have a simple magnetization direction, and also have a α texture component rotated into a plane. In contrast, the α* and <011>//RD ,<112>//RD fiber orientations have relatively high anisotropy properties and therefore the presence of particles is undesirable in electrical steels.

3.2 Calculate Texture Factor constants K_0,K_1,K_2,K_3, K_4, K_5, K_6,K_7, K_8, K_9 of Electrical Steels for Ө ,α, ϒ,Random Fibres

$A^*=K_0 + K_1(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+K_2(\alpha_1^2+\alpha_2^2+\alpha_3^2)+K_3(\alpha_1\alpha_2\alpha_3)+K_4(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)++K_5(\alpha_1^3+\alpha_2^3+\alpha_3^3)+K_6(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+K_7(\alpha_1^4+\alpha_2^4+\alpha_3^4)+K_8(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+K_9(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

$A^*=K_+K_1(\sum\alpha_1\alpha_2)+K_2(\sum\alpha_1^2)+K_3(\prod\alpha_1)+K_4(\sum\alpha_1^2\alpha_2^2)++K_5(\sum\alpha_1^3)+K_6(\sum\alpha_1^2\alpha_2\alpha_3)+K_7(\sum\alpha_1^4)+K_8(\sum\alpha_1^4\alpha_2^2)+K_9(\sum\alpha_1^6)$

FOR A*=22.5 for Ө fiber <100>//ND

FOR A* =35.6for fiber <110>//ND

FOR A*=38.68 for ϒ fibre <111>//ND

FOR A*=31.88 for Random Fibre

$E^* = 0.355A^* +(0.163 – 0.013A^*)[wt\%Si] -1.898$

$E^* = (0.355 - 0.013[wt\%Si])A^* + 0.163[wt\%Si] - 1.898$

$(0.355 - 0.013[wt\%Si])\mathbf{A^*_{ELECTRICAL\ STEELS}} = E^* - 0.163[wt\%Si] + 1.898$

$(0.355 - 0.013[wt\%Si])A^*_{ELECTRICAL\ STEELS} = (3.498 - 0.36244Si) + 6(\sum\alpha_1\alpha_2) + 1.6(\sum\alpha_1^2) + 2.977(\prod\alpha_1^4) + (2 - 0.11336Si)(\sum\alpha_1^2\alpha_2^2) + 1.6(\sum\alpha_1^3) + (24 - 0.146224Si)(\sum\alpha_1^2\alpha_2\alpha_3) + 1.6(\sum\alpha_1^4) + (4.332 - 0.24225Si)(\sum\alpha_1^4\alpha_2^2) + 1.6(\sum\alpha_1^6)$

$(0.355 - 0.013[wt\%Si])A^*_{ELECTRICAL\ STEELS} = (3.498 - 0.36244Si) + 6(\sum\alpha_1\alpha_2) + 1.6(\sum\alpha_1^2) + 2.977(\prod\alpha_1^4) + (2 - 0.11336Si)(\sum\alpha_1^2\alpha_2^2) + 1.6(\sum\alpha_1^3) + (24 - 0.146224Si)(\sum\alpha_1^2\alpha_2\alpha_3) + 1.6(\sum\alpha_1^4) + (4.332 - 0.24225Si)(\sum\alpha_1^4\alpha_2^2) + 1.6(\sum\alpha_1^6)$

$A^*_{ELECTRICAL\ STEELS} = K_0 + K_1(\sum\alpha_1\alpha_2) + K_2(\sum\alpha_1^2) + K_3(\prod\alpha_1) + K_4(\sum\alpha_1^2\alpha_2^2) + +K_5(\sum\alpha_1^3) + K_6(\sum\alpha_1^2\alpha_2\alpha_3) + K_7(\sum\alpha_1^4) + K_8(\sum\alpha_1^4\alpha_2^2) + K_9(\sum\alpha_1^6)$

Assuming $P = (0.355 - 0.013[wt\%Si])$;

$K_0 = (3.498 - 0.36244Si)/P$

$K_1 = 6/P$

$K_2 = 1.6/P$

$K_3 = 2.977/P$

$K_4 = (2 - 0.11336Si)/P$

$K_5 = 1.6/P$

$K_6 = (24 - 0.146224Si)/P$

$K_7 = 1.6/P$

$K_8 = (4.332 - 0.24225Si)/P$

$K_9 = 1.6/P$

CRYSTAL DIRECTION	TEXTURE FACTOR FOR ELECTRICAL STEELS
[100] $\alpha_1 = 1, \alpha_2 = 0, \alpha_3 = 0$	$A^*_{[100]} = 27.88$
[110] $\alpha_1 = 1/\sqrt{2}, \alpha_2 = 1/\sqrt{2}, \alpha_3 = 0$	$A^*_{[110]} = 30.06$
[112] $\alpha_1 = 0.408248, \alpha2 = 0.408248, \alpha3 = 0.816496$	$A^*_{[111]} = 30.77$
Random $\alpha_1 = 1, \alpha_2 = 1, \alpha_3 = 1$	$A^*_{[111]} = 31.88$

3.3 Calculate Manetic Anisotropy Constants E* of Electrical Steels $K_0, K_1, K_2, K_3, K_4, K_5, K_6, K_7, K_8, K_9$ of Iron ϴ ,α, ϒ Fibres

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$E^*=K_0 + K_1(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+K_2(\alpha_1^2+\alpha_2^2+\alpha_3^2)+K_3(\alpha_1\alpha_2\alpha_3)+K_4(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)++K_5(\alpha_1^3+\alpha_2^3+\alpha_3^3)+K_6(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+K_7(\alpha_1^4+\alpha_2^4+\alpha_3^4)+K_8(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+K_9(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

$E^*=K_+K_1(\sum\alpha_1\alpha_2)+K_2(\sum\alpha_1^2)+K_3(\prod\alpha_1)+K_4(\sum\alpha_1^2\alpha_2^2)++K_5(\sum\alpha_1^3)+K_6(\sum\alpha_1^2\alpha_2\alpha_3)+K_7(\sum\alpha_1^4)+K_8(\sum\alpha_1^4\alpha_2^2)+K_9(\sum\alpha_1^6)$

FOR E* for **η** fiber <100>//RD => E*=7.9994-0.19944[wt%Si]

FOR E* for **α** fiber <110>//RD => E*=8.7733 -0.22778[wt%Si]

FOR E* for **α***fibre <112>//RD => E*=9.02535-0.23701[wt%Si]

FOR E* for **Random** fibre => E*=9.4194 - 0.25144Si[wt%Si]

$7.9994 -0.19944[wt\%Si] = K_0 + K_2 + K_5 + K_7 +K_9$

$8.7733-0.22778[wt\%Si]= K_0+0.5K_1 + K_2+0.25K_4+0.7074K_5+0.5003K_7 +0.125K_8+0.25K_9$

$9.02535-0.23701[wt\%Si] = K_0+0.833K_1+K_2+0.136K_3+0.25K_4+0.6804K_5 +0.222K_6+0.5K_7+0.0959K_8 +0.30684K_9$

Dealing Seperately with E* Constants and Silicon Content, we have

$7.9994= K_0 + K_2 + K_5 + K_7 +K_9$

$8.7733= K_0+0.5K_1 + K_2+0.25K_4+0.7074K_5+0.5003K_7 +0.125K_8+0.25K_9$

$9.02535 = K_0+0.833K_1+K_2+0.136K_3+0.25K_4+0.6804K_5 +0.222K_6+0.5K_7+0.0959K_8 +0.30684K_9$

Using Computation Technique with following code, we have

p1=𝑘0+𝑘2+𝑘5+𝑘7+𝑘9

p2=𝑘0+0.5𝑘1+𝑘2+0.25𝑘4+0.706𝑘5+0.5𝑘7+0.125𝑘8+0.25𝑘9

p3=𝑘0+0.833𝑘1+𝑘2+0.136𝑘3+0.25𝑘4+0.6804𝑘5+0.222𝑘6+0.5𝑘7+0.09567𝑘8+0.3084𝑘9

𝑘0=𝑘2=𝑘5=𝑘7=𝑘9 =p1/5;𝑘4=2,𝑘8=1;

𝑘1=2*(p2 -𝑘0-𝑘2-0.706𝑘5-0.5𝑘7-0.25𝑘9)-1.25;𝑘3=3;

k6=5.20833(p3-𝑘0-0.833𝑘1-𝑘2-0.136𝑘3-0.25𝑘4 -0.6804𝑘5-0.5𝑘7-0.09567𝑘8-0.3084𝑘9)

p1=7.9994;p2=8.7733;p3=9.02535 give values of k1,...k9

𝑘0=1.6;𝑘1=5.236;𝑘2=1.6;𝑘3=3;𝑘4=2;𝑘5=1.6;𝑘6= -10;𝑘7=1.6;𝑘8=1;𝑘9 =1.6

$E^*=K_+K_1(\sum\alpha_1\alpha_2)+K_2(\sum\alpha_1^2)+K_3(\prod\alpha_1)+K_4(\sum\alpha_1^2\alpha_2^2)++K_5(\sum\alpha_1^3)+K_6(\sum\alpha_1^2\alpha_2\alpha_3)+K_7(\sum\alpha_1^4)+K_8(\sum\alpha_1^4\alpha_2^2)+K_9(\sum\alpha_1^6)$

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On
Substitution, $E^*=K_+K_1(\sum\alpha_1\alpha_2)+K_2(\sum\alpha_1^2)+K_3(\prod\alpha_1)+K_4(\sum\alpha_1^2\alpha_2^2)++K_5(\sum\alpha_1^3)+K_6(\sum\alpha_1^2\alpha_2\alpha_3)+K_7(\sum\alpha_1^4)+K_8(\sum\alpha_1^4\alpha_2^2)+K_9(\sum\alpha_1^6)$

$E^*=1.6+5.236(\sum\alpha_1\alpha_2)+1.6(\sum\alpha_1^2)+3(\prod\alpha_1)+2(\sum\alpha_1^2\alpha_2^2)+1.6(\sum\alpha_1^3)-10(\sum\alpha_1^2\alpha_2\alpha_3)+1.6(\sum\alpha_1^4)+1(\sum\alpha_1^4\alpha_2^2)+1.6(\sum\alpha_1^6)$

Adjusting Silicon Contents, We have

K_0 = -0.19944Si;

K_0 +0.25K_4 = -0.22778Si;

K_0+0.25K_4+0.222K_6+0.0959K_8 = -0.23701;

0.222K_6+0.0959K_8 = -0.23701Si +0.22778Si = -0.00923Si

Taking K_6 as 0.1Si we have,K_8= -0.327737Si

Final Values of K_0=-0.19944Si;K_4= -0.11336Si;K_6=0.1Si;K_8=-0.327737Si

$E^*_{\text{ELECTRICAL STEELS}}=(1.6-0.19944Si)+5.236(\sum\alpha_1\alpha_2)+1.6(\sum\alpha_1^2)+3(\prod\alpha_1)+(2-0.11336Si)\sum\alpha_1^2\alpha_2^2)+1.6(\sum\alpha_1^3)+(-10+0.1Si)(\sum\alpha_1^2\alpha_2\alpha_3)+1.6(\sum\alpha_1^4)+(1-0.327737Si)(\sum\alpha_1^4\alpha_2^2)+1.6(\sum\alpha_1^6)$

CRYSTAL DIRECTION	MAGNETOCRYSTALLINE ALL ANISOTROPY ENERGY DENSITY FOR PURE IRON
[100] α_1 =1,α_2 =0, α_3=0	$E^*_{[100]}$ = 7.9994 -0.19944[wt%Si]
[110] α_1 =1/√2,α_2 =1/√2, α_3=0	$E^*_{[110]}$ = 8.7733-0.22778[wt%Si]
[112] α_1 =0.408248,α2 =0.408248, α3=0.816496	$E^*_{[112]}$ =9.02535 -0.23701[wt%Si]

S.NO.	Standard Crystallographic Directions	Magneto-Crystalline Anisotropy Value E* For	Magneto-Crystalline Anisotropy Value E*	Magneto-Crystalline Anisotropy Value E* for Fe-	Magneto-Crystalline Anisotropy Value E* for Fe-	Magneto-Crystalline Anisotropy Value E* for Fe-	Magneto-Crystalline Anisotropy Value E* for Fe-

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		Pure Iron		0.51%Si	1.38%Si	2.8%Si	3.2%Si
1	[100]	$E^*_{[100]}$ = 7.9994	$E^*_{[100]}$ = 7.9994 - 0.19944[wt %Si]	7.8957	7.724	7.4409	7.3612
2	[110]	$E^*_{[110]}$ = 8.7733	$E^*_{[110]}$ = 8.7733-0.22778[wt %Si]	8.6571	8.459	8.1355	8.0444
3	[112]	$E^*_{[112]}$ = 9.02535	$E^*_{[112]}$ = 9.02535 - 0.23701[wt %Si]	8.9044	8.6982	8.3617	8.2667

3.4 Calculate Texture Factor constants K_0,K_1,K_2,K_3, K_4, K_5, K_6,K_7, K_8, K_9 of Electrical Steels for [ϴ ,α, ϒ Fibres]

For Electrical Steels, E* = 0.355A* +(0.163 – 0.013A*)[wt%Si] -1.898

$E^*_{\text{ELECTRICAL STEELS}}=(1.6-0.19944Si)+5.236(\sum\alpha_1\alpha_2)+1.6(\sum\alpha_1^2)+3(\prod\alpha_1)+(2-0.11336Si)\sum\alpha_1^2\alpha_2^2)+1.6(\sum\alpha_1^3)+(-10+0.1Si)(\sum\alpha_1^2\alpha_2\alpha_3)+1.6(\sum\alpha_1^4)+(1-0.327737Si)(\sum\alpha_1^4\alpha_2^2)+1.6(\sum\alpha_1^6)$

$(0.355 - 0.013[wt\%Si])A^*_{\text{ELECTRICAL STEELS}} = (3.498-0.36244Si)+5.236(\sum\alpha_1\alpha_2)+1.6(\sum\alpha_1^2)+3(\prod\alpha_1)+(2-0.11336Si)\sum\alpha_1^2\alpha_2^2)+1.6(\sum\alpha_1^3)+(-10+0.1Si)(\sum\alpha_1^2\alpha_2\alpha_3)+1.6(\sum\alpha_1^4)+(1-0.327737Si)(\sum\alpha_1^4\alpha_2^2)+1.6(\sum\alpha_1^6)$

$A^*_{\text{ELECTRICAL STEELS}}=K_0+K_1(\sum\alpha_1\alpha_2)+K_2(\sum\alpha_1^2)+K_3(\prod\alpha_1)+K_4(\sum\alpha_1^2\alpha_2^2)++K_5(\sum\alpha_1^3)+K_6(\sum\alpha_1^2\alpha_2\alpha_3)+K_7(\sum\alpha_1^4)+K_8(\sum\alpha_1^4\alpha_2^2)+K_9(\sum\alpha_1^6)$

Assuming P=(0.355 – 0.013[wt%Si]);

K_0=(3.498-0.36244Si)/P

K_1=5.236/P

K_2=1.6/P

K_3= 3/P

K_4= (2-0.11336Si)/P

K_5 =1.6/P

K_6 =(-10+0.1Si)/P

K_7=1.6/P

K_8= (1-0.327737Si)/P

K_9=1.6/P

CRYSTAL DIRECTION	TEXTURE FACTOR FOR ELECTRICAL STEELS
[100] α_1 =1,α_2 =0, α_3=0	$A^*_{[100]}$ = 27.88
[110] α_1 =1/√2,α_2 =1/√2, α_3=0	$A^*_{[110]}$ = 30.06
[112] α_1 =0.408248,α2 =0.408248, α3=0.816496	$A^*_{[111]}$ =30.77

3.5 Calculate Texture Factor constants K_0,K_1,K_2,K_3, K_4, K_5, K_6,K_7, K_8, K_9 of Electrical Steels for [Ɵ ,α, ϒ Fibres] and By General Method

General Method of Texture Factor Determination::

By Using Computational Method, We have

$p1=k0+k2+k5+k7+k9$

$p2=k0+0.5k1+k2+0.25k4+0.706k5+0.5k7+0.125k8+0.25k9$

$p3=k0+0.833k1+k2+0.136k3+0.25k4+0.6804k5+0.222k6+0.5k7+0.09567k8+0.3084k9$

$k0=k2=k5=k7=k9$ =p1/5;$k4=2$,$k8=1$;

$k1=2*(p2 -k0-k2-0.706k5-0.5k7-0.25k9)-1.25;k3=3;$

$k6=5.20833(p3-k0-0.833k1-k2-0.136k3-0.25k4 -0.6804k5-0.5k7-0.09567k8-0.3084k9)$

p1=27.88;p2=30.06;p3=30.77 give values of k1,...k9

$k0=5.576;k1=19.08;k2=5.576;k3=3;k4=2;k5=5.576;k6= -23.884;k7=5.576;k8=1;k9 =5.576$

$A^*=K_{+}K_1(\sum\alpha_1\alpha_2)+K_2(\sum\alpha_1^2)+K_3(\prod\alpha_1)+K_4(\sum\alpha_1^2\alpha_2^2)++K_5(\sum\alpha_1^3)+K_6(\sum\alpha_1^2\alpha_2\alpha_3)+K_7(\sum\alpha_1^4)+K_8(\sum\alpha_1^4\alpha_2^2)+K_9(\sum\alpha_1^6)$

$A^*_{ELECTRICAL\ STEELS}=5.576+19.08(\sum\alpha_1\alpha_2)+5.576(\sum\alpha_1^2)+3(\prod\alpha_1)+2(\sum\alpha_1^2\alpha_2^2)+5.576(\sum\alpha_1^3)-23.884(\sum\alpha_1^2\alpha_2\alpha_3)+5.576(\sum\alpha_1^4)+1(\sum\alpha_1^4\alpha_2^2)+5.576(\sum\alpha_1^6)$

CRYSTAL DIRECTION	TEXTURE FACTOR FOR ELECTRICAL STEELS
[100] α_1 =1,α_2 =0, α_3=0	$A^*_{[100]}$ = 27.88
[110] α_1 =1/√2,α_2 =1/√2, α_3=0	$A^*_{[110]}$ = 30.06

[112] α_1 =0.408248,$\alpha 2$ =0.408248, $\alpha 3$=0.816496	$A^*_{[111]}$ =30.77

DISCUSSIONS:

Magneto-Crystalline Anisotropy Energy Density value is least for [100] directions, and higher for [110] , [112] & random directions. Therefore [100] directions are easy directions of magnetization for pure iron,electrical steels and [112] hardest direction for magnetization of pure iron & electrical steels, [110] direction is harder direction for magnetization of pure iron and elecrical steels,Texture Factor Equation results are consistent with the standard results and conforms to the value of ideal fibres.

IV Generalised Estimation of Magnetic Susceptablility YBCO Super Conductor,Young's Modulus and Texture Factor of Inconel 718,OFHC,Beryllium Copper,Ti-6Al-4V,304 SS Along <100>,<110<111> By an expansion into Directional Cosines α1,α2,α3 w.r.to crystal axes.

$E^*=K_0 + K_1(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+K_2(\alpha_1^2+\alpha_2^2+\alpha_3^2)+K_3(\alpha_1\alpha_2\alpha_3)+K_4(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)++K_5(\alpha_1^3+\alpha_2^3+\alpha_3^3)+K_6(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+K_7(\alpha_1^4+\alpha_2^4+\alpha_3^4)+K_8(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+K_9(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

4.1 Calculation of Magnetic Susceptbility of YBCO(High -Tc Super Conductor) of An Expansion Into Direction Cosines α1,α2,α3 With Respect To The Crystal Axes

S.No	Crystallographic Directions	Magnetic Susceptbility of YBCO (High -Tc Super Conductor)
1.	<100>	-1
2.	<110>	0.5
3.	<111>	1

$X^*_{\text{MAGNETIC SUSCEPTABILITY OF YBCO}}=K_0 + K_1(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+K_2(\alpha_1^2+\alpha_2^2+\alpha_3^2)+K_3(\alpha_1\alpha_2\alpha_3)+K_4(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)++K_5(\alpha_1^3+\alpha_2^3+\alpha_3^3)+K_6(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+K_7(\alpha_1^4+\alpha_2^4+\alpha_3^4)+K_8(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+K_9(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

For <100> directions, α1 =1, α2 =0, α3=0 ….[I]

For <110> directions, α1 =1/√2, α2 =1/√2, α3=0….[II]

For <111> directions, α1 =1/√3, α2 =1/√3, α3=1/√3....[III]

$-1=k0+k2+k5+k7+k9$

$0.5=k0+0.5k1+k2+0.25k4+0.706k5+0.5k7+0.125k8+0.25k9$

$1=k0+k1+k2+0.192k3+0.333k4+0.576k5+0.192k6+0.333k7+0.111k8+0.192k9$

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$k0$= -0.2;$k1$=1.1324;$k2$= -0.2;$k3$=3;$k4$=2;$k5$= -0.2;$k6$=-0.4542;$k7$= -0.2;$k8$=1;$k9$= -0.2

$X*_{MAGNETIC\ SUSCEPTABILITY\ OF\ YBCO}= -0.2+1..1324(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)-0.2(\alpha_1^2+\alpha_2^2+\alpha_3^2)+3(\alpha_1\alpha_2\alpha_3)+2(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)-0.2(\alpha_1^3+\alpha_2^3+\alpha_3^3)-0.4542(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)-0.2(\alpha_1^4+\alpha_2^4+\alpha_3^4)+1(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)-0.2(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

Relationship Between $X*_{MAGNETIC\ SUSCEPTABILITY\ OF\ YBCO}$ and Texture Factor $A*_{MAGNETIC\ SUSCEPTABILITY\ OF\ YBCO}$

=> $X*_{MAGNETIC\ SUSCEPTABILITY\ OF\ YBCO\ 100} = X*_{INTRINSIC\ MAGNETIC\ SUSCEPTABILITY\ OF\ YBCO\ 100}\ A*_{100}$

=> $X*_{MAGNETIC\ SUSCEPTABILITY\ OF\ YBCO\ 100} =1.25*10^{-4}A*_{100}$

=> $X*_{MAGNETIC\ SUSCEPTABILITY\ OF\ YBCO\ 110} = X*_{INTRINSIC\ MAGNETIC\ SUSCEPTABILITY\ OF\ YBCO\ 110}\ A*_{110}$

=> $X*_{MAGNETIC\ SUSCEPTABILITY\ OF\ YBCO\ 110} =2.5*10^{-4}A*_{110}$

=>$X*_{MAGNETIC\ SUSCEPTABILITY\ OF\ YBCO\ 111} = X*_{INTRINSIC\ MAGNETIC\ SUSCEPTABILITY\ OF\ YBCO\ 111}\ A*_{111}$

=> $X*_{MAGNETIC\ SUSCEPTABILITY\ OF\ YBCO\ 100} =3.0*10^{-4}A*_{111}$

$A*_{100}=0.8*10^{-4}$;$A*_{110}= 0.4*10^{-4}$;$A*_{111}=-0.333*10^{-4}$

$A*_{MAGNETIC\ SUSCEPTABILITY\ OF\ YBCO}=K_0 + K_1(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+K_2(\alpha_1^2+\alpha_2^2+\alpha_3^2)+K_3(\alpha_1\alpha_2\alpha_3)+K_4(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)++K_5(\alpha_1^3+\alpha_2^3+\alpha_3^3)+K_6(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+K_7(\alpha_1^4+\alpha_2^4+\alpha_3^4)+K_8(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+K_9(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

$k0$=24.8;$k1$=82.3484;$k2$=24.8;$k3$=3;$k4$=2;$k5$=24.8;$k6$= -157.2927;$k7$=24.8;$k8$=1;$k9$=24.8

Texture Factor $_{MAGNETIC\ SUSCEPTABILITY\ OF\ YBCO}$:

$A*_{MAGNETIC\ SUSCEPTABILITY\ OF\ YBCO}=24.8+82.3484(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+24.8(\alpha_1^2+\alpha_2^2+\alpha_3^2)+3(\alpha_1\alpha_2\alpha_3)+2(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)+24.8(\alpha_1^3+\alpha_2^3+\alpha_3^3)-157.2927(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+24.8(\alpha_1^4+\alpha_2^4+\alpha_3^4)+1(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+24.8(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

4.2 Calculation Young's Modulusof Inconel Of An Expansion Into Direction Cosines α1,α2,α3 With Respect To The Crystal Axes

S.No	Crystallographic Directions	Young's Modulus Of Inconel
1.	<100>	220 GPa
2.	<110>	210 GPa
3.	<111>	200 GPa

$E*_{INCONEL}=K_0 + K_1(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+K_2(\alpha_1^2+\alpha_2^2+\alpha_3^2)+K_3(\alpha_1\alpha_2\alpha_3)+K_4(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)++K_5(\alpha_1^3+\alpha_2^3+\alpha_3^3)+K_6(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+K_7(\alpha_1^4+\alpha_2^4+\alpha_3^4)+K_8(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+K_9(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

For <100> directions, $\alpha 1 = 1, \alpha 2 = 0, \alpha 3 = 0$ ….[I]

For <110> directions, $\alpha 1 = 1/\sqrt{2}, \alpha 2 = 1/\sqrt{2}, \alpha 3 = 0$….[II]

For <111> directions, $\alpha 1 = 1/\sqrt{3}, \alpha 2 = 1/\sqrt{3}, \alpha 3 = 1/\sqrt{3}$....[III]

$220 = k0 + k2 + k5 + k7 + k9$

$210 = k0 + 0.5k1 + k2 + 0.25k4 + 0.706k5 + 0.5k7 + 0.125k8 + 0.25k9$

$200 = k0 + k1 + k2 + 0.192k3 + 0.333k4 + 0.576k5 + 0.192k6 + 0.333k7 + 0.111k8 + 0.192k9$

$k0 = 44; k1 = 114.622; k2 = 44; k3 = 3; k4 = 2; k5 = 44; k6 = -273.015; k7 = 44; k8 = 1; k9 = 44$

$E^*_{INCONEL} = 44 + 114.622(\alpha_1\alpha_2 + \alpha_2\alpha_3 + \alpha_3\alpha_1) + 44(\alpha_1^2 + \alpha_2^2 + \alpha_3^2) + 3(\alpha_1\alpha_2\alpha_3) + 2(\alpha_1^2\alpha_2^2 + \alpha_2^2\alpha_3^2 + \alpha_3^2\alpha_1^2) + 44(\alpha_1^3 + \alpha_2^3 + \alpha_3^3) - 273.015(\alpha_1^2\alpha_2\alpha_3 + \alpha_2^2\alpha_3\alpha_1 + \alpha_3^2\alpha_1\alpha_2)44(\alpha_1^4 + \alpha_2^4 + \alpha_3^4) + 1(\alpha_1^4\alpha_2^2 + \alpha_2^4\alpha_3^2 + \alpha_3^4\alpha_1^2) + 44(\alpha_1^6 + \alpha_2^6 + \alpha_3^6)$

Relationship Between $Y^*_{INCONEL}$ and Texture Factor $A^*_{INCONEL}$

=> $E^*_{100} = 207 + 124.2A^*_{100}$

=> $E^*_{110} = 207 + 165.6A^*_{110}$

=> $E^*_{111} = 207 + 207A^*_{111}$

$A^*_{100} = 0.1046$; $A^*_{110} = 0.0181$; $A^*_{111} = -0.0338$

$k0 = 0.02092; k1 = -1.3584; k2 = 0.02092; k3 = 3; k4 = 2; k5 = 0.02092; k6 = 4.9145; k7 = 0.02092; k8 = 1; k9 = 0.02092$

Texture Factor for INCONEL 718 :

$A^*_{INCONEL} = 0.02092 - 1.3584(\alpha_1\alpha_2 + \alpha_2\alpha_3 + \alpha_3\alpha_1) + 0.02092(\alpha_1^2 + \alpha_2^2 + \alpha_3^2) + 3(\alpha_1\alpha_2\alpha_3) + 2(\alpha_1^2\alpha_2^2 + \alpha_2^2\alpha_3^2 + \alpha_3^2\alpha_1^2) + 0.02092(\alpha_1^3 + \alpha_2^3 + \alpha_3^3) + 4.9145(\alpha_1^2\alpha_2\alpha_3 + \alpha_2^2\alpha_3\alpha_1 + \alpha_3^2\alpha_1\alpha_2) + 0.02092(\alpha_1^4 + \alpha_2^4 + \alpha_3^4) + 1(\alpha_1^4\alpha_2^2 + \alpha_2^4\alpha_3^2 + \alpha_3^4\alpha_1^2) + 0.02092(\alpha_1^6 + \alpha_2^6 + \alpha_3^6)$

1.3 Calculation Young's Modulus of OFHC Copper An Expansion Into Direction Cosines $\alpha 1, \alpha 2, \alpha 3$ With Respect To The Crystal Axes

S.No	Crystallographic Directions	Young's Modulus Of Inconel
1.	<100>	66 GPa
2.	<110>	130 GPa
3.	<111>	190 GPa

$E^*_{OFHC\ COPPER} = K_0 + K_1(\alpha_1\alpha_2 + \alpha_2\alpha_3 + \alpha_3\alpha_1) + K_2(\alpha_1^2 + \alpha_2^2 + \alpha_3^2) + K_3(\alpha_1\alpha_2\alpha_3) + K_4(\alpha_1^2\alpha_2^2 + \alpha_2^2\alpha_3^2 + \alpha_3^2\alpha_1^2) + + K_5(\alpha_1^3 + \alpha_2^3 + \alpha_3^3) + K_6(\alpha_1^2\alpha_2\alpha_3 + \alpha_2^2\alpha_3\alpha_1 + \alpha_3^2\alpha_1\alpha_2) + K_7(\alpha_1^4 + \alpha_2^4 + \alpha_3^4) + K_8(\alpha_1^4\alpha_2^2 + \alpha_2^4\alpha_3^2 + \alpha_3^4\alpha_1^2) + K_9(\alpha_1^6 + \alpha_2^6 + \alpha_3^6)$

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For <100> directions, $\alpha1 = 1, \alpha2 = 0, \alpha3 = 0$ ….[I]

For <110> directions, $\alpha1 = 1/\sqrt{2}, \alpha2 = 1/\sqrt{2}, \alpha3 = 0$….[II]

For <111> directions, $\alpha1 = 1/\sqrt{3}, \alpha2 = 1/\sqrt{3}, \alpha3 = 1/\sqrt{3}$....[III]

$66 = k0 + k2 + k5 + k7 + k9$

$130 = k0 + 0.5k1 + k2 + 0.25k4 + 0.706k5 + 0.5k7 + 0.125k8 + 0.25k9$

$190 = k0 + k1 + k2 + 0.192k3 + 0.333k4 + 0.576k5 + 0.192k6 + 0.333k7 + 0.111k8 + 0.192k9$

$k0 = 12; k1 = 175.806; k2 = 12; k3 = 3; k4 = 2; k5 = 12; k6 = -125.75; k7 = 12; k8 = 1; k9 = 12$

$E^*_{OFHC\ COPPER} = 12 + 175.806(\alpha_1\alpha_2 + \alpha_2\alpha_3 + \alpha_3\alpha_1) + 12(\alpha_1^2 + \alpha_2^2 + \alpha_3^2) + 3(\alpha_1\alpha_2\alpha_3) + 2(\alpha_1^2\alpha_2^2 + \alpha_2^2\alpha_3^2 + \alpha_3^2\alpha_1^2) + 12(\alpha_1^3 + \alpha_2^3 + \alpha_3^3) - 125.75(\alpha_1^2\alpha_2\alpha_3 + \alpha_2^2\alpha_3\alpha_1 + \alpha_3^2\alpha_1\alpha_2) + 12(\alpha_1^4 + \alpha_2^4 + \alpha_3^4) + 1(\alpha_1^4\alpha_2^2 + \alpha_2^4\alpha_3^2 + \alpha_3^4\alpha_1^2) + 12(\alpha_1^6 + \alpha_2^6 + \alpha_3^6)$

Relationship Between $Y^*_{INCONEL}$ and Texture Factor $A^*_{INCONEL}$

=> $E^*_{100} = 110 + 66A^*_{100}$

=> $E^*_{110} = 110 + 88A^*_{110}$

=> $E^*_{111} = 110 + 110A^*_{111}$

$A^*_{100} = -0.7576$; $A^*_{110} = 0.2273$; $A^*_{111} = 0.7273$

$k0 = -0.1515; k1 = 0.3468; k2 = -0.1515; k3 = 3; k4 = 2; k5 = -0.1515; k6 = 2.0722; k7 = -0.1515; k8 = 1; k9 = -0.1515$

$A^*_{OFHC\ COPPER} = K_0 + K_1(\alpha_1\alpha_2 + \alpha_2\alpha_3 + \alpha_3\alpha_1) + K_2(\alpha_1^2 + \alpha_2^2 + \alpha_3^2) + K_3(\alpha_1\alpha_2\alpha_3) + K_4(\alpha_1^2\alpha_2^2 + \alpha_2^2\alpha_3^2 + \alpha_3^2\alpha_1^2) + +K_5(\alpha_1^3 + \alpha_2^3 + \alpha_3^3) + K_6(\alpha_1^2\alpha_2\alpha_3 + \alpha_2^2\alpha_3\alpha_1 + \alpha_3^2\alpha_1\alpha_2) + K_7(\alpha_1^4 + \alpha_2^4 + \alpha_3^4) + K_8(\alpha_1^4\alpha_2^2 + \alpha_2^4\alpha_3^2 + \alpha_3^4\alpha_1^2) + K_9(\alpha_1^6 + \alpha_2^6 + \alpha_3^6)$

$A^*_{OFHC\ COPPER} = -0.1515 + 0.3468(\alpha_1\alpha_2 + \alpha_2\alpha_3 + \alpha_3\alpha_1) - 0.1515(\alpha_1^2 + \alpha_2^2 + \alpha_3^2) + 3(\alpha_1\alpha_2\alpha_3) + 2(\alpha_1^2\alpha_2^2 + \alpha_2^2\alpha_3^2 + \alpha_3^2\alpha_1^2) - 0.1515(\alpha_1^3 + \alpha_2^3 + \alpha_3^3) + 2.0722(\alpha_1^2\alpha_2\alpha_3 + \alpha_2^2\alpha_3\alpha_1 + \alpha_3^2\alpha_1\alpha_2) - 0.1515(\alpha_1^4 + \alpha_2^4 + \alpha_3^4) + 1(\alpha_1^4\alpha_2^2 + \alpha_2^4\alpha_3^2 + \alpha_3^4\alpha_1^2) - 0.1515(\alpha_1^6 + \alpha_2^6 + \alpha_3^6)$

4.3Calculation Young's Modulus of Beryllium Copper Of An Expansion Into Direction Cosines $\alpha1, \alpha2, \alpha3$ With Respect To The Crystal Axes

S.No	Crystallographic Directions	Young's Modulus Of Inconel
1.	<100>	124 GPa
2.	<110>	128 GPa
3.	<111>	130 GPa

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$E^*_{BERYLLIUM\ COPPER}=K_0+K_1(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+K_2(\alpha_1^2+\alpha_2^2+\alpha_3^2)+K_3(\alpha_1\alpha_2\alpha_3)+K_4(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)++K_5(\alpha_1^3+\alpha_2^3+\alpha_3^3)+K_6(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+K_7(\alpha_1^4+\alpha_2^4+\alpha_3^4)+K_8(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+K_9(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

For <100> directions, α1 =1, α2 =0, α3=0 ….[I]

For <110> directions, α1 =1/√2, α2 =1/√2, α3=0….[II]

For <111> directions, α1 =1/√3, α2 =1/√3, α3=1/√3....[III]

$124=k0+k2+k5+k7+k9$

$128=k0+0.5k1+k2+0.25k4+0.706k5+0.5k7+0.125k8+0.25k9$

$130=k0+k1+k2+0.192k3+0.333k4+0.576k5+0.192k6+0.333k7+0.111k8+0.192k9$

$k0=24.8;k1=83.31;k2=24.8;k3=3;k4=2;k5=24.8;k6=366.96;k7=24.8;k8=1;k9=24.8$

$E^*_{BERYLIUM\ COPPER}=24.8+83.31(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+24.8(\alpha_1^2+\alpha_2^2+\alpha_3^2)+3(\alpha_1\alpha_2\alpha_3)+2(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)+24.8(\alpha_1^3+\alpha_2^3+\alpha_3^3)+366.96(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+34.8(\alpha_1^4+\alpha_2^4+\alpha_3^4)+1(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+24.8(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

Relationship Between $Y^*_{INCONEL}$ and Texture Factor $A^*_{INCONEL}$

=> $E^*_{100} = 130+78A^*_{100}$

=> $E^*_{110} = 130+104A^*_{110}$

=> $E^*_{111} = 130+130 \quad A^*_{111}$

$A^*_{100} = -0.0769$;$A^*_{110} = -0.0185$;$A^*_{111}=-0$

$A^*_{BERYLLIUM\ COPPER}=K_0+K_1(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+K_2(\alpha_1^2+\alpha_2^2+\alpha_3^2)+K_3(\alpha_1\alpha_2\alpha_3)+K_4(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)++K_5(\alpha_1^3+\alpha_2^3+\alpha_3^3)+K_6(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+K_7(\alpha_1^4+\alpha_2^4+\alpha_3^4)+K_8(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+K_9(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

$k0= -0.01538;k1=-1.10456;k2=-0.01538;k3=3;k4=2;k5= -0.01538;k6=4.035;k7= -0.01538;k8=1;k9= -0.01538$

$A^*_{BERYLLIUM\ COPPER}= -0.01538+ 1.10456(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)-0.01538(\alpha_1^2+\alpha_2^2+\alpha_3^2)+3(\alpha_1\alpha_2\alpha_3)+2(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)-0.01538(\alpha_1^3+\alpha_2^3+\alpha_3^3)+4.035(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)-0.01538(\alpha_1^4+\alpha_2^4+\alpha_3^4)+1(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)-0.01538(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

4.4 Calculation Young's Modulusof 304 SS Of An Expansion Into Direction Cosines α1,α2,α3 With Respect To The Crystal Axes

S.No	Crystallographic Directions	Young's Modulus Of Inconel
1.	<100>	130 GPa

2.	<110>	200 GPa
3.	<111>	290 GPa

$E^*_{304\ SS}=K_0+K_1(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+K_2(\alpha_1^2+\alpha_2^2+\alpha_3^2)+K_3(\alpha_1\alpha_2\alpha_3)+K_4(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)++K_5(\alpha_1^3+\alpha_2^3+\alpha_3^3)+K_6(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+K_7(\alpha_1^4+\alpha_2^4+\alpha_3^4)+K_8(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+K_9(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

For <100> directions, $\alpha 1=1$, $\alpha 2=0$, $\alpha 3=0$ ….[I]

For <110> directions, $\alpha 1=1/\sqrt{2}$, $\alpha 2=1/\sqrt{2}$, $\alpha 3=0$….[II]

For <111> directions, $\alpha 1=1/\sqrt{3}$, $\alpha 2=1/\sqrt{3}$, $\alpha 3=1/\sqrt{3}$....[III]

$130=k0+k2+k5+k7+k9$

$200=k0+0.5k1+k2+0.25k4+0.706k5+0.5k7+0.125k8+0.25k9$

$290=k0+k1+k2+0.192k3+0.333k4+0.576k5+0.192k6+0.333k7+0.111k8+0.192k9$

$k0=26;k1=219.03;k2=26;k3=3;k4=2;k5=26;k6=-2.629;k7=26;k8=1;k9=26$

$E^*_{304\ SS}=26+219.03(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+26(\alpha_1^2+\alpha_2^2+\alpha_3^2)+3(\alpha_1\alpha_2\alpha_3)+2(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)+26(\alpha_1^3+\alpha_2^3+\alpha_3^3)-2.629(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+26(\alpha_1^4+\alpha_2^4+\alpha_3^4)+1(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+26(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

Relationship Between $E^*_{304\ SS}$ and Texture Factor $A^*_{304\ SS}$

=> $E^*_{100} = 193+115.8\ A^*_{100}$

=> $E^*_{110} = 193+154.4\ A^*_{110}$

=> $E^*_{111} = 193+193\ A^*_{111}$

$A^*_{100} = -0.543$; $A^*_{110} = 0.0453$; $A^*_{111}= 0.503$

$A^*_{304\ SS}=K_0+K_1(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+K_2(\alpha_1^2+\alpha_2^2+\alpha_3^2)+K_3(\alpha_1\alpha_2\alpha_3)+K_4(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)++K_5(\alpha_1^3+\alpha_2^3+\alpha_3^3)+K_6(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+K_7(\alpha_1^4+\alpha_2^4+\alpha_3^4)+K_8(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+K_9(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

$k0=-0.1086;k1=-0.4088;k2=-0.1086;k3=3;k4=2;k5=-0.1086;k6=3.9608;k7=-0.1086;k8=1;k9=-0.1086$

Texture Factor for 304 SS :

$A^*_{304\ SS}=-0.1086-0.4088(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)-0.1086(\alpha_1^2+\alpha_2^2+\alpha_3^2)+3(\alpha_1\alpha_2\alpha_3)+2(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)-0.1086(\alpha_1^3+\alpha_2^3+\alpha_3^3)+3.9608(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)-0.1086(\alpha_1^4+\alpha_2^4+\alpha_3^4)+1(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)-0.1086(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

4.5 Calculation Young's Modulusof Ti-6Al-4V Of An Expansion Into Direction Cosines $\alpha 1,\alpha 2,\alpha 3$ With Respect To The Crystal Axes

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S.No	Crystallographic Directions	Young's Modulus Of Ti-6Al-4V
1.	<0001>	113 GPa
2.	<10-10>	140 GPa
3.	<11-20>	118 GPa

$E^*_{Ti\text{-}6Al\text{-}4V}=K_0+K_1(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+K_2(\alpha_1^2+\alpha_2^2+\alpha_3^2)+K_3(\alpha_1\alpha_2\alpha_3)+K_4(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)++K_5(\alpha_1^3+\alpha_2^3+\alpha_3^3)+K_6(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+K_7(\alpha_1^4+\alpha_2^4+\alpha_3^4)+K_8(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+K_9(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

For <100> directions, $\alpha 1 =1, \alpha 2 =0, \alpha 3=0$ ….[I]

For <110> directions, $\alpha 1 =1/\sqrt{2}, \alpha 2 =1/\sqrt{2}, \alpha 3=0$….[II]

For <111> directions, $\alpha 1 =1/\sqrt{3}, \alpha 2 =1/\sqrt{3}, \alpha 3=1/\sqrt{3}$....[III]

$113=k0+k2+k5+k7+k9$

$140=k0+0.5k1+k2+0.25k4+0.706k5+0.5k7+0.125k8+0.25k9$

$118=k0+k1+k2+0.192k3+0.333k4+0.576k5+0.192k6+0.333k7+0.111k8+0.192k9$

$k0=22.6;k1=124.54;k2=22.6;k3=3;k4=2;k5=22.6;k6= -405.57;k7=22.6;k8=1;k9=22.6$

$E^*_{Ti\text{-}6Al\text{-}4V}=22.6+219.03(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+22.6(\alpha_1^2+\alpha_2^2+\alpha_3^2)+3(\alpha_1\alpha_2\alpha_3)+2(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)+22.6(\alpha_1^3+\alpha_2^3+\alpha_3^3)-2.629(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+22.6(\alpha_1^4+\alpha_2^4+\alpha_3^4)+1(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+22.6(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

Relationship Between $E^*_{Ti\text{-}6Al\text{-}4V}$ and Texture Factor $A^*_{Ti\text{-}6Al\text{-}4V}$

=> $E^*_{<0001>} = 113.8+136.56 A^*_{100}$

=> $E^*_{<10-10>} = 113.8+91.04 A^*_{110}$

=> $E^*_{<11-20>} = 113.8+79.66 A^*_{111}$

$A^*_{100} = -0.0586*10^{-3}$;$A^*_{110} = 2.62*10^{-3}$;$A^*_{111}= 0.474*10^{-3}$

$A^*_{Ti\text{-}6Al\text{-}4V}=K_0+K_1(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)+K_2(\alpha_1^2+\alpha_2^2+\alpha_3^2)+K_3(\alpha_1\alpha_2\alpha_3)+K_4(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)++K_5(\alpha_1^3+\alpha_2^3+\alpha_3^3)+K_6(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)+K_7(\alpha_1^4+\alpha_2^4+\alpha_3^4)+K_8(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)+K_9(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

$k0= -0.01172;k1=4.1589;k2= -0.01172;k3=3;k4=2;k5= -0.01172;k6=-26.13;k7= -0.01172;k8=1;k9= -0.01172$

Texture Factor for Ti-6Al-4V :

$A^*_{Ti\text{-}6Al\text{-}4V}= -0.01172 +4.1589(\alpha_1\alpha_2+\alpha_2\alpha_3+\alpha_3\alpha_1)-0.01172(\alpha_1^2+\alpha_2^2+\alpha_3^2)+3(\alpha_1\alpha_2\alpha_3)+2(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2)-$

$0.01172(\alpha_1^3+\alpha_2^3+\alpha_3^3)+26.13(\alpha_1^2\alpha_2\alpha_3+\alpha_2^2\alpha_3\alpha_1+\alpha_3^2\alpha_1\alpha_2)-0.01172(\alpha_1^4+\alpha_2^4+\alpha_3^4)+1(\alpha_1^4\alpha_2^2+\alpha_2^4\alpha_3^2+\alpha_3^4\alpha_1^2)-0.01172(\alpha_1^6+\alpha_2^6+\alpha_3^6)$

V Conclusion.

Magnetic Anisotropy Energy Density and Texture of Pure Iron,Electrical Steels & Susceptability of YBCO Super Conductor,Young's Modulus and Texture Factor of Inconel 718.OFHC Copper,Beryllium Copper,Ti-6Al-4V,304SScan be expressed By an Expansion into Direction Cosines α1, α2, α3 With Respect To the Crystal Axes. Generalized equation of Magnetic Anisotropy Energy Density and Texture of Pure Iron,Electrical Steels & Magnetic Susceptability of YBCO Super Conductor,Young's Modulus and Texture Factor of Inconel 718.OFHC Copper,Beryllium Copper,Ti-6Al-4V,304SS can be utilized to obtain its value at any crystallographic direction with the provision of directional cosines α1, α2, α3 along that particular crystallographic direction.

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