IMPROVING THE SPECIFICATION AND THE REQUIREMENTS OF THE D.CWAVE WINDING MACHINE [+]

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Abstract :

The search suggests to add new factor on D.C wave winding machine equation to simplfy its hardly requirements and to improve the specification of machine and to accept any no.of slots, coils & segments. Taken 88 symbole of coils and applied the factor on the winding equation which led to the improvement of machine for example the area of brushes which covers the surfaces of commutator will be increased & at the same time the no. of brushes will be increased which led to decrease the spark ,improve the commutation , increase the age of machine,production and its efficiency .The factor plays alarge important role to wide the selection of coils by cancel the hardly requirements.

تطوير خصائص وشروط ماكنة التيار المستمر ذات اللف التموجي

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المستخلص :

البحث يقترح اظافة عامل جديد إلى معادلة اللف التموجي لماكنة التيار بهدف تسهيل الشروط الصعبة ألموضوعه على تلك المعادلة وتحسين خصائص الماكنة وقبول أي عدد من المجارى والملفات وقطع الموحد. لقد تناول البحث اخذ 88 نموذجا من الملف (كعينات) وقام بتطبيق العامل أعلاه على معادلة اللف ولاحظ تحسن على خصائص الماكنة من خلال زيادة مساحات الفرش التي تغطى سطح الموحد وزيادة إعدادها والتي أدت إلى تقليل ألشراره وتحسين التبديل الأمر الذي أدى إلى زيادة عمر الماكنة وزيادة إنتاجها وكفاءتها. إن العامل المضاف لعب دورا كبيرا في توسيع دائرة اختيار عدد الملفات التي أدت إلى قبول أعداد الملفات المرفوضة سابقا وإزالة الشروط الصعبة ألموضوعه عليها.

Abbreviations :

1- c_s → Starting segment.
2- R.B.C.→Return back segment (i.e. final segment at once tracing around the armature).
3- c_s► → This is mean that the R. B.C. is after Cs at once tracing around armature.
4- c_s ◄→ This is mean that the R. B.C. is before Cs at once tracing around armature.
5- ≡→This is meaning that R. B .C coincides on Cs at once tracing around armature.
6- bc_s► → No. of segments after Cs when we go once tracing around the armature.

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7- bc_s◄ → No. of segments before Cs when we go once tracing around the armature.
8- ◄& ►→Retrogressive & progressive respectively.
9- C ,c_o& p→ No. Of (segments, coils & poles) respectively.
10- Y_S,Y_C&Y_F → (Coil span ,commutator pitch & front pitch) respectively .
11- B &B_w = (No. of brushes & brush width measured by no. of segments) respectively.
12- e_a,e_p = (Armature &path) e.m.f. respectively.
13- G.→Generator.
14- M.→ Motor.
15- I_p , I_a&I_c= (path, armature & coil) current respectively.
16- a = No. of parallel paths.
17- R_a,R_p= (Armature & path) resistance respectively.
18- m = Multiplicity factor.
19- R = Reentrant.

1- Introduction :

The coil span (Y_s) of d.c . winding (lap & wave) machine is calculated as follow:-

Y_s = S/P – k_s...1

where S,P are no. of slots, poles respectivelly & k is factor to make Y_s always integer. There are many differences between lap & wave windings , one of them is the way by which the coil ends of two types are connected to commutator segments [1].The commutator pitch (Y_c) in wave type approximatly equal to 360° (i.e. not exact.), because it is impossible to connect compeletly all winding if Y_c equal exact 360° , but It is possible at approximation . At Y_c = 360° exact , so every group of coils would consistute a complete reentrancy (R) . The commutator pitch is calculated as follow:-

Y_c = (C ± m) / (P/2) 2

where C , p & m are no. of seqments , poles & multiplicity factor respectivelly, and m = ± (1, 2 , 3 , 4....) where (+) means progressive & (-) is retrogressive. Also (1 ,2 , 3, 4) are simplex, douplex,triplex & quaderlex respectivelly[2]. Y_c must be integer in equation no. 2 above,so there is restrection on selection of C . If we start from segment to segment, so the entire winding must be traced from coil side to coil side befor closure occurs,that is befor the winding reenters [3]. After one complete tracing around the commutator the connection with first segment is befor or after it, the befor means retrogressive & after means progressive. If the no. of segments in befor case equal one this is mean simplex & if equal two this is mean doublex & three is triplex & so on.The same thing happens in progressive case [4].The simplex,douplex,triplex,& quiderlex.....act, have onle one,two,three & four degrees of reentrances(R) respectivelly.The no. of segments must be selected with relation to the no. of poles,that the commutator pitch Y_c can be made alittle more or less than two pole pitches[5].After tracing the winding once around the commutator,the last coil end should arrive one segment behind or one segment ahead of the starting segment.In this way further tracing of the winding will result in droping back or going ahead one segment at a time ,until

the entire winding is traced & the first segment is reached,thus the winding will reenter only after every coil &segments are connected [6].
The no. of parallel paths (a) in simplex wave winding is only two regardless of poles, in lap type the no. of paths are :-

a = mp..3

The conductors in each of two paths of wave winding are distributed under all the poles,so wave wound need two sets of brushes only .If the brush sets as poles , one or more of the satisfactrory operation is still possible ,that is not true in lap wound machine[7]. The sparkless commutation of wave wound is more likely to occur than lap wound. The reason for this is that each of two parallel paths in lap winding contains condoctors distributed compeletly a round the entire circumferance under two poles only. If fluxes produced by all the poles are not exactly the same ,the voltages generated in both of the paths of the wave type are still exactly equal because the two pathes are affacted similarly .The designers have attempted to use multiplex wave windin, such windings have (2*plex) paths in parallel regardless no. of poles[8].

2- The proposed work :

The new suggesting equation is:

Y_c = ((C ± m)/p/2) ± k 4

where k is the new additional factor. To prove the activity of new factor in equation no.4 ,we shall take four main cases each one has 22 secondary cases as follow :

Case (1): -At C = 25 (odd no.) , p = 4 &Ys = (180° & 150°) ,then we take Y_c as follow:-
1 − Y_c = 6 → 16 (i.e. Y_c = 1 or 2 or 3 or 4 or 5..........till Yc = 16)…for Ys=180°only.
2 − $Y_c$is repeated (i.e.Y_c = 6→ 16) for Ys = 150° only. From 6 to 16 we have 11 cases, h hence there are 11 secondary cases for each one of two items 1 & 2 above & finally the total is 22 secondary cases.

Case (2): - AT C = 24 (even no.) , p = 4 &Ys = (180° & 150 °) ,then we takeY_c as follow:-
Y_c =6 →16……….(i. e. case (2) has also 22 secondary cases like case(1) above).

Case (3): – At C = 25, P = 6 &Ys = (180° & 135°) ,then we take Y_c as follow:-
Y_c = 6 →16……..(i.e. case(3) has also 22 secondary cases.).

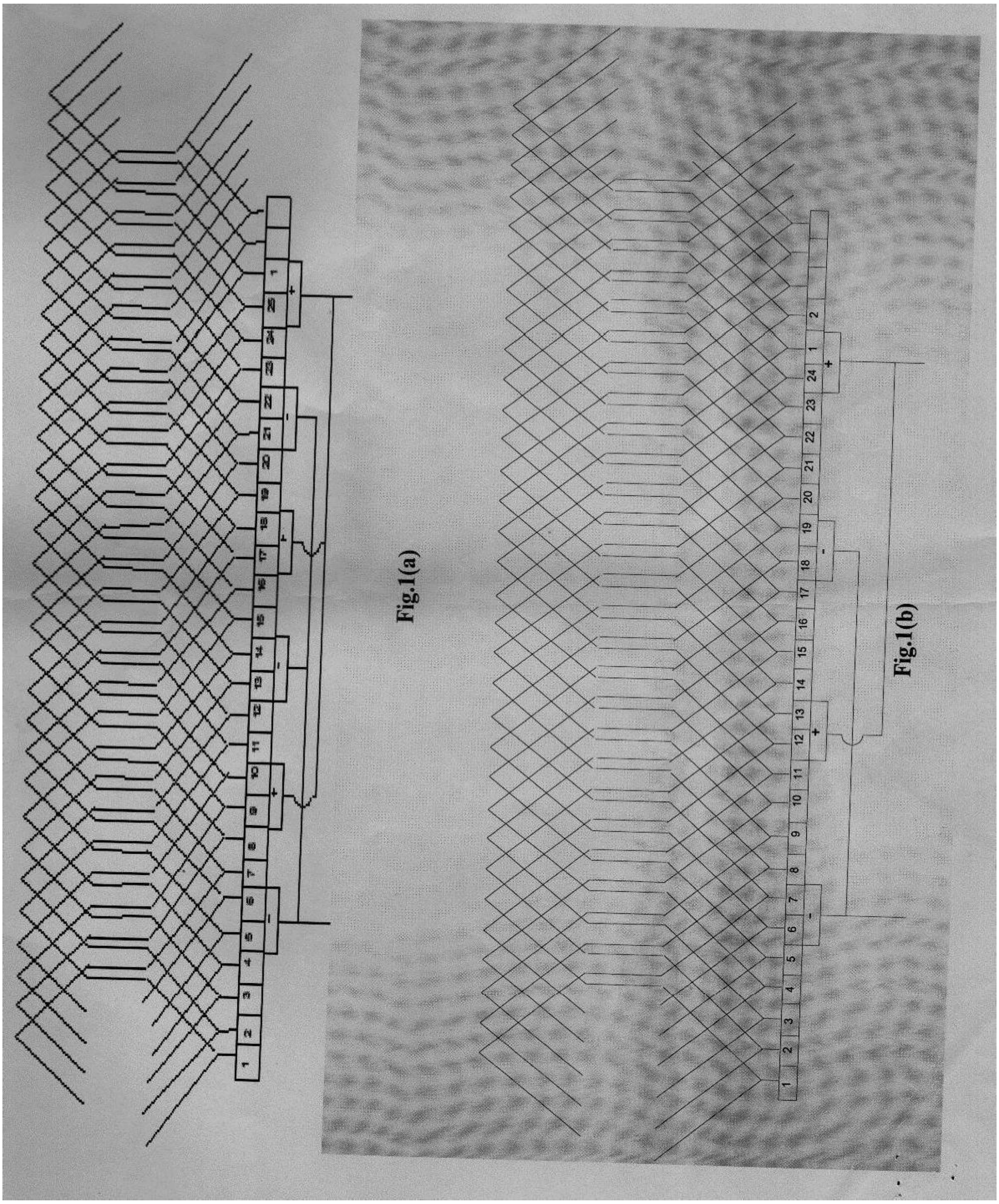
Case (4): - At C = 24 ,p = 6 &Ys = (180° & 135 °).,then we take Y_c as follow:
Y_c= 6→16……..hence case (4) also has 22 secondary cases.

Case study:

There are 88 cases was taken in concern, fig.(1.a,b&c) was taken a symbol to show the complete wave winding for three cases & these are:-

1- (25C, 4pole, Ys= (180°&150°), Yc =10).
2- (24C, 4pole, Ys= (180°&150°), Yc = 11).
3- (25C, 6pole, Ys= (180°&150°), Yc= 6).

The other cases are shown in the appendix. From the diagrams many table were concluded



Fig,1(a)

Fig.1(b)

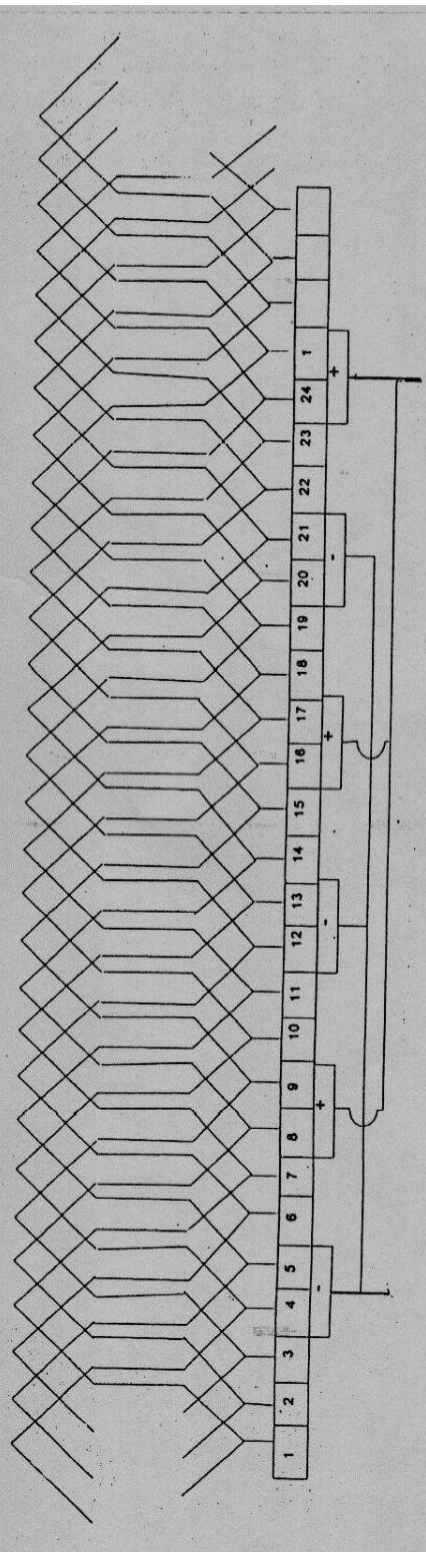


Fig.1.3 (c)

Fig.1. (a,b,c) shows a complete wave winding for three cases above a- (25C,6p,10yc), b- (24C,4p,11yc)& c- (24C,6p,6yc) respectively

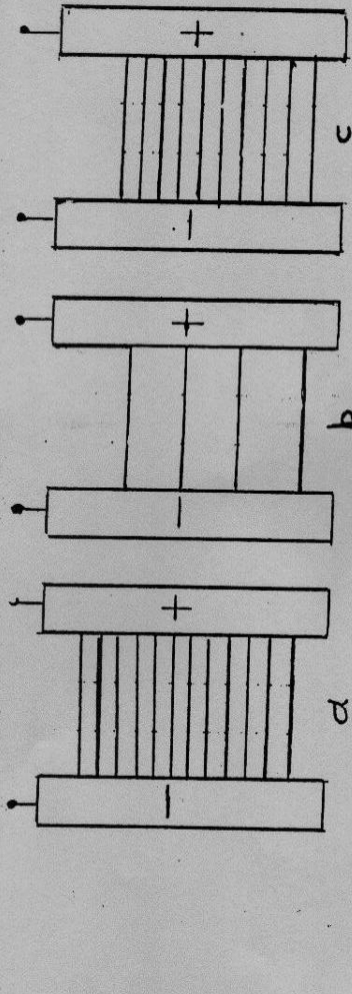


FIG.2(a,b,c)shows the parallel paths of fig . 1 (a,b,c) above respectively

C=24 P=4 Ys=180

Yc	B	Bw	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1
9	4	3				+	+	+				-	-	-				+	+	+				-	-	-	
10	4	2				+	+					-	-					+	+					-	-		
11	4	1				+						-						+						-			
13	4	1				+						-						+						-			
14	4	2				+	+					-	-					+	+					-	-		
15	4	3				+	+	+				-	-	-				+	+	+				-	-	-	
16	4	3				+	+	+	+			-	-	-	-			+	+	+	+			-	-	-	

(a)

C=24 P=4 Ys =150

Yc	B	Bw	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1	2
6	4	5	+	+	+	+	+		-	-	-	-	-		+	+	+	+	+		-	-	-	-	-			
7	4	4	+	+	+	+			-	-	-	-			+	+	+	+			-	-	-	-				
8	4	3	+	+	+				-	-	-				+	+	+				-	-	-					
9		3	+	+	+				-	-	-				+	+	+				-	-	-					
10	4	1	+						-						+						-							
11	4	2	+	+					-	-					+	+					-	-						
12	4	3	+	+	+				-	-	-				+	+	+				-	-	-					
13	4	2	+	+					-	-					+	+					-	-						
14	4	3	+	+	+				-	-	-				+	+	+				-	-	-					
15	4	3	+	+	+				-	-	-				+	+	+				-	-	-					
16	4	5	+	+	+	+	+		-	-	-	-	-		+	+	+	+	+		-	-	-	-	-			

(b)

C=24 P=6 Ys =180

Yc	B	Bw	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1	2
6	6	1	+				-				+				-				+				-					
7	6	2	+	+			-	-			+	+			-	-			+	+			-	-				
8	6	1	+				-				+				-				+				-					
9		2	+	+			-	-			+	+			-	-			+	+			-	-				
10	6	3	+	+	+		-	-	-		+	+	+		-	-	-		+	+	+		-	-	-			
11	6	4	+	+	+	+	-	-	-	-	+	+	+	+	-	-	-	-	+	+	+	+	-	-	-	-		
12	6	3	+	+	+		-	-	-		+	+	+		-	-	-		+	+	+		-	-	-			
13	6	2	+	+			-	-			+	+			-	-			+	+			-	-				
14	6	1	+				-				+				-				+				-					
15	6																											
16	6																											

(c)

Figure (3): (a,b,c):- Shows the brash position & their no. for three types of winding with different commutator pitches

C=24 P=6 Ys =135																												
Yc	B	Bw	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1	2
6	6	1	+				-				+				-				+				-					
7	6	1	+				-				+				-				+				-					
8	6																											
9		1	+				-				+				-				+				-					
10	6	2	+	+			-	-			+	+			-	-			+	+			-	-				
11	6	3	+	+	+		-	-	-		+	+	+		-	-	-		+	+	+		-	-	-			
12	6	4	+	+	+	+	-	-	-	-	+	+	+	+	-	-	-	-	+	+	+	+	-	-	-	-		
13	6	3	+	+	+		-	-	-		+	+	+		-	-	-		+	+	+		-	-	-			
14	6	3	+	+	+		-	-	-		+	+	+		-	-	-		+	+	+		-	-	-			
15	6	1	+				-				+				-				+				-					
16	6																		+									

(a)

C=25 P=4 Ys =180																												
Yc	B	Bw	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1	2
9	4	3	+	+	+				-	-	-					+	+	+			-	-	-					
10	4	2	+	+					-	-						+	+				-	-						
11	4	1	+						-							+					-							
12	4	1	+						-							+					-							
13	4	1	+						-							+					-							
14	4	1	+						-							+					-							
15	4	3	+	+	+				-	-	-					+	+	+			-	-	-					
16	4	3	+	+	+				-	-	-					+	+	+			-	-	-					
14	4																											
15	4																											
16	4																											

(b)

C=25 P=4 Ys =150																												
Yc	B	Bw	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1	2
6	4	5	+	+	+	+	+		-	-	-	-	-		+	+	+	+	+		-	-	-	-	-			
7	4	4	+	+	+	+			-	-	-	-			+	+	+	+			-	-	-	-				
8	4	3	+	+	+				-	-	-				+	+	+				-	-	-					
9	4	2	+	+					-	-					+	+					-	-						
10	4	1	+						-						+						-							
11	4	1	+						-						+						-							
12	4	1	+						-						+						-							
13	4	2	+	+					-	-					+	+					-	-						
14	4	3	+	+	+				-	-	-				+	+	+				-	-	-					
15	4	4	+	+	+	+			-	-	-	-			+	+	+	+			-	-	-	-				
16	4	4	+	+	+	+			-	-	-	-			+	+	+	+			-	-	-	-				

(c)

Figure (4): (a,b,c): Shows brush positions & their no. for three types of windings with different commutator pitchs(see tables 4 &3).

C=25 P=6 Ys =180																												
Yc	B	Bw	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1	2
7	6	1	+				-				+				-				+				-					
8	6	1	+				-				+				-				+				-					
9	6	1	+				-				+				-				+				-					
10		1	+				-				+				-				+				-					
11	6	3	+	+	+		-	-	-		+	+	+		-	-	-		+	+	+		-	-	-			
12	6	3	+	+	+		-	-	-		+	+	+		-	-	-		+	+	+		-	-	-			
13	6	3	+	+	+		-	-	-		+	+	+		-	-	-		+	+	+		-	-	-			
14	6	3	+	+	+		-	-	-		+	+	+		-	-	-		+	+	+		-	-	-			
15	6	1	+				-				+				-				+				-					
16	6	1	+				-				+				-				+				-					
17	6																											

(a)

C=25 P=6 Ys =135																												
6	6	1	+				-				+				-				+				-					
7	6	2	+	+			-	-			+	+			-	-			+	+			-	-				
8	6	1	+				-				+				-				+				-					
9	6	2	+	+			-	-			+	+			-	-			+	+			-	-				
10	6	3	+	+	+		-	-	-		+	+	+		-	-	-		+	+	+		-	-	-			
11	6	4	+	+	+	+	-	-	-	-	+	+	+	+	-	-	-	-	+	+	+	+	-	-	-	-		
12	6	4	+	+	+	+	-	-	-	-	+	+	+	+	-	-	-	-	+	+	+	+	-	-	-	-		
13	6	3	+	+	+		-	-	-		+	+	+		-	-	-		+	+	+		-	-	-			
14	6	2	+	+			-	-			+	+			-	-			+	+			-	-				
15	6						-								-													
16	6																											

(b)

Figure (5): (a,b):-Shows brush positions & their no.for two types of windings with different commutator pitchs

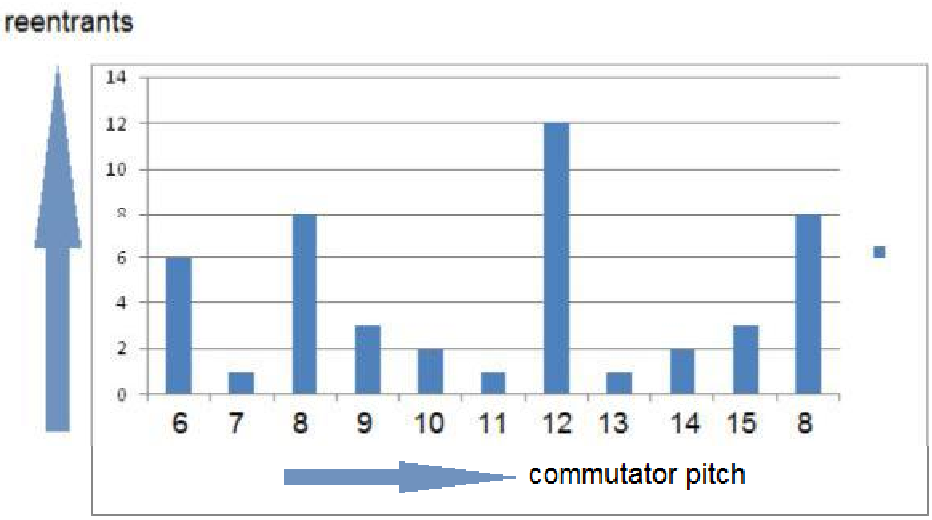


Figure (6): Shows the relation between reentrants and commutatore pitchs (At C=25,P=4,&6,Ys=180,150&135)

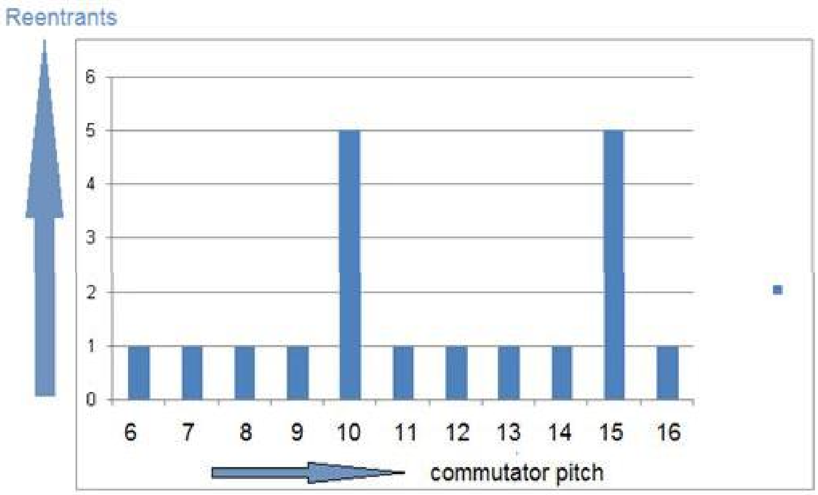


Figure (7): Shows the relation between Reentrants and commutatore pitchs at c = 25 , p = 4 & 6 at ys = 180° , 150° & 135° (see table 1)

Table (1): Shows the direction of windings & reentrants

item	y_c	K	C= 24 (even no.).. y_s = 180°&150°				C = 25 (odd no.)....y_s = 180°& 135°			
			m	*P = 6*		P=4	P = 6			P=4
				R.B.C	◀ or ▶ & plex	R	m	R.B.C	◀ or ▶ & plex	R
1	6	-12/2	0	≡	Nothing	6	-1	1Cs	◀ simplex	1
2	7	-7/2	-3	3Cs	◀ Triplex	1	+3	3Cs	▶ Triplex	1
3	7	-14/2	+4	4Cs	▶ Quaderlex	1	-4	4Cs	◀ Quaderlex	1
4	8	-8/2	0	≡	Nothing	8	-1	1Cs	◀ Simplex	1
5	9	-9/2	+3	3Cs	▶ Triplex	3	+2	1Cs	▶ Doublex	1
6	10	0	-4	4Cs	◀ quaderlex	2	±5	5Cs	◀or▶ Fifthlex	5
7	11	0	-2	2Cs	◀ Doublex	1	-3	3Cs	◀ triplex	1
8	12	0	0	≡	Nothing	12	-1	1Cs	◀ Simplex	1
9	13	0	+2	2Cs	▶doublex	1	+1	1Cs	▶ Simplex	1
10	14	0	+4	4Cs	▶ Quaderlex	2	+3	3Cs	▶ Triplex	1
11	15	0	+6	6Cs	▶ Sislex	3	+5	5Cs	▶ Fifthlex	5
12	16	+16/2	+8	8Cs	▶ Eightlex	8	-7	7Cs	▶ Sevenlex	1
13	16	0	-8	8Cs	◀ eightlex	8	+7	7Cs	◀ ninelex	1

3- Discusstion :

1- According to fig.3 (a,b , c) , fig. 4 (a, b,c) & fig.5 (a ,b) one can noticed:
   a- For fig. 3 (a , b) & fig. 4 (b,c) : As Y_c increases (from 9 to 11),the brush width will be decreased, as Y_c is continoue to increase from (13 to 16) , the brush width will be increased (i.e brush width is inversly proportional with the values of Y_c and directly With remaining values) and due to that the spark is canceld through the proccess of commutation and the machine has a different charactirstics .
   b- Fig.3(c) , Fig.4(a), Fig.5(a,b) show an opposite cases so there are better charactiristics of machine but in retrogressive side.
2- Tables (3, 4) show that at C = 24 & 25(even&odd), p = 4 &6 is noticed the following : if Y_c is more than 12 , all the cases are progressive ,also if Y_c is less than 12,then some cases are retrogressive,this led to a wide range of charactistics for the machine.(see table (1).
3- Fig. 6 shows that at (C = 24 , p = 4 , 6 &Y_s = 180° , 150°) : At Y_c =6→11 (except Y_c = 8), the reentrant (R) is inversly proportional with Yc, and when Y_c = 13 →16 , the (R) is directly proportional with Yc. Also when Y_c = 12 ,then R = 12. So the machine has several specifications (see tables (3,4)).The variation of R is very utilizing because different specifications led to different applications.
4- Fig.7 shows that at (C=25 ,p = 4 & 6 & ys=180°&150 °), R always=1,except Y_c =10 ,15 (see tables(3,4)) .
5- In classical way the Y_c is very nearly to 360°,it may has widly domain but in uniform steps.
6- The results show that the no. of paths (a) is always twice of the no. of reentrances (R) & the value of armature resistance(R_a) will be decreaced,finally & the armature current(I_a) will increased due to parallel connection. (see table 6 & Fig.'s (2 & 3).
7- Table (5) shows that the increasing of reentraces plays alarge important role to improve the performing of machine because it produces inversely realation between armature resistance and armature current.
8- It is clear that the Y_f element is directly effected by Y_c(they are directly proportional),but there is no any action from it on other factors,and the way of connection with segments becomes easy when it decreases.

Table (2): Shows the no. of brushes & brush width for different factors (At even no. of segments,4P)

item	Y_c	K	*m*	C = 24 (even no.)			P=4		
				Y_s = 180°			Y_s =150°		
				B	B_{w1}	Y_{f1}	B	B_{w2}	Y_{f2}
1	6	-12/2	0	4	3	1	4	5	1
2	7	-7/2	-3	4	2	1	4	4	2
3	7	-14/2	+4	4	1	1	4	3	2
4	8	-8/2	0	4	1	2	4	3	3
5	9	-9/2	+3	4	1	3	4	1	4
6	10	0	-4	4	2	4	4	2	5
7	11	0	-2	4	3	5	4	3	6
8	12	0	0	4	4	6	4	2	7
9	13	0	+2	4	1	7	4	3	8
10	14	0	+4	4	2	8	4	3	9
11	15	0	+6	4	3	9	4	5	10
12	16	0	+8	4	3	10	4	5	11
13	16	+16/2	-8	4	3	10	4	5	11

Table (3): Shows the no. of brushes & brush width for different factors(At 0dd no. of segments,4P)

item	Yc	K	m	C = 25 (odd no.)			P = 4		
				Ys = 180°			Ys = 150°		
				B	Bw1	Yf1	B	Bw2	Yf2
1	6	-12/2	-1	4	3	1	4	5	1
2	7	-14/2	+3	4	2	1	4	4	2
3	7	-7/2	-4	4	1	1	4	3	2
4	8	-8/2	-1	4	1	2	4	2	3
5	9	-9/2	+2	4	1	3	4	1	4
6	10	-10/2	±5	4	1	4	4	1	5
7	11	0	-3	4	3	5	4	1	6
8	12	0	-1	4	3	6	4	2	7
9	13	0	+1	4	1	7	4	3	8
10	14	0	+3	4	2	8	4	4	9
11	15	0	+5	4	3	9	4	4	10
12	16	0	+7	4	3	10	4	4	11

Table (4): Shows the no. of brushes & brush width for different factors (at even no. of segments, 6P)

item	Y_c	K	m	C = 24(even) P = 6					
				Y_s = 180°			Y_s = 135°		
				B	B_{w1}	Y_{f1}	B	B_{w2}	Y_{f2}
1	6	-6/3	0	6	1	2	6	1	3
2	7	-7/3	+4	6	2	3	6	1	4
3	7	0	-3	6	1	3	6	1	4
4	8	0	0	6	2	4	6	1	5
5	9	0	+3	6	3	5	6	2	6
6	10	+10/3	-4	6	4	6	6	3	7
7	11	+11/3	-2	6	3	7	6	4	8
8	12	+12/3	0	6	2	8	6	3	9
9	13	+13/3	+2	6	1	9	6	3	10
10	14	+14/3	+4	6	1	10	6	1	11
11	15	+15/3	+6	6	1	11	6	1	12
12	16	+32/3	-8	6	1	12	6	3	13
13	16	+16/3	+8	6	21	13	6	4	14

Table (5): Shows the no. of brushes & brush width for different factors (at odd no. of segments,6P)

item	Y_c	K	m	C = 25(odd) P =6					
				Y_s = 180°			Y_s = 135°		
				B	B_{w1}	Y_{f1}	B	B_{w2}	Y_{f2}
1	6	-6/3	-1	6	1	2	6	1	3
2	7	-7/3	+3	6	1	3	6	2	4
3	7	0	-4	6	1	3	6	1	4
4	8	0	-1	6	1	4	6	2	5
5	9	0	+2	6	3	5	6	3	6
6	10	+10/3	±5	6	3	6	6	4	7
7	11	+11/3	-3	6	3	7	6	4	8
8	12	+12/3	-1	6	3	8	6	3	9
9	13	+13/3	+1	6	1	9	6	2	10
10	14	+14/3	+3	6	1	10	6	1	11
11	15	+15/3	+5	6	1	11	6	2	12
12	16	+16/3	+7	6	1	12	6	2	13

Table (6): Shows the relation between reentrats (R) & calculations of paraller paths (see table 1 and fig's 1&2)

CO= 24	P = 4	Y_s = 180°& 150Where R_c, ec &I_c = 1(Ω, V, A) respectively					
R	**A**	R_p	R_a	e_p	I_p	I_a	e_p*I_a
6	12	2	0.166	2	1	12	24
1	2	12	6	12	1	2	24
1	2	12	66	12	1	2	24
8	16	1.5	0.093	1.5	1	16	24
3	6	4	0.666	4	1	6	24
2	4	6	1.5	6	1	4	24
1	2	12	6	12	1	2	24
12	24	1	0.041	1	1	24	24
1	2	12	6	12	1	2	24
2	4	6	1.5	6	1	4	24
3	6	4	0.666	4	1	6	24
8	16	1.5	0.093	1.5	1	16	24

4- Conculosion :

The new K factor plays alarge important role to produce different types of d.c. wave windings which is leading to perfect new cases that are shown as follow:

a- It cancels the hardly requirements on the equation of winding so it is possible touse any number of segments and coils in that equation.

b- It makes the machine as sparkless as possible to improve its commutationand charactiristics.

c- It gives different specifications to the machine which led to different applications.

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