Applications of Integration in Retaining Ring

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Abstract: *The main intention of this paper is about the accuracy in the quality of retaining ring. Retaining ring is a fastener which helps to assemble shafts. There are lots of types of retaining rings but in this study we have taken self- locking retaining ring and the simple retaining ring. Here we are applying integration on retaining ring to check its' smoothness and plain surface. First order integration is used to get the arch length of simple retaining ring and surface area of self-locking retaining ring.*

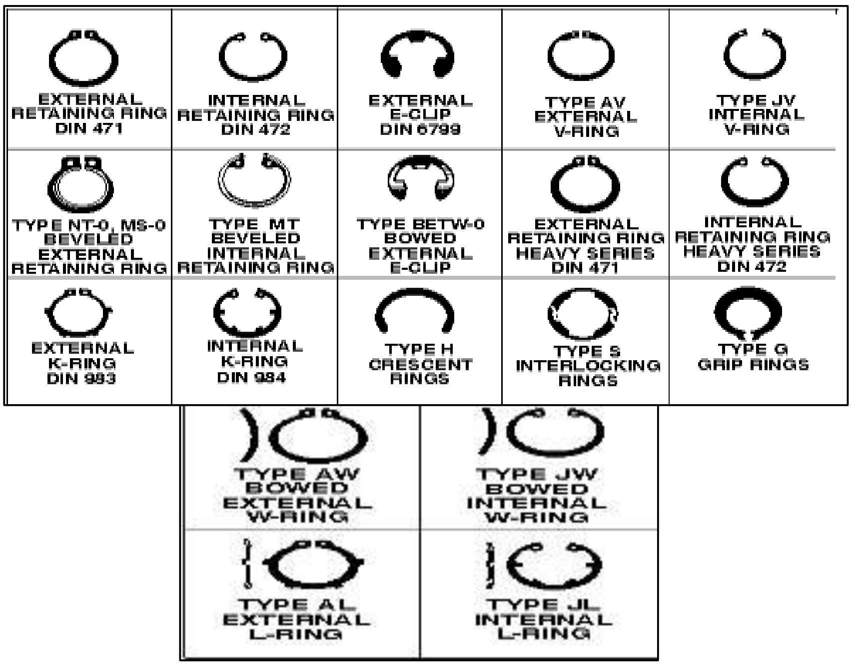
Key Words: *Retaining ring, Integration, Arc length, Surface area.*

1. INTRODUCTION:

A retaining ring is known for fastener which assembles the parts of shafts or holds components using a typical groove. There are many types of retaining rings with specifications and its own standard measurements. Simple retaining rings are also known as housing rings. Self-locking retaining ring is another type of ring which cannot be removed after installation. These retaining rings are easy to assemble rather than any other fastener. It is also low in cost to produce from raw materials. It helps to allocate the shaft parts in it's' place where it is more reliable than traditional ones. Only a groove is required to connect. Self-locking rings are having tolerance to a specified extent.

2. TYPES OF RETAINING RING:

Figure 1



3. DEFINITIONS:

A retaining ring is also known as circlips which is a fastener help to hold or assembles the shaft parts in its' positions. Once it is inserted to assemble shaft it can't be removed easily. It can be said that it is impossible to remove retaining ring from the shaft.

In integral the arc length of a curve can be computed. Let us define variables x and y where the function y of x is over the interval between a and b, then y(x) can be written as

$$S = \int_a^b \sqrt{1 + (f'(x))^2}\, dx$$

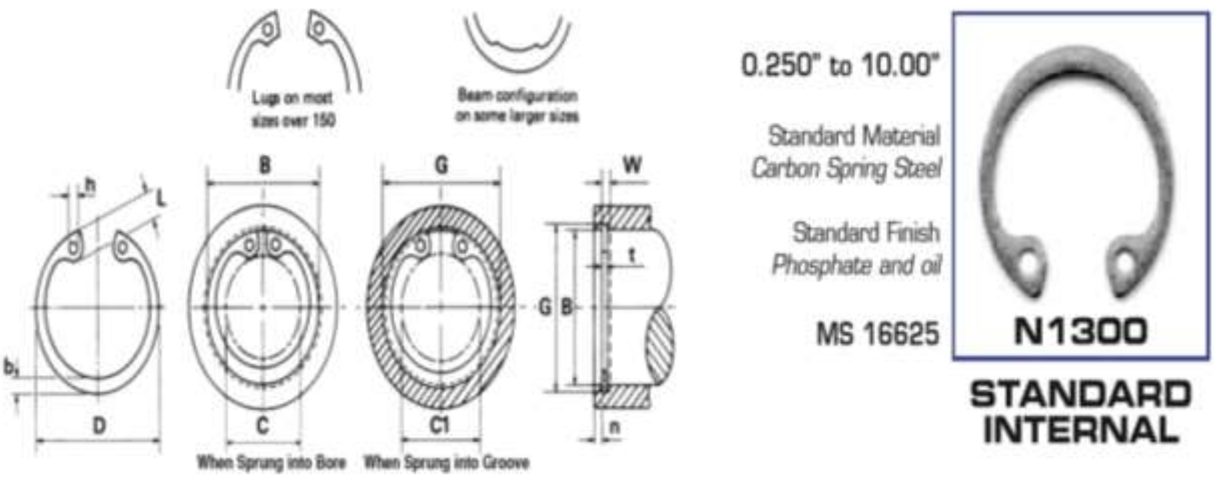
Surface area of a curve can be calculated through first order derivative which is continuous with the interval of $a \le x \le b$, where the curve is revolving to form a sphere. Thus, it can be given as $2\int_0^a 2\pi y\sqrt{1+\left(\frac{dy}{dx}\right)^2}\,dx$

4. APPLICATIONS OF REATAING RING:

- Car parts
- Shafts used in industries
- Valve- parts
- Turbines
- Motors
- Pistons

5. STANDARD RING MEASUREMENTS:

Figure 2



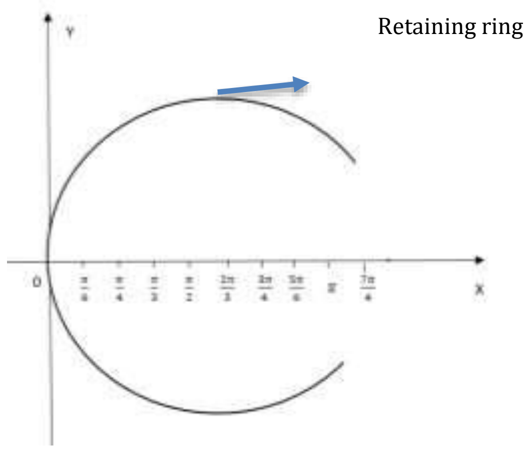
PART NUMBER	BORE DIAMETER B			RING THICKNESS		RING FREE DIAMETER		RING					GROOVE DIAMETER		GROOVE WIDTH			APPROX WT. LB / 1000 PCS.	THRUST LOAD (LBS)	PLIER No.
	Frac. inch	Dec. inch	mm	t inches	Tol. inches	D inches	Tol. inches	C	C1	L (max)	b	h (min)	G inches	Tol. inches	W inches	Tol. inches	n (min)			
N1300-268	–	2.677	68	.093		2.980		2.05	2.21	.268	.236	.108	2.837		.103		.240	35.0	35400	
N1300-268	2 11/16	2.688	–	.093		2.980	+.040	2.06	2.22	.268	.236	.108	2.848		.103		.240	35.0	35400	
N1300-275	2 3/4	2.750	–	.093		3.050	-.030	2.12	2.28	.284	.234	.108	2.914		.103		.246	35.5	36100	
N1300-281	2 13/16	2.812	–	.093		3.121		2.18	2.34	.284	.230	.108	2.980		.103		.252	36.0	36900	
N1300-281	–	2.835	72	.093		3.121		2.21	2.38	.284	.230	.108	3.006		.103		.252	36.0	36950	
N1300-287	2 7/8	2.875	–	.093		3.191		2.22	2.39	.284	.240	.108	3.051		.103		.264	41.0	37800	
N1300-300	–	2.953	75	.093		3.325		2.30	2.48	.284	.250	.108	3.135		.103		.273	42.5	39500	Std. 5
N1300-300	3	3.000	–	.093		3.325		2.35	2.53	.284	.250	.108	3.182		.103		.273	42.5	39500	
N1300-306	3 1/16	3.062	–	.109		3.418		2.41	2.59	.299	.254	.123	3.248		.120		.279	53.0	47100	
N1300-312	3 1/8	3.125	–	.109		3.488		2.47	2.66	.299	.260	.123	3.315		.120		.285	56.0	48000	
N1300-315	–	3.150	80	.109		3.523		2.49	2.68	.299	.260	.123	3.341		.120		.288	57.0	48600	
N1300-315	3 5/32	3.156	–	.109		3.523		2.50	2.69	.299	.260	.123	3.348		.120		.288	57.0	48600	
N1300-325	3 1/4	3.250	–	.109		3.623		2.54	2.73	.299	.269	.123	3.446		.120	+.005	.294	60.0	50000	
N1300-334	3 11/32	3.346	–	.109		3.734	±.055	2.63	2.83	.323	.276	.123	3.546		.120	-.000	.300	65.0	51600	
N1300-347	3 15/32	3.469	–	.109		3.857		2.76	2.96	.350	.294	.123	3.675	±.006	.120		.309	69.0	53400	
N1300-350	3 1/2	3.500	–	.109	±.003	3.890		2.79	3.00	.350	.294	.123	3.710		.120		.315	71.0	53900	
N1300-354	–	3.543	90	.109		3.936		2.83	3.04	.350	.292	.123	3.755		.120		.321	72.0	54600	
N1300-354	3 9/16	3.562	–	.109		3.936		2.85	3.06	.350	.292	.123	3.776		.120		.321	72.0	54650	
N1300-362	3 5/8	3.625	–	.109		4.024		2.91	3.12	.350	.305	.123	3.841		.120		.324	73.0	55900	
N1300-375	–	3.740	95	.109		4.157		3.02	3.24	.350	.309	.123	3.964		.120		.336	78.0	57700	
N1300-375	3 3/4	3.750	–	.109		4.157		3.03	3.25	.350	.309	.123	3.974		.120		.336	78.0	57700	
N1300-387	3 7/8	3.875	–	.109		4.291		3.11	3.34	.350	.312	.123	4.107		.120		.348	87.0	59600	
N1300-393	3 15/16	3.938	–	.109		4.358		3.17	3.40	.350	.319	.123	4.174		.120		.354	88.0	60700	
N1300-400	4	4.000	–	.109		4.424		3.23	3.47	.378	.330	.123	4.240		.120		.360	93.0	61700	
N1300-412	4 1/8	4.125	–	.109		4.558		3.36	3.60	.378	.330	.123	4.365		.120		.360	97.0	63600	
N1300-425	4 1/4	4.250	–	.109		4.691		3.48	3.72	.378	.335	.123	4.490		.120		.360	101.0	65500	

N1300-433	–	4.331	110	.109		4.756	±.065	3.50	3.74	.413	.338	.151	4.571		.120		.360	105.0	66600	
N1300-450	4 1/2	4.500	–	.109		4.940		3.66	3.90	.413	.351	.151	4.740		.120		.360	111.0	69300	
N1300-462	4 5/8	4.625	–	.109		5.076		3.79	4.03	.413	.350	.151	4.865		.120		.360	117.0	71300	
N1300-475	–	4.724	120	.109		5.213		3.88	4.12	.413	.358	.151	4.969		.120		.366	124.0	73200	
N1300-475	4 3/4	4.750	–	.109		5.213		3.90	4.14	.413	.358	.151	4.995		.120		.366	124.0	73200	
N1300-500	5	5.000	127	.109		5.485		4.08	4.34	.445	.385	.151	5.260		.120		.405	136.0	77000	
N1300-525	5 1/4	5.250	–	.125		5.770		4.31	4.58	.465	.408	.151	5.520		.139		.405	174.0	92700	
N1300-537	5 3/8	5.375	–	.125		5.910		4.41	4.68	.465	.408	.151	5.650		.139		.405	179.0	94900	Major
N1300-550	5 1/2	5.500	–	.125	±.004	6.066		4.53	4.80	.465	.408	.151	5.770	±.007	.139	+.006	.405	183.0	97200	77
N1300-575	5 3/4	5.750	146	.125		6.336		4.78	5.05	.465	.408	.151	6.020		.139	-.000	.405	192.0	101600	
N1300-600	6	6.000	–	.125		6.620		5.03	5.30	.465	.416	.151	6.270		.139		.405	201.0	105900	
N1300-625	6 1/4	6.250	–	.156		6.895		5.24	5.52	.454	.441	.182	6.530		.174		.420	266.0	137700	
N1300-650	6 1/2	6.500	165	.156		7.170		5.49	5.78	.454	.441	.182	6.790		.174		.435	281.0	143300	
N1300-662	6 5/8	6.625	–	.156		7.308	±.080	5.60	5.90	.454	.441	.182	6.925		.174		.450	305.0	146000	
N1300-675	6 3/4	6.750	–	.156		7.445		5.65	5.95	.508	.456	.182	7.055		.174		.456	325.0	148800	
N1300-700	7	7.000	–	.156		7.720		5.88	6.19	.540	.474	.182	7.315		.174		.471	344.0	154000	
N1300-725	7 1/4	7.250	–	.187		7.995		6.08	6.40	.570	.490	.182	7.575		.209		.486	428.0	191500	
N1300-750	7 1/2	7.500	–	.187		8.270		6.33	6.67	.570	.507	.182	7.840		.209		.510	485.0	198200	
N1300-775	7 3/4	7.750	–	.187	±.005	8.545		6.58	6.93	.560	.500	.182	8.100		.209		.525	520.0	204800	
N1300-800	8	8.000	–	.187		8.820		6.75	7.11	.600	.530	.182	8.360	±.008	.209	+.008	.540	555.0	211400	
N1300-825	8 1/4	8.250	–	.187		9.095		7.00	7.37	.600	.548	.182	8.620		.209	-.000	.555	603.0	218000	
N1300-850	8 1/2	8.500	–	.187		9.285		7.13	7.51	.632	.573	.182	8.880		.209		.570	634.0	224600	
N1300-875	8 3/4	8.750	–	.187		9.558	±.090	7.38	7.77	.632	.576	.182	9.145		.209		.591	653.0	230400	
N1300-900	9	9.000	–	.187		9.830		7.63	8.03	.632	.592	.182	9.405		.209		.606	732.0	237800	
N1300-925	9 1/4	9.250	235	.187		10.102		7.88	8.30	.632	.622	.182	9.668		.209		.627	767.0	244000	
N1300-950	9 1/2	9.500	–	.187		10.375		7.98	8.41	.632	.622	.182	9.930		.209		.645	803.0	251000	
N1300-975	9 3/4	9.750	–	.187		10.648		8.23	8.67	No	.622	.182	10.190		.209		.660	833.0	257600	
N1300-1000	10	10.000	–	.187		10.920		8.48	8.93	Lug	.622	.182	10.450		.209		.675	863.0	264200	

PROBLEM (1):

Find the arc length of retaining ring which has the diameter 4 inch using integration.

Figure 3



Given:

Diameter (d): 4 inches = 10.16 cm

Radius (a): 2 inches = 5.08cm

We know that:

The Arc length r $= a\theta$

Therefore,

We take $f(x) = a \cos\left(\frac{x}{a}\right)$

On differentiating we get,

$f'(x) = -\sin\left(\frac{x}{a}\right)$

We know that:

Arc Length (L) = $\int_a^b \sqrt{1 + [f'(x)]^2}\, dx$

From the figure 3 we get,

a =0; b $= \frac{7\pi}{6}$

Substituting $f'(x)$, a, b in the arc length formula we get,

$$L = \int_0^{\frac{7\pi}{6}} \sqrt{1 - \sin^2\left(\frac{x}{a}\right)}\, dx$$

We know that,

$$\cos^2\theta + \sin^2\theta = 1$$

$$L = \int_0^{\frac{7\pi}{6}} \sqrt{\cos^2\left(\frac{x}{a}\right)}\, dx$$

$$L = a \sin\left(\frac{\frac{7\pi}{6}}{a}\right)$$

We know that,

a= 5.08cm

Therefore,

$$L = 5.08 * \sin\left(\frac{\frac{7\pi}{6}}{5.08}\right)$$

L = 3.3554 cm

Thus we have found the arc length of upper part of the retaining ring.
To find the full arc length of the rotor clip we have to multiply the value of upper part of the retaining ring by 2.
Therefore,

L = 2 * 3.3554

L = 6.7107cm

The arc length of retaining ring whose diameter is 4 inch =2.642 inch.

PROBLEM (2):

Find the arc length of retaining ring which have the diameter 2.5 inches using integration.
Given:
Diameter (d): 2.5 inches = 6.35 cm
Radius (a): 1.25 inches = 3.175cm
We know that:
The Arc length r=$a\theta$
Therefore,
We take $f\ (x) = a\ \cos\left(\frac{x}{a}\right)$
On differentiating we get,

$$f'(x) = -\sin\left(\frac{x}{a}\right)$$

We know that:
Arc Length (L) = $\int_a^b \sqrt{1+\ [f'(x)]^2}\, dx$
From the figure 4 we get,
a =0; b =$\frac{3\pi}{4}$
Substituting, $f'(x)$, a, b in the arc length formula

$$L = \int_0^{\frac{3\pi}{4}} \sqrt{1-\ \sin^2\left(\frac{x}{a}\right)}\ dx$$

We know that,

$$cos^2\theta + sin^2\theta = 1$$

$$L = \int_0^{\frac{3\pi}{4}} \sqrt{cos^2\left(\frac{x}{a}\right)}\, dx$$

$$L = a\ sin\ \left(\frac{\frac{3\pi}{4}}{a}\right)$$

We know that,

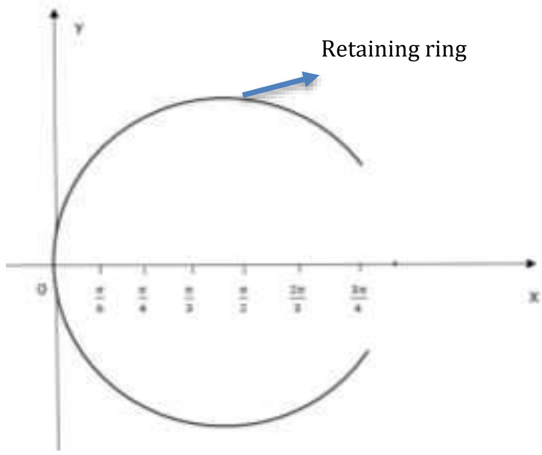
a= 3.175cm

Therefore,

$$L = 3.175 * \ sin\ \left(\frac{\frac{3\pi}{4}}{3.175}\right)$$

L = 2.1458 cm

Figure 4



Thus we have found the arc length of upper part of the retaining ring.
To find the full arc length of the rotor clip we have to multiply the value of upper part of the retaining ring by 2.
Therefore,

L = 2 * 2.1458

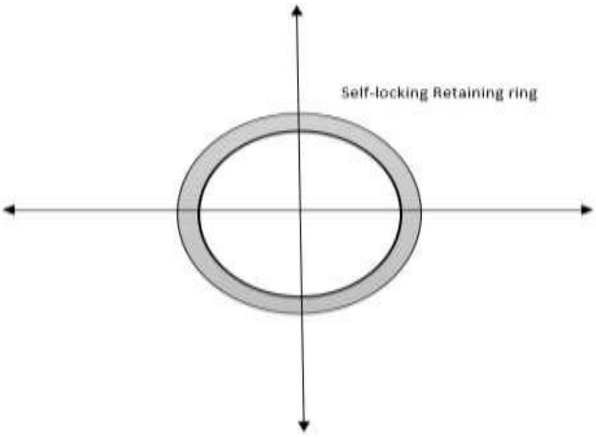
L = 4.2916cm

The arc length of retaining ring whose diameter is 2.5 inch = 1.6896 inch.

PROBLEM (3):

Find the surface area of the retaining ring whose Outer diameter is 3 inch and Inner diameter is 2.16inch.

Figure 5



Given:

Outer diameter (O.D) = 3 inch = 7.62 cm
Inner diameter (I.D) = 2.16 inch = 5.49 cm
Outer radius (O.R) = 1.5 inch = 3.81 cm
Inner radius (I.R) = 1.07 inch = 2.74 cm

Let the outer diameter sphere be A and the inner diameter sphere be B.

To find the surface area of retaining ring we have to find the surface area of sphere A and surface are of sphere B of retaining ring. Then, we have to differentiate it. Since the retaining clip is in circular shape we can take it's equation as

$\sqrt{x^2+y^2} = a$ Where a is outer radius (O.R)
The semi-circle be $x^2 + y^2 = a^2$
On differentiating the above equation we get,

$$\frac{dy}{dx} = -\frac{x}{y}$$

$$\sqrt{1+\left(\frac{dy}{dx}\right)^2} = \sqrt{1+\frac{x^2}{y^2}}$$

$$\sqrt{1+\left(\frac{dy}{dx}\right)^2} = \frac{a}{y}$$

Surface area of sphere A $= 2\int_0^a 2\pi y\sqrt{1+\left(\frac{dy}{dx}\right)^2}\,dx$

$$= 4\pi\int_0^a y\sqrt{1+\left(\frac{dy}{dx}\right)^2}\,dx$$

$$= 4\pi a^2$$

Here, a = 3.81 cm
Therefore,
Surface area of sphere A = $4\pi\,(3.81)^2$
=58.06 π sq.cm
Similarly,
In the sphere B the equation will be $\sqrt{x^2+y^2} = b$ where b is outer radius (O.R)
The semi-circle be $x^2 + y^2 = b^2$
Therefore, $\sqrt{1+\left(\frac{dy}{dx}\right)^2} = \frac{b}{y}$
Surface area of B = $4\pi b^2$

Here, b = 2.74 cm
Therefore,
Surface area of sphere B= $4\pi (2.74)^2$
$=30.03\pi$ sq.cm
Then the surface area of the retaining ring 3 inch is the difference of the surface area of sphere A and B is
The surface area of sphere A – The surface area of the sphere B = 28.03π sq.cm

6. CONCLUSION:

The retaining ring's arc length is found using first order derivative integral formula which will help to find the ring's aspects to fit in the shaft assembling. Also, the surface area of the self-locking retaining ring is estimated using integration which will ensure the smoothness on the ring.

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