PhD Proposal Writeup

A realtime and parallel look-ahead control and feedrate compensation strategy for CNC reference-pulse interpolation.

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7	Type of Study	Research
8	Mode of Study	Full Time
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Reference: Draft-44-Report-Latex-PhD-Proposal-WRY.tex

Date: **June 15, 2023** Version: **Draft-44** CONTENTS Page 1 of 16

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Listings

1 Simulation Results

1.1 The Parametric Equations

The ten(10) 2D parametric curves covered in this work are:

- 1. Teardrop
- 2. Butterfly
- 3. Ellipse
- 4. Skewed-Astroid
- 5. Circle
- 6. AstEpi = Astroid + Epicycloid combination
- 7. Snailshell
- 8. SnaHyp = Snailshell + Hypotrocoid combination
- 9. Ribbon-10L
- 10. Ribbon-100l = 10 times scaleup of Ribbon-10L

The parametric equations describing each of the curves x(u), and y(u) are provided in the next table. The independent parameter u is limited to

$$u \in [0.0, 1.0]$$

The curves were selected based on their different characteristics like closed loop curves, open ended curves, symmetric or non-symmetric about the x-axis and y-axis, and having concave or convex turns. The x and y dimensions (sizes) vary among the different curves.

The main objective of the selection criteria is to ensure that the interpolation algorithm for the parametric curve succeeds and does not break in all cases.

The results for the feedrates in machining the ten(10) curves show continuity, smoothness, with no abrupt jumps as the CNC machine traverse the entire curve from the start (u = 0.0) until the end (u = 1.0).

No. 1 - Teardrop parametric curve

$$x(u) = -150u + 450u^{2} - 300u^{3}$$

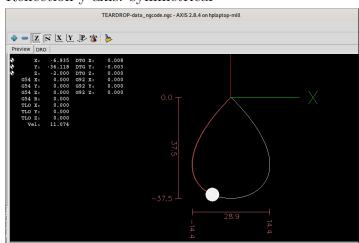
$$y(u) = -150u + 150u^{2}$$

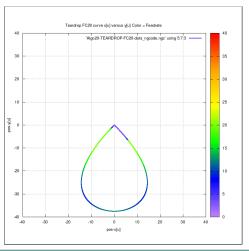
$$u \in [0.0, 1.0]$$

Closed loop

Overall Single loop

Reflection x-axis: non-symmetrical Reflection y-axis: symmetrical





No. 2 - Butterfly parametric curve

$$x(u) = \sin(2\pi u) \left[e^{\cos(2\pi u)} - 2\cos(8\pi u) - (\sin(2\pi u/12))^5 \right]$$

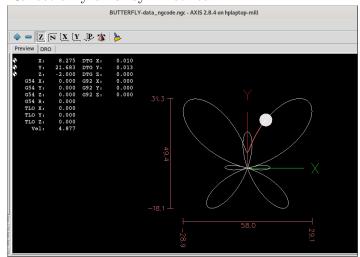
$$y(u) = \cos(2\pi u) \left[e^{\cos(2\pi u)} - 2\cos(8\pi u) - (\sin(2\pi u/12))^5 \right]$$

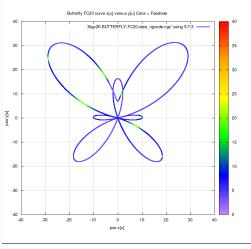
$$u \in [0.0, 1.0]$$

Closed loop

Overall Multiple loops

Reflection x-axis: non-symmetrical Reflection y-axis: symmetrical





No. 3 - Ellipse parametric curve

$$x(u) = 11\sin(2\pi u)$$

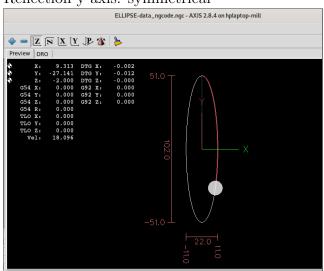
$$y(u) = 51\cos(2\pi u)$$

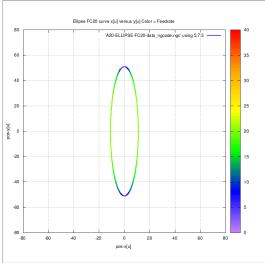
$$u \in [0.0, 1.0]$$

Closed loop

Overall Single loop, smooth convex curves

Reflection x-axis: symmetrical Reflection y-axis: symmetrical





No. 4 - Skewed-Astroid parametric curve

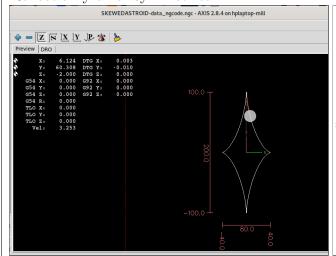
$$x(u) = 40[\sin(2\pi u)]^3$$

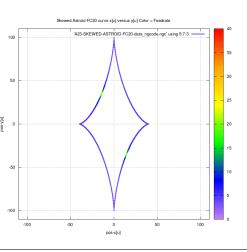
 $y(u) = 100[\cos(2\pi u)]^3$
 $u \in [0.0, 1.0]$

Closed loop

Overall Single loop, 4 cusps and 4 concave curves

Reflection x-axis: symmetrical Reflection y-axis: symmetrical





No. 5 - Circle parametric curve

$$x(u) = 79\sin(2\pi u)$$

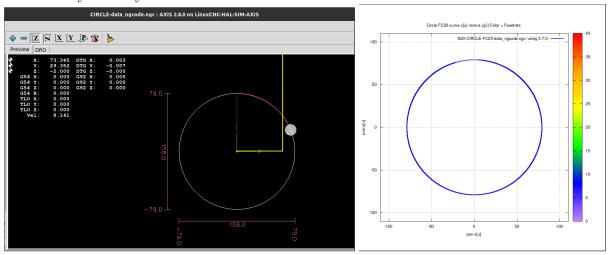
$$y(u) = 79\cos(2\pi u)$$

$$u \in [0.0, 1.0]$$

Closed loop

Overall Single loop, smooth convex curves

Reflection x-axis: symmetrical Reflection y-axis: symmetrical



No. 6 - AstEpi = Sum of (Astroid + Epicycloid) parametric curves

$$tiny = 1.0 \times 10^{-10}$$

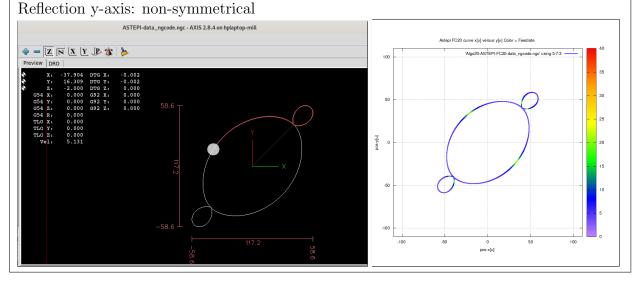
$$x(u) = 40[\sin(2\pi u)]^3 + 50\cos(2\pi u + tiny) - 10\cos(10\pi u - tiny)$$

$$y(u) = 40[\cos(2\pi u)]^3 + 50\sin(2\pi u + tiny) - 10\sin(10\pi u - tiny)$$

$$u \in [0.0, 1.0]$$

Closed loop

Overall Three loops, all convex curves Reflection x-axis: non-symmetrical



No. 7 - Snailshell parametric curve

$$x(u) = 79\sin(2\pi u)$$

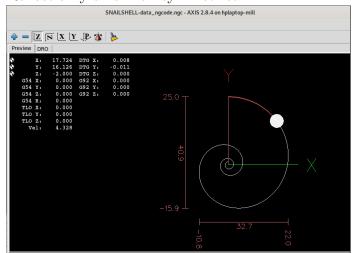
$$y(u) = 79\cos(2\pi u)$$

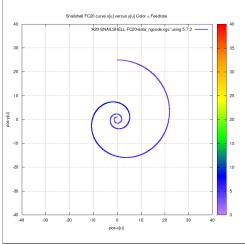
$$u \in [0.0, 1.0]$$

Open ended curve

Overall No loop, smooth and continuous convex curves

Reflection x-axis: non-symmetrical Reflection y-axis: non-symmetrical





No. 8 - SnaHyp = Sum of (Snailshell + Hypotrocoid) parametric curves

$$tiny = 1.0 \times 10^{-10}$$

$$x(u) = 40[\sin(2\pi u)]^3 + 50\cos(2\pi u + tiny) - 10\cos(10\pi u - tiny)$$

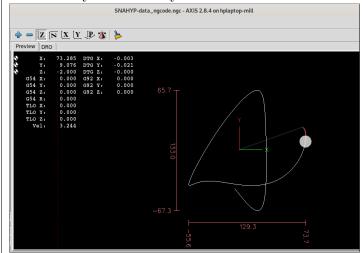
$$y(u) = 40[\cos(2\pi u)]^3 + 50\sin(2\pi u + tiny) - 10\sin(10\pi u - tiny)$$

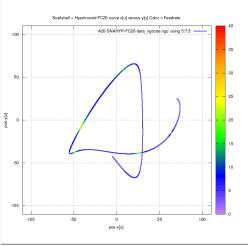
$$u \in [0.0, 1.0]$$

Open ended curve

Overall 1 loop, except for 1 concave curve, the rest are convex curves

Reflection x-axis: non-symmetrical Reflection y-axis: non-symmetrical





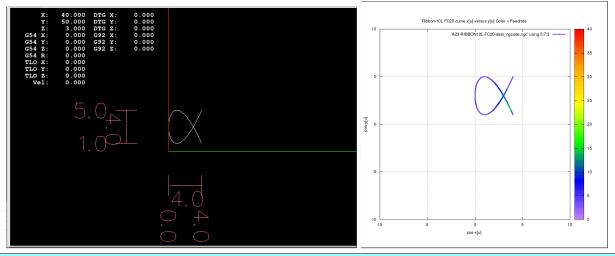
No. 9 - Ribbon-10L parametric curve

 $x(u) = 79\sin(2\pi u)$ $y(u) = 79\cos(2\pi u)$ $u \in [0.0, 1.0]$

Open ended curve

Overall Single loop, smooth convex curves

Reflection x-axis: non-symmetrical Reflection y-axis: non-symmetrical



No. 10 - Ribbon-100L parametric curve

$$tiny = 1.0 \times 10^{-10}$$

$$x(u) = 40[\sin(2\pi u)]^3 + 50\cos(2\pi u + tiny) - 10\cos(10\pi u - tiny)$$

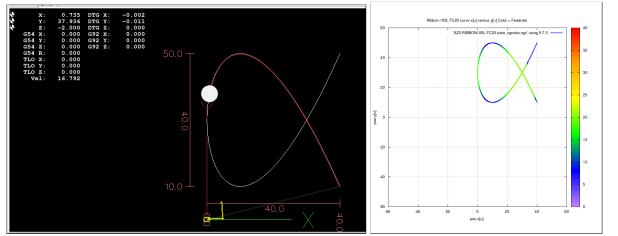
$$y(u) = 40[\cos(2\pi u)]^3 + 50\sin(2\pi u + tiny) - 10\sin(10\pi u - tiny)$$

$$u \in [0.0, 1.0]$$

Open ended curve (10 times larger than RIBBON-10L)

Overall Single loop, smooth convex curves

Reflection x-axis: non-symmetrical Reflection y-axis: non-symmetrical



	Author: wruslandr@gmail.com	Part 1 of				ric curves						
ΈМ	DESCRIPTION			RDROP CI					ERFLY C			
1	Run user feedrate command (mm/s)	FC10		FC25							FC	
2	Total interpolated u-points	10261	7599	7385		7347	35656			12343	97	
3	Parameter completion (reached u-end)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.	
	Pushdown epsilon eps(u) algorithm											
4	Count before pushdown, eps(u) is below (1E-6)	8498	1427	527	0	0					72	
5	Count pushdown points, eps(u) to below (1E-6)	1763	6172	6858	7347	7347	191	608	975	1333	24	
	Epsilon eps(u) chord error	_										
6	Count eps(u) above (1E-6)	10001	7500	7205		7247	2005				0.7	
7	Count eps(u) in (1E-7, 1E-6)	10261	7599	7385		7347	2995			12343	97	
9	Count eps(u) in (1E-8, 1E-7)	0	0	0		0		5535		0		
_	Count eps(u) in (1E-9, 1E-8)	0	0	0						0		
10 11	Count eps(u) in (1E-10, 1E-9)	0	0	0		0	0			0		
11	Count eps(u) below (1E-10)	0	0	0	0	U	U	0	0	0		
10	Count interpolated u-points	0.00	400	0.00	0.70	070	4000	000	575	500		
12	Count_rising_S_curve u-points	960	480	389	370	370	1323	693		500	4	
13	Count_frate is_lower than fratelimit	4734	4342	4260	4202	4049	17751	8968		6129	47	
14	Count_frate is_equal to fratelimit	0	2200	0		0	15354	_		5212	4.4	
15	Count_frate is_higher than fratelimit	3608	2298	2348		2559	15254			5213	41	
16	Count_falling_S_curve u-points	959	479	388	369	369	1328	695	576	501	4	
17	Count u-points histogram (G01 codes)	1704	0.75	700	7.40	740	0.400	1700	1 40 1	1014	,	
17	Count u-points [0.00 <= u < 0.10)	1734	875	768	748	748	3463	1763		1214	9	
18	Count u-points [0.10 <= u < 0.20)	1120	791	791	791	791	4332	2167			11	
19	Count u-points [0.20 <= u < 0.30)	809	794	794	794	794	2983			1117	9	
20	Count u-points [0.30 <= u < 0.40)	726	710	710	711	711	3220				8	
21	Count u-points [0.40 <= u < 0.50)	741	629	629		629					9	
22	Count u-points [0.50 <= u < 0.60)	742	629 710	629		629				-	9	
23	Count u-points [0.60 <= u < 0.70)	726		711	711	711	3222	1612		1098	3	
24	Count u-points [0.70 <= u < 0.80)	809	794	793		793	2981			-	9	
25	Count u-points [0.80 <= u < 0.90)	1120	791	791	791	792	4323			-	11	
26	Count u-points [0.90 <= u <= 1.00]	1734	876	769		749	3471	1768		1217	9	
27	Check Total u-points	10261	7599	7385	7347	7347	35656	18029	14577	12343	97	
20	Performance	0.005000	0.0074.44	0.007004	0.007007	0.007005	0.001.000	0.000504	0.004004	0.0040474	0.000	
28 29	Total curve error (sum of epsilon(u))									0.004847		
30	Total dist traversed (sum of chord lengths) Percentage (Tot curve error / Tot dist traversed)		0.007012							356.0728 0.001361		
30	Percentage (Tot curve error / Tot dist traversed)	0.005704	0.007012	0.00717	0.007203	0.007203	0.000545	0.000993	0.001100	0.001361	0.0010	
⁴⁰ [Teardrop FC20 curve x[u] versus y[u] Color = Feedrate 'Algo20-TEARDROP-FC20-data_ngcode.ngc' usi	ng 5:73	40	40 [rsus y[u] Color =	Feedrate	5.7.3	40	
30	Ago to		35	30			7.1g020 001121	Er i ded date	goodsgo dolling		35	
					(0.5	
20 -			30	20	· \			\/	/	/	30	
10			25	10			X	γ		_	25	
0 -			20	[n].k-sod							20	
				sod			\nearrow	1				
10 -			15	-10 -					1		15	
20 -			10	-20						_	10	
			5	-30 -							5	
30 -				1.1								
30												

Figure 1.1: Teardrop and Butterfly run data summary

	Date: 2023-06-06 Author: wruslandr@gmail.com				e Interpol				g		
ITEM	DESCRIPTION	rait 201		IPSE CU		(x-y) pai	ametric ci		-ASTROII	O CLIDVE	
	Run user feedrate command (mm/s)	FC10	FC20			FC40	FC10				FC4
2		21575	7599	9448		7351	116194	58102	46483		2905
	Total interpolated u-points Parameter completion (reached u-end)	1.00	1.00	1.00	1.00	1.00				38738 1.00	
3	,	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0
_	Pushdown epsilon eps(u) algorithm	21 20 0	1.407	7040	F1.40	000	110104	E0100	40400	20720	2005
	Count before pushdown, eps(u) is below (1E-6)	21396	1427	7046	5149	928		58102	46483	38738	2905
5	Count pushdown points, eps(u) to below (1E-6)	179	6172	2402	3189	6423	0	0	0	0	
_	Epsilon eps(u) chord error									_	
	Count eps(u) above (1E-6)	0	0	0	0	0			0		
7	Count eps(u) in (1E-7, 1E-6)	7058	7599	9448	8338	7351	0	_	0		843
	Count eps(u) in (1E-8, 1E-7)	14517	0	0	0	0		33004	46483	37283	2062
-	Count eps(u) in (1E-9, 1E-8)	0	0	0		0		25098	0		
10	Count eps(u) in (1E-10, 1E-9)	0	0	0	0	0	_	_	_		
11	Count eps(u) below (1E-10)	0	0	0	0	0	0	0	0	0	
	Count interpolated u-points										
12	Count_rising_S_curve u-points	443	480	370	370	370	3673	1837	1470	1225	91
13	Count_frate is_lower than fratelimit	14764	4342	6120	5270	3308	75069	39802	31837	26531	1993
14	Count_frate is_equal to fratelimit	0	0	0	0	0	0	0	0	0	
	Count frate is higher than fratelimit	5926	2298	2589	2329	3304		_	11707	9757	727
_	Count falling S curve u-points	442	479	369	369	369		1837	1469	1225	91
	Count u-points histogram (G01 codes)		-110	000	000	000	00.0	200.	2,00	1220	
17	Count u-points [0.00 <= u < 0.10)	1231	779	748	748	748	7322	3661	2929	2441	183
	Count u-points [0.00 <= u < 0.10) Count u-points [0.10 <= u < 0.20)	2586	1292	1035	878	740	12603	6302	5042	4202	315
_	,										456
19	Count u-points [0.20 <= u < 0.30)	3154	1578	1262	1051	797		9123 6302	7298 5042	6081 4202	315
	Count u-points [0.30 <= u < 0.40)	2586	1293	1034	863	710					
-	Count u-points [0.40 <= u < 0.50)	1230	704	644	628	629		3662	2930	2442	183
	Count u-points [0.50 <= u < 0.60)	1228	704	644	629	629		3662	2930		183
	Count u-points (0.60 <= u < 0.70)	2586	1293	1034	862	710			5041	4201	315
24	Count u-points [0.70 <= u < 0.80)	3155	1577	1262	1051	796			7298	6082	456
25	Count u-points [0.80 <= u < 0.90)	2586	1293	1035	878	791	12604	6303	5043	4202	315
26	Count u-points [0.90 <= u <= 1.00]	1233	782	750	750	750	7324	3663	2930	2443	183
27	Check Total u-points	21575	11295	9448	8338	7351	116194	58102	46483	38738	2905
	Performance										
28	Total curve error (sum of epsilon(u))	0.002991	0.007141	0.005928	0.006562	0.007332	0.000516	0.001033	0.001291	0.001549	0.0020
29	Total dist traversed (sum of chord lengths)				215.6478						
	Percent (Tot curve error / Tot dist traversed)				0.003043		0.000116			0.000347	
	· ciccin (i ci cai i c ciici i i ci cai i cai ci cai	0.00200.	0.000011	0.0020	0.0000 10	0.000	0.000110	0.000202	0.00020	0.0000	0.00010
80 -	Ellipse FC20 curve x[u] versus y[u] Color = Feedrate		40			Skewed Astroid F	FC20 curve x[u] ve	ersus y[u] Color =	Feedrate		
60 -	'A20-ELUPSE-FC20-data_ngcode.ngc' using	g 5:7:3	35 30	100 -		'A23-Sk	KEWED-ASTROID	-FC20-data_ngco	de.ngc' using 5:7:	3	40 - 35 - 30
20 - [n]/-sod			25 20	[n]/-sod						-	- 25 - 20
-20 – -40 –			15	-50 -							- 15 - 10
-80 -80	-60 -40 -20 0 20 40 pos-x[u]	60 80	5 0	-100	-100	-50	0 pos-x[u]		50	100	5 0

Figure 1.2: Ellipse and Skewed-Astroid run data summary

	Date: 2023-06-06				/e Interpo		-	y mackin	9		
EM	Author: wruslandr@gmail.com	Part301	5 Circle a			metric cu		TEROID +	EDICYCL	OID CLID	\r_
	DESCRIPTION	F010		CLE CUF		FC40					_
	Run user feedrate command (mm/s)	FC10				FC40			FC25	FC30	FC
	Total interpolated u-points	49641	24822	19859		12413	76275	38169	30563	25499	191
3	Parameter completion (reached u-end)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.
	Pushdown epsilon eps(u) algorithm	10011	0.1000	40050	10510	10110	7.0075	00004	00110	0.50.00	100
4	Count before pushdown, eps(u) is below (1E-6)	49641	24822	19859	16549	12413	76275	38061	30413	25309	189
5	Count pushdown points, eps(u) to below (1E-6)	0	0	0	0	0	Ü	108	150	190	2
	Epsilon eps(u) chord error										
6	Count eps(u) above (1E-6)	0						0	0	0	
	Count eps(u) in (1E-7, 1E-6)	0		17603		12413	407	820	4011	6679	139
8	Count eps(u) in (1E-8, 1E-7)	49641	17863	2256	0	0		37349	26552	18820	52
	Count eps(u) in (1E-9, 1E-8)	0	0	0				0	0	0	
10	Count eps(u) in (1E-10, 1E-9)	0	0	0	0	0	0	0	0	0	
11	Count eps(u) below (1E-10)	0	0	0	0	0	0	0	0	0	
	Count interpolated u-points										
12	Count_rising_S_curve u-points	2483	1242	993	828	621	4437	2219	1775	1479	1
13	Count_frate is_lower than fratelimit	22363	11171	8936	7449	5586	33349	16686	13352	11144	8
	Count frate is equal to fratelimit	0		0	0	0		0	0	0	
	Count frate is higher than fratelimit	22313		8937	7445	5585	35536	17787	14254	11891	9
_	Count falling S curve u-points	2482		993	827	621	2953	1477	1182	985	
	Count u-points histogram (G01 codes)	2-102	12-71	555	OL1	OLI	2000	2411	1102	000	
17	Count u-points [0.00 <= u < 0.10)	4964	2482	1985	1654	1241	8110	4055	3244	2704	2
	Count u-points [0.00 <= u < 0.10) Count u-points [0.10 <= u < 0.20)	4964		1986	1655	1241	4901	2478	2009	1702	1
	,	4964		1986	1655	1241	7391	3696	2957	2464	1
	Count u-points [0.20 <= u < 0.30) Count u-points [0.30 <= u < 0.40)	4964		1986		1241	7391	3696	2894	2464	1
_	Count u-points (0.40 <= u < 0.50)	4964		1986		1242	9182	4592	3673	3061	2
	Count u-points [0.50 <= u < 0.60)	4964		1985		1241	7216	3608	2887	2406	1
_	Count u-points (0.60 <= u < 0.70)	4964		1986		1241	9831	4916	3933	3278	2
	Count u-points [0.70 <= u < 0.80)	4964		1986		1241	7525	3763	3010	2508	1
25	Count u-points [0.80 <= u < 0.90)	4964		1986		1242	8801	4401	3521	2935	2
26	Count u-points [0.90 <= u <= 1.00]	4965	2483	1987	1656	1242	6084	3043	2435	2029	1
27	Check Total u-points	49641	24822	19859	16549	12413	76275	38169	30563	25499	19
	Performance										
28	Total curve error (sum of epsilon(u))	0.001094	0.001094	0.002188	0.002735	0.004375	0.00084	0.001642	0.00202	0.00239	0.003
29	Total dist traversed (sum of chord lengths)	496.3786	496.3772	496.3964	496.3757	496.3943	426.2622	426.2622	426.2622	426.2622	426.2
30	Percent (Tot curve error / Tot dist traversed)	0.00022	0.00022	0.000441	0.000551	0.000881	0.000197	0.000385	0.000474	0.000561	0.00
Г	Circle FC20 curve x[u] versus y[u] Color = Feedrate 'A20-CIRCLE-FC20-data_ngcode.ngc' usir	og 5:7:3	40		·	Astepi FC		sus y[u] Color = Fo		57.3	40
50 -	AZO-GINELE-Pizz-Gala_rigocoa-rigo (sal	937.3	35 - 30	50			AlgozorAsi	EFF-020-uata II	O		35 30
-50			- 25 - 20 - 15 - 10	[n] k 600d				/			- 25 - 20 - 15 - 10

Figure 1.3: Circle and AstEpi run data summary

	Author: wruslandr@gmail.com	Part 4 of	NC Param 5 Snailsh	all and Sn	aHvn (v.v				5		
EM	DESCRIPTION	Part 4 Or		SHELL C) paramet			HVDATD	OCOID CL	IDVE
	Run user feedrate command (mm/s)	FC10	FC20	FC25	FC30	FC40	FC10				FC
	Total interpolated u-points	15621		8935	8370		38672	20223			8
$\overline{}$										_	
3	Parameter completion (reached u-end = 1.00)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.706104	0.703
.	Pushdown epsilon eps(u) algorithm	40045	E010	0.00	0.0714	4500	07007	40407	4 4000		
	Count before pushdown, eps(u) is below (1E-6)	12245	5010	3569	2671	1592	37227	18167	14266	0	
5	Count pushdown points, eps(u) to below (1E-6)	3376	4873	5366	5699	6174	1445	2056	2352	0	
	Epsilon eps(u) chord error										
$\overline{}$	Count eps(u) above (1E-6)	0	_	0	0		0	_	_	0	
	Count eps(u) in (1E-7, 1E-6)	7893		8935	8370			6971			
8	Count eps(u) in (1E-8, 1E-7)	7728	560	0	0	0	24178	13252	6718	0	
9	Count eps(u) in (1E-9, 1E-8)	0	0	0	0	0	10388	0	0	0	
10	Count eps(u) in (1E-10, 1E-9)	0	0	0	0	0	0	0	0	0	
11	Count eps(u) below (1E-10)	0	0	0	0	0	0	0	0	0	
	Count interpolated u-points										
12	Count rising S curve u-points	2320	1161	929	774	581	3177	1589	1272	0	
$\overline{}$	Count_frate is_lower than fratelimit	11722	6605	5826	5386	4860	18305	9773		0	
_	Count_frate is_lower than materimit	0		0	0		10303	0		0	
	Count_frate is_equal to fratelimit Count_frate is_higher than fratelimit	1210		1811	1859	1956	14859	7695		0	
_											
16	Count_falling_S_curve u-points	369	370	359	369	369	2331	1166	933	***	**
	Count u-points histogram (G01 codes)										
	Count u-points [0.00 <= u < 0.10)	4435	2218	1774	1479		4631	2317	1856	1563	1
$\overline{}$	Count u-points [0.10 <= u < 0.20)	3237	1619	1296	1080	849	8961	4480		2987	2
19	Count u-points [0.20 <= u < 0.30)	2054		851	796		6140	3074		2072	1
20	Count u-points [0.30 <= u < 0.40)	1312	714	710	711	711	2960	1526	1257	1086	
21	Count u-points [0.40 <= u < 0.50)	881	629	629	629	629	4860	2431	1945	1620	1
22	Count u-points [0.50 <= u < 0.60)	657	628	628	629	628	3973	1987	1589	1325	
	Count u-points [0.60 <= u < 0.70)	710	711	711	710	711	1324	841	769	732	
_	Count u-points [0.70 <= u < 0.80)	794		794	794		794	794		112	
$\overline{}$	Count u-points [0.80 <= u < 0.90)	791	791	792	792	792	1141	828		0	
	Count u-points [0.90 <= u <= 1.00]	750	751	750	750		3888	1945		0	
_	, ,										
27	Check Total u-points	15621	9883	8935	8370	7766	38672	20223	16618	11497	8
	Performance										
28	Total curve error (sum of epsilon(u))	0.005115							0.004459	0	
29	Total dist traversed (sum of chord lengths)							478.9987		0	
30	Percent (Tot curve error / Tot dist traversed)	0.003692	0.004525	0.004733	0.004882	0.005085	0.000594	0.000836	0.000931	0	
							I	ı			
		•	•								
10	Snallshell FC20 curve x[u] versus y[u] Color = Feedrate		40		s	nailshell + Hypotr	ocoid FC20 curve	x[u] versus y[u] (Color = Feedrate		
10	Snalishell FC20 curve x[u] versus y[u] Color = Feedrate 'A20-SNAILSHELL-FC20-data_ngcode.ngc' using	j 5:7:3 ———	40		s	nailshell + Hypotr			Color = Feedrate	5:7:3	40
10		y 5:7:3 ———	40	100	s	nailshell + Hypotr				5:7:3	40
		J 5:7:3 ———	40	100	s	nailshell + Hypotr				57:3	
		J 5:7:3		100	s	nailshell + Hypotr				5.7:3	
		15:7:3		100	S	nailshell + Hypotr				5:7:3	
10		5:7:3			S	nailshell + Hypotr				5:7:3	35
10		15:7:3	35	100	s	nailshell + Hypotr				5:7:3	35
10		15:7:3	35		s	nailshell + Hypotr				5-7:3	35
0		5:7:3	35		s	nailshell + Hypotr				5773	35 30
0		5:7:3	35		s	nailshell + Hypotr				5:7:3	35 30
0		15.7.3	35	50 -	S	nailshell + Hypotr				57.3	35 30 25
0		15.73 -	35	50 -	S	nalishell + Hypotr				57.3	35 30
0		15.7.3	35	50 .	S	nalishell + Hypotr				i7.3	35 30 25
0		15.73	35 30 25	50 -	S	nalishell + Hypotr				i73 <u> </u>	35 30 25 20
0		157/3	35	50 -	S	nailshell + Hypotr				57.3	35 30 25 20
0		1573	35 30 25	50 · · · · · · · · · · · · · · · · · · ·	S	nailshell + Hypotr				\$7.3	35 30 25 20
0		15.7.3	35 30 25 20	50 -	S	nalisheli + Hypotr				i7.3	35 30 25 20
0		15.73	35 30 25	50 · · · · · · · · · · · · · · · · · · ·	S	nalishell + Hypotr				i73 —	35 30 25 20
0		157/3	35 30 25 20	50 · · · · · · · · · · · · · · · · · · ·	S	nailshell + Hypotr				57.3	35 30 25 20
0		15.7.3	35 30 25 20 15	50 · · · · · · · · · · · · · · · · · · ·	S	nailshell + Hypotr				57.3	35 30 25 20 15
0		15.73	35 30 25 20	50 · · · · · · · · · · · · · · · · · · ·	S	nalishell + Hypotr				i7:3 ——	35 30 25 20
0		157/3	35 30 25 20 15	50 · · · · · · · · · · · · · · · · · · ·	S	nailshell + Hypotr				i.7.3 ——	35 30 25 20 15
0		157/3	35 30 25 20 15	50 - 10/k so d	S S	nalishell + Hypotr				100	35 30 25 20 15

Figure 1.4: Snailshell and SnaHyp run data summary

	Author: wruslandr@gmail.com	Part 5 of	5 Ribbon-			0L (x-y) pa	arametric				
ГЕМ	DESCRIPTION			ON-10L C					ON-100L C		
1	Run user feedrate command (mm/s)	FC10									FC
2	Total interpolated u-points	7351	7352	7352	7353	7353	7480	7348			73
3	Parameter completion (reached u-end)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1
	Pushdown epsilon eps(u) algorithm										
4	Count before pushdown, eps(u) is below (1E-6)	0	0	0	0	0	919	0	0	0	
5	Count pushdown points, eps(u) to below (1E-6)	7351	7352	7352	7353	7353	6561	7348	7349	7349	7
	Epsilon eps(u) chord error										
6	Count eps(u) above (1E-6)	0	0	0	0	0	0	0	0	0	
7	Count eps(u) in (1E-7, 1E-6)	7351	7352	7352	7353	7353	7480	7348	7349	7349	7
8	Count eps(u) in (1E-8, 1E-7)	0		0	0						
9	Count eps(u) in (1E-9, 1E-8)	0			0	_	_				
10	Count eps(u) in (1E-10, 1E-9)	0		0	0				_		
11	Count eps(u) below (1E-10)	0	0	0	0	0					
ΙΙ		U	U	U	U	U	U	U	U	U	
	Count interpolated u-points	0.00				0.770	10.0	0.70			
12	Count_rising_S_curve u-points	370	370	370	370	370	436	370		370	
13	Count_frate is_lower than fratelimit	3491	3310	3310	3308	3309	5562	3939		3545	3
14	Count_frate is_equal to fratelimit	0	0	0	0	0	-	0	_	_	
15	Count_frate is_higher than fratelimit	3121	3303	3303	3305	3305	1047	2670		3065	3
16	Count_falling_S_curve u-points	369	369	369	370	369	435	369	369	369	
	Count u-points histogram (G01 codes)										
17	Count u-points [0.00 <= u < 0.10)	749	749	749	749	749	815	748	748	748	
18	Count u-points [0.10 <= u < 0.20)	791	792	792	792	792	791	792	792	792	
19	Count u-points [0.20 <= u < 0.30)	795	794	794	794	794	794	794		794	
20	Count u-points [0.30 <= u < 0.40)	711	711	711	711	712	711	711	711	711	
21	Count u-points [0.40 <= u < 0.50)	629	629	629	630	629	629	628		629	
22	Count u-points [0.50 <= u < 0.60)	629	630	630	629	629	628	629			
	, ,		711	711		711	711				
23	Count u-points [0.60 <= u < 0.70)	711			711			711		711	
24	Count u-points [0.70 <= u < 0.80)	794	794	794	795	795	794	794		794	
25	Count u-points [0.80 <= u < 0.90)	792	792	792	791	792	791	791	791	791	
26	Count u-points [0.90 <= u <= 1.00]	750	750	750	751	750	816	750			
27	Check Total u-points	7351	7352	7352	7353	7353	7480	7348	7349	7349	7
	Performance										
28	Total curve error (sum of epsilon(u))	0.007332	0.007331	0.00733	0.007331	0.00733	0.007227	0.007334	0.007335	0.007334	0.007
29	Total dist traversed (sum of chord lengths)	15.2108	15.21069	15.20945	15.21391	15.21192	152.0974	152.1029	152.1321	152.1103	152.1
30	Percent (Tot curve error / Tot dist traversed)	0.048201	0.048194	0.048195	0.048185	0.048187	0.004752	0.004822	0.004821	0.004821	0.00
10 [Ribbon-10L FC20 curve x[u] versus y[u] Color = Feedrate		40	60 -		Ribbon-100L I		ersus y[u] Color =			40
	'A23-RIBBON10L-FC20-data_ngcode.ngc' usin	g 5:7:3					'A23-RIBBON10	00L-FC20-data_no	gcode.ngc' using 5	5:7:3 ——	
									1		
			35					/ }	/ /		35
				40					\ /	-	
		<u>-</u>	30						X		30
5 -	1 1			20					/ \	·····	25
5 -	(X		25						N.		
	X		25								20
		<u>-</u>	20	5						<u>-</u>	20
0 -			20	[n]/v-sod							15
5 - 0 5 -		_	20 15	[n]/v-sod							15
0 -			20	[n]/k sod							- 15
0 -	5 0 5		20	[n]/k sod	40	-20	0	20	40	60	

Figure 1.5: Ribbon-10L and Ribbon-100L run data summary