

Our experimental setting is illustrated in Figure 1. Table 1 summarized the experimental statistics.

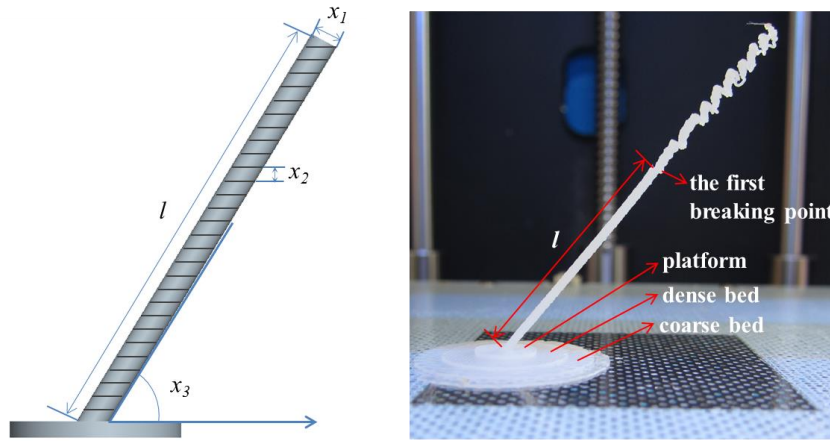


Figure 1 (a) The parameters that influence the growing length of a branch, the bottom of the bar is fixed on a platform to prevent it from being toppled by the nozzle; (b) A branch printed by an FDM 3D printer, where the coarse bed and the dense bed are automatically generated by the printer to hold the branch.

Table 1 Printing Experimental Results with different groups of parameters

x_3	10 °	20 °	30 °	40 °	50 °	60 °	70 °	80 °
Group1 ($x_1=0.5\text{mm}$ $x_2=0.09\text{mm}$)	3.5	14.05	18.05	22	26.4	31.44	34.4	38.44
	4.04	14.85	18.7	23.34	27.26	31.08	34.08	38.1
Group2 ($x_1=1.0\text{mm}$ $x_2=0.09\text{mm}$)	19.2	24.8	28.04	31.98	42.9	49.48	58.08	61.8
	20.8	26.5	28.94	30.68	43.56	49.9	59.86	61.28
Group3 ($x_1=1.5\text{mm}$ $x_2=0.09\text{mm}$)	41.48	41.6	38	40.7	45.4	49.62	56.2	59.3
	43.5	40.4	36.4	38.2	45.12	48.7	55.6	62.72
Group4 ($x_1=2.0\text{mm}$ $x_2=0.09\text{mm}$)	63.5	53.28	50.44	49.68	52.2	59	68.6	79.82
	67.2	54.2	47	46.7	52.68	60.3	69.2	80.1
Group5 ($x_1=0.5\text{mm}$ $x_2=0.19\text{mm}$)	*	9	15	18	21.8	22.3	22.5	24.6
	*	10.3	14.08	20.78	22	22.8	24.2	24.06
Group6 ($x_1=1.0\text{mm}$ $x_2=0.19\text{mm}$)	40.59	36.48	34.5	37	40	44.08	49.1	50.9
	44.3	38	33.28	36.4	39.6	44	47.9	51.86
Group7 ($x_1=1.5\text{mm}$ $x_2=0.19\text{mm}$)	64.7	56	43.5	41.66	47.7	51.4	58.9	69.6
	65.4	55.1	42.2	40.58	49.02	50.5	57.86	70.1
Group8 ($x_1=2.0\text{mm}$ $x_2=0.19\text{mm}$)	89	79	76.7	66.2	70.5	66.07	70.04	79.1
	89	79	77.6	60	67	68.4	69.54	79
Group9 ($x_1=0.5\text{mm}$ $x_2=0.29\text{mm}$)	*	*	*	*	*	*	*	*
	*	*	*	*	*	*	*	*
Group10 ($x_1=1.0\text{mm}$ $x_2=0.29\text{mm}$)	56.4	53	51.54	47.7	36.8	39.1	41	42.56
	58	54.8	49.6	45.3	35.5	38.2	40.6	42.5
Group11 ($x_1=1.5\text{mm}$ $x_2=0.29\text{mm}$)	67	58	55	54	52.6	56	62.4	72.5
	69.1	59.5	56.4	53.6	52.3	55.6	61.04	70.2
Group12 ($x_1=2.0\text{mm}$ $x_2=0.29\text{mm}$)	#	#	#	#	#	#	#	#
	#	#	#	#	#	#	#	#

* indicates that the bar is not printable

indicates that the bar is longer than 10cm, and is omitted from consideration

The unit of l is mm;

Nozzle temperature: 200°C;

Deposition speed: 60mm/s for the infill and 20 mm/s for the contour healing;

Machine: Zortax M200 FDM 3D printer;

Material: ABS.