

# 系统效应—自下而上的设计

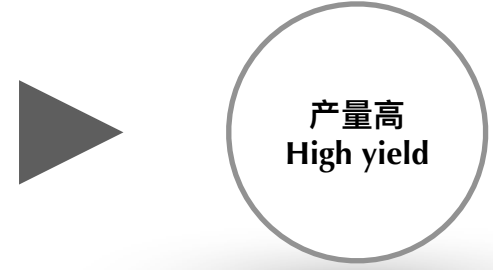
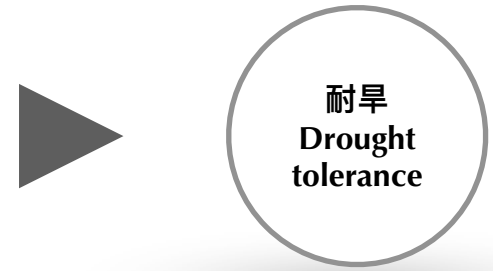
指导教师：李世奇/杨凯/黄胤俊  
小组学生：刘智鹏/殷楚君/段庚鑫

System effect - bottom up design



**高粱的蓝色循环经济**  
**The blue circular economy of Sorghum**

Topic research





- 2019全国高粱种植面积：928.1万亩
- 2019全国高粱总产值： 290.9万吨
- Sorghum Planting Area in China in 2019: 928.1万亩
- Total output value of Sorghum in China in 2019: 290.9万吨





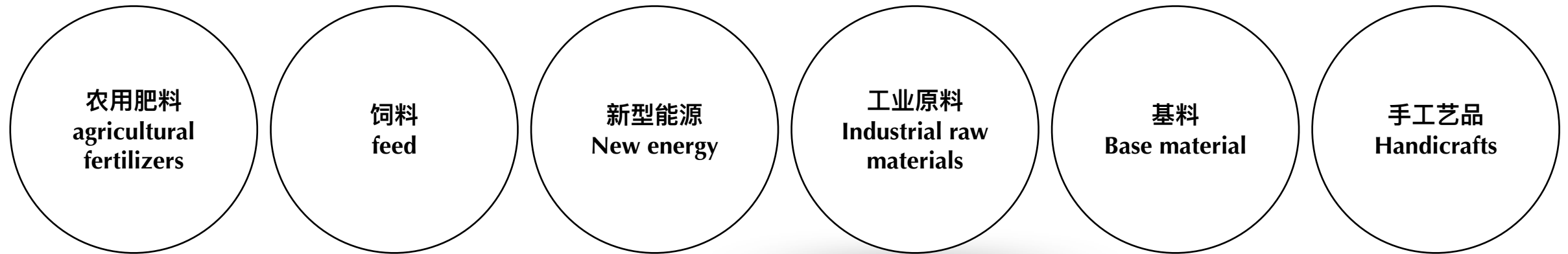
我国秸秆综合利用处于两难境地，解决的关键就在于规模化和运营模式创新，如果能转化我国每年7亿多吨秸秆的50%，将是一个巨大的新兴产业；若能创建以秸秆为原料的新型生态工业，实行建材业种植业、养殖业、农副产品加工业、秸秆生态工业四业相结合的生态农业的生产模式、生物液体燃料、有机肥、生物饲料等都是秸秆转化的产物，那将是一种新型的产业模式

China's comprehensive utilization of straw is in a dilemma. The key to solve this problem lies in the innovation of scale and operation mode. If we can transform 50% of China's more than 700 million tons of straw every year, it will be a huge emerging industry; if we can create a new type of ecological industry based on straw, we will implement the combination of construction industry, planting industry, breeding industry, agricultural and sideline products processing industry and straw ecological industry Agricultural production mode, biological liquid fuel, organic fertilizer, biological feed and so on are the products of straw conversion, which will be a new industrial model



# 高粱用途

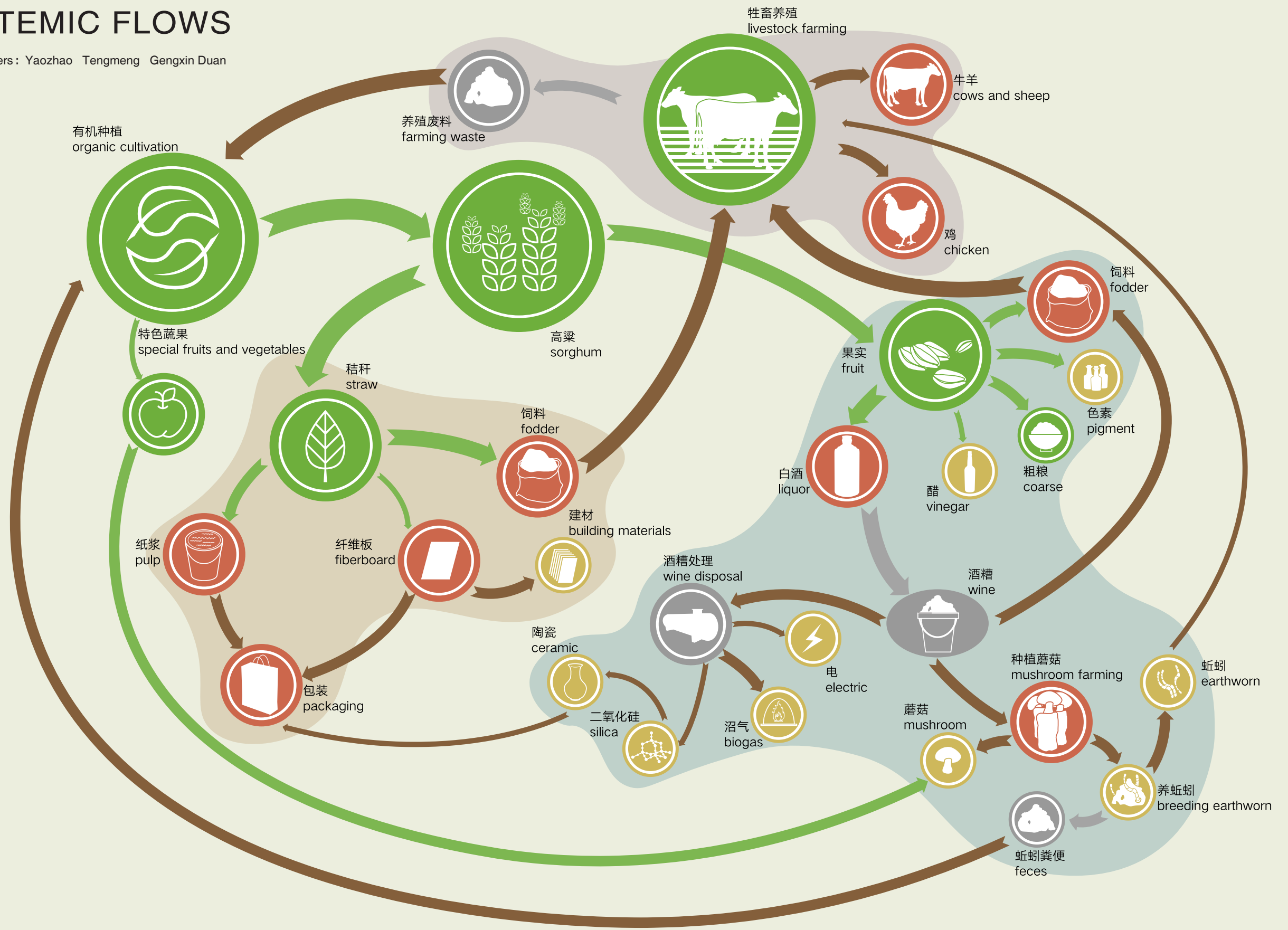
## Application of sorghum





# SYSTEMIC FLOWS

Group members: Yaozhao Tengmeng Gengxin Duan





# 高粱 Sorghum

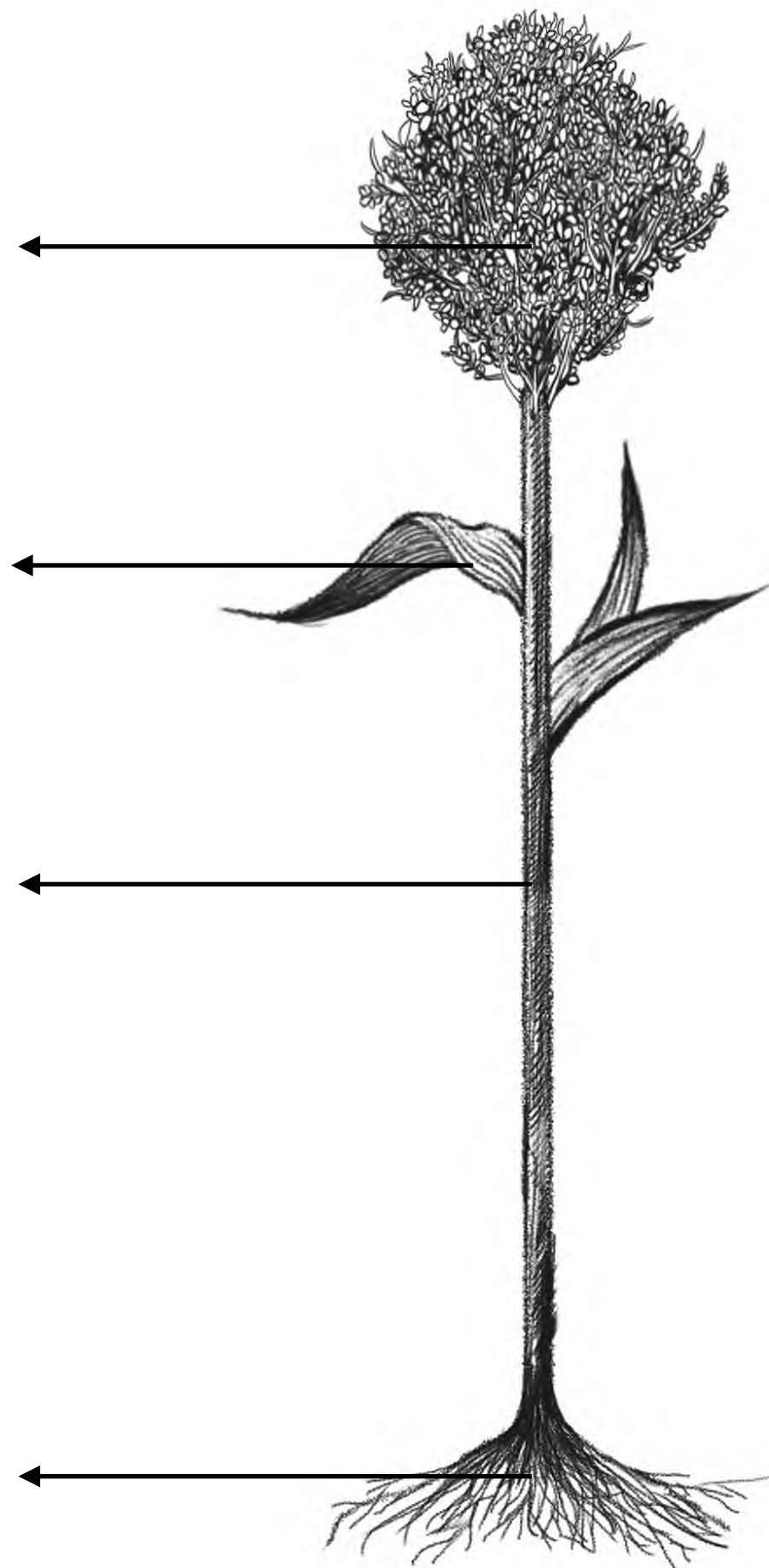


子粒  
grain

叶  
leaf

秸秆  
straw


根  
root



传统处理方式  
Traditional treatment





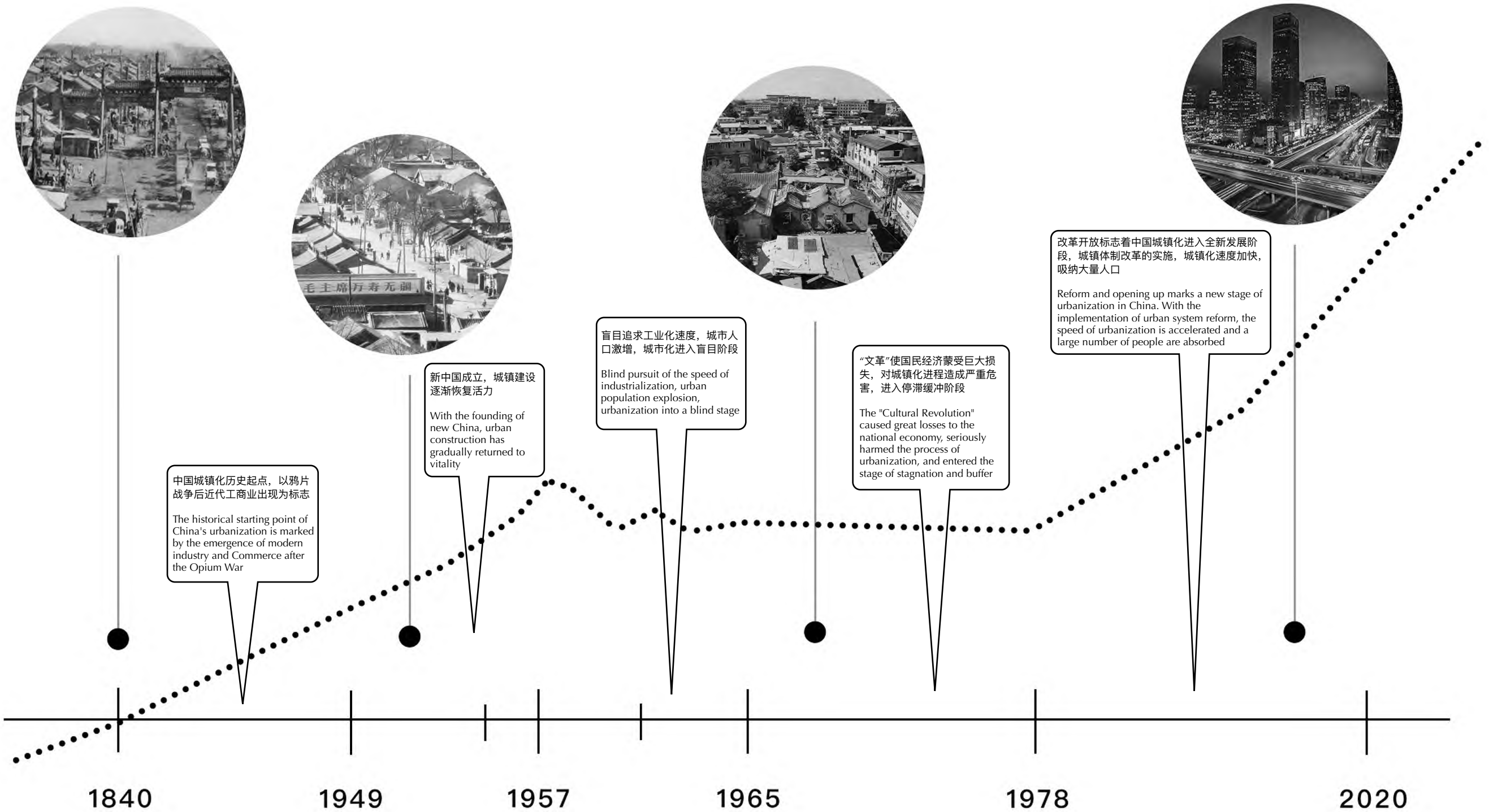


北京故宫博物院，由于国庆期间华北地区焚烧秸秆，排放污染物增加，10月4日至7日遭遇严重雾霾天气，PM2.5浓度突破300微克每立方米，部分地区能见度不足100米。受冷空气和偏北风影响，10月8日雾霾消散，空气质量达到优良水平。

Beijing Palace Museum, due to the burning of straw in North China during the National Day period, increased emissions of pollutants. From October 4 to 7, the concentration of PM2.5 exceeded 300 micrograms per cubic meter, and visibility in some areas was less than 100 meters. Affected by the cold air and northerly wind, the haze disappeared on October 8, and the air quality reached an excellent level.



# 中国城镇化建设进程 The process of urbanization in China



恢复和稳步发展

调整和停滞阶段

快速发展阶段



中国环联此前的调查结果显示，我国在城市建设施工过程中产生的垃圾数据总量已占城市垃圾总量的30%-40%，成为一大城市垃圾园。目前我国建筑废弃物资源化率不足5%，而欧盟国家每年资源化率超过90%，韩国日本资源化率甚至高达95%以上。

According to the previous survey results of China Environmental Union, the total amount of waste data generated in the process of urban construction in China has accounted for 30% - 40% of the total amount of urban garbage, becoming a large urban garbage garden. At present, the recycling rate of construction waste in China is less than 5%, while that of EU countries is more than 90%, and that of South Korea and Japan is more than 95%.





严重污染水资源：堆放填埋等过程中，由于雨水淋溶冲刷以及地表地下水浸泡而渗滤的污水造成严重的水污染  
 Serious pollution of water resources: in the process of stacking and landfilling, serious water pollution is caused by the infiltration of sewage due to rainwater leaching and surface groundwater immersion

影响空气质量：有机物分解产生有害气体  
 Impact on air quality: harmful gas produced by decomposition of organic matter

占用土地降低质量：大多数建筑垃圾以露天堆放为主，有害物质流入土壤中降低土地质量  
 Occupation of land reduces quality: most construction waste is mainly piled in the open air, and harmful substances flow into the soil to reduce the quality of land

安全隐患：建筑垃圾崩塌，阻碍道路，崩塌其他建筑物等  
 Potential safety hazard: construction waste collapses, blocks roads, collapses other buildings, etc





# 联合国可持续发展目标 Sustainable Development Goals

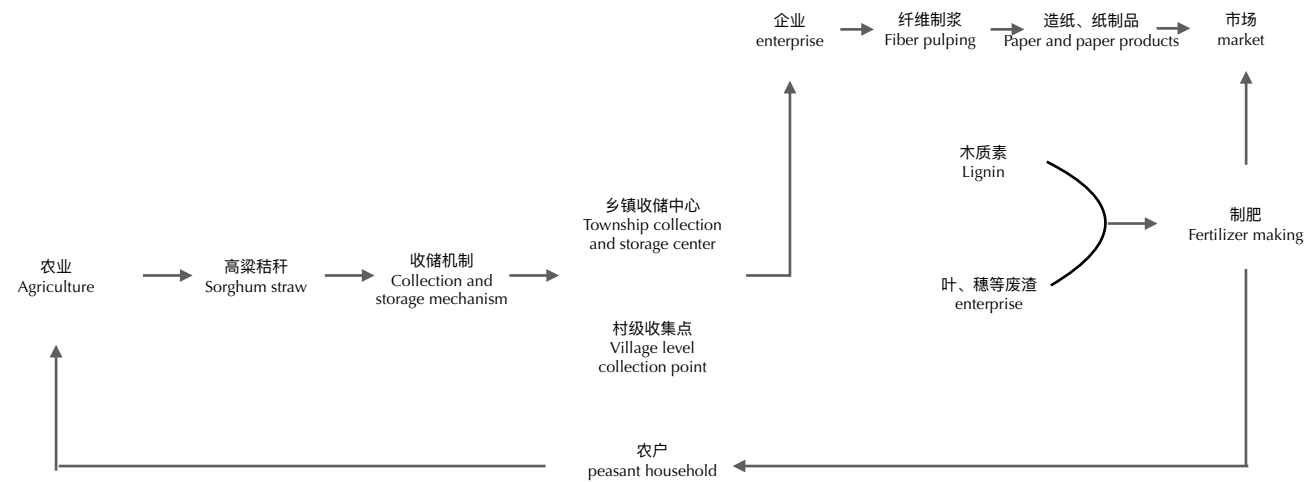


2015年9月25日，联合国可持续发展峰会在纽约总部召开，193个成员国正式通过17个可持续发展目标。旨在从2015年到2030年间以综合方式彻底解决社会、经济和环境三个维度的发展问题，转向可持续发展道路。

On September 25, 2015, the United Nations Sustainable Development Summit was held in New York headquarters, and 193 Member States officially adopted 17 sustainable development goals. From 2015 to 2030, it aims to solve the development problems of social, economic and environmental dimensions in an integrated way, and turn to the sustainable development path.

- 11 可持续城市和社区
- 13 气候行动
- 11 sustainable cities and communities
- 13 climate action

# 泉林纸业 Quanlin paper industry



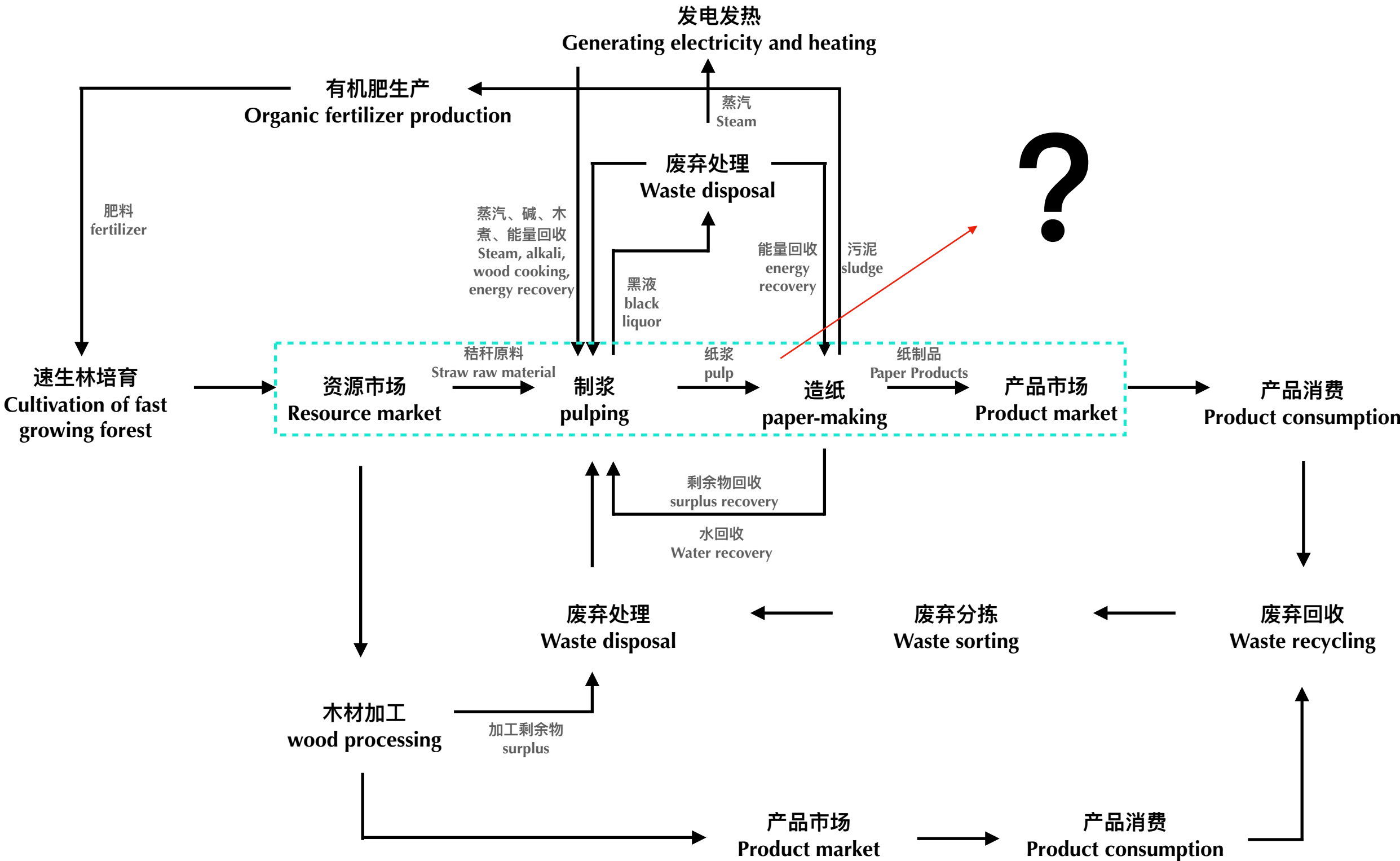
循环经济中的秸秆在前端环节的痛点问题

The pain point of straw in the front link of circular economy

- 秸秆难收集的关键是没好去处
- 时间短 (举例: 从麦收到玉米种下只有十天时间)

- The key to difficult collection of straw is that there is no good place to go
- Short time (e.g. only 10 days from wheat harvest to corn planting)

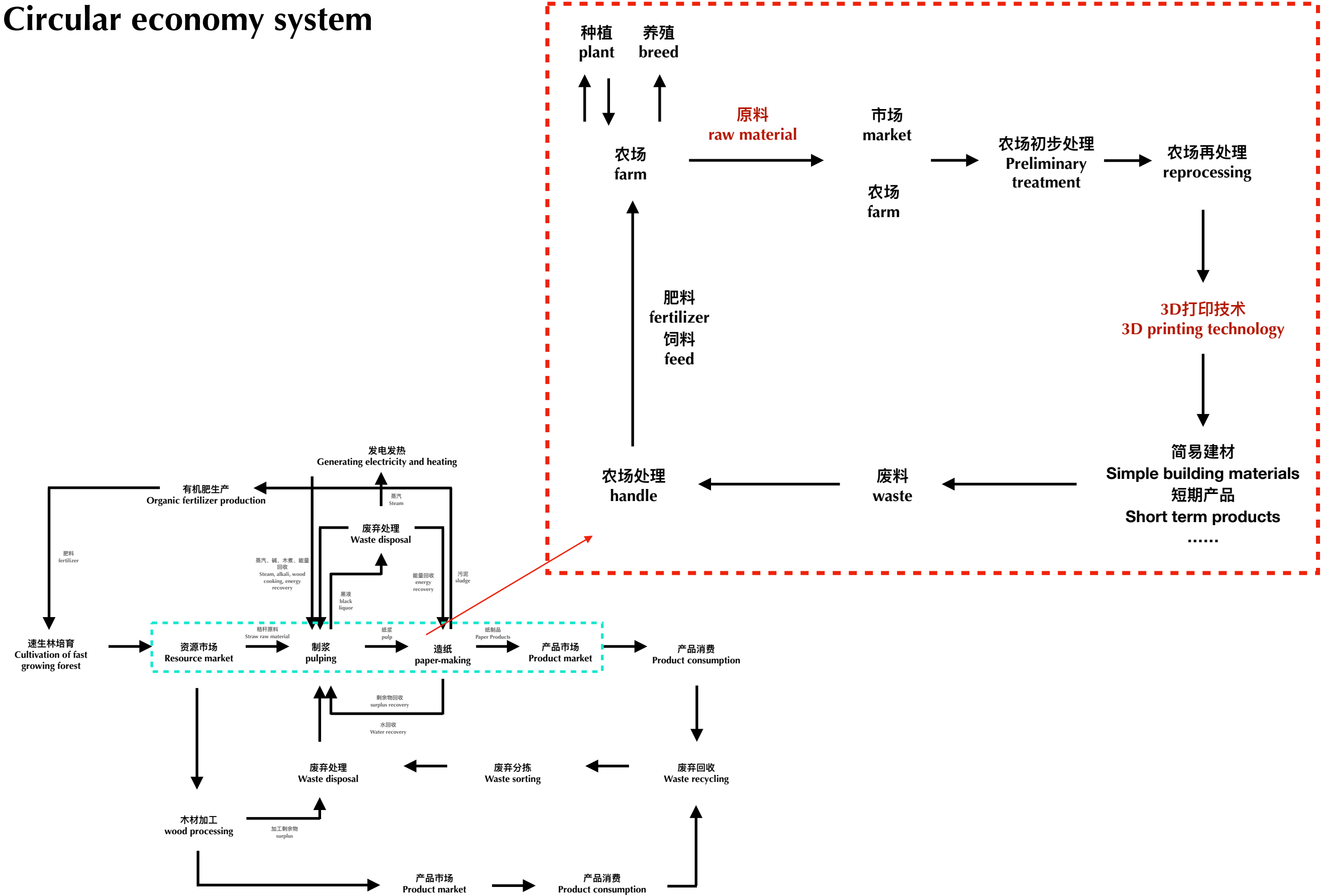
# 循环经济系统 Circular economy system

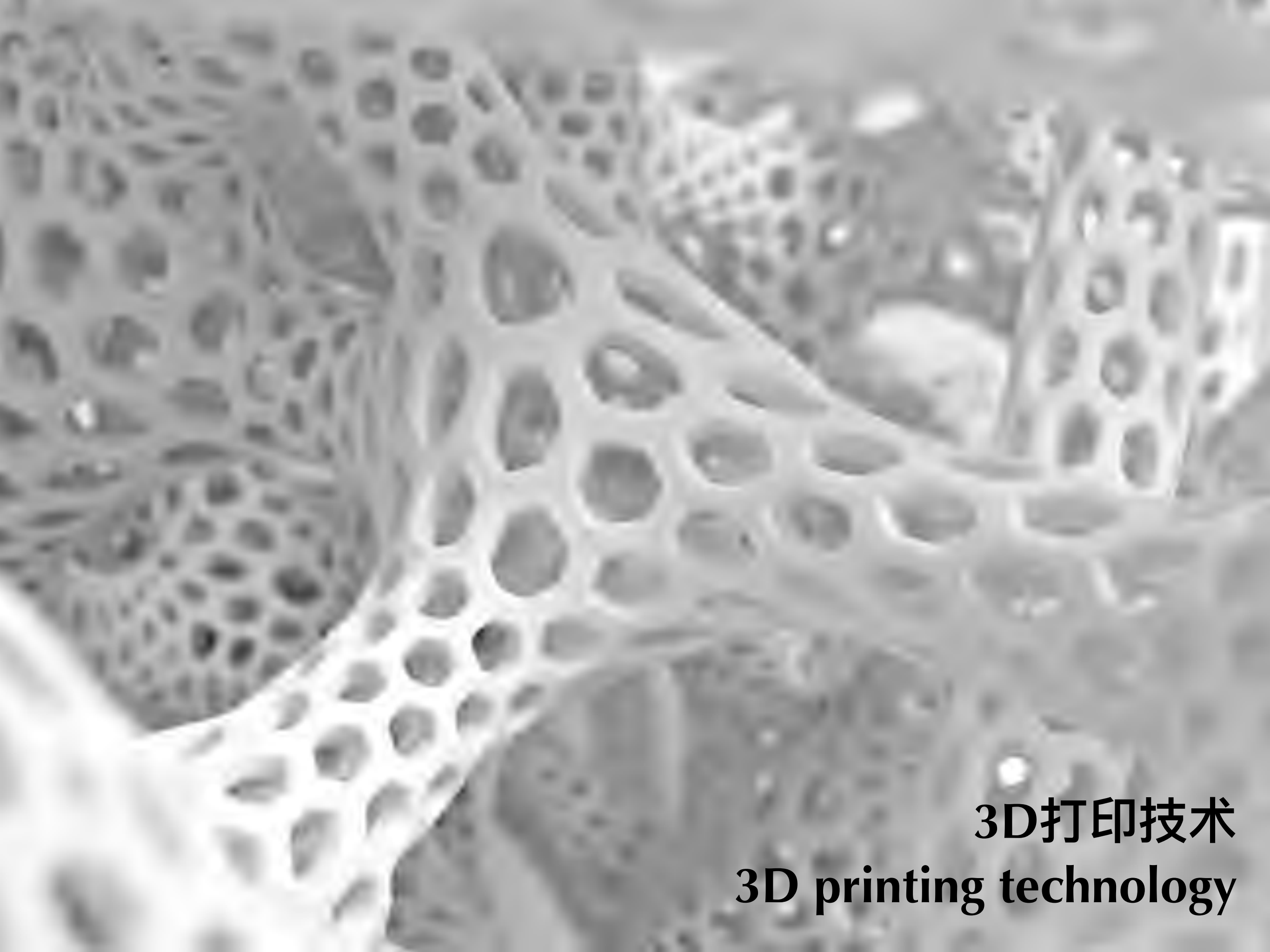




# 循环经济系统

# Circular economy system





**3D打印技术**  
**3D printing technology**

# 高粱秸秆—特性

## sorghum straw—characteristic

**表 1 几种主要禾草类原料纤维长宽的比较**

种类	一般长度(mm)	一般宽度(μm)	长宽比值
高粱秆	0.726 ~ 2.235	9 ~ 14	127.0
稻草	1.14 ~ 1.52	6 ~ 9	113.7
麦草	1.71 ~ 2.30	17 ~ 19	
芦苇	0.92 ~ 1.52	9 ~ 19	约 120
甘蔗渣	1.5 ~ 2.0	15 ~ 25	63
龙须草	0.636 ~ 2.706	53 ~ 198	202

(武恩吉整理,1981)

高粱茎叶中含有14%-18%的纤维素，是造纸的好原料，纤维细胞越细越长并富有绕曲性和柔韧性，越适合做造纸原料，高亮的纤维细胞长度与宽度之比优于芦苇，甘蔗渣相当于稻、麦而次于龙须草，因此高粱茎叶造纸的利用价值是较高的。

Sorghum stems and leaves contain 14% - 18% cellulose, which is a good raw material for paper-making. The thinner and longer the fiber cells are, the more flexible and flexible they are. The ratio of length to width of bright fiber cells is better than that of reed. Sugarcane bagasse is equivalent to rice and wheat and inferior to Eulaliopsis binata. Therefore, the utilization value of sorghum stem and leaf paper-making is higher.

**表 2 常用禾草类造纸原料化学组成成分**

种类	抽取物(%)				果胶(%)	多糖戊糖(%)	蛋白质(%)	木质素(%)	纤维素(%)
	冷水	热水	乙醚	NaOH					
高粱秆	8.08	13.88	0.10	25.12	-	24.40	1.81	22.52	39.70
小麦秆	5.36	23.15	0.51	44.56	0.30	25.56	2.30	22.34	40.40
玉米秆	10.65	20.40	0.56	45.62	0.45	24.58	3.83	18.38	37.68
稻草	6.85	28.50	0.65	47.70	0.21	18.06	6.04	14.05	36.20
甘蔗渣	7.63	15.88	0.85	26.26	0.26	23.51	3.42	19.30	42.16

(中国科学院植物研究所,1978)

**表 3 高粱茎叶中不同部位的化学成分分析**

部位	灰分(%)	树脂(%)	乙醇提取物(%)	纤维素(%)	木质素(%)	蛋白质(%)	乙酸盐(%)	铜价
全秆	7.65	1.19	10.26	48.83	20.12	0.34	5.62	8.05
节间	4.89	0.84	7.65	49.98	19.68	0.31	5.57	-
表皮	4.13	0.79	9.89	50.29	18.98	0.28	-	4.09
叶部	10.38	1.56	6.05	43.23	21.93	0.59	-	8.25
节部	6.99	1.65	11.61	37.12	16.38	0.37	-	17.29
髓部	4.88	1.12	13.51	42.99	16.19	0.58	-	19.36

(广瀨保,1943)

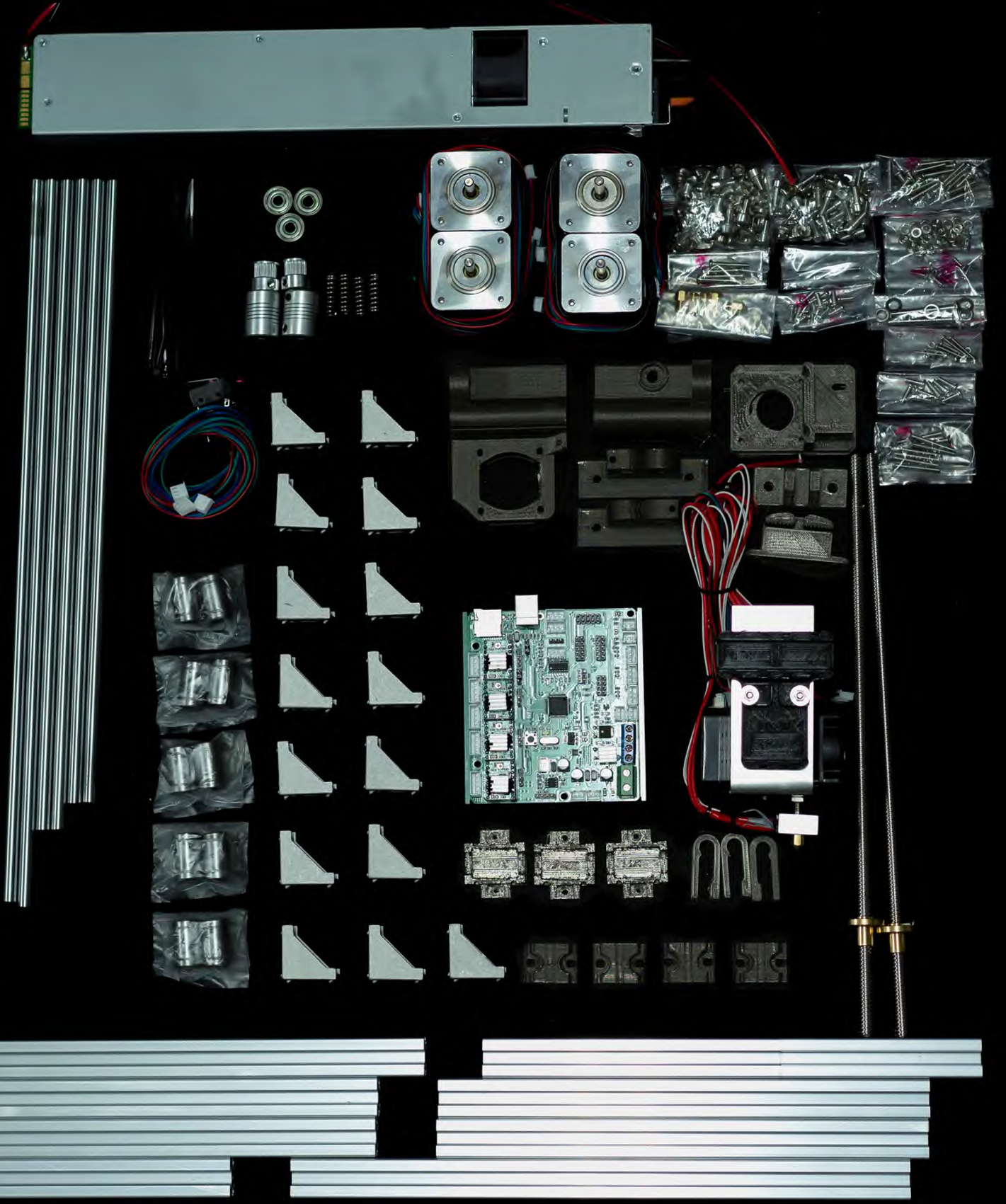
高粱不同品种之间,同一品种茎秆与叶片、茎秆不同部位之间,其纤维细胞长度和宽度都是有区别的。通常茎秆表皮的纤维是最优造纸原料,叶片次之,节部硅质化程度高,髓部纤维较短,造纸价值较低。

Among different sorghum varieties, the length and width of fiber cells of the same variety are different from that of leaves and stems of the same variety. In general, the fiber of stem epidermis is the best raw material for paper-making, followed by leaves, with high silicification degree in node, short fiber in pulp, and low paper-making value.



**First**

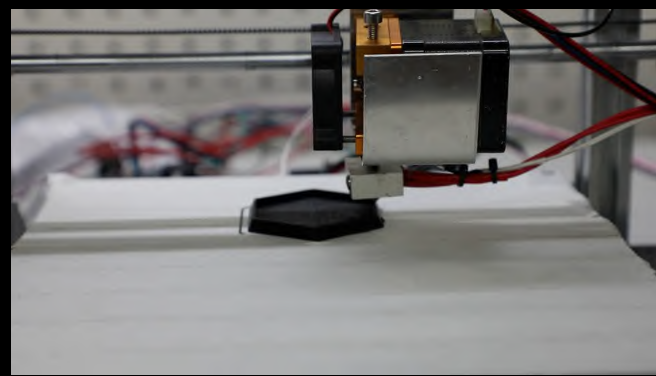
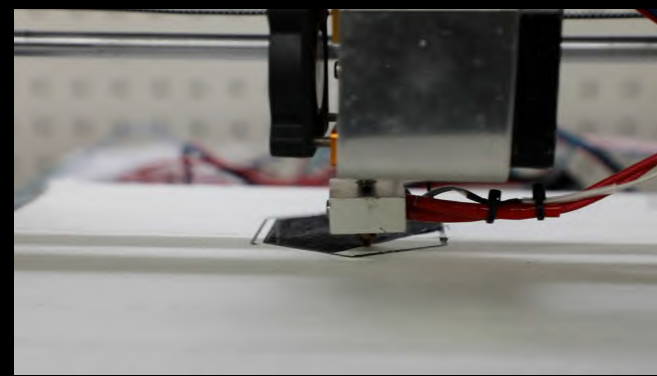
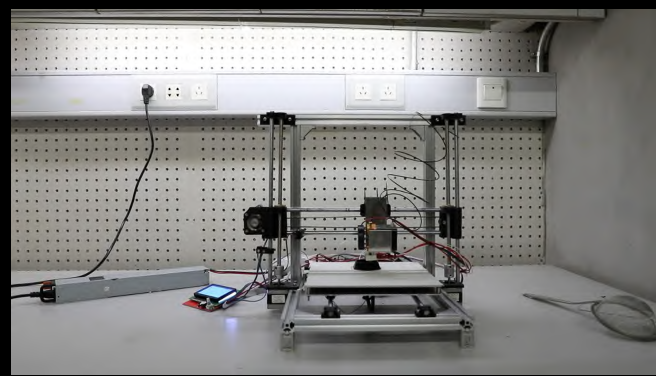
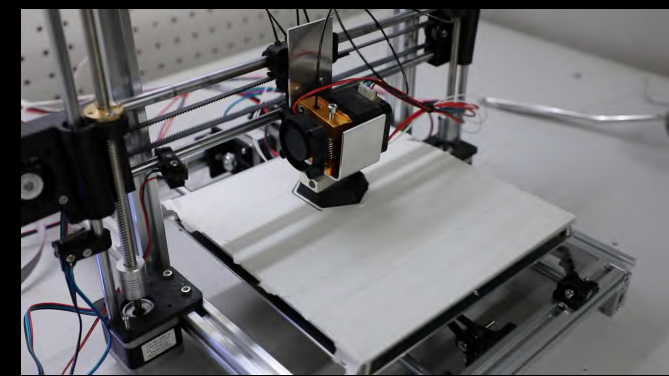
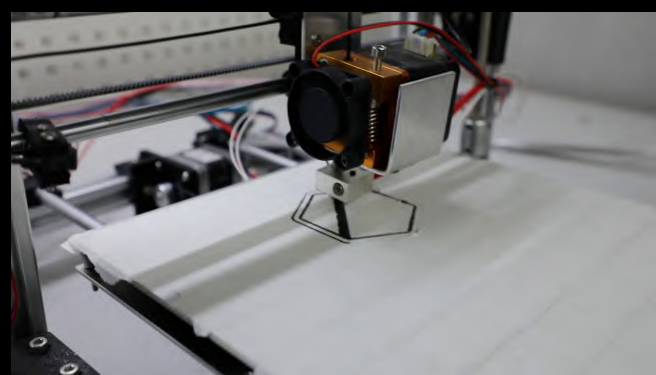
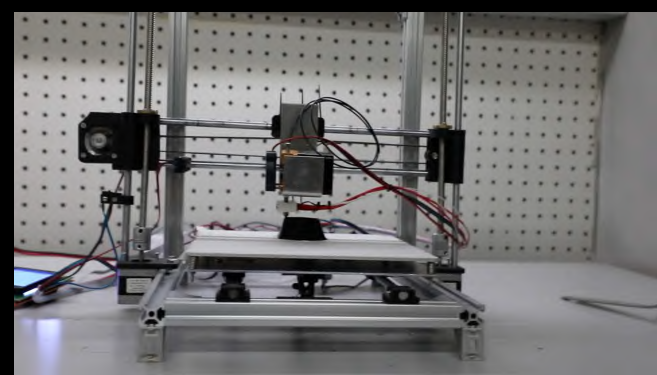
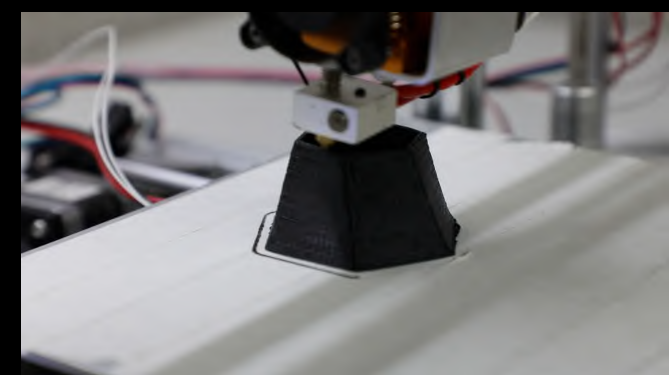
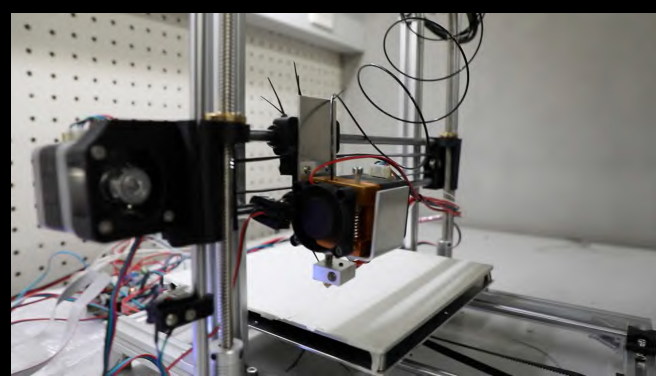
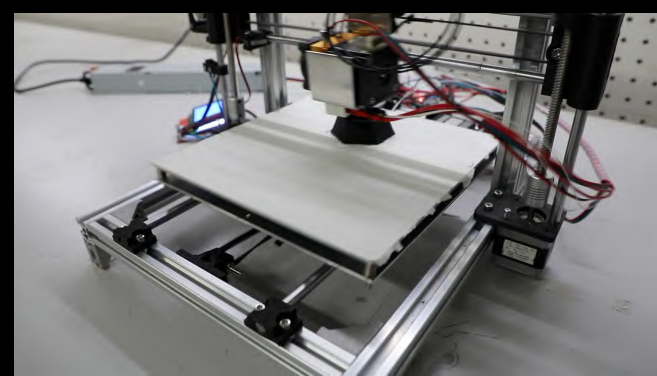
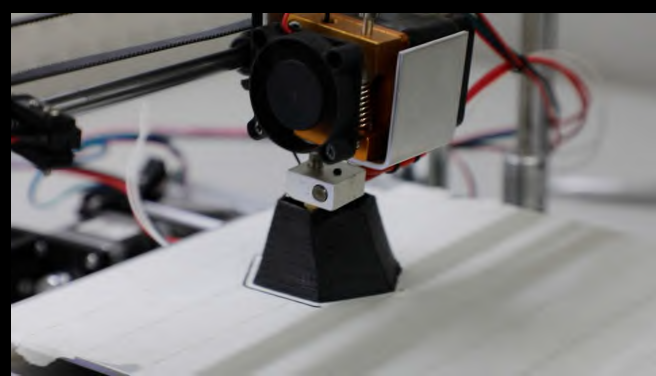
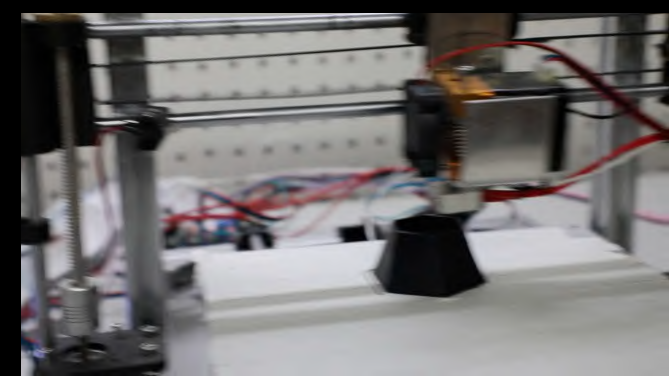
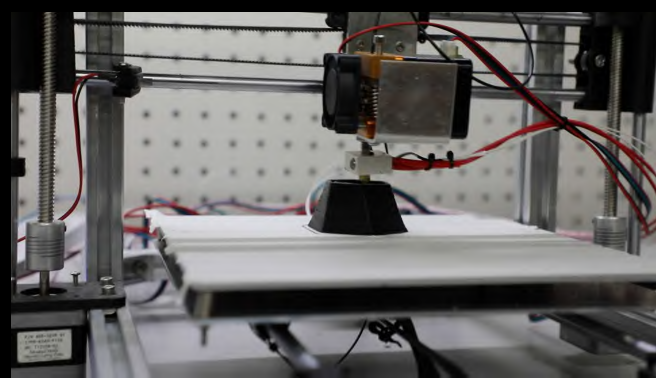
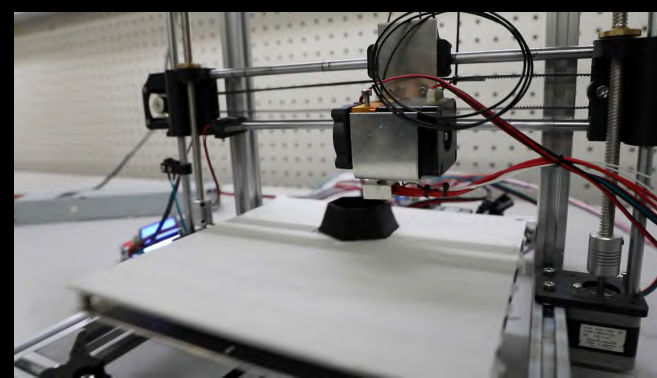
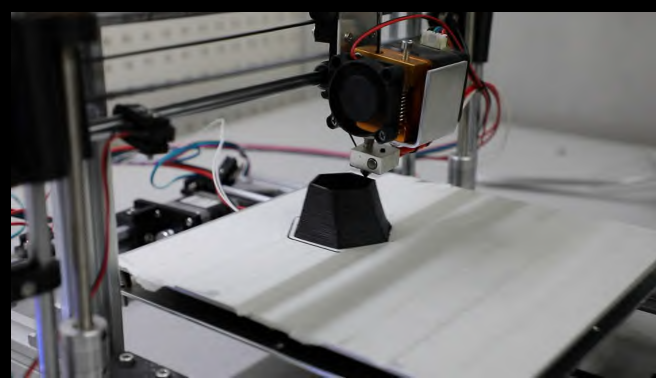
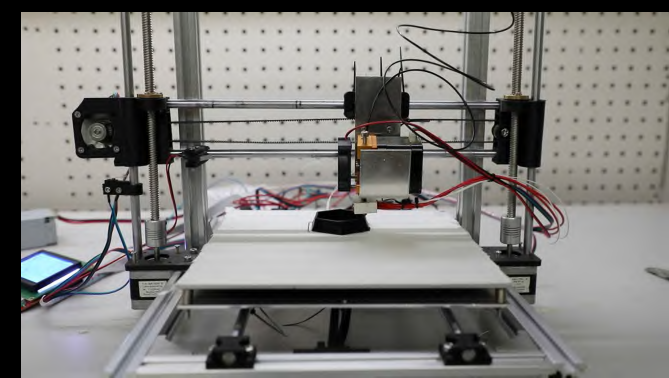
- 打印尺寸: 200\*200\*170MM
- 机器尺寸: 410\*385\*528MM
- 定位精度: 0.11\*0.11\*0.025MM
- 操作系统: Windows /Mac



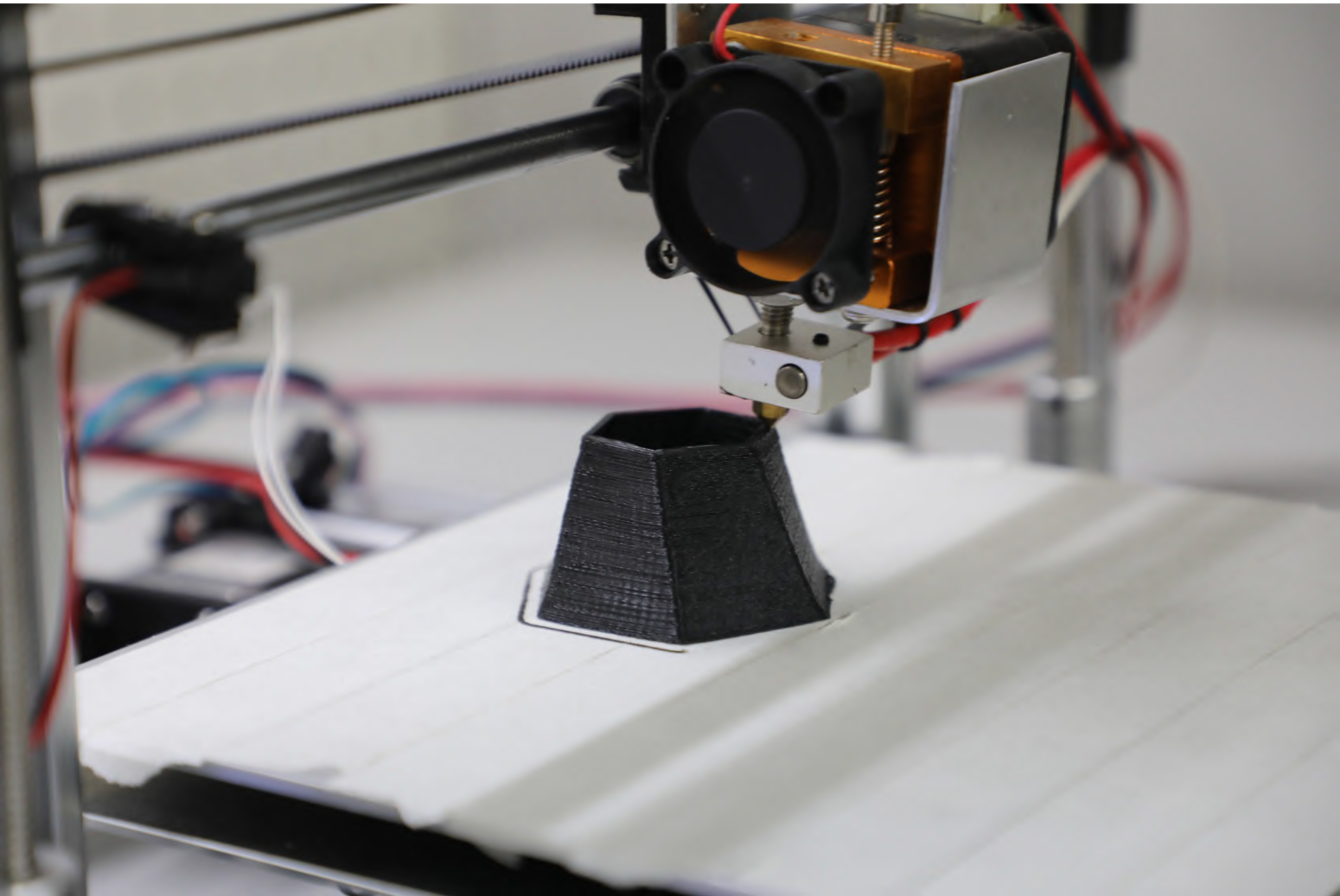
- 310MM 2020铝材 \*2
- 385MM 2020铝材 \*2
- 410MM 2020铝材 \*1
- 246MM 2020铝材 \*2
- 150MM 2020铝材 \*1
- 100MM 2020铝材 \*1
- 光轴Z 330 \*2
- 光轴X 345 \*2
- 光轴Y 385 \*2
- T丝杆300 \*2
- 2020角件 \*15
- M5\*8螺丝 \*26
- M5T螺母 \*26
- M5\*30螺丝(平头)\*2
- M5垫片 \*8
- M5螺母 \*2
- M4\*10螺丝 \*20
- M4T螺母 \*20
- M3\*10自攻 \*8
- M3\*10 \*8
- M3\*20 \*4
- M3\*8 \*12
- M3\*35 \*1
- M3螺母 \*31
- M3\*16 \*19
- M3\*25 \*8
- M2\*16螺丝 \*6
- M2螺母 \*6
- 8-5联轴器 \*2
- 625轴承 \*4
- 直线轴承 \*10
- 同步带 \*2
- 同步轮 \*2
- 热床弹簧 \*4
- 扎带 \*1
- 缝管 \*1
- 卡簧 \*2
- 行程开关 \*3
- 铝热床/带探头 \*1
- 热床平台铝板 \*1
- 整机打印件 \*1
- 步进电机 \*1
- 试机耗材 \*1
- 电控版 \*1
- 数据线 \*1
- 电源线 \*1
- 电源 \*1
- 电源输出线 \*1
- 100K热敏电阻 \*1
- M4\*45 \*2
- M3螺母 \*2
- 喉管 \*1
- 发热丝 \*1
- MK8铝块总成 \*1
- 喷嘴 \*1
- 加热铝块 \*1



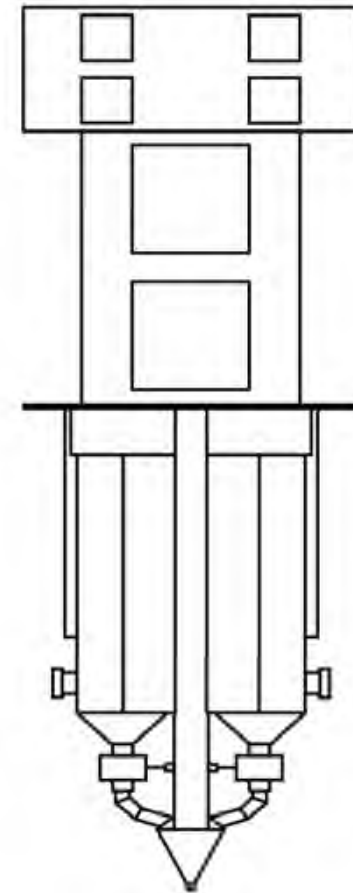
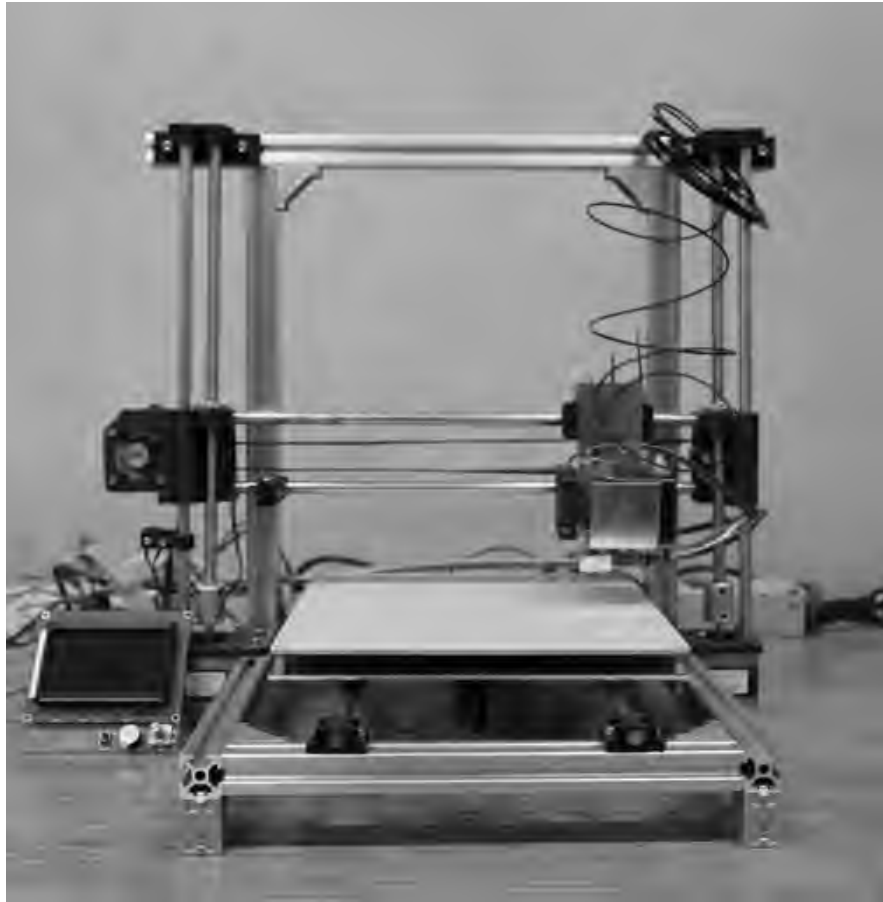








系统效应—自下而上的设计  
System effect - bottom up design



## 系统效应—自下而上的设计

### System effect - bottom up design



#### Step1



从通轴步进电机(4针电线旁边)上卸下两个M3螺栓,  
然后把2 x M3 30mm的螺栓安装到3D打印的风扇上。  
Remove the two m3 bolts from the through axis stepper motor  
(next to the 4-pin wire) and install the 2 x m3 30mm bolts to the 3D printing fan

#### Step2



使用2个X M3 10mm螺栓安装40mm的冷却风扇。  
该风扇将用于在打印过程中冷却步进电机。  
Install the 40mm cooling fan with 2 x m3 10mm bolts.  
The fan will be used to cool the stepper motor during printing.

#### Step3



从风扇中伸出2针电线,长度与步进电机的4芯电线相同。  
使用电缆包和拉链系统整理电线,可以顺便将导线焊接在一起。  
Extend 2-pin wire from fan, same length as 4-core wire of stepper motor.  
Use cable bags and zipper systems to organize wires,  
which can be soldered together by the way.



## 系统效应—自下而上的设计 System effect - bottom up design

Step4



准备3D打印活塞、60cc注射器的橡胶柱塞和步进电机的螺纹轴，然后把它们组装起来，放入步进电机。  
Prepare 3D printing piston, rubber plunger of 60cc syringe and threaded shaft of stepper motor, then assemble them and put them into stepper motor.

Step5



准备3D打印的注射器支架和2 X M3 6mm的螺栓，用螺栓固定注射器筒。  
Prepare 3D printed syringe holder and 2 x m3 6mm bolts, Secure syringe barrel with bolt.

Step6



用抹刀等工具将粘土装入注射器，挤出机就准备好了。  
Use a spatula and other tools to put the clay into the syringe, and the extruder is ready.

Step7



要使挤出机正常打印，就需要进行一些测试来调整设置，例如打印速度、给料速度、层高和粘土粘度等等。  
To make the extruder print properly, you need to do some tests to adjust the settings, Such as printing speed, feeding speed, layer height and clay viscosity, etc.



**Second**

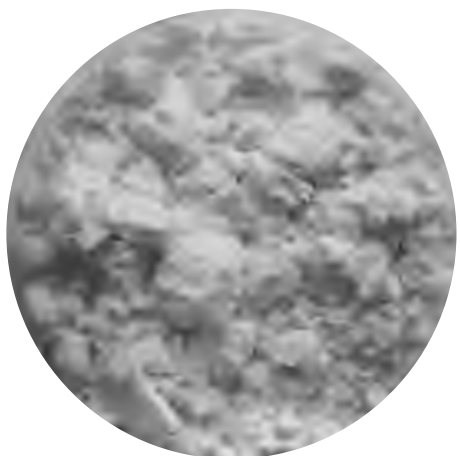




秸秆原材料  
Straw raw materials



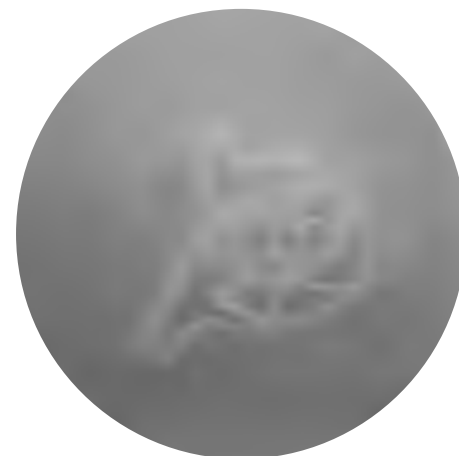
过筛两遍原料  
Sift the raw materials twice



高粱淀粉  
Sorghum straw



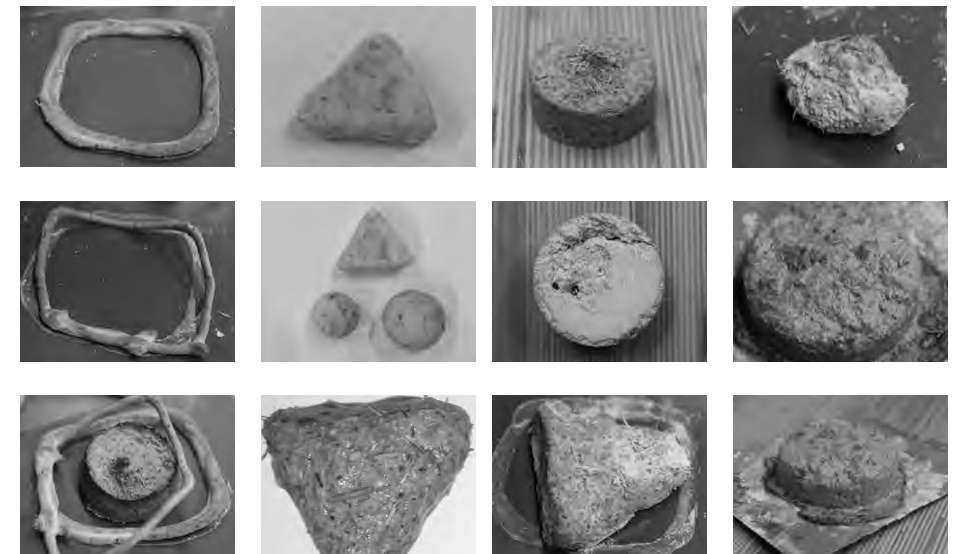
糯米粉  
glutinous rice flour



白乳胶  
White latex



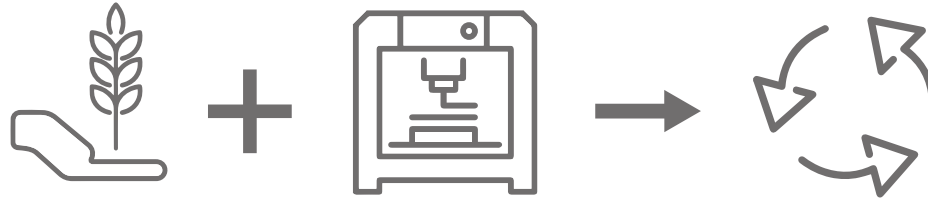
水泥  
cement



# 高粱的蓝色循环经济—

## 模拟高粱秸秆的3D打印试验

### Blue circular economy of sorghum — 3D printing experiment of simulated sorghum straw



#### 原材料

#### Raw material



秸秆原材料  
Straw raw materials



过筛两遍原料  
Sift the raw materials twice



高粱淀粉  
Sorghum starch



糯米粉  
glutinous rice flour



白乳胶  
White latex



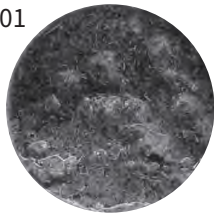
水泥  
Cement

#### 实验配比

#### Experimental proportioning



A-001



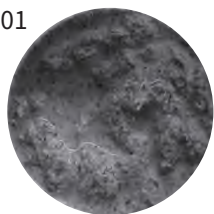
12g 秸秆原料+  
20g 淀粉+70ml 水  
12g straw +  
20g starch + 70ml water

A-002



12g 秸秆原料+  
45g 淀粉+70ml 水  
12g straw +  
45g starch + 70ml water

B-001



12g 秸秆原料+  
20g 糯米粉+70ml 水  
12g straw +  
20g glutinous rice flour +  
70ml water

B-002



12g 秸秆原料+  
45g 糯米粉+70ml 水  
12g straw +  
45g glutinous rice flour +  
70ml water

C-001



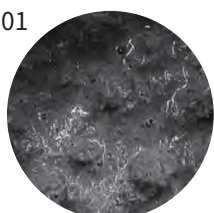
12g 秸秆原料+  
20g 乳胶+70ml 水  
12g straw +  
20g latex + 70ml water

C-002



12g 秸秆原料+  
55g 乳胶+70ml 水  
12g straw +  
55g latex + 70ml water

D-001



12g 秸秆原料+  
20g 水泥+70ml 水  
12g straw +  
20g cement + 70ml water

D-002

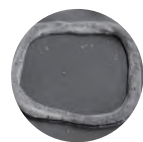


12g 秸秆原料+  
45g 水泥+70ml 水  
12g straw +  
45g cement + 70ml water

F-032



12g 秸秆原料+45g 淀粉+  
20g 糯米粉+10g 乳胶+10g 水泥+30ml 水  
12g straw + 45g starch +  
20g glutinous rice powder +  
10g latex + 10g cement + 30ml water

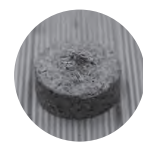


流动性好, 成膜性高, 成型快, 可从针管挤出, 材质较硬, 承重力较好。是目前成为3D打印建材材料可行性最高的一组。

F-036



12g 秸秆原料+45g 淀粉+  
20g 糯米粉+10g 乳胶+30g 水泥+70ml 水  
12g straw + 45g starch +  
20g glutinous rice powder +  
10g latex + 30g cement + 70ml water



流动性好, 成膜性高, 成型快, 但较难从针管挤出, 材质较硬, 承重力强。若要成为3D打印建材材料需对机器挤出头送料部分进行改造。

F-034

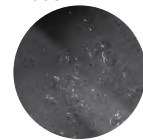


12g 秸秆原料+45g 淀粉+  
20g 糯米粉+10g 乳胶+20g 水泥+50ml 水  
12g straw + 45g starch +  
20g glutinous rice powder +  
10g latex + 20g cement + 50ml water



流动性一般, 成膜性高, 成型快, 不可从针管挤出, 材质较硬, 承重力强。成为3D打印建材材料可行性较低。

F-038



12g 秸秆原料+45g 淀粉+  
20g 糯米粉+10g 乳胶+40g 水泥+90ml 水  
12g straw + 45g starch +  
20g glutinous rice powder +  
10g latex + 40g cement + 90ml water



流动性差, 成膜性一般, 成型快, 不可从针管挤出, 材质较硬, 承重力一般。成为3D打印建材材料可行性较低。

#### 静置48h状态对比

#### Comparison of 48h static state

A-002



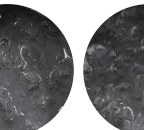
B-002



C-002





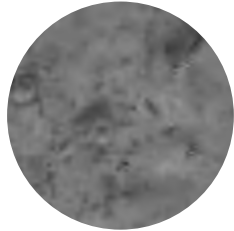
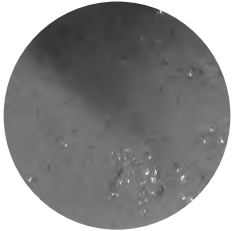
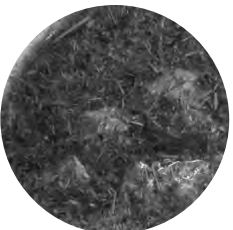
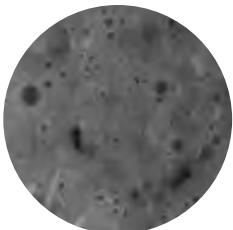
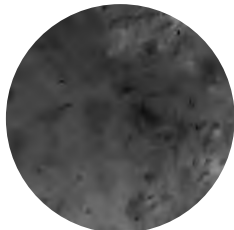
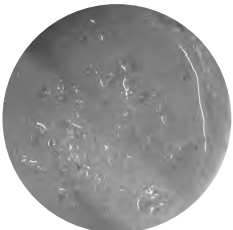

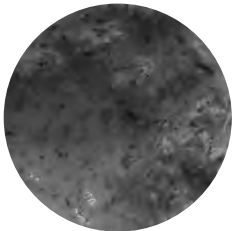
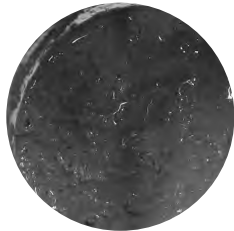
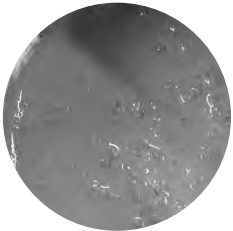
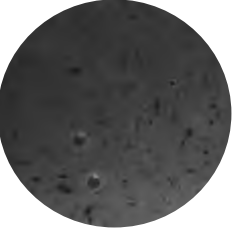
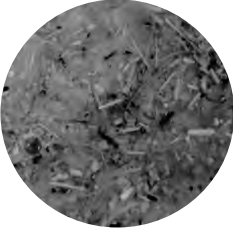
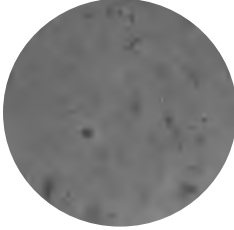

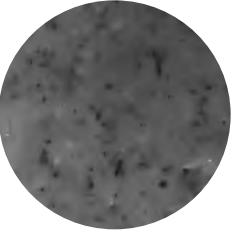
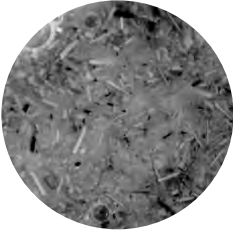
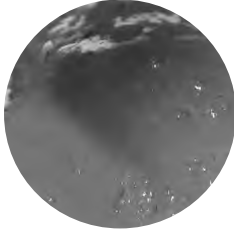
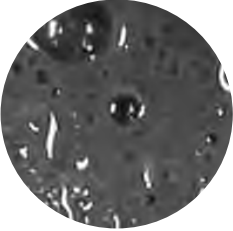
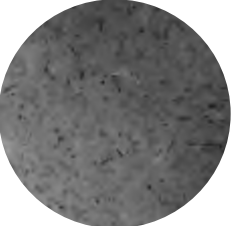
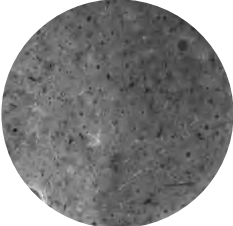
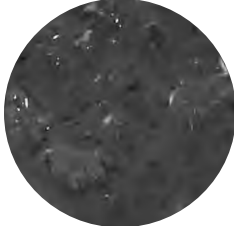
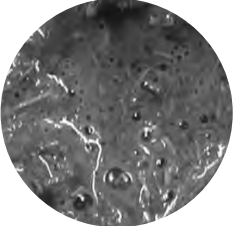
D-002







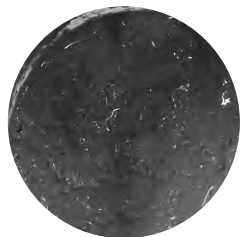
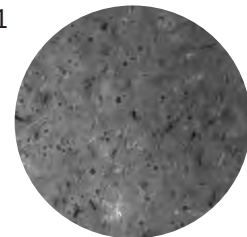
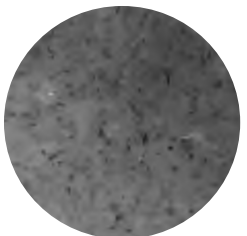
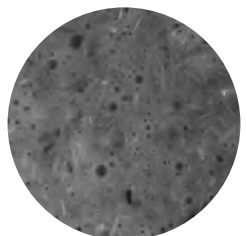

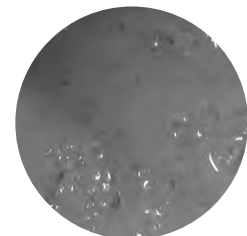
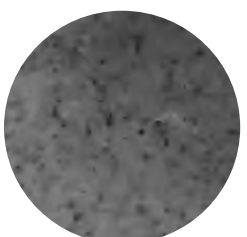
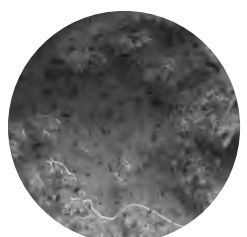
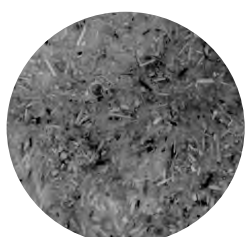
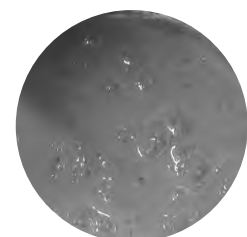
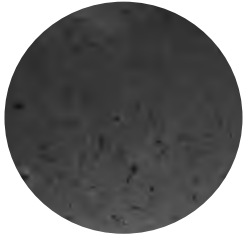
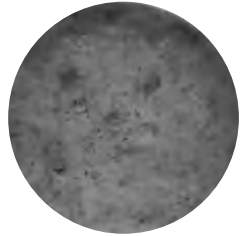
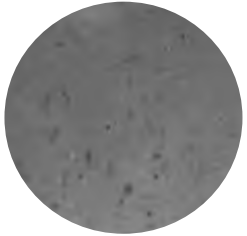
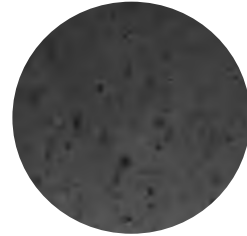


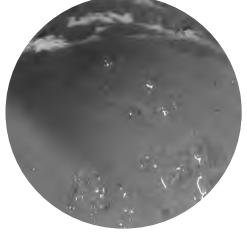
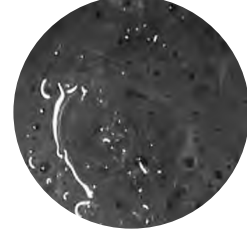
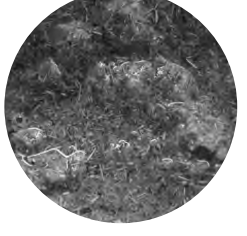

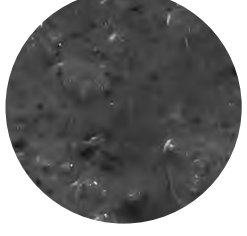
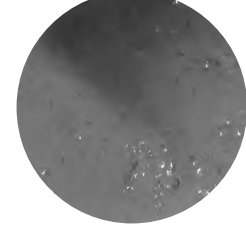
# 模拟高粱秸秆的3D打印试验

## 3D printing experiment of simulated sorghum straw

E-003		12g 秸秆原料+ 5g 淀粉+10g 糯米粉+50ml 水 12g straw + 5g starch + 10g glutinous rice flour+ 50ml water	E-014		25g 秸秆原料+ 5g 淀粉+10g 糯米粉+50ml 水 25g straw + 5g starch + 10g glutinous rice flour+ 50ml water	E-024		25g 秸秆原料+ 8g 淀粉+20g 糯米粉+80ml 水 25g straw + 8g starch + 20g glutinous rice flour+ 80ml water	E-032		12g 秸秆原料+ 5g 淀粉+15g 糯米粉+20ml 水 12g straw + 5g starch + 15g glutinous rice flour+ 20ml water
E-005		12g 秸秆原料+ 5g 淀粉+15g 糯米粉+50ml 水 12g straw + 5g starch + 15g glutinous rice flour+ 50ml water	E-017		10g 秸秆原料+ 8g 淀粉+15g 糯米粉+60ml 水 10g straw + 8g starch + 15g glutinous rice flour+ 60ml water	E-025		25g 秸秆原料+ 25g 淀粉+8g 糯米粉+50ml 水 25g straw + 25g starch + 8g glutinous rice flour+ 50ml water	E-035		12g 秸秆原料+ 5g 淀粉+15g 糯米粉+15ml 水 12g straw + 5g starch + 15g glutinous rice flour+ 15ml water
E-006		12g 秸秆原料+ 8g 淀粉+20g 糯米粉+50ml 水 12g straw + 8g starch + 20g glutinous rice flour+ 50ml water	E-018		10g 秸秆原料+ 8g 淀粉+25g 糯米粉+60ml 水 10g straw + 8g starch + 25g glutinous rice flour+ 60ml water	E-026		25g 秸秆原料+ 35g 淀粉+8g 糯米粉+50ml 水 25g straw + 35g starch + 8g glutinous rice flour+ 50ml water	E-036		12g 秸秆原料+ 8g 淀粉+20g 糯米粉+15ml 水 12g straw + 8g starch + 20g glutinous rice flour+ 15ml water
E-008		12g 秸秆原料+ 8g 淀粉+20g 糯米粉+70ml 水 12g straw + 8g starch + 20g glutinous rice flour+ 70ml water	E-019		25g 秸秆原料+ 5g 淀粉+10g 糯米粉+50ml 水 25g straw + 5g starch + 10g glutinous rice flour+ 50ml water	E-029		12g 秸秆原料+ 5g 淀粉+30g 糯米粉+50ml 水 12g straw + 5g starch + 30g glutinous rice flour+ 50ml water	E-037		12g 秸秆原料+ 8g 淀粉+30g 糯米粉+15ml 水 12g straw + 8g starch + 30g glutinous rice flour+ 15ml water
E-009		12g 秸秆原料+ 8g 淀粉+25g 糯米粉+70ml 水 12g straw + 8g starch + 25g glutinous rice flour+ 70ml water	E-020		25g 秸秆原料+ 8g 淀粉+15g 糯米粉+50ml 水 25g straw + 8g starch + 15g glutinous rice flour+ 50ml water	E-030		15g 秸秆原料+ 8g 淀粉+30g 糯米粉+40ml 水 15g straw + 8g starch + 30g glutinous rice flour+ 40ml water	E-040		15g 秸秆原料+ 8g 淀粉+15g 糯米粉+20ml 水 15g straw + 8g starch + 15g glutinous rice flour+ 20ml water
E-010		12g 秸秆原料+ 8g 淀粉+30g 糯米粉+70ml 水 12g straw + 8g starch + 30g glutinous rice flour+ 70ml water	E-023		25g 秸秆原料+ 8g 淀粉+15g 糯米粉+80ml 水 25g straw + 8g starch + 15g glutinous rice flour+ 80ml water	E-031		20g 秸秆原料+ 8g 淀粉+50g 糯米粉+40ml 水 20g straw + 8g starch + 50g glutinous rice flour+ 40ml water	E-042		15g 秸秆原料+ 8g 淀粉+30g 糯米粉+20ml 水 15g straw + 8g starch + 30g glutinous rice flour+ 20ml water

# 模拟高粱秸秆的3D打印试验

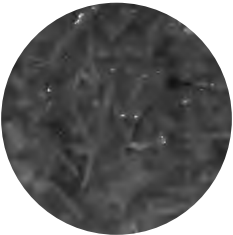
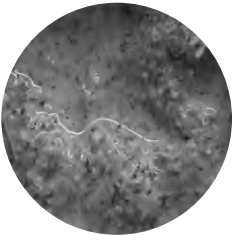
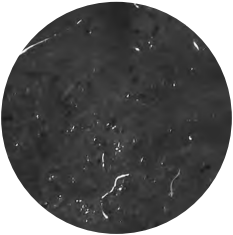

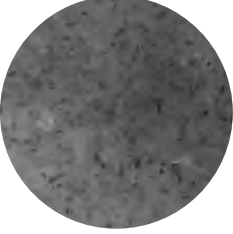
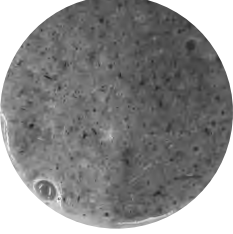
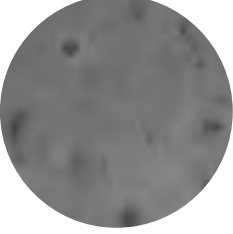

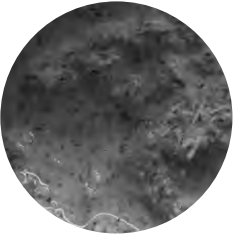
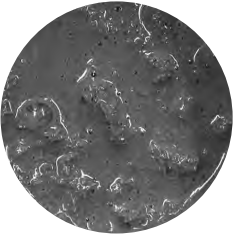
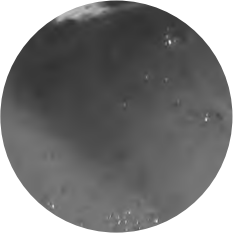
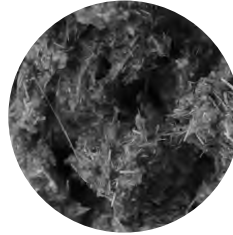
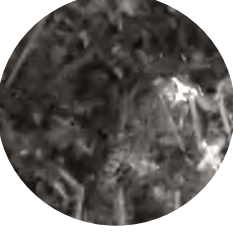
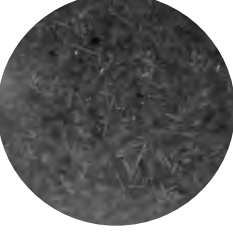
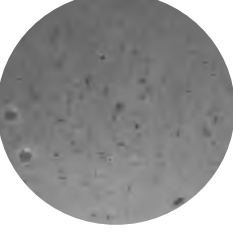
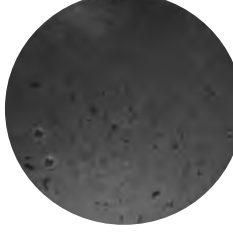
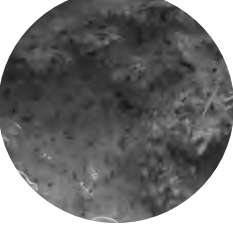
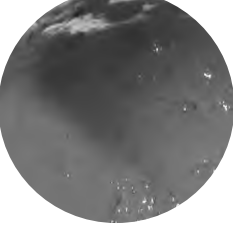
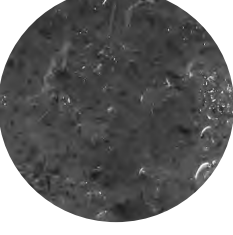
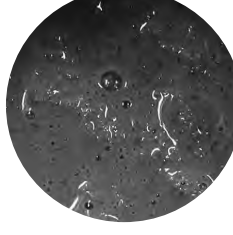

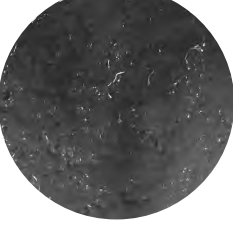
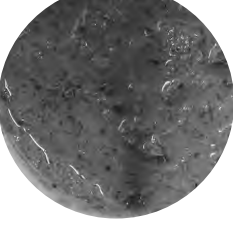
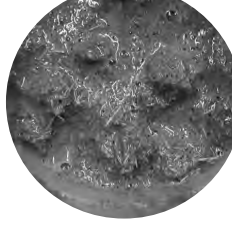
## 3D printing experiment of simulated sorghum straw

E-045		25g秸秆原料+5g水泥+ 10g糯米粉+30ml水 25g straw + 5g cement + 10g glutinous rice flour+ 30ml water	E-053		25g秸秆原料+10g淀粉+ 10g水泥+50ml水 25g straw + 10g starch + 10g cement+ 50ml water	E-061		15g秸秆原料+25g水泥+ 15g乳胶+25ml水 15g straw + 25g cement + 15g latex+ 25ml water	E-071		20g秸秆原料+20g淀粉+ 20g乳胶+40ml水 20g straw + 20g starch + 20g latex+ 40ml water
E-048		20g秸秆原料+5g水泥+ 20g糯米粉+40ml水 20g straw + 5g cement + 20g glutinous rice flour+ 40ml water	E-055		15g秸秆原料+8g淀粉+ 5g水泥+50ml水 15g straw + 8g starch + 5g cement+ 50ml water	E-063		35g秸秆原料+12g水泥+ 20g乳胶+20ml水 35g straw + 12g cement + 20g latex+ 20ml water	E-072		20g秸秆原料+20g淀粉+ 25g乳胶+40ml水 20g straw + 20g starch + 25g latex+ 40ml water
E-049		20g秸秆原料+10g水泥+ 20g糯米粉+40ml水 20g straw + 10g cement + 20g glutinous rice flour+ 40ml water	E-056		15g秸秆原料+20g淀粉+ 10g水泥+50ml水 15g straw + 20g starch + 10g cement+ 50ml water	E-065		35g秸秆原料+20g水泥+ 15g乳胶+20ml水 35g straw + 20g cement + 15g latex+ 20ml water	E-073		20g秸秆原料+25g淀粉+ 20g乳胶+40ml水 20g straw + 25g starch + 20g latex+ 40ml water
E-050		25g秸秆原料+10g水泥+ 15g糯米粉+40ml水 25g straw + 10g cement + 15g glutinous rice flour+ 40ml water	E-057		15g秸秆原料+5g水泥+ 30g乳胶+20ml水 15g straw + 5g cement + 30g latex+ 20ml water	E-066		12g秸秆原料+5g淀粉+ 30g乳胶+50ml水 12g straw + 5g starch + 30g latex+ 50ml water	E-075		25g秸秆原料+25g淀粉+ 20g乳胶+40ml水 25g straw + 25g starch + 20g latex+ 40ml water
E-051		25g秸秆原料+15g淀粉+ 15g水泥+40ml水 25g straw + 15g starch + 15g cement+ 40ml water	E-060		30g秸秆原料+10g水泥+ 30g乳胶+20ml水 30g straw + 10g cement + 30g latex+ 20ml water	E-067		15g秸秆原料+10g淀粉+ 30g乳胶+50ml水 15g straw + 10g starch + 30g latex+ 50ml water	E-077		35g秸秆原料+20g淀粉+ 30g乳胶+40ml水 35g straw + 20g starch + 30g latex+ 40ml water
E-010		30g秸秆原料+25g淀粉+ 15g水泥+40ml水 30g straw + 25g starch + 15g cement+ 40ml water	E-023		40g秸秆原料+15g水泥+ 35g乳胶+20ml水 15g straw + 15g cement + 35g latex+ 20ml water	E-068		30g秸秆原料+10g淀粉+ 40g乳胶+50ml水 30g straw + 10g starch + 40g latex+ 50ml water	E-078		20g秸秆原料+12g淀粉+ 30g乳胶+25ml水 20g straw + 12g starch + 30g latex+ 25ml water



# 模拟高粱秸秆的3D打印试验

## 3D printing experiment of simulated sorghum straw

F-005		12g 秸秆原料+20g 淀粉+ 10g 乳胶+10g 糯米粉+ 70ml 水 12g straw + 20g starch+ 10g latex + 10g glutinous rice flour + 70 ml water	F-016		20g 秸秆原料+30g 淀粉+ 15g 乳胶+40g 糯米粉+ 80ml 水 20g straw +30g starch+ 15g latex + 40g glutinous rice flour + 80 ml water	F-025		12g 秸秆原料+30g 淀粉+ 10g 乳胶+70g 水泥+ 90ml 水 12g straw + 30g starch+ 10g latex + 70g cement+ 90 ml water	F-033		25g 秸秆原料+30g 淀粉+ 10g 乳胶+20g 糯米粉+ 70ml 水 25g straw + 30g starch+ 10g latex + 20g glutinous rice flour + 70 ml water
F-008		12g 秸秆原料+40g 淀粉+ 10g 乳胶+10g 糯米粉+ 70ml 水 12g straw + 40g starch+ 10g latex + 10g glutinous rice flour + 70 ml water	F-018		20g 秸秆原料+30g 淀粉+ 10g 乳胶+40g 糯米粉+ 90ml 水 20g straw + 30g starch+ 10g latex + 40g glutinous rice flour + 90 ml water	F-026		12g 秸秆原料+20g 淀粉+ 20g 乳胶+40g 糯米粉+ 70ml 水 12g straw + 20g starch+ 20g latex + 40g glutinous rice flour + 70 ml water	F-035		25g 秸秆原料+20g 淀粉+ 20g 乳胶+20g 糯米粉+ 70ml 水 25g straw + 20g starch+ 20g latex + 20g glutinous rice flour + 70 ml water
F-009		12g 秸秆原料+40g 淀粉+ 30g 乳胶+20g 糯米粉+ 70ml 水 12g straw +40g starch+ 30g latex + 20g glutinous rice flour + 70 ml water	F-019		12g 秸秆原料+20g 淀粉+ 10g 乳胶+20g 水泥+ 80ml 水 12g straw + 20g starch+ 10g latex + 20g cement + 80 ml water	F-027		12g 秸秆原料+50g 淀粉+ 10g 乳胶+10g 糯米粉+ 60ml 水 12g straw +50g starch+ 10g latex + 10g glutinous rice flour + 60 ml water	F-037		25g 秸秆原料+20g 淀粉+ 10g 乳胶+10g 糯米粉+ 70ml 水 25g straw + 20g starch+ 10g latex + 10g glutinous rice flour + 70 ml water
F-010		12g 秸秆原料+40g 淀粉+ 30g 乳胶+20g 糯米粉+ 80ml 水 12g straw + 40g starch+ 30g latex + 20g glutinous rice flour +80 ml water	F-020		20g 秸秆原料+20g 淀粉+ 10g 乳胶+20g 水泥+ 80ml 水 20g straw + 20g starch+ 10g latex + 20g cement + 80 ml water	F-028		12g 秸秆原料+40g 淀粉+ 10g 乳胶+40g 糯米粉+ 80ml 水 12g straw + 40g starch+ 10g latex + 40g glutinous rice flour + 80 ml water	F-039		25g 秸秆原料+40g 淀粉+ 10g 乳胶+20g 糯米粉+ 80ml 水 25g straw + 40g starch+ 10g latex + 20g glutinous rice flour + 80 ml water
F-012		20g 秸秆原料+30g 淀粉+ 10g 乳胶+30g 糯米粉+ 80ml 水 20g straw + 30g starch+ 10g latex + 30g glutinous rice flour + 80 ml water	F-023		12g 秸秆原料+20g 淀粉+ 10g 乳胶+30g 水泥+ 80ml 水 12g straw + 20g starch+ 10g latex + 30g cement + 80 ml water	F-030		12g 秸秆原料+20g 淀粉+ 10g 乳胶+10g 糯米粉+ 70ml 水 12g straw + 20g starch+ 10g latex + 10g glutinous rice flour + 70 ml water	F-041		25g 秸秆原料+20g 淀粉+ 10g 乳胶+10g 水泥+ 70ml 水 25g straw + 20g starch+ 10g latex + 10g cement+ 70 ml water
F-015		20g 秸秆原料+30g 淀粉+ 20g 乳胶+30g 糯米粉+ 80ml 水 20g straw + 30g starch+ 20g latex + 30g glutinous rice flour + 80ml water	F-024		12g 秸秆原料+20g 淀粉+ 10g 乳胶+50g 水泥+ 90ml 水 12g straw + 20g starch+ 10g latex + 50g cement+ 90 ml water	F-031		20g 秸秆原料+50g 淀粉+ 10g 乳胶+20g 糯米粉+ 70ml 水 20g straw + 50g starch+ 10g latex + 20g glutinous rice flour + 70 ml water	F-045		25g 秸秆原料+20g 淀粉+ 10g 乳胶+30g 水泥+ 80ml 水 25g straw + 20g starch+ 10g latex + 30g cement + 80 ml water



**Third**

# 高粱秸秆3D打印运用场景

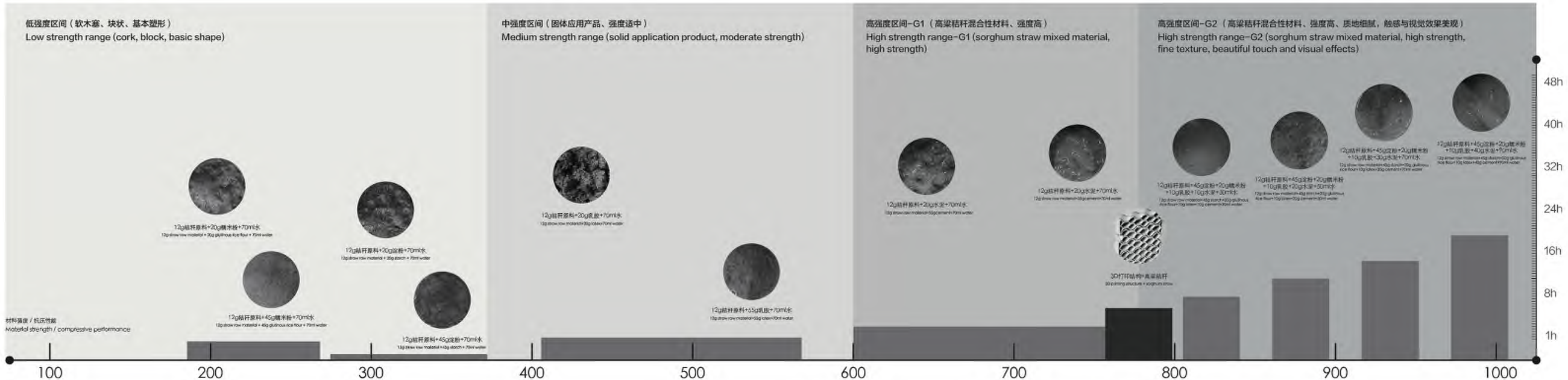
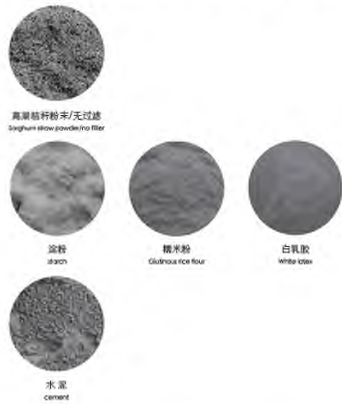
## Sorghum straw 3D printing application scenarios

### 场景核心定位 / Scene core positioning

在整个设计推进的过程中我们都在围绕着高粱秸秆蓝色循环经济的系统模式进行不断的探索与分析。而这些高粱秸秆的背后一定会归结到一个“地方”（place）。毋庸置疑，我们选择回归到高粱秸秆的源头产地 --- 乡村。以期在乡村的诸多生产架构、组织架构中发挥高粱秸秆3D打印技术的可持续性、功能性。帮助乡村在处理高粱秸秆问题上得到最优质的解决方案。

In the whole process of design advancement, we are constantly exploring and analyzing the system model of sorghum straw blue circular economy. And behind these sorghum stalks must be attributed to a "place". Undoubtedly, we chose to return to the source of sorghum stalks --- the countryside. In order to give play to the sustainability and functionality of sorghum straw 3D printing technology in many production structures and organizational structures in the countryside. Helping villages to get the best quality solution to the problem of sorghum straw.

### 材料与应用场景的关系 / The relationship between materials and application scenarios

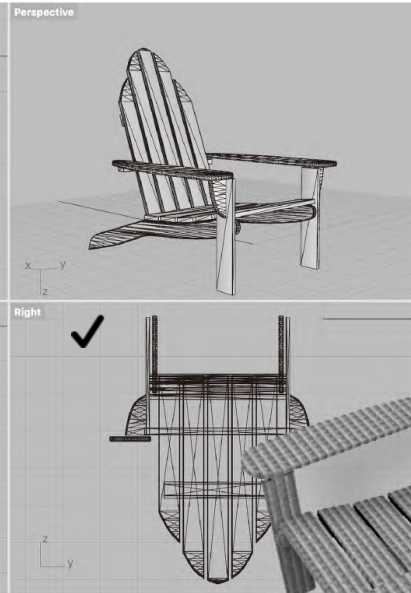
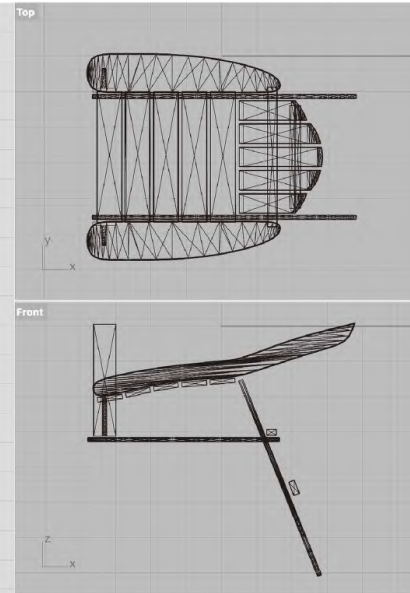
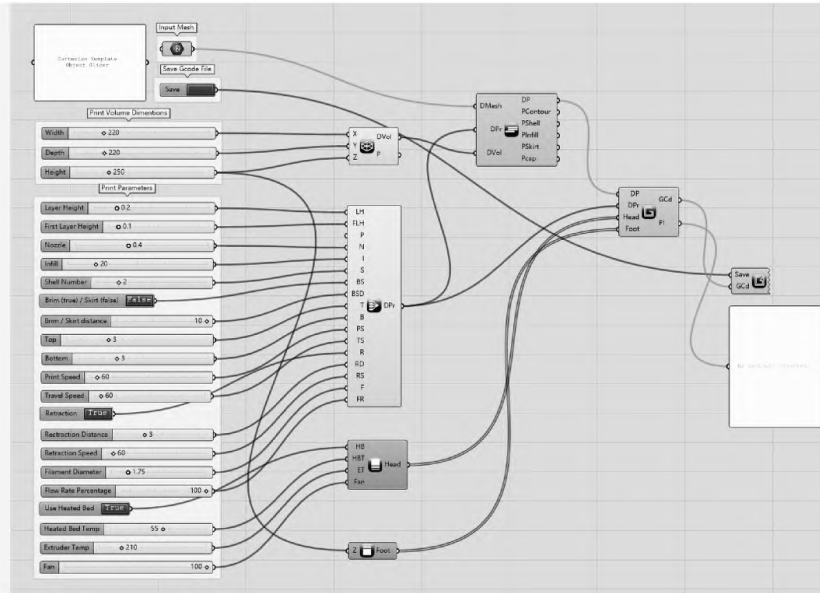




# grasshopper与高粱秸秆3D打印运用场景 Grasshopper and sorghum straw 3D printing application scene

在本设计当中，我们完成了高粱3D打印原型的组装、测试以及打印，能够在28\*16\*42的立体区间里面的物体打印。在通过大量的材料试验以及秸秆打印模拟之后，我们论证了高粱秸秆3D打印技术应用的可能性与合理性。我们通过在原型机中总结的材料实验结果，打印控制程序，利用grasshopper技术的参数模拟，能够实现更大型高粱秸秆3D打印机的构建以及打印物体的实际操作。给下一阶段高粱秸秆3D打印机的迭代做了技术的测试。我们由此得出，通过本设计的方法、实验可以实现更广泛区域、体积物体的打印与实操

In this design, we have completed the assembly, testing and printing of the sorghum 3D printing prototype, which can print objects in the 28\*16\*42 three-dimensional interval. After a large number of material tests and straw printing simulations, we demonstrated the possibility and rationality of the application of sorghum straw 3D printing technology. Through the material experiment results summarized in the prototype, the printing control program, and the parameter simulation of the grasshopper technology, we can realize the construction of a larger sorghum straw 3D printer and the actual operation of the printed object. The next stage of the iteration of the sorghum straw 3D printer was tested. From this we can conclude that the printing and practical operation of a wider area and volume objects can be achieved through the method and experiment of this design



## 高粱秸秆3D打印运用场景 Sorghum straw 3D printing application scenarios

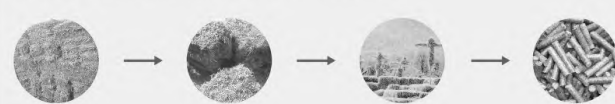
### 低强度区间 (软木塞、块状、基本塑形) Low strength range (cork, block, basic shape)



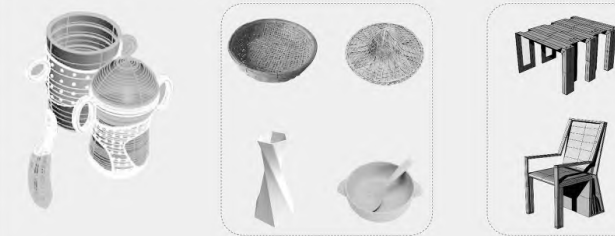
在此区间的材料具备了固体成形的属性，但是抗压强度与韧性有限，糯米粉与淀粉的实验方案所得出的样品呈现质地光滑细腻等特点。打印和挤出过程流畅因此被用来制作和运用的相关场景因匹配其配比简单、塑形能力强、时间短、无需反复抗压等特点

The materials in this range have the properties of solid forming, but the compressive strength and toughness are limited. The samples obtained from the experimental program of glutinous rice flour and starch present the characteristics of smooth and fine surface texture. The printing and extrusion process is smooth. Therefore, the related scenes used for production and application match the characteristics of simple ratio, strong shaping ability, short time, and no need to repeatedly resist pressure.

### 饲料、燃烧物、田间稻草人、固态材料与储藏 Fodder, burning material, field scarecrow, Solid materials and storage



### 居家可持续制造 - 图纸 - 生活用品 - 家具产品 Sustainable home manufacturing - drawings - daily necessities - furniture products



材料强度 / 抗压性  
Material strength / compressive performance

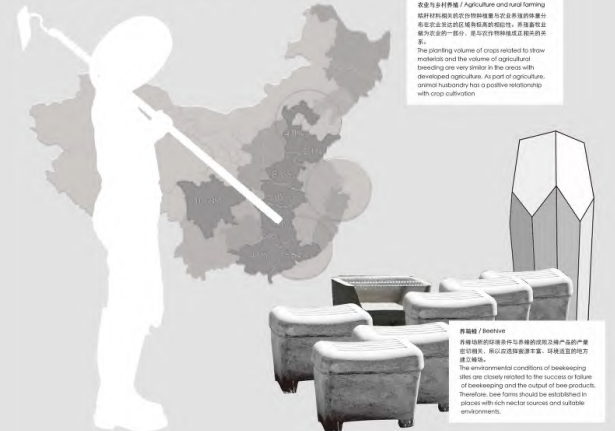
### 中强度区间 (固体应用产品、强度适中) Medium strength range (solid application product, moderate strength)



乳胶的强粘性特点使得材料的抗压能力，塑形能力得到了增强。在使用秸秆原料做为打印材料、乳胶做为添加剂的配比之下，此方案的应用面积以及制作成本是材料实验中最为突出的方案。在运用场景中的选择以及运用维度都相比其他材料具有一定的优势。

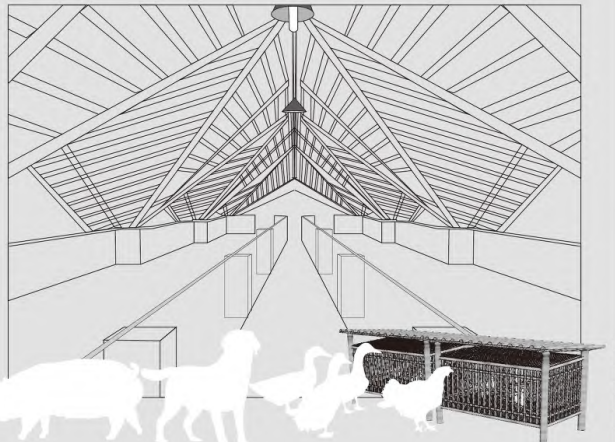
The strong adhesion characteristics of latex make the material's compression resistance and shaping ability enhanced. Under the ratio of using straw as printing material and latex as additive, the application area and production cost of this scheme are the most prominent schemes in the material experiment. The selection and application dimensions in the application scenarios have certain advantages over other materials.

### 农业 - 农具 / 养殖畜牧业 - 养殖场地 Agriculture-Farm Tools / Livestock Farming-Breeding Site

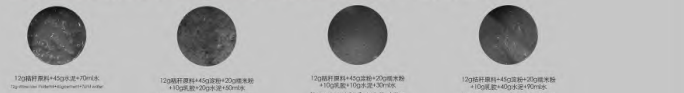


我们选择在农业种植之后的废物与废料继续回馈到农业畜牧业之中做为运用场景之一，通过畜牧养殖空间的调研，能够发现在对待畜牧养殖空间时，传统的建造方式在成本、灵活性、环保性以及功能属性上都存在诸多弊端。通过本设计我们可以扩大对于高粱秸秆的3D打印尺度来满足其中需求

We chose to continue to feed back the waste and waste materials after agricultural planting to the agriculture and animal husbandry as one of the application scenarios. Through the investigation of the animal husbandry space, we can find that the traditional construction method is cost and flexibility when treating the animal husbandry space. There are many disadvantages in environmental protection and functional attributes. Through this design, we can expand the 3D printing scale of sorghum straw to meet the needs.



### 高强度区间 (建筑材料、支撑架原材料) High-strength range (building materials, supporting structure raw materials)



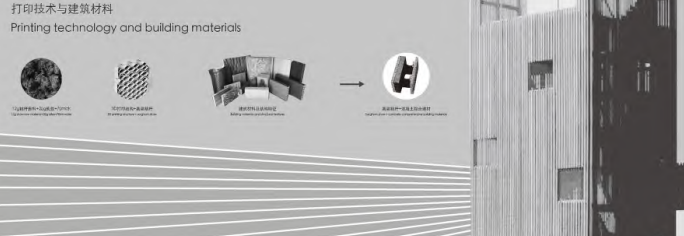
当秸秆材料实验中加入适量水泥时，我们发现其干燥的时间巨幅增加，同时其抗压性测试强度也大幅增加，能够在与秸秆材料相配合的情况之下做为建筑材料来使用。

When an appropriate amount of cement is added to the straw material experiment, we found that its drying time has been greatly increased, and its compressive strength test strength has also been greatly increased. It can be used as a building material when matched with the straw material.

### 打印技术与建筑材料 Printing technology and building materials



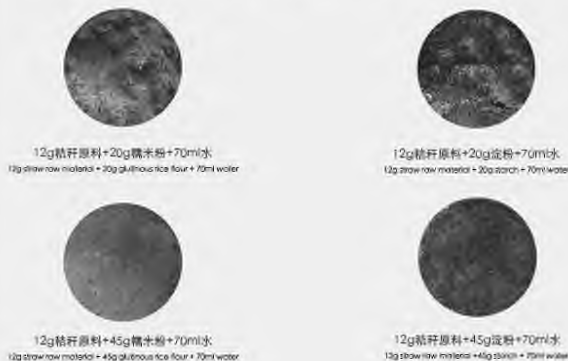
### 打印技术与建筑材料 Printing technology and building materials



100 200 300 400 500 600 700 800 900 1000



低强度区间 (软木塞、块状、基本塑形)  
Low strength range (cork, block, basic shape)



在此区间的材料具备了固体成形的属性，但是抗压强度与韧性有限，糯米粉与淀粉的实验方案所得出的样品呈现表面质地光滑细腻等特点。打印和挤出过程流畅因此被用来制作和运用的相关场景因匹配其配比简单、塑形能力强、时间短、无需反复抗压等特点

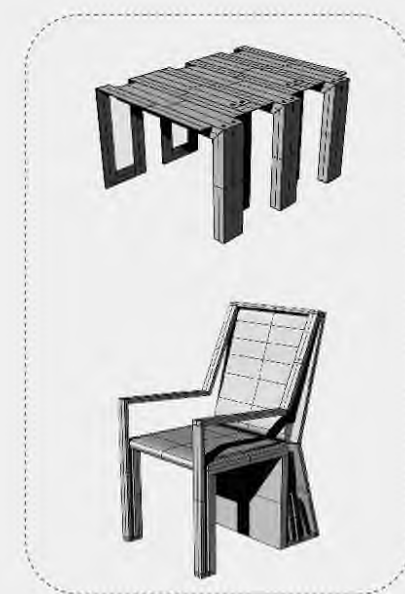
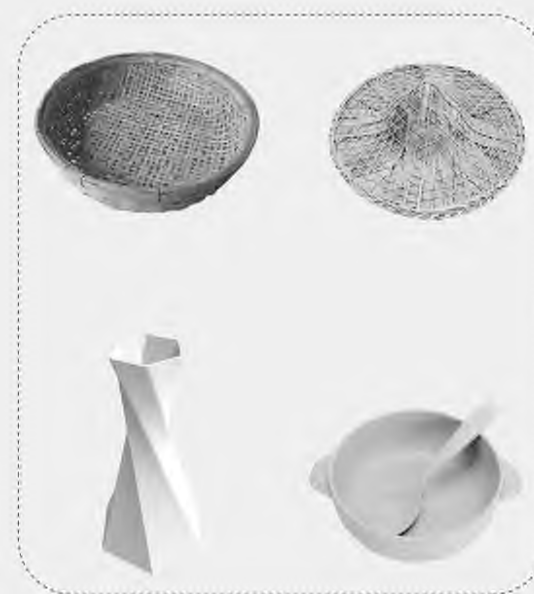
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饲料、燃烧物、田间稻草人、固态材料与储藏  
Fodder, burning material, field scarecrow, Solid materials and storage



居家可持续制造 - 图纸 - 生活用品 - 家具产品  
Sustainable home manufacturing - drawings - daily necessities - furniture products



材料强度 / 抗压性能  
Material strength / compressive performance



# 应用场景 Application scenarios



# 应用场景 Application scenarios

## 中强度区间 (固体应用产品、强度适中) Medium strength range (solid application product, moderate strength)



12g秸秆原料+20g乳胶+70ml水  
12g straw raw material+20g latex+70ml water



秸秆原料+乳胶+水配比静置48小时  
12g straw material + latex + water proportion after standing for 48h



12g秸秆原料+35g乳胶+70ml水  
12g straw raw material+35g latex+70ml water

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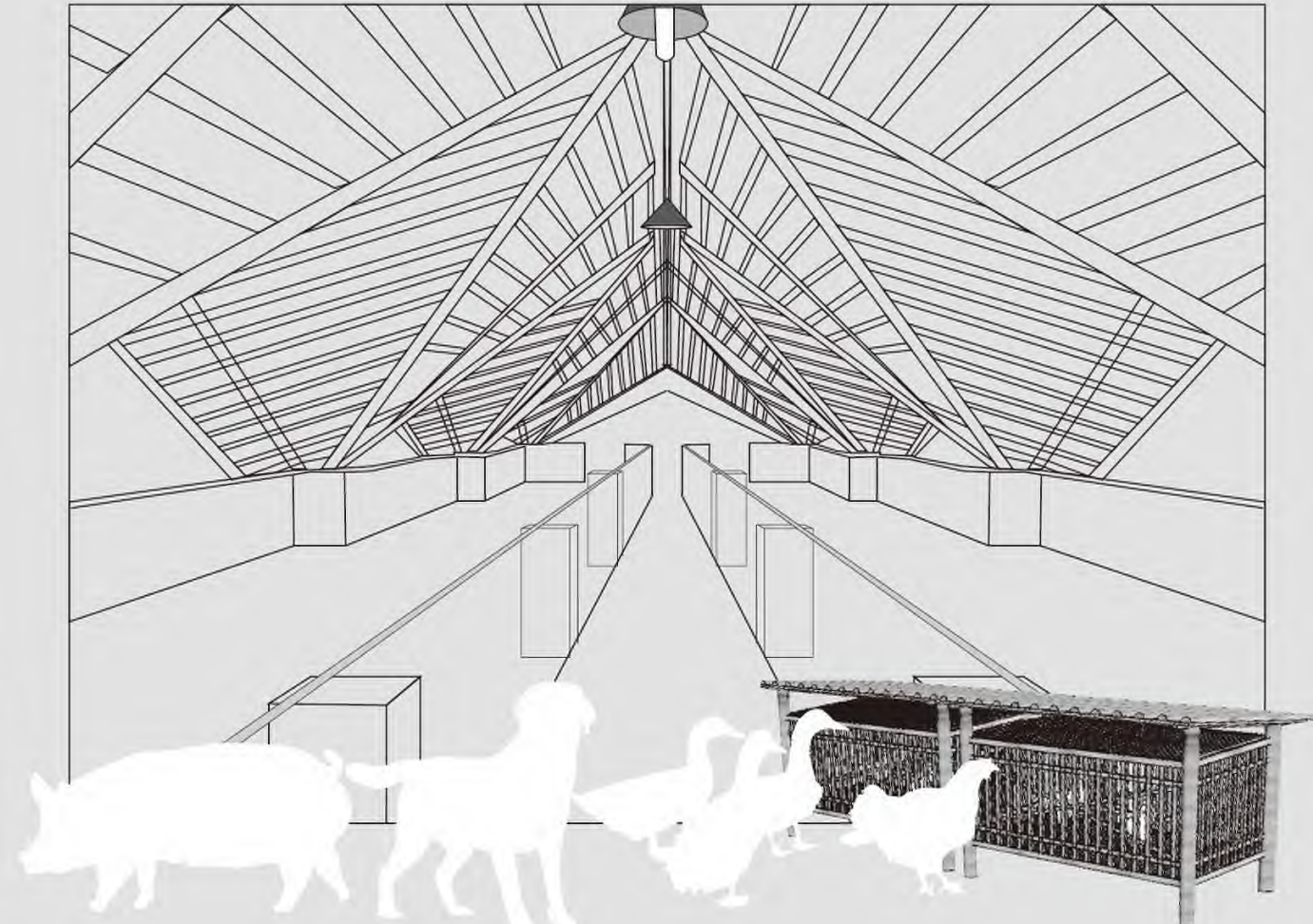
## 农业 - 农具 / 养殖畜牧业 - 养殖场地 Agriculture-Farm Tools / Livestock Farming-Breeding Site



农业与乡村养殖 / Agriculture and rural farming  
秸秆材料相关的农作物种植量与农业养殖的体量分布在农业发达的区域有较高的相似性。养殖畜牧业做为农业的一部分，是与农作物种植成正相关的关系。  
The planting volume of crops related to straw materials and the volume of agricultural breeding are very similar in the areas with developed agriculture. As part of agriculture, animal husbandry has a positive relationship with crop cultivation.



养箱蜂 / Beehive  
养蜂场所的环境条件与养蜂的成败及蜂产品的产量密切相关，所以应选择蜜源丰富、环境适宜的地方建立蜂场。  
The environmental conditions of beekeeping sites are closely related to the success or failure of beekeeping and the output of bee products. Therefore, bee farms should be established in places with rich nectar sources and suitable environments.





高强度区间 ( 建筑材料、支撑架构原材料 )  
High-strength range ( building materials, supporting structure raw materials )



12g 秸秆原料 + 45g 水 + 70ml 水  
12g straw raw material + 45g water + 70ml water



12g 秸秆原料 + 45g 淀粉 + 20g 糯米粉 + 10g 乳胶 + 10g 水 + 30ml 水  
12g straw raw material + 45g starch + 20g glutinous rice flour + 10g latex + 10g water + 30ml water



12g 秸秆原料 + 45g 淀粉 + 20g 糯米粉 + 10g 乳胶 + 20g 水 + 50ml 水  
12g straw raw material + 45g starch + 20g glutinous rice flour + 10g latex + 20g water + 50ml water



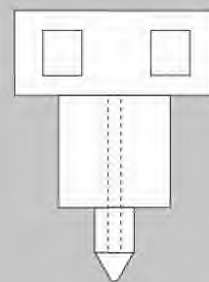
12g 秸秆原料 + 45g 淀粉 + 20g 糯米粉 + 10g 乳胶 + 40g 水 + 90ml 水  
12g straw raw material + 45g starch + 20g glutinous rice flour + 10g latex + 40g water + 90ml water

当秸秆材料实验中加入适量水泥时，我们发现其干燥的时间巨幅增加，同时其抗压性测试强度也大幅增加，能够在与秸秆材料相配合的情况之下做为建筑材料来使用。

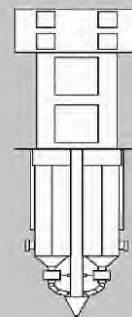
When an appropriate amount of cement is added to the straw material experiment, we found that its drying time has been greatly increased, and its compressive strength test strength has also been greatly increased. It can be used as a building material when matched with the straw material.



打印技术与建筑材料  
Printing technology and building materials



基础打印喷头  
Basic print head



综合打印喷头  
Integrated print head



打印技术与建筑材料  
Printing technology and building materials



12g 秸秆原料 + 20g 乳胶 + 70ml 水  
12g straw raw material + 20g latex + 70ml water



3D 打印结构 + 高粱秸秆  
3D printing structure + sorghum straw



建筑材料及结构特征  
Building material and structure feature



高粱秸秆 + 混凝土复合打印  
Sorghum straw + concrete composite printing material



应用场景  
Application scenarios



# 高粱的蓝色循环经济—模拟高粱秸秆的3D打印试验

## Blue circular economy of sorghum —3D printing experiment of simulated sorghum straw



过筛两遍原料  
Sift the raw materials twice



高粱淀粉  
Sorghum starch



糯米粉  
glutinous rice flour



白乳胶  
White latex



水泥  
Cement



### 高粱简易建筑

高粱秸秆与水泥、混凝土的混合打印,形成层次粉末,功能综合、造型可变的基础建筑原料,建造乡民所需简易建筑。

### Simple sorghum architecture

The mixed printing of sorghum straw, cement and concrete forms layered powder, basic building materials with comprehensive functions and variable shape, which can build simple buildings needed by villagers.

### “高粱节”

中国传统节日,俗称“节节高”,节期在每年农历八月十三日。主要流行于我国北方。高粱节是我国盛大节日之一,这天人们会把丰收的高粱的籽粒部分酿制成高粱酒及其它食材,将高粱的秸秆叶片等通过碾碎以及加入水、高粱淀粉等一系列作业,通过3D打印机生成节日所需的一切物品,遵循节日最大特点“一切来源于高粱”,并相聚在一起庆祝丰收的喜悦在节日当天。经年传承逐渐成为家喻户晓的节日。

### "Sorghum Festival"

Chinese traditional festival, commonly known as "jiejiégao", falls on August 13 of the lunar calendar every year. It is mainly popular in the north of China. Sorghum Festival is one of the grand festivals in China. On this day, people will brew sorghum grains into sorghum wine and other food materials, crush sorghum straw leaves, add water, sorghum starch and other operations, generate all the items needed for the festival through 3D printer, follow the biggest feature of the festival "everything comes from Sorghum", and get together to celebrate the festival. The joy of harvest is on the day of the festival. After years of inheritance, it has gradually become a well-known Festival

### 高粱饭盒

利用秸秆的特性来打造可循环节约材料,制作无污染可循环节约型的3d打印高粱餐具。

### Sorghum lunch box

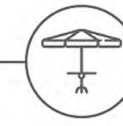
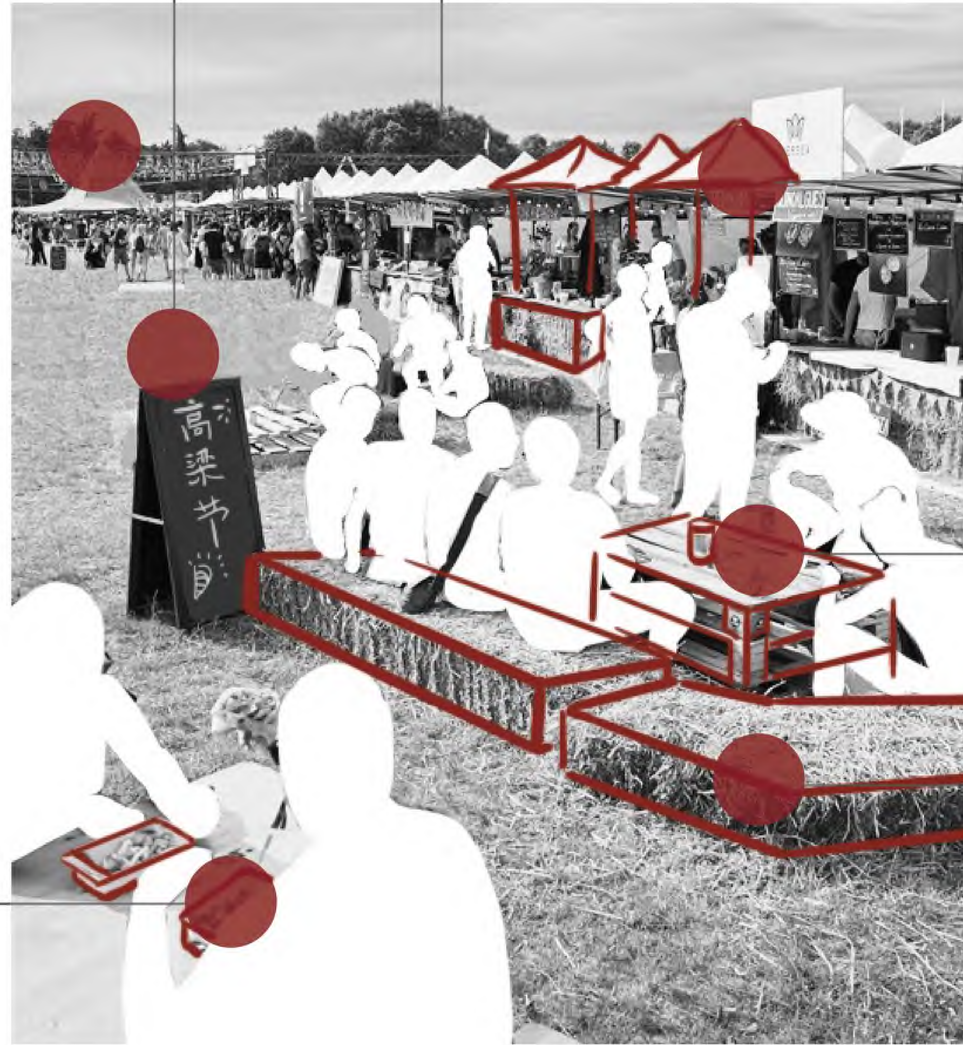
The characteristics of straw are used to create recyclable and economical materials, and to produce pollution-free recyclable and economical sorghum 3D printing tableware.

### 高粱食物

将高粱进行炊饭或磨制成粉后再做成其他各种食品。

### Sorghum food

Sorghum will be cooked or ground into powder, and then made into other kinds of food.

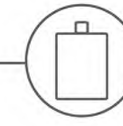


### 高粱遮阳伞

充分发挥高粱秸秆能够起到遮挡阳光的作用,达到物尽其用的效果。

### Sorghum umbrella

Full use of sorghum straw can block sunlight, To achieve the best use of the effect.



### 高粱酒

以高粱为原料制作的白酒以其色、香、味和风格展现了我国酒文化的深厚底蕴。

### Sorghum liquor

The liquor made with sorghum as raw material shows the profound details of liquor culture in China with its color, aroma, taste and style.



### 高粱纸杯

以秸秆为原材料,进行3d打印的环保纸杯。

### Sorghum paper cup

Green paper cup with straw 3D printing



### 高粱凳子

收集大量秸秆进行挤压组合,通过加入一些提升抗压性的材料,进行3d打印,提升生产效率。

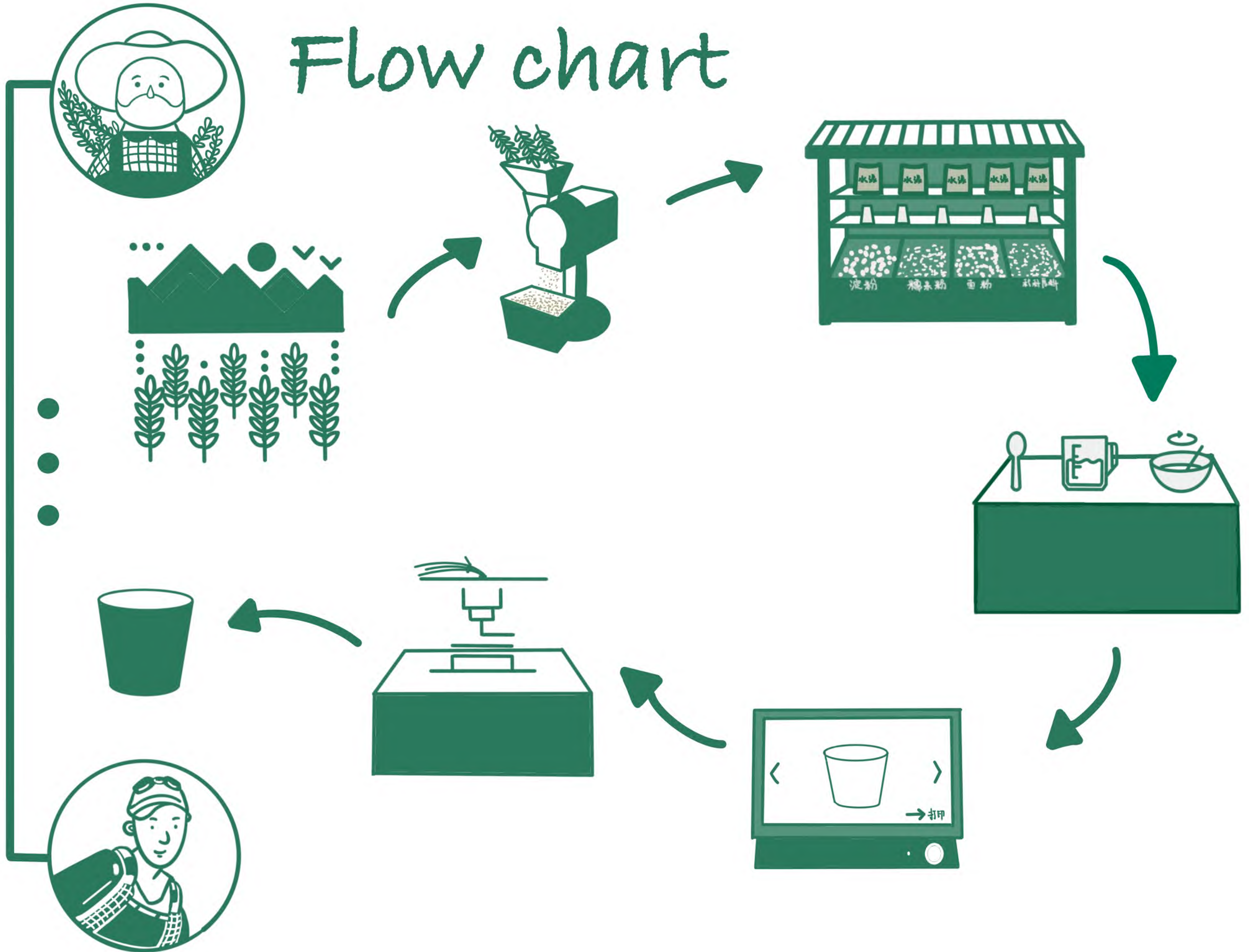
### Sorghum stool

A large number of straw was collected for extrusion combination, and the production efficiency was improved by adding some materials to improve the compression resistance.





# Flow chart







高粱秸秆是在这粉碎吗?

快来商店选打印的模型和添加剂呀

听说这个房子就是高粱打出来的呢

一起去采高粱秸秆吧

用刚刚打印的餐盘吧

看我新打的帐篷

高粱节





感谢倾听

Thanks for listening

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系统效应—自下而上的设计  
System effect - bottom up design

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