WFP World Food Programme

Middle & large-scale grain storage

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Cloud School

Sharing for Learning

Middle & large-scale grain storage

大中型粮食仓库

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基本概念及基本知识

1 Basic concepts and knowledge
基本概念及基本知识

1.1 Grain storage facility 粮库 / 粮仓

1.2 Grain storage facility classification 粮库分类

1.1 Grain storage facility 粮库 / 粮仓

A place or building that can safely store grain and oil seed, by suitable storage facilities, equipment, and management measures.

通过配置适宜的仓储设施、设备和管理措施，能够安全储存粮食、油料的场所或建筑物。

granary 粮仓

place 粮库

1.2 Grain storage facility classification 粮库分类

1.2.1 Classified by total storage capacity

按总仓容分

1.2.2 Classified by function

按功能分

1.2.3 Classified type of stored grain

按储存粮食的类型分

1.2.1 Classified by total storage capacity （of depot）

按（粮库）总仓容分类

name 名称	capacity Q 总仓容 Q
small-scale storage 小型库	$Q < 50{,}000$ t
middle-scales torage 中型库	$50{,}000\ \text{t} \leqslant Q < 150{,}000$ t
large-scale storage 大型库	$Q \geqslant 150{,}000$ t

1.2.1.1 small-scale storage 小型库

capacity 总仓容：$Q < 50{,}000$ t

1.2.1.2 middle-scale storage 中型库

capacity 总仓容：50,000 t ⩽ Q < 150,000 t

1.2.1.3 large-scale storage 大型库

capacity总仓容： $Q \geqslant 150{,}000$ t

1.2.1.3 large-scale storage 大型库

capacity总仓容： $Q \geqslant 150{,}000$ t

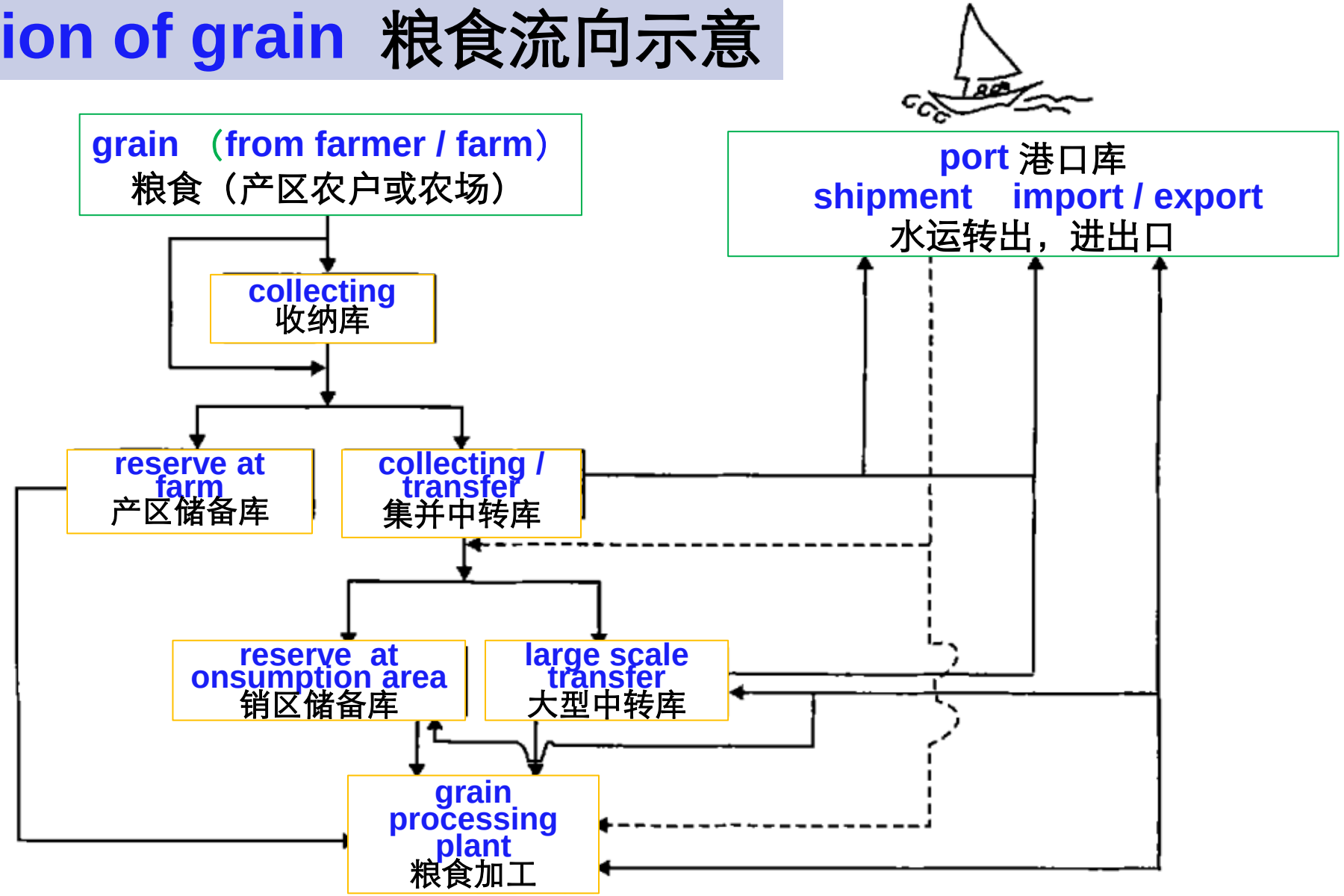
1.2.1.3 large-scale storage 大型库

capacity总仓容： $Q \geqslant 150{,}000$ t

1.2.2 Classified by function（of depot）
按（粮库）功能分类

name 名称	function 功能
grain storage facility for collecting 收纳库	for receiving grain from farmers or farm in the production area, and transfer out timely 接收农民或农场粮食入库，适时转出
grain storage facility for transfer 中转库	for receiving grain from collecting/ port & transporting grain to other storage facility, such as large transfer facility, reserve facility or processing plant 接收收纳库/港口库来粮，转运去其他粮库（大中转库/ 储备库）或加工厂
grain storage facility for reserve 储备库	for longer time （＜2 years） 长期储存（＜2年），轮换次数最少

flow direction of grain 粮食流向示意



flow direction of grain 粮食流向示意

1.2.2.1 Grain collecting storage facility 粮食收纳库

Grain storage facility that built in grain producing areas that directly purchase grain and oil from farmers or farm.

建在产粮区、直接对农户或农场收购粮食和油料的粮食仓库。

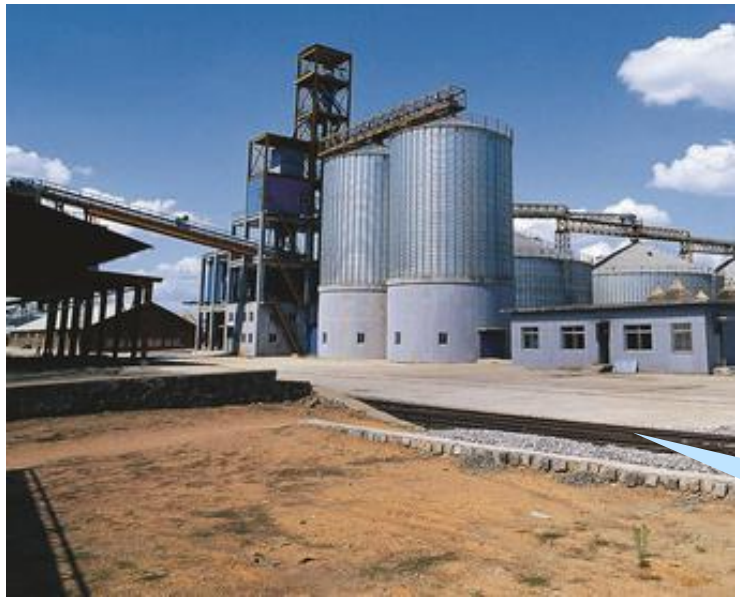
1.2.2.2 Grain storage facility for transfer purpose 粮食中转库

Grain storage facility that primarily for short-term storage and turnovere，Receiving grain from collecting/ port & transporting grain to other storage facility, such as large transfer facility, reserve facility or processing plant，

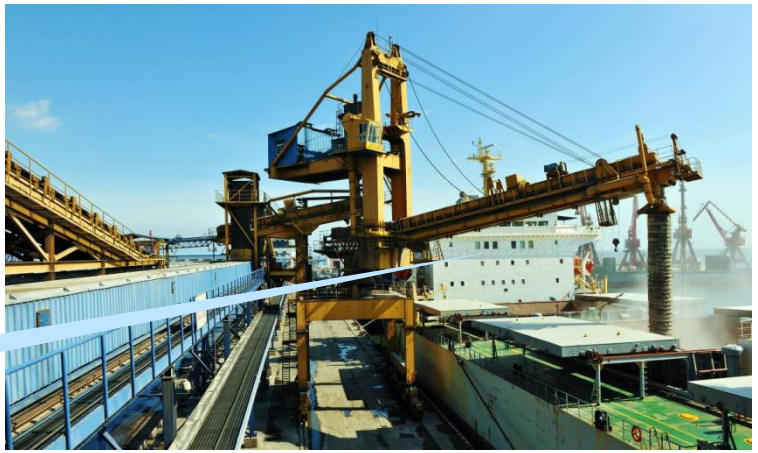
拥有粮食、油料接收和发放设施，以短期储存和周转为主的粮食仓库，接收收纳库/港口库来粮，转运去其他粮库（大中转库/ 储备库）或加工厂。一般建于铁路、水路、公路干线等交通枢纽处。

1.2.2.2 Grain storage facility for transfer purpose
粮食中转库

Generally built at transportation hubs such as railways, waterways, and highways.
一般建于铁路、水路、公路干线等交通枢纽处。



railway siding 铁路专用线
Truck——train



ship unloader 卸船机
ship——conveyor

port transfer 港口中转库
ship——ship/ truck / train

1.2.2.2 Grain storage facility for transfer purpose
粮食中转库（港口库，大船、小船、火车、汽车互通）

ship uploader & loader 卸船机、装船机
ship——conveyor

1.2.2.3 Grain storage facility for reserve purpose
粮食储备库

Grain storage facility that can safely store grain and oil for a long time in case of emergency needs.

能较长时间安全储存粮食、油料以备紧急需要的粮食仓库。

1.2.3 Classified by type of stored grain

按储存粮食的类型分类

name 名称	definition 定义
storage facility located at processing plant 原料库	storing raw grains 储存原粮
finished products storage 成品库	stored finished product 储存成品粮

1.2.3.1 Storage facility located at processing plant
原料库

Grain storage facility that located within or near a grain processing plant that stores raw materials for the processing plant.

位于粮食加工厂内或附近，为加工厂存放原料的粮食仓库。

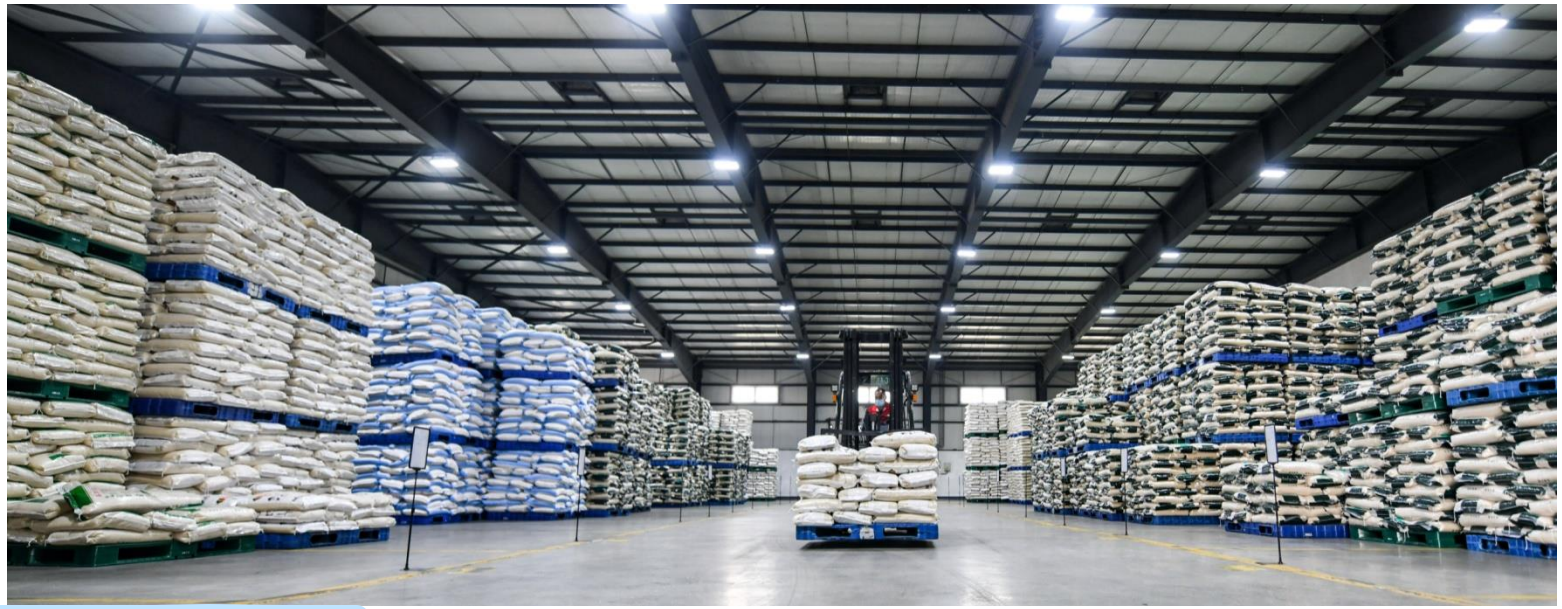
packed 包装原粮

buck 散装原粮

1.2.3.2 Warehouse for finished product
成品库

Warehouse located within or near a grain processing plant for storing finished products.

位于粮食加工厂内或附近，为加工厂存放成品的粮食仓库。



packed 包装成品粮

02

Main storage facility
主要储粮设施

2 Main storage facility
主要储粮设施

2.1 House type warehouse 房式仓

2.2 Vertical silo 筒式仓

2.1 House type warehouse 房式仓

A granary shaped like a bungalow or building, including

外形如平房或楼房的粮仓，包括:

2.1.1 large size horizontal warehouse 高大平房仓

2.1.2 multi-storied warehouse 楼房仓

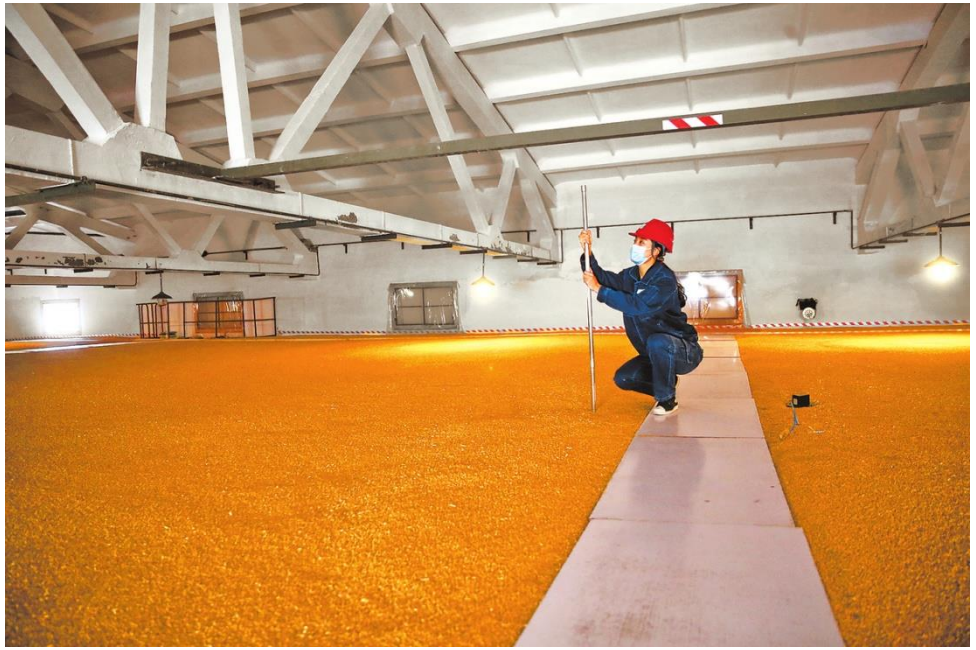
2.1.3 simple warehouse 简易平房仓

2.1.4 mechanized warehouse 机械化平房仓

2.1.1 Large size horizontal warehouse 高大平房仓

House type warehouses with a span of over 21 meters and a grain pile height of over 6 meters.

跨度21m以上，粮堆高度6米以上的房式仓。



2.1.1 Large size horizontal warehouse 高大平房仓

for bulk paddy 散装稻谷
loading & unloading by mobile conveyors
用移动输送机进出仓

loading 散粮进仓

unloading 散装出仓

2.1.2 Multi-storied warehouse 楼房仓

Multi story house type warehouse.

多层的房式仓。

packed 包粮储存

2.1.2 Multi-storied warehouse 楼房仓

for packed paddy /brown rice/ white rice/ milled rice

包装稻谷、糙米、白米等

loading & unloading by cargo lift 用货梯进出仓

2.1.2 Multi-storied warehouse 楼房仓

Advantage 优点

- simply structure 结构简单
- less area occupied 节约用地

Disadvantage 缺点

- higher investment 造价高
- only used in large city，such as Shanghai，Shenzhen，Guangzhou上海、深圳、广东等地

2.1.3 Simple warehouse 简易平房仓

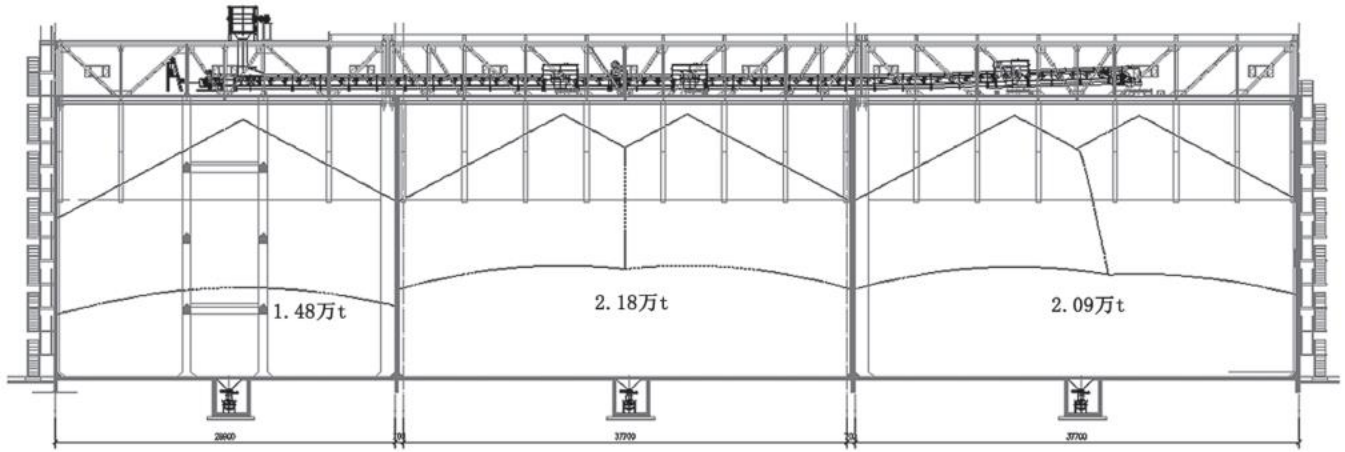
A house type warehouse with relatively simple buildings, grain storage facilities, and equipment.

建筑物和储粮设施、设备比较简陋的平房仓。

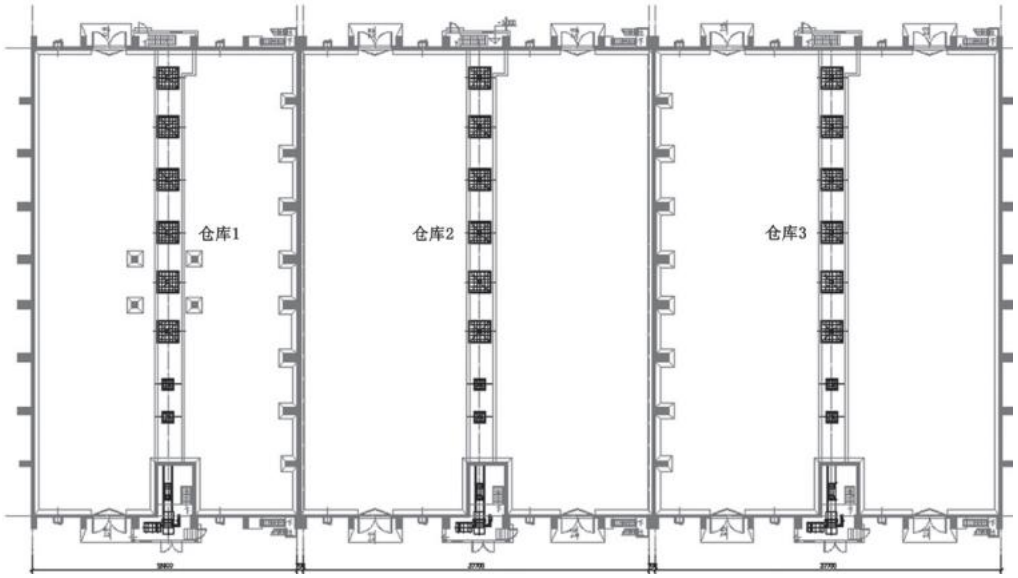
2.1.4 Mechanized warehouse 机械化平房仓

A house type warehouse equipped with fixed loading and unloading equipment.

配备固定的进出仓设备的平房仓。



2.1.4 Mechanized warehouse 机械化平房仓



Advantage of house type warehouse 房式仓的优点

- simply structure　结构简单
- easy construction 施工方便
- short construction period 建设周期短
- good for bulk grain & bagged grain可适用于散装粮，也可用于包装粮
- mature storage technology储藏技术成熟
- safety for grain 储粮安全

Disadvantage of house type warehouse 房式仓的缺点

- large area occupied 占地面积大
- large roof area 屋顶面积大
- strong thermal radiation）热辐射量大
- poor heat insulation 太阳隔热性差
- poor air tightness for fumigation 密闭性差
- low level of mechanization 机械化程度低
- hard to input or output grain 进出粮较困难
- need more labor 费人力

2.2 Vertical silo 筒式仓

A granary shaped like a bungalow or building, including
外形如筒状的粮仓，包括:

2.2.1 squat silo 浅圆仓

2.2.2 silo 立筒仓

2.2.1 Squat silo 浅圆仓

Cylindrical grain silos with a diameter generally not less than 20m and a ratio of the height of the silo wall to the diameter inside the silo less than 1.5.

仓内直径一般不小于20m，且仓壁高度与仓内直径之比小于1.5的筒形粮仓。

2.2.2 Silo 立筒仓

Also known as silos, cylindrical grain silos with a ratio of wall height to inside diameter greater than 1.5.

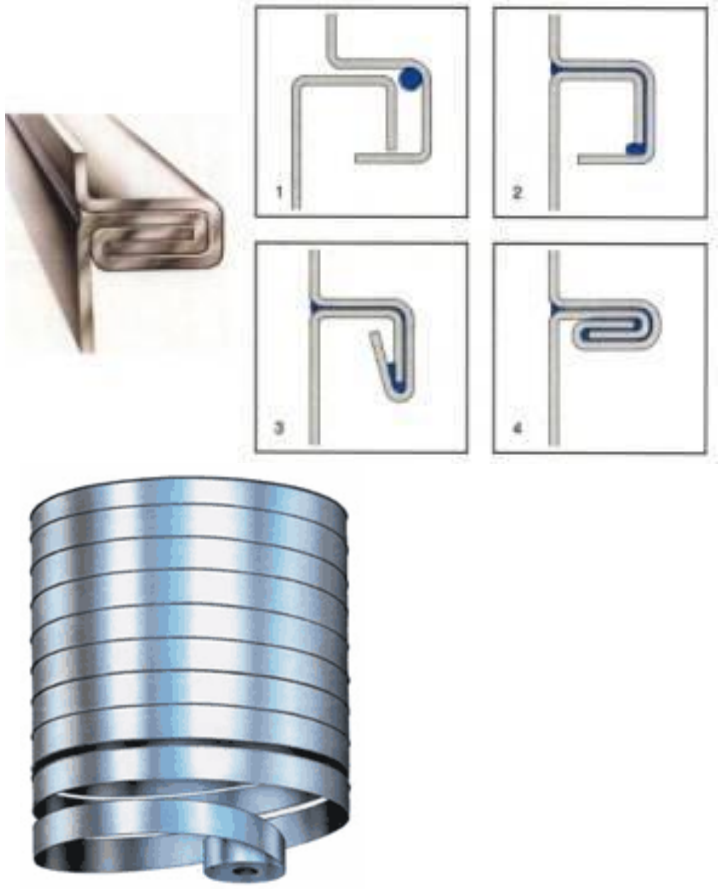
亦称筒仓，仓壁高度与仓内直径之比不小于1.5的筒形粮仓。

concrete 混凝土

steel 钢板仓

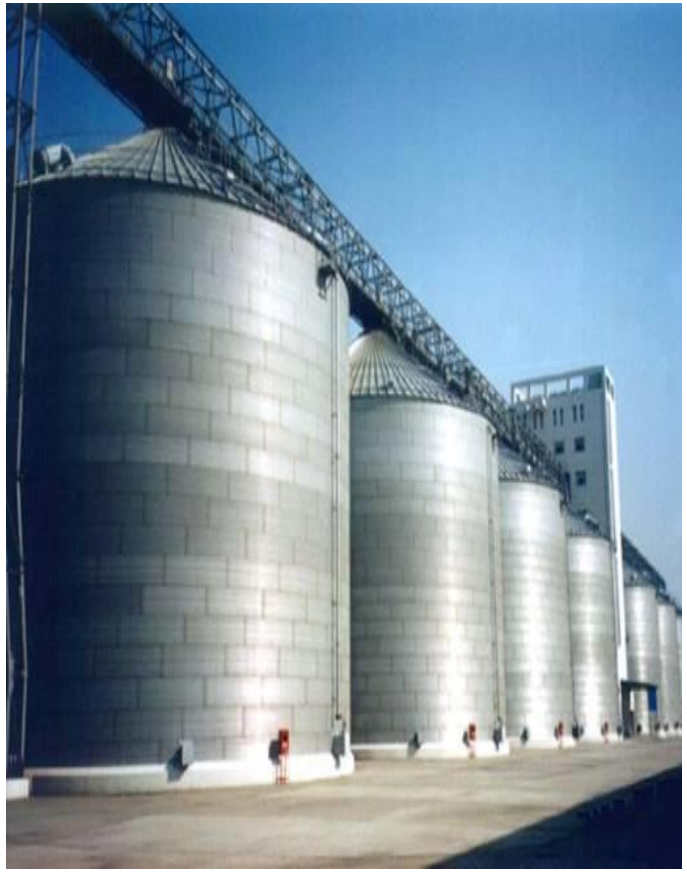
silo 隔热钢板仓

steel silo 钢板仓——Lipp style 利普



Lipp style 利普（现场咬合式）

steel silo 钢板仓——fabricated style 现场组装式



fabricated steel silo 现场组装式

corrugated steel 波纹

Advantage of vertical silo 筒式仓的优点

- less area occupied占地面积小
- need less labor使用人员少
- high level of mechanization机械化程度高
- lower cost 流通费用低

Disadvantage of vertical silo 筒式仓的缺点

- serious segregation in loading 入仓时自动分级严重
- high broken rate 破碎率高
- Significant "hot lay & cold center” 储藏期出现明显的 “冷心热皮”

03

Main storage technology
主要储藏技术

3 Main storage technology

主要储藏技术

3.1 Conventional technique of grain storage 常规储藏

3.2 Low temperature storage 低温储藏

3.3 Low oxygen storage 低氧储藏

storage technology classification

储藏技术分类

- to reduce quality loss & quantity loss, such as damaged by ***stored grain pest*** by conventional technique of grain storage

  conventional technique of grain storage 常规储藏

- to reduce quality loss, such as higher FAV （fatty acid value), by low temp. / low O_2 concentration technique of grain storage

  low temp. technique of grain storage 低温储藏
  low O_2 concentration technique of grain storage 低氧储藏

- ***stored grain pest 储粮有害生物***

Insects, mites, microorganisms, rodents, and birds that harm grain and oil seed in storage.

危害储藏状态下粮食、油料的昆虫、螨类、微生物、鼠类和鸟类。

3.1 Conventional technique of grain storage 常规储藏

Under natural climatic conditions, general technical treatment and conventional management measures such as cleaning and hygiene, natural ventilation, digging ditches and overturning grain surfaces, and regular monitoring of grain conditions are adopted for the storage of grain and oil seed.

在自然气候条件下，对储藏的粮食、油料采取清洁卫生、自然通风、扒沟翻倒粮面、定期监测粮情等一般技术处理和常规管理措施的储藏方法。

3.1 Conventional technique of grain storage 常规储藏

natural ventilation自然通风

The process of using natural convection of air to exchange gas inside and outside the grain depot .

利用空气自然对流的作用，进行粮仓内外气体交换的过程称为自然通风。

3.2 Low Temperature storage 低温储藏

the average grain temperature is maintained at ⩽15 ℃ throughout the year, and the local highest grain temperature ⩾ 20 ℃.

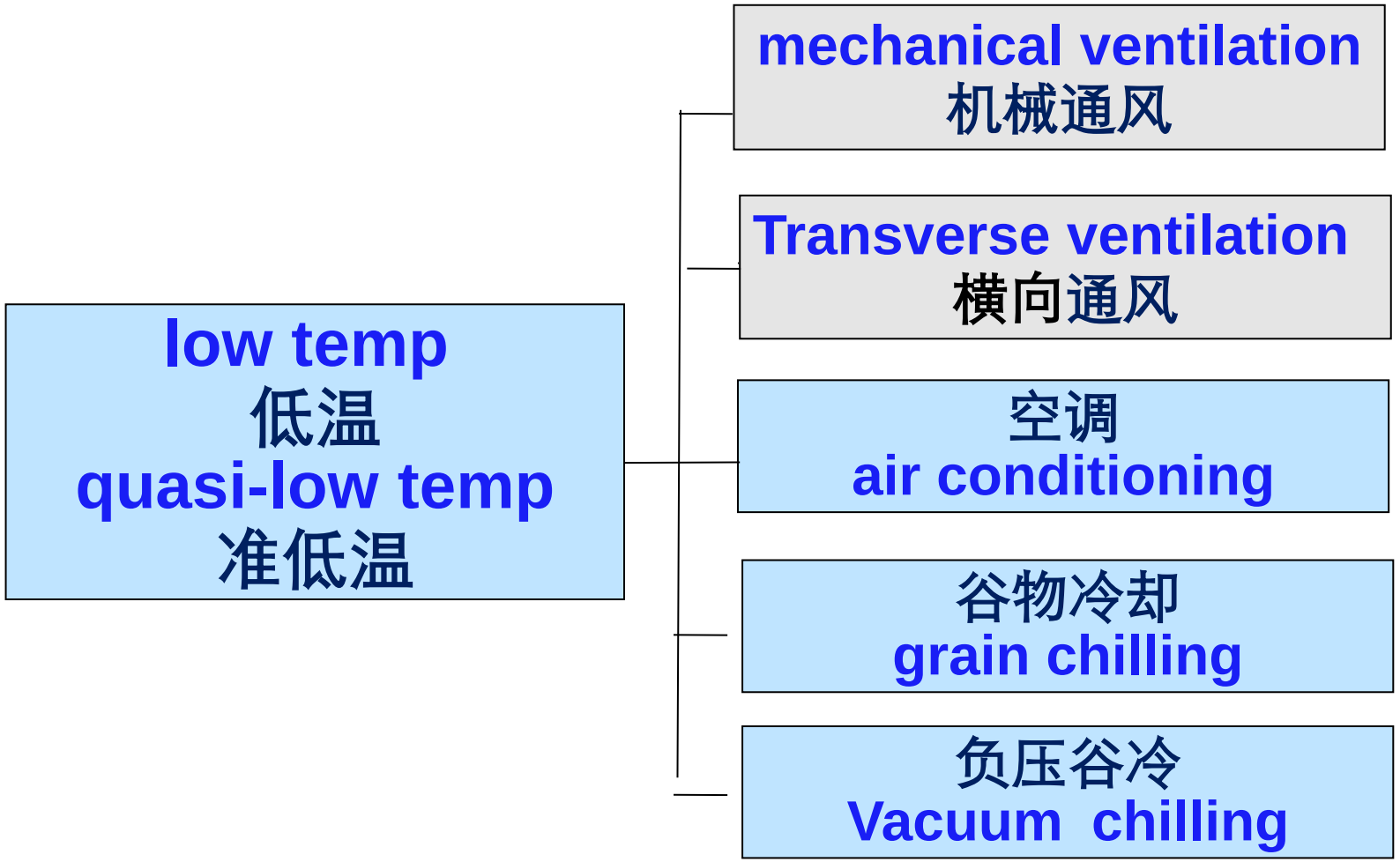
平均粮温常年保持在15℃及以下，局部最高粮温不超过20℃。

quasi-low Temperature storage 准低温储藏

The average grain temperature is maintained at ⩽ 20 ℃ throughout the year, and the local highest grain temperature ⩾ 25 ℃.

平均粮温常年保持在20℃及以下，局部最高粮温不超过25℃。

temperature control tech. 控温方法



3.3 Low oxygen 低氧储藏

oxygen concentration in the air of grain piles: 2%~ 12%.

粮堆空气中氧气浓度为2%~12%的状态。

oxygen dificit 缺氧

oxygen concentration in the air of grain piles: ⩽2%.

粮堆空气中氧气浓度不高于2%的状态。

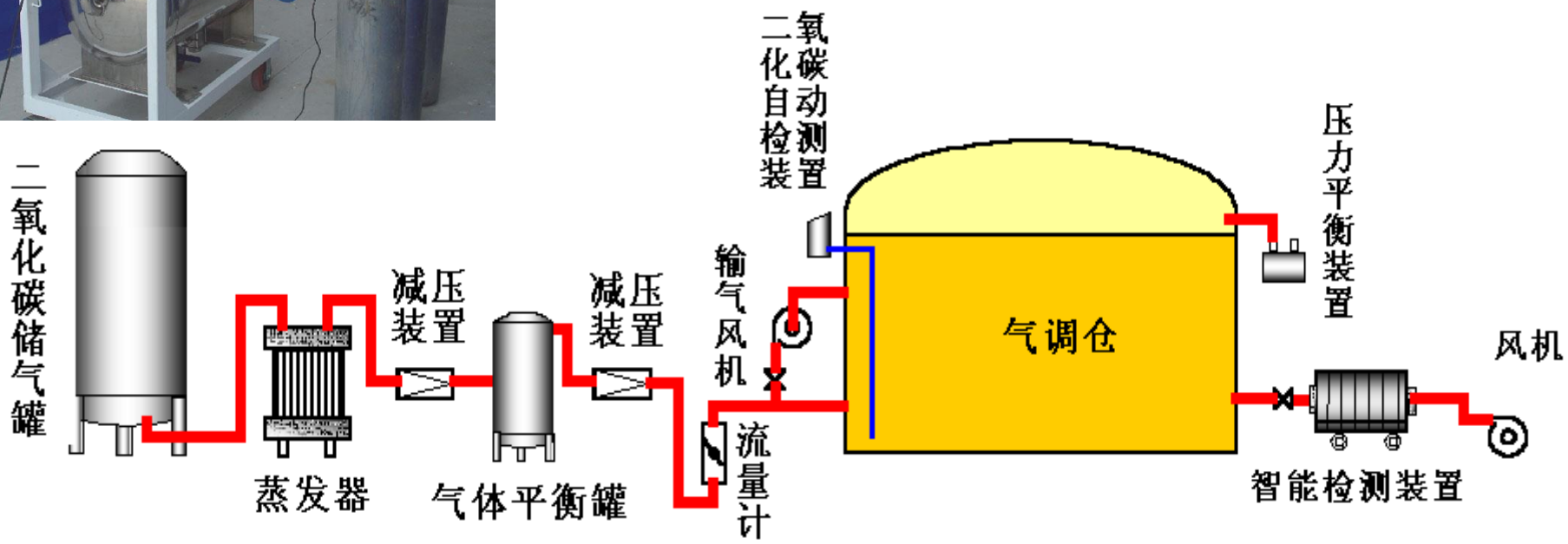
3.3 Low oxygen storage technique 低氧储藏技术

3.3.1 air tight 气密

3.3.2 controlled atmosphere storage of grain 气调储粮

（CO_2 or N_2 充CO_2或 N_2 ）

air tight + air control 气密+气调



air tight + air control 气密+气调

PSA制氮系统

04

Application experience and achievements in China

中国应用经验及成绩

4 Application experience and achievements in China

中国应用经验及成绩

4.1 Double-low storage 双低储藏

4.2 Triple-low storage 三低储藏

4.3 Four in one storage 四合一储藏

4.4 New four in one storage 新四合一储藏

4.5 New technology application 新技术应用

4.1 Double-low storage 双低储藏

Storage technology combination of low dose Phosphine fumigation after achieving low oxygen.

实现低氧后再进行低剂量磷化氢熏蒸的储藏技术组合。

4.1.1 Low dose fumigation 低剂量熏蒸

A fumigation technique where the amount of medication used is lower than that of conventional fumigants. Generally used for low oxygen grain pile fumigation or circulation fumigation technology.

用药量低于常规熏蒸剂用量的熏蒸技术。一般用于低氧粮堆熏蒸或环流熏蒸技术。

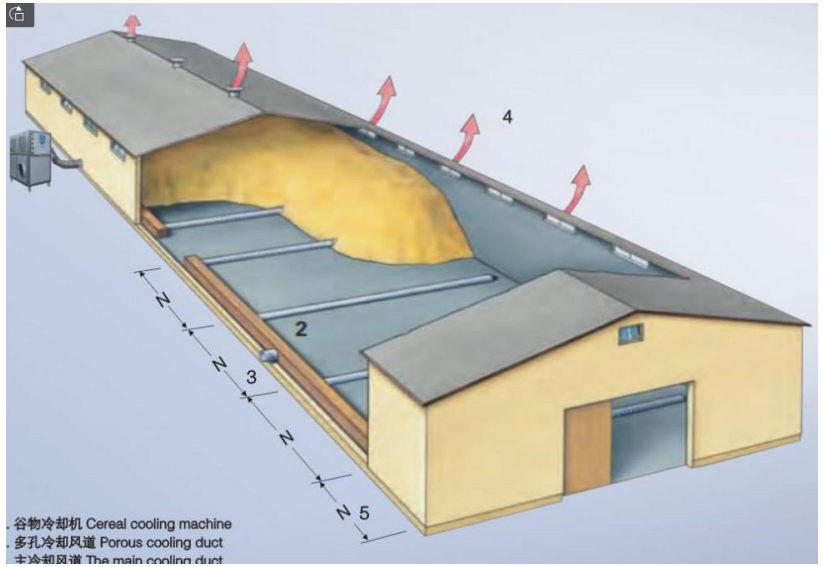
4.1.2 Conventional fumigation 常规熏蒸

In enclosed grain warehouses or grain pile, conventional doses of fumigants are applied, relying on fumigation techniques that convert the agents into gaseous natural diffusion.

在密闭粮仓或粮堆内，施用常规剂量的熏蒸剂量的熏蒸剂，依靠药剂转化为气态自然扩散的熏蒸技术。

$$AlP + 3H_2O = Al(OH)_3 + PH_3\uparrow$$

（aluminium phosphide tablets）



4.2 Triple-low storage 三低储藏

A combination of grain storage technologies that reduce grain temperature after achieving a double-low storage effect.

实现双低储藏效果后，再降低粮温的储粮技术组合。

low oxygen

low dose Phosphine fumigation

low temperature

4.3 Four in one storage 四合一储藏

The integration and optimization combination of computer grain condition detection, circulation fumigation, mechanical ventilation, grain cooling and other technologies and equipment are adopted in the grain storage warehouse..

在储粮仓房中采用计算机粮情检测、环流熏蒸、机械通风、谷物冷却等技术和装备的集成及优化组合。

4.1.1 Computer grain condition detection 计算机粮情检测

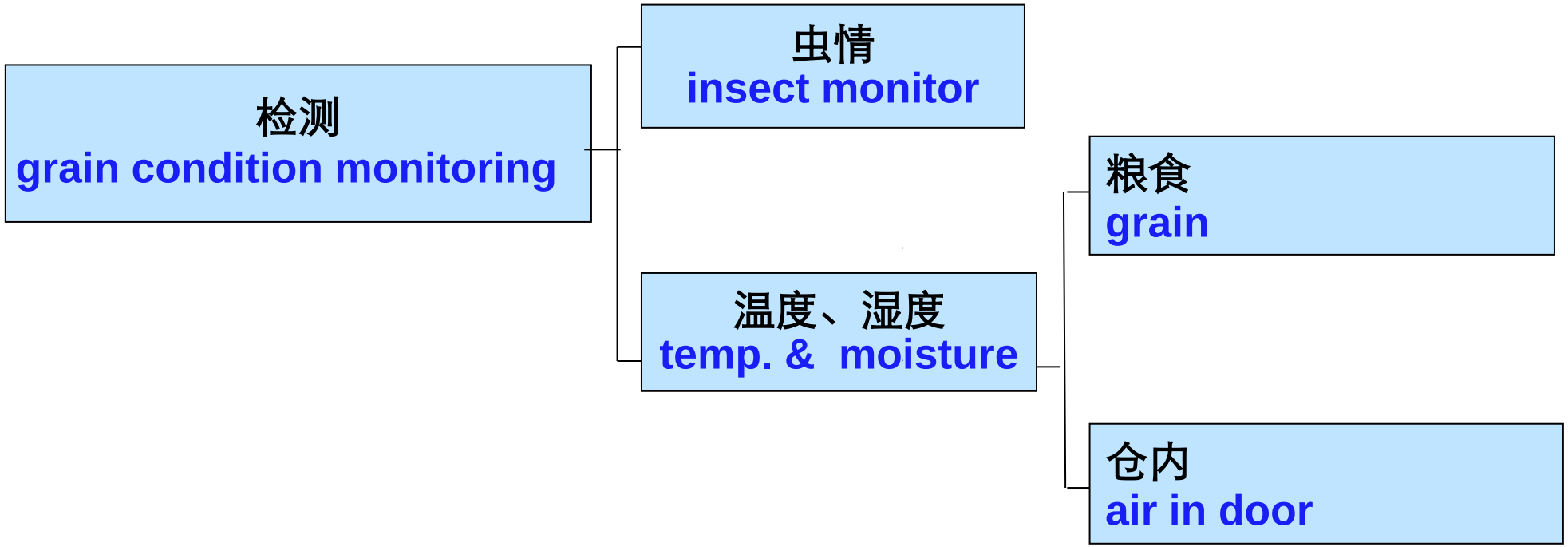
4.3.2 Circulation fumigation 环流熏蒸

4.1.3 Mechanical ventilation 机械通风

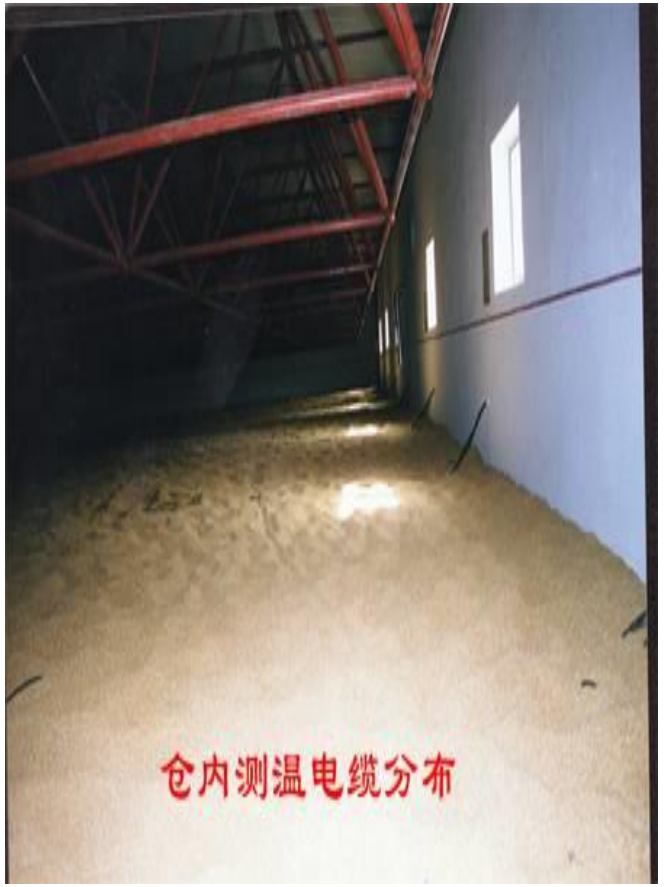
4.1.4 Grain cooling 谷物冷却

4.3.1 Computer grain condition detection计算机粮情检测

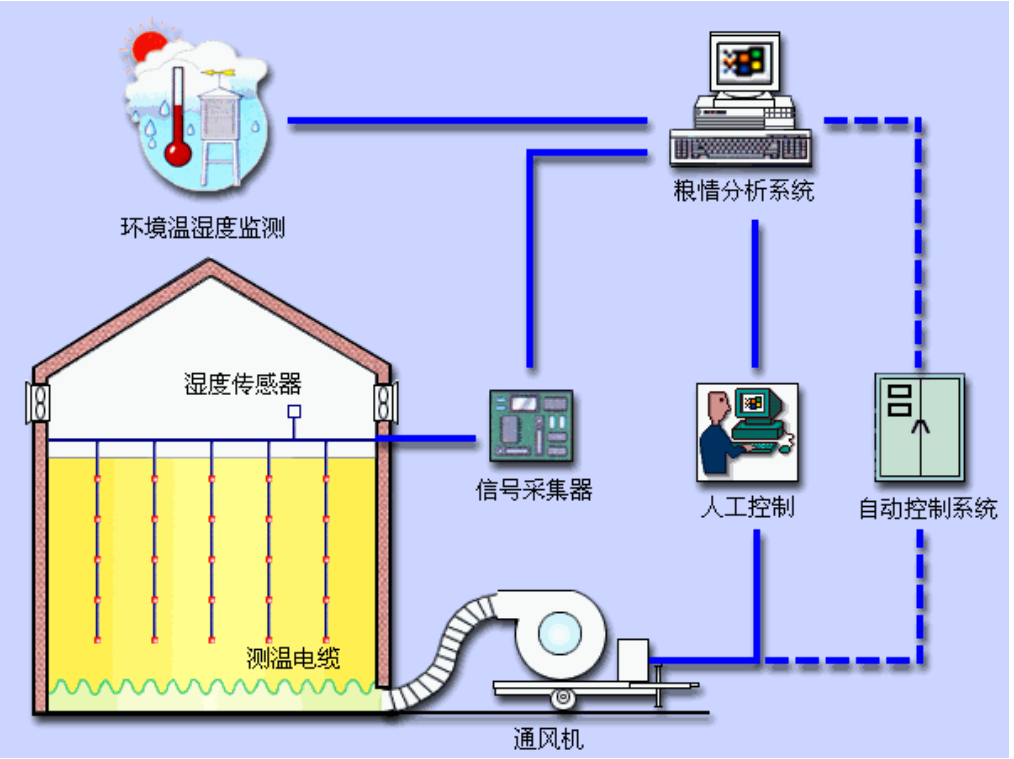
A system that utilizes computer and electronic technology to automatically detect grain conditions, store and analyze data, and control ventilation and other facilities.利用计算机和电子技术对粮情自动检测、数据存储与分析，并控制通风等设施进行的系统。



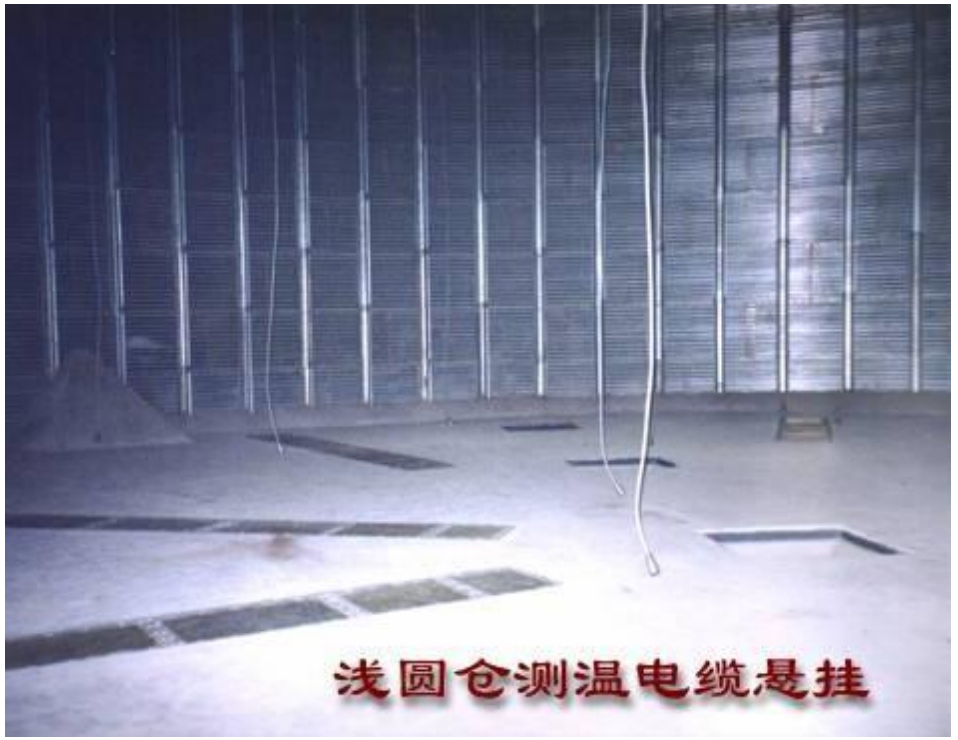
4.3.1 Computer grain condition detection计算机粮情检测



4.3.1 Computer grain condition detection计算机粮情检测



4.3.1 Computer grain condition detection计算机粮情检测

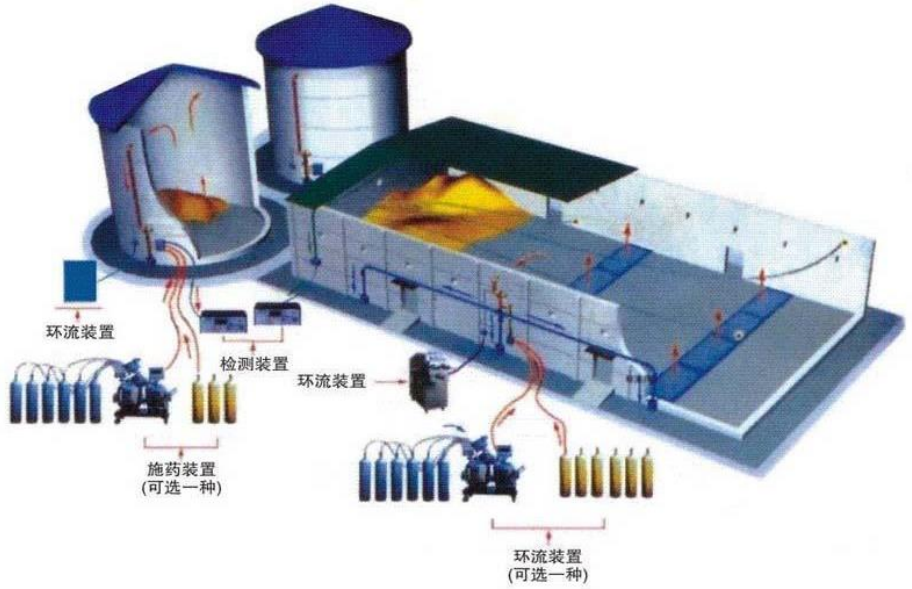


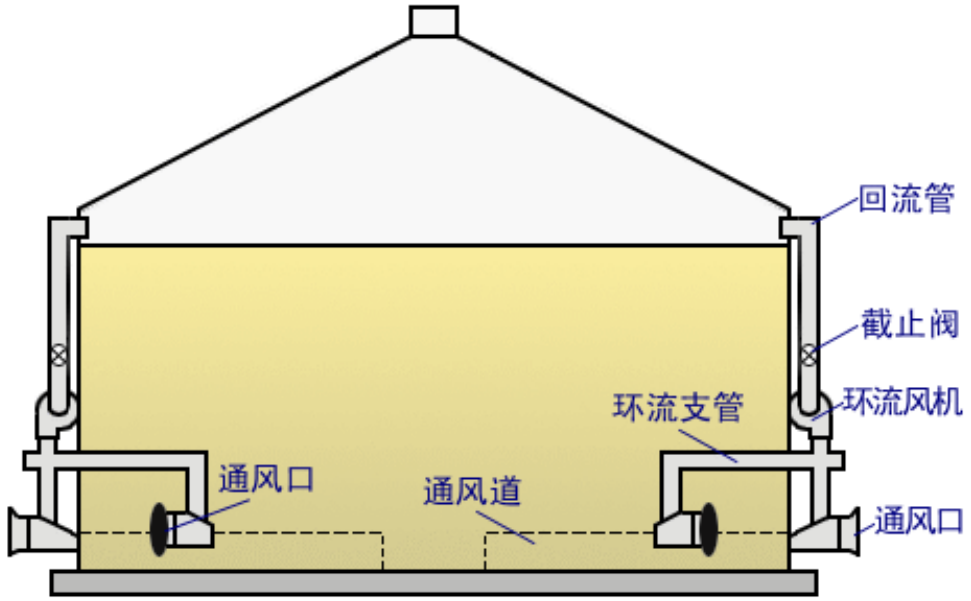
4.3.1 Computer grain condition detection计算机粮情检测

4.3.2 Circulation fumigation 环流熏蒸

A fumigation technology that uses the circulating fumigation system to force the circulation of fumigation gas and promote the rapid and uniform distribution of fumigation gas in the grain pile..

利用环流熏蒸系统强制熏蒸气体循环，促使熏蒸气体在粮堆内快速均匀分布的熏蒸技术。





浅圆仓固定环流熏蒸工艺示意图
(仓顶锥体部分不装粮)

4.3.2 Circulation fumigation 环流熏蒸

4.3.2 Circulation fumigation 环流熏蒸

Phosphine generator 磷化氢发生器

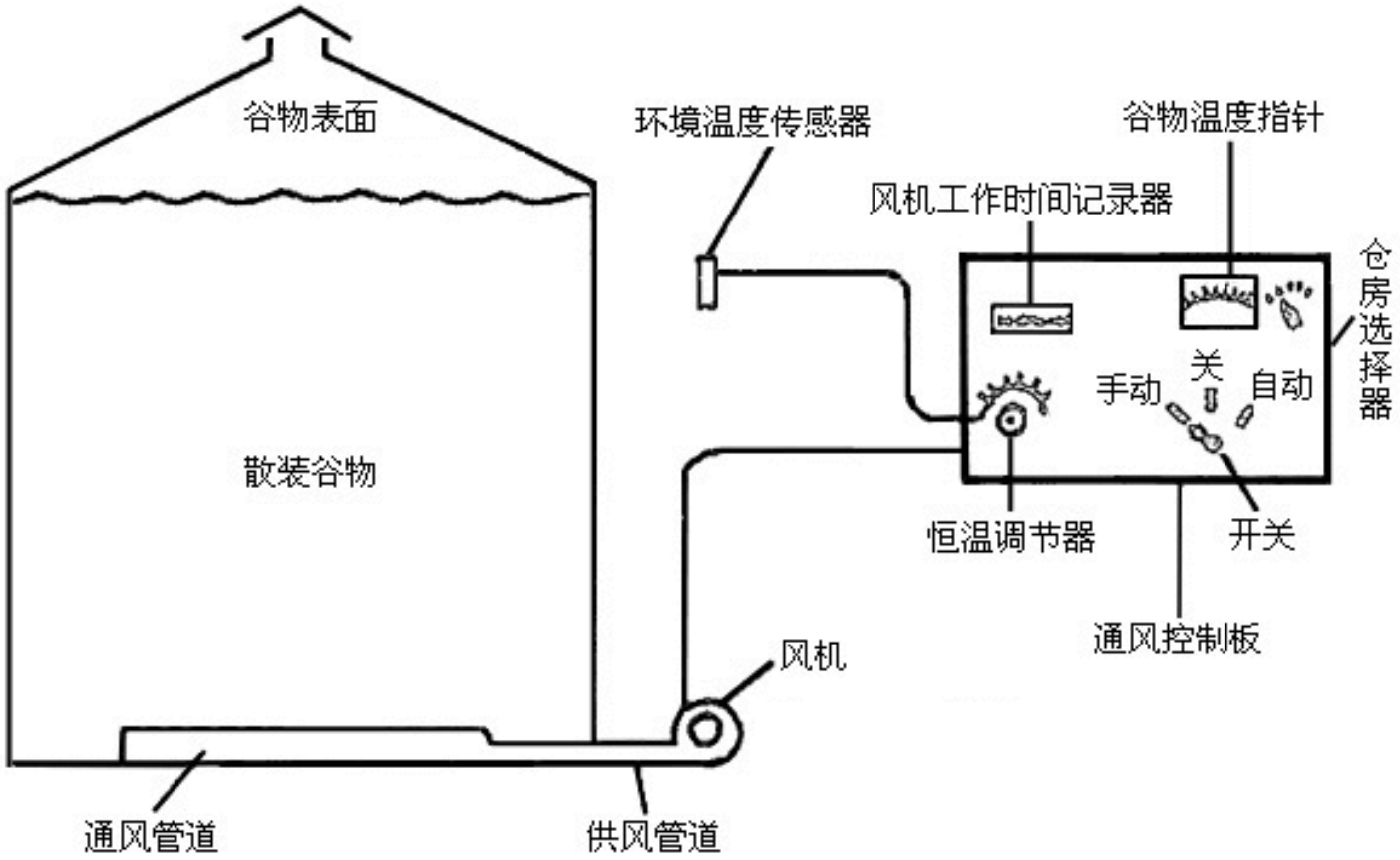
Phosphine concentration detector 磷化氢浓度检测

4.3.3 Mechanical ventilation 机械通风

4.3.3 Mechanical ventilation 机械通风

通风道 vent-pipe

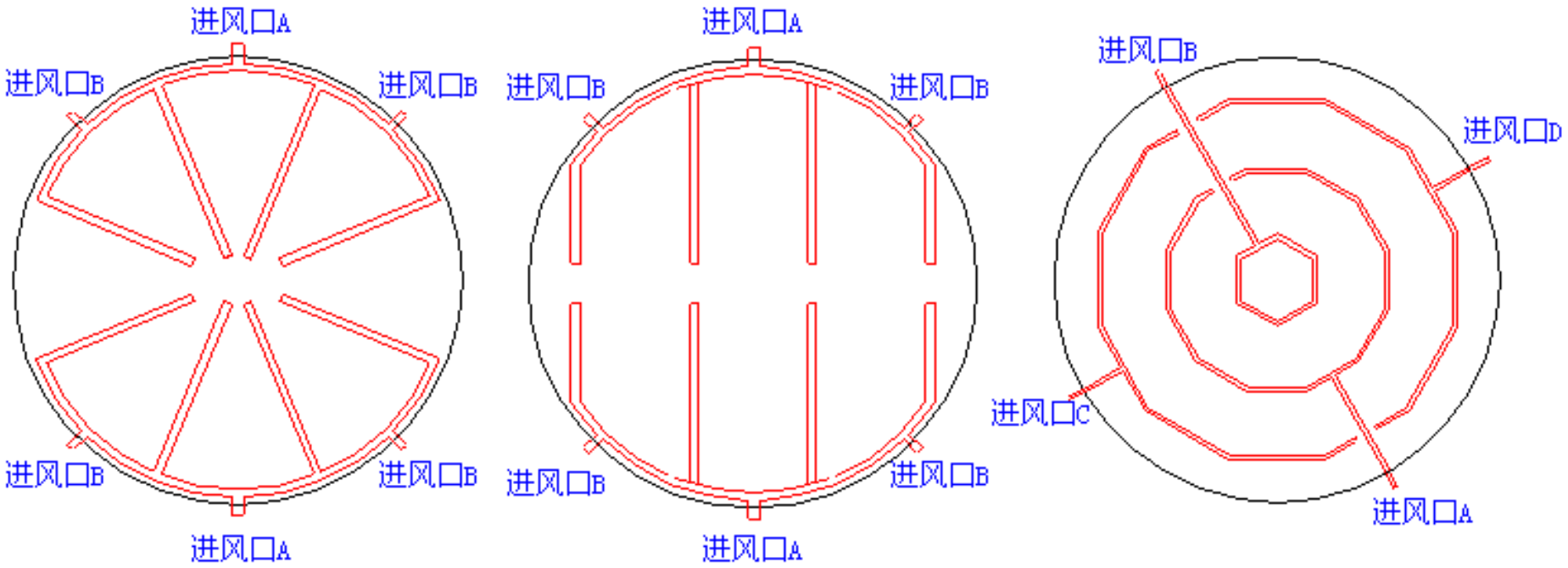
4.3.3 Mechanical ventilation 机械通风



4.3.3 Mechanical ventilation 机械通风

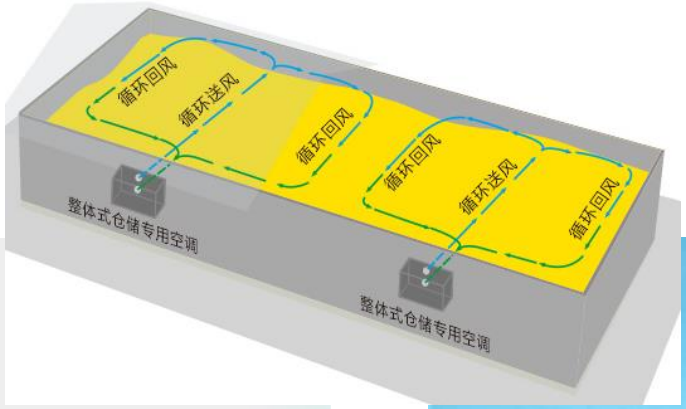
vent-pipe for squat silo / silo 筒仓、浅圆仓通风道

4.3.3 Mechanical ventilation 机械通风



vent-pipe for squat silo / silo 筒仓、浅圆仓通风道

4.3.4 Grain chilling 谷物冷却



Grain cooler 谷冷机

4.3.4 Grain chilling 谷物冷却

Grain cooler 谷冷机

4.3.4 Grain chilling 谷物冷却

Grain cooler for silo 筒仓+谷冷机

4.3.4 Grain chilling 谷物冷却

Grain cooler for squat silo 浅圆仓谷冷机

4.4 New four in one storage 新四合一储藏

The integration and optimization combination of Multi-parameter grain condition detection, Multi- agent prevental, Transverse ventilation, Vacuum cooling and other technologies and equipment are adopted in the grain storage warehouse..

在储粮仓房中采用多参数粮情检测、多介质防治、横向通风、负压冷却等技术和装备的集成及优化组合。

4.4.1 Multi-parameter grain condition detection 多参数粮情

4.4.2 Multi- agent prevental 多介质防治

4.4.3 Transverse ventilation 横向通风

4.4.4 Vacuum cooling 负压谷冷

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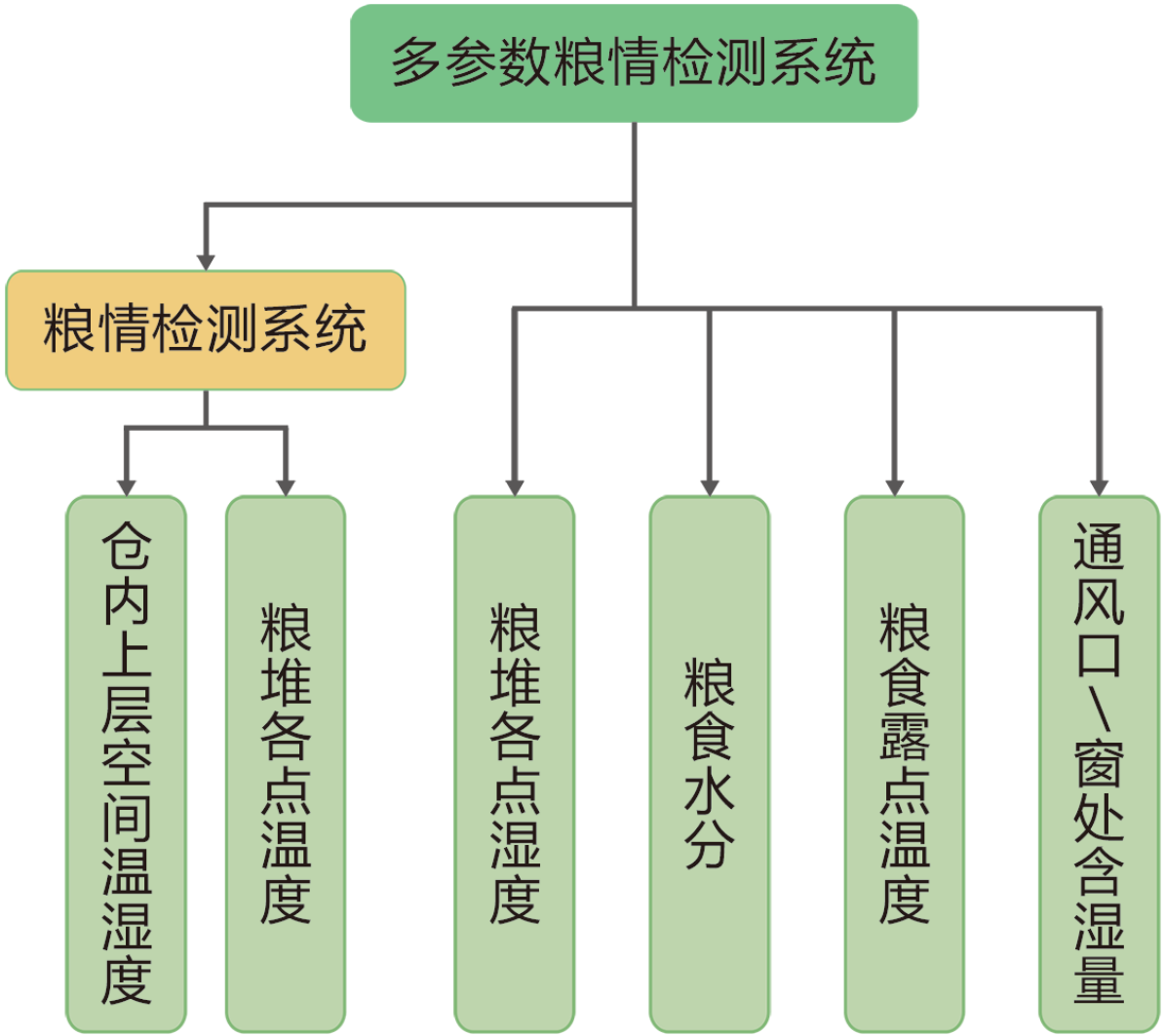
Multi-parameter grain condition detection 多参数粮情	**Multi- agent prevental** 多介质防治	**Transverse ventilation** 横向通风	**Vacuum cooling** 负压谷冷
Computer grain condition detection 计算机粮情检测	**Circulation fumigation** 环流熏蒸	**Mechanical ventilation** 机械通风	**Grain cooling** 谷物冷却

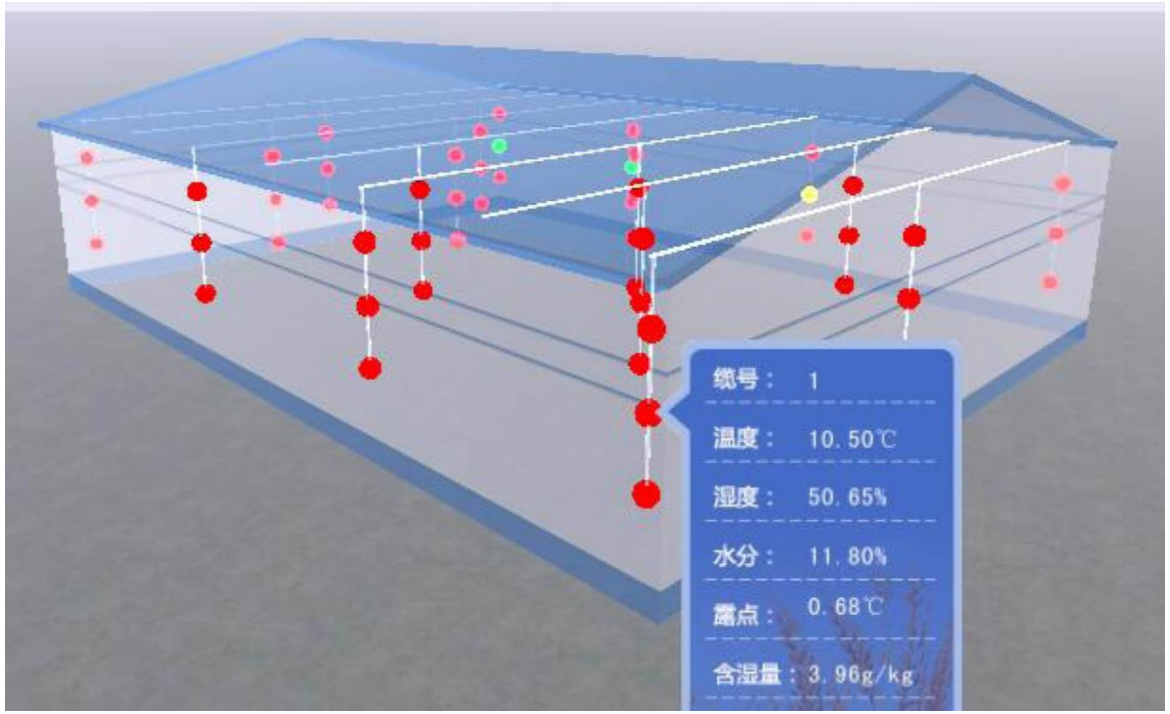
4.4.1 Multi-parameter grain condition detection

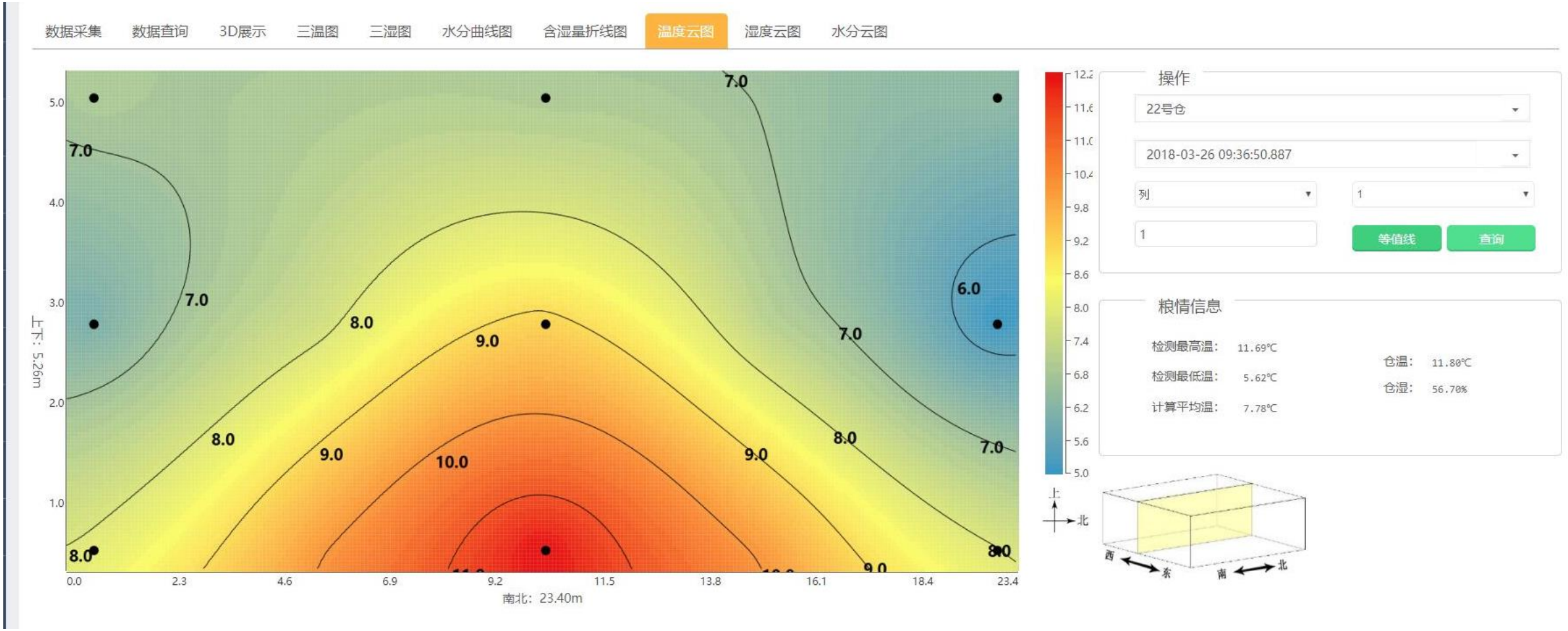
多参数粮情监测

A real-time online detection system for temperature, humidity, and grain moisture of stored grains based on the theory of heat and moisture balance and the principle of moisture absorption/desorption.

基于热湿平衡理论和吸湿/解吸湿原理的一种实时在线检测储粮温度、湿度、粮食水分的系统。


多参数粮情检测系统
粮情检测系统
仓内上层空间温湿度
粮堆各点温度
粮堆各点湿度
粮食水分
粮食露点温度
通风口\窗处含湿量


缆号： 1
温度： 10.50℃
湿度： 50.65%
水分： 11.80%
露点： 0.68℃
含湿量： 3.96g/kg



Temperature nephogram 温度云图

4.4.2 Multi- agent prevental 多介质防治

filling N_2（Low O_2)
充氮气调（低氧）

Food grade inert powder
for insect prevention
食品级惰性粉防虫
（physically ）
（物理机理）

New four in one
新四合一

Horizontal
circulation fumigation
横向环流熏蒸

Circulation fumigation
环流熏蒸
（four in one 四合一）

Food grade inert powder for insect prevention
食品级惰性粉防虫

Food grade inert powder is a type of powder that falls into the joints of pests, abrades the internode membrane, causes severe dehydration of the insect body, and physically kills stored grain pests.The average particle size of food grade inert powder is about 5um, the density is about 0.2g/cm3, and it can be dispersed and suspended in the air。

食品级惰性粉是通过粉粒落入害虫关节,磨损节间膜,导致虫体严重失水,以物理方式杀死储粮害虫。食品级惰性粉平均粒径约为5um,密度约为0.2g/cm3,可分散并悬浮于空气中。

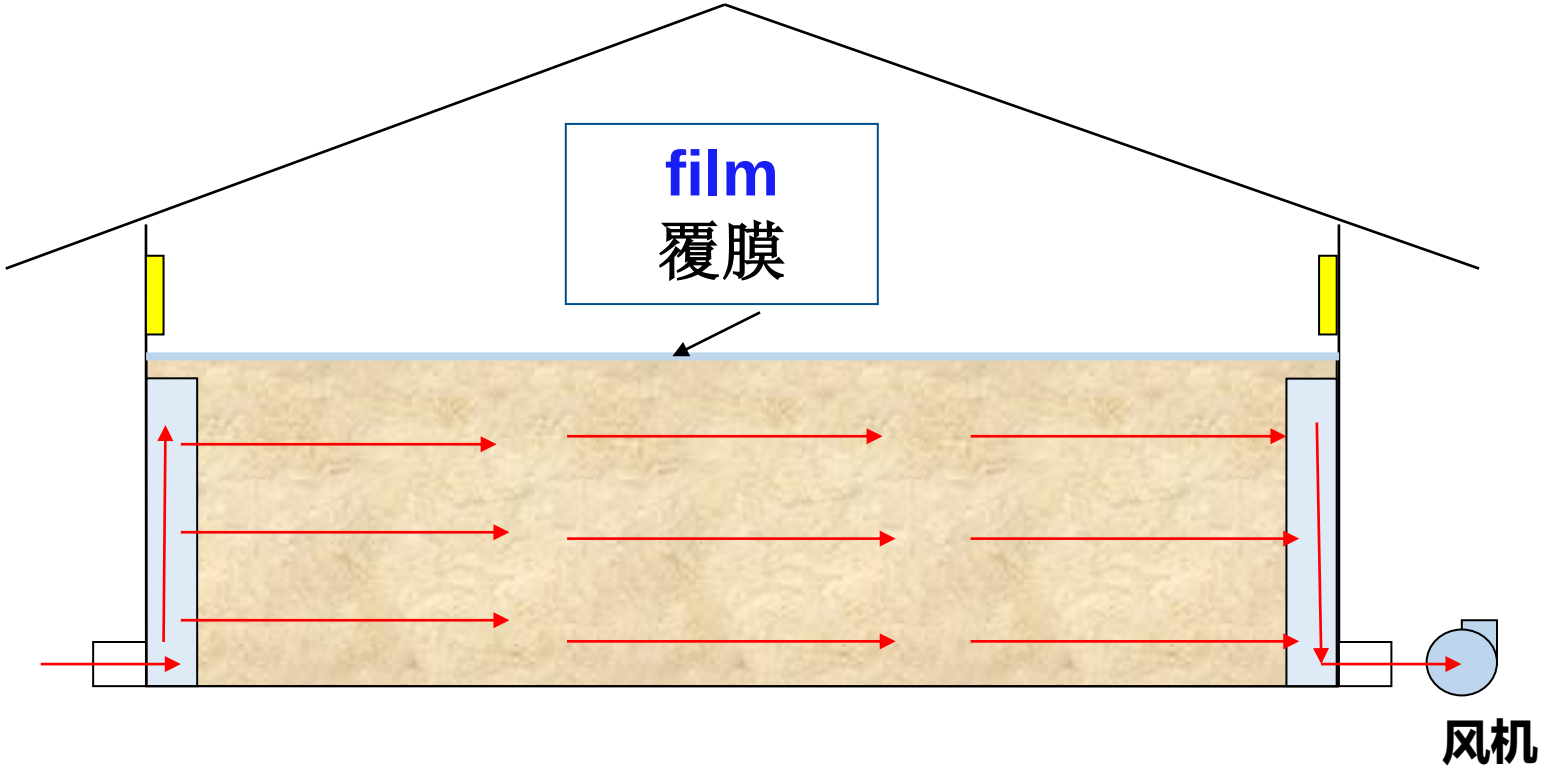
Food grade inert powder for insect prevention
食品级惰性粉防虫

4.4.3 Transverse ventilation 横向通风

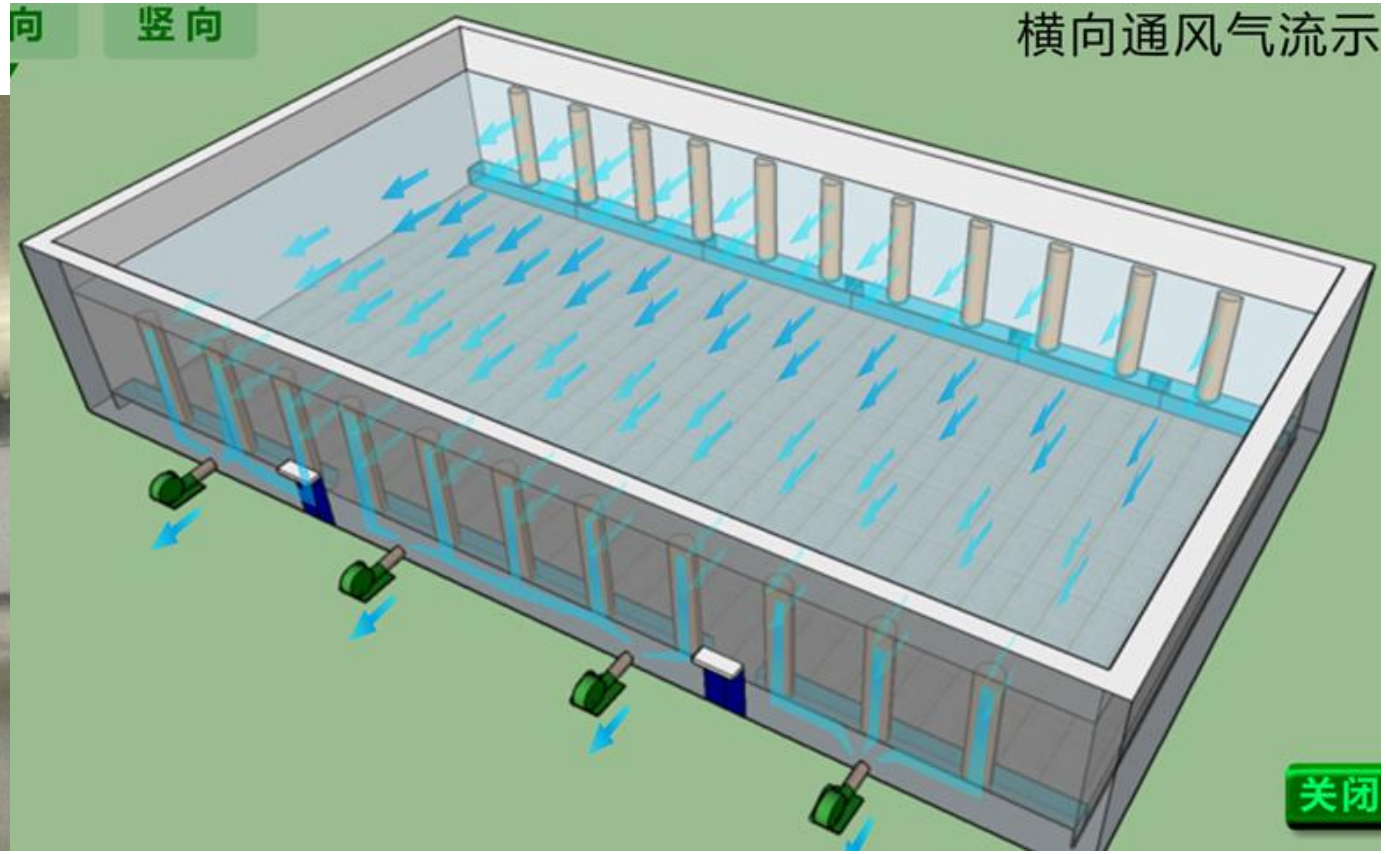
A ventilation method that uses a suction fan installed on one side of the ventilation opening of a bungalow warehouse to allow airflow to be sucked in from the ventilation opening on the opposite side of the warehouse through a horizontal ventilation duct, and then discharged from the fan after passing through the film covered and sealed grain pile, thereby changing the gas state parameters inside the grain pile, adjusting the temperature and humidity of the grain pile, and achieving safe grain storage or improving the quality of the grain storage and processing process.

利用安置在平房仓一侧通风口的吸出式风机，通过横向通风管使气流从仓房对面一侧的通风口吸入，并横向穿过覆膜密闭的粮堆后从风机排出，从而改变粮堆内气体状态参数，调整粮堆温度、湿度等，达到安全储粮或改善储粮加工工艺品质的一种通风方式。

4.4.3 Transverse ventilation 横向通风



4.4.3 Transverse ventilation 横向通风



4.5 New technology application 新技术应用

4.5.1 Air film granary 气膜仓（新仓型）

4.5.2 Solar energy 太阳能（新能源）

4.5.3 Membrane separation 膜分离（新材料）

4.5.4 Cloud platform 云平台（智能化）

4.5.1 Air film granary 气膜仓（新仓型）

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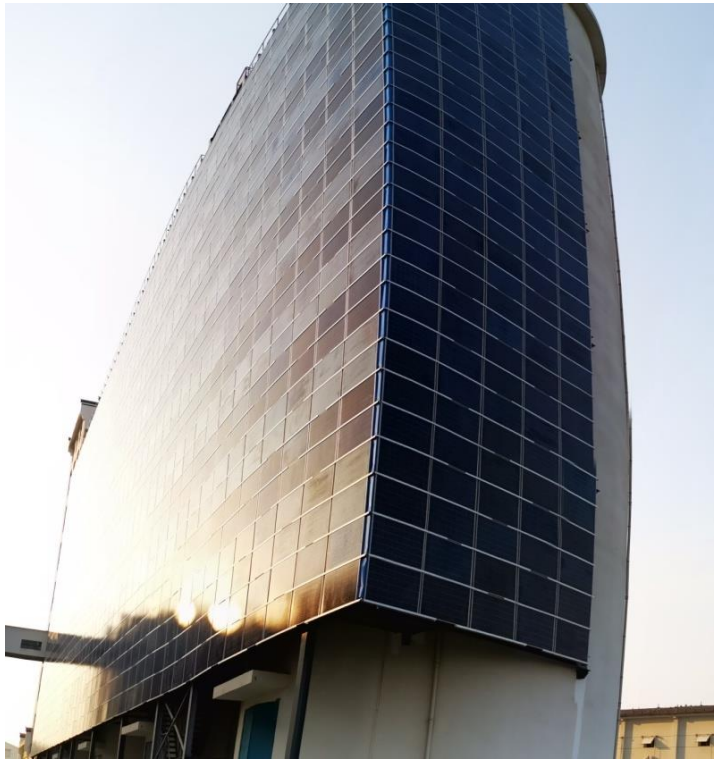


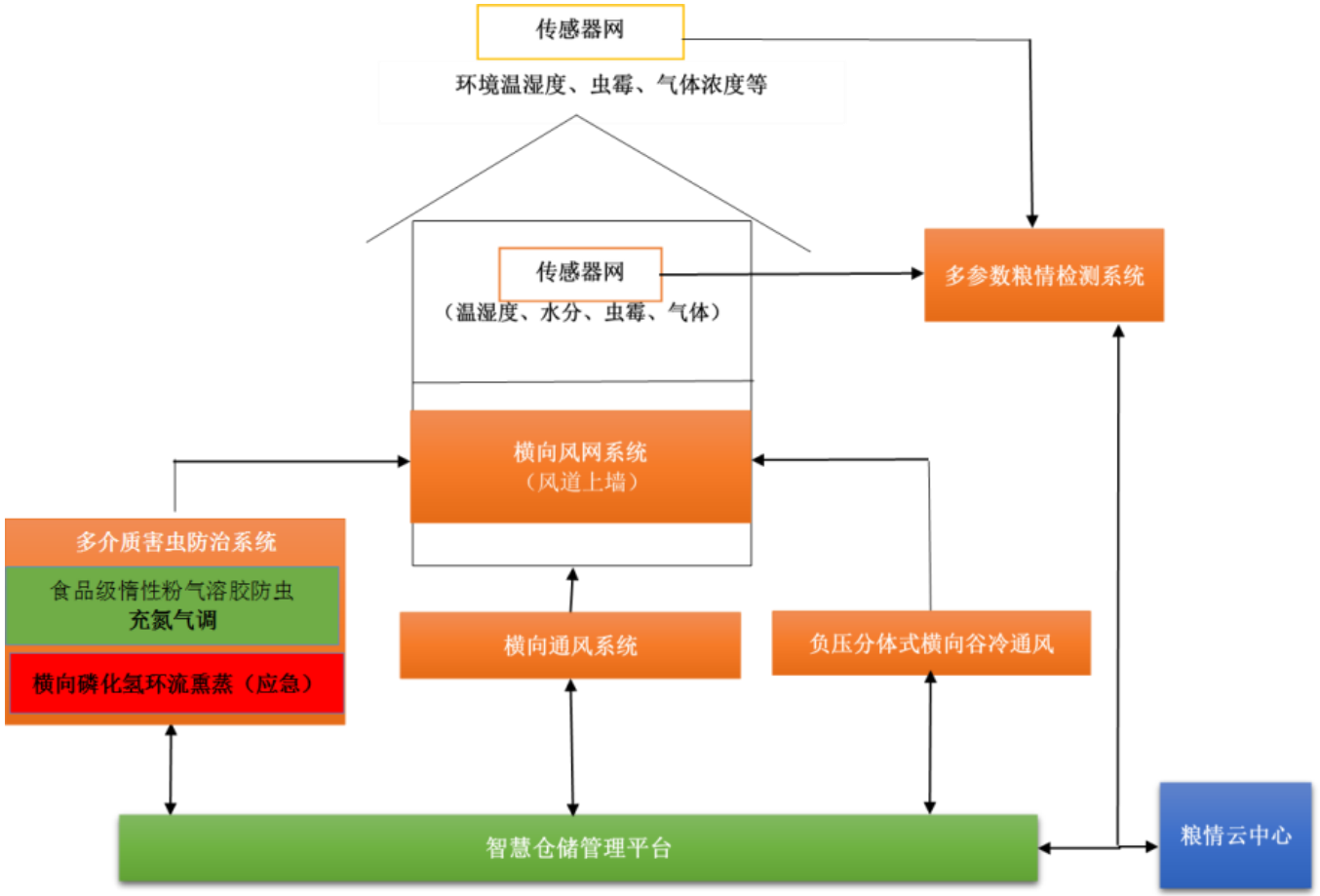
warehouse‘s roof 平房仓顶

silo‘s wall 筒仓侧壁

4.5.3 Membrane separation 膜分离（新材料）

Membrane separation for nitrogen production 膜分离制氮气

4.5.4 Cloud platform 云平台（智能化）



Intelligent cloud platform
智能云平台

Thank You

The project is funded by Bill and Melinda Gates Foundation.

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