Extrusion Technology

R&D Center, Muyang Group

Main Contents

Part 1

MUYANG

Aquafeed Extrusion Technology

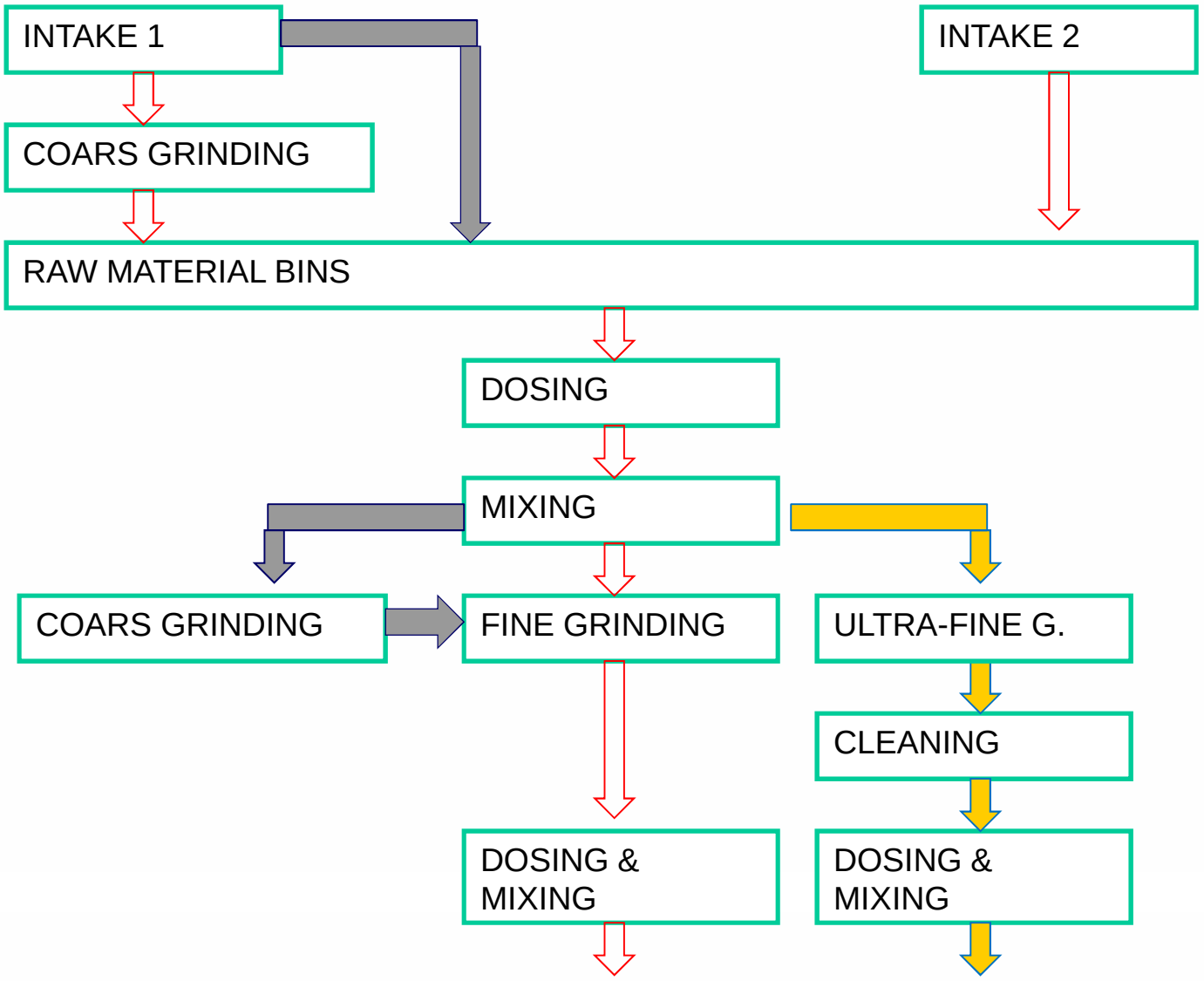
Aquafeed Extrusion Technology

1. Typical process of fish feed line in China

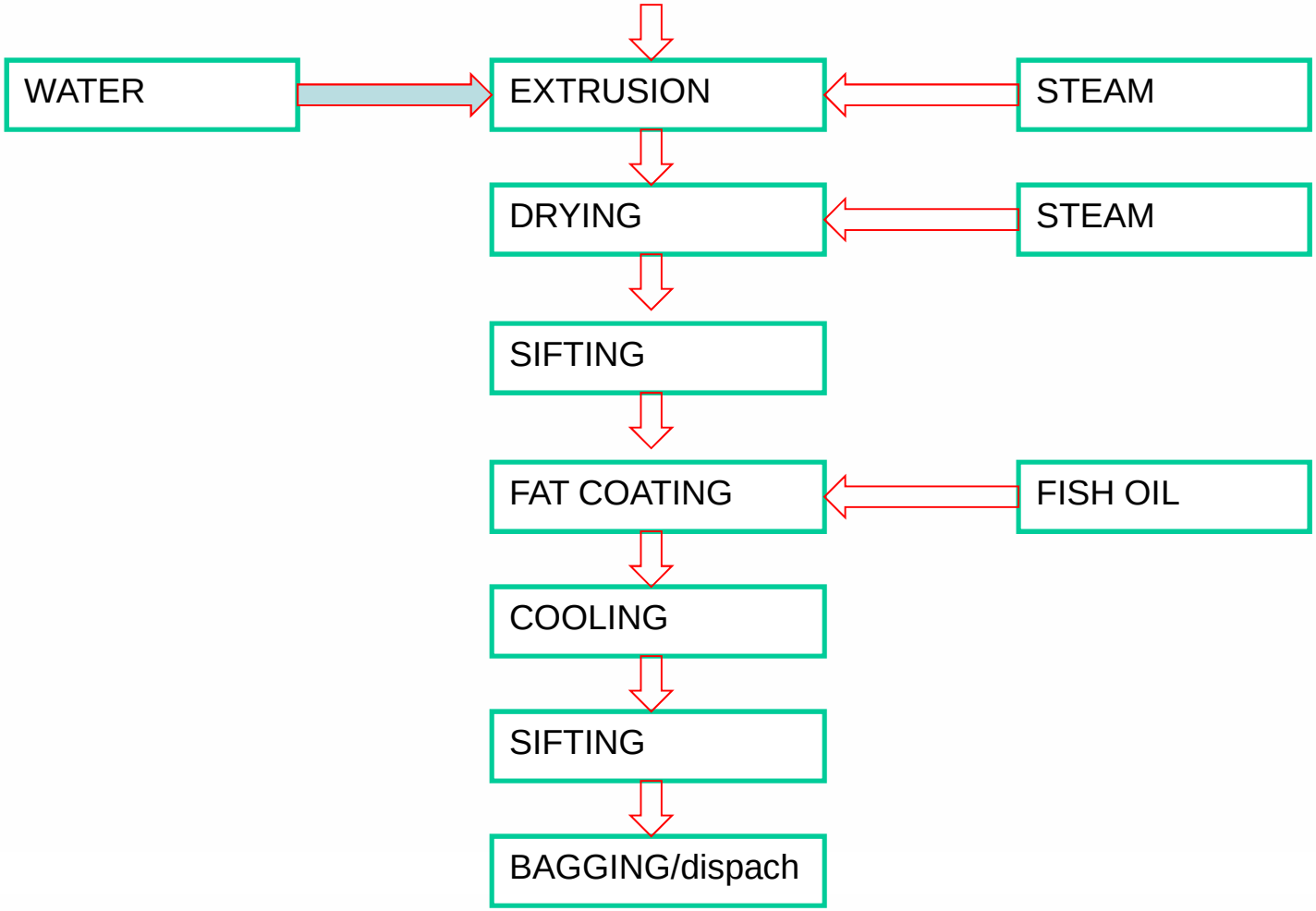
2. Muyang new techniques about aquafeed extrusion

3. Common problems in aquafeed extrusion & analysis

1) Fish feed production process flow



1) Fish feed production process flow



2) Key points of the extrusion process

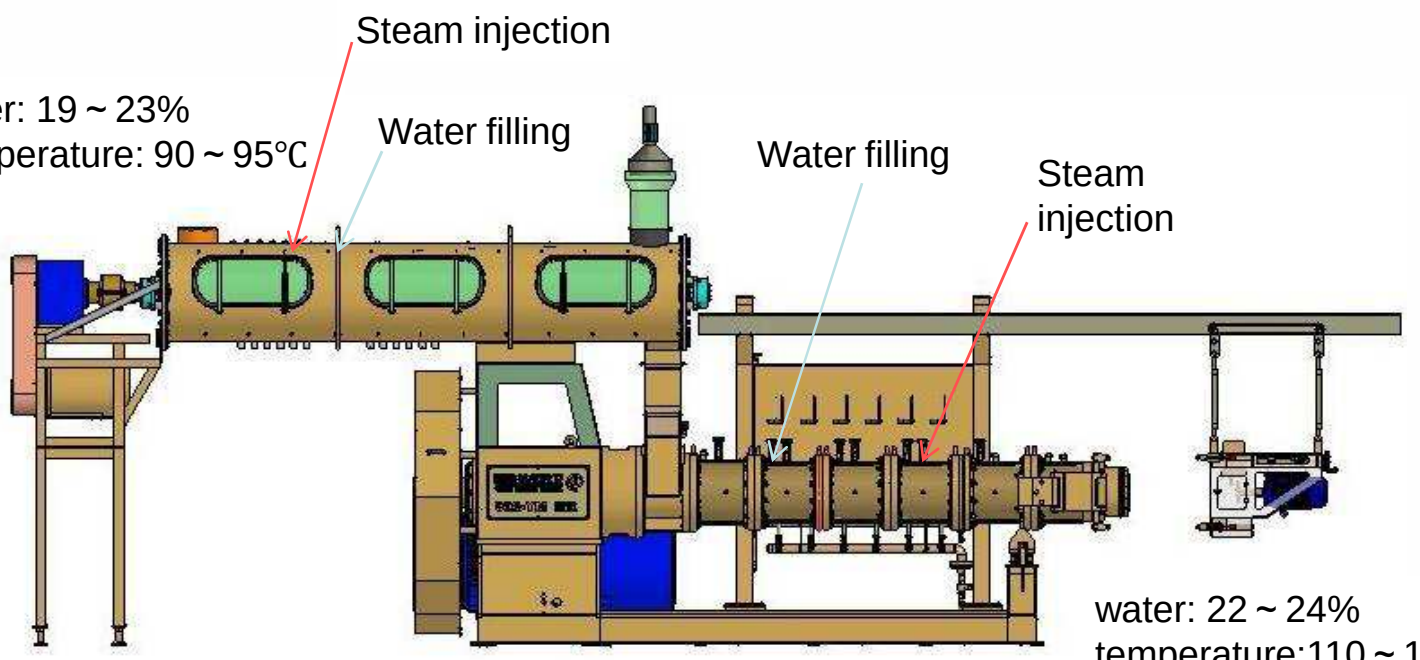
Mission:

- To increase the capacity
- To improve the quality
- To reduce the power consumption
- To enhance the lifespan of the parts

a. Functions of extrusion

- *Agglomeration*
- *Degassing*
- *Dehydration*
- *Gelatinization*
- *Grinding*
- *Homogenization*
- *Mixing*
- *Pasteurization and sterilization*
- *Protein denaturization*
- *Shaping and sizing*
- *Shearing*
- *Texture alteration*
- *Thermal cooking*

b. General technical parameters



c. Bulk density correlation with float-sink properties for aqua-feed

Feed characteristics	Sea water - 20℃ (3% salinity)	Fresh water - 20℃
Fast-sinking	> 640 g/l	> 600 g/l
Slow-sinking	580-600 g/l	540-560 g/l
Neutral buoyancy	520-540 g/l	480-500 g/l
floating	< 480 g/l	< 440 g/l

d. Process parameters for aqua feed production

Parameters	Floating fish feed	Sinking fish feed	Slow sinking
Temperature prior to die discharging	125-135 ℃	110-125℃	115-130℃
Moisture prior to die discharging	22-26%	25-32%	24-28%
Moisture of extruded product	21-24%	24-27%	22-26%
Pressure of discharging barrel	34-37 atmos	20-29 atmos	30-35 atmos

e. Methods for controlling the density of extruded aquafeed

- Regulating the starch content in feed formula:
  floating aquafeed,
  - > 20% for pellet Ø 1.0 mm
  - > 12% for pellet above Ø 3.0 mm

  sinking aquafeed ≥ 10%

- Adjusting the open area of discharging die plate:
  floating aquafeed: 200 ~ 250 mm^2/t/h
  sinking aquafeed: 550 ~ 600 mm^2/t/h

- Increasing oil added
  When the oil addition is between 12% ~ 22%, the feed density will be increased proportionally with the increasing of oil addition.

- Properly reducing screw rotating speed.

f. Conditioning time and temperature required

Category	Pre Conditioning time	Pre Conditioning Temperature
Floating feed	90-120 S	95-105℃
Sinking feed	90-120 S	85-95℃
Shrimp feed	150-180 S	93-95℃

Aquafeed Extrusion Technology

1. Typical process of fish feed line in China

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3. Common problems in aquafeed extrusion & analysis

III. Muyang Single Screw Extruder

IV. Muyang Twin Screw Extruder

Improvement of Muyang single screw extruder

1). Preconditioner

a. **Single paddle conditioner**
b. **2-pass paddle conditioner**
c. **Double shaft different speed conditioner**
d. **Complex conditioner**

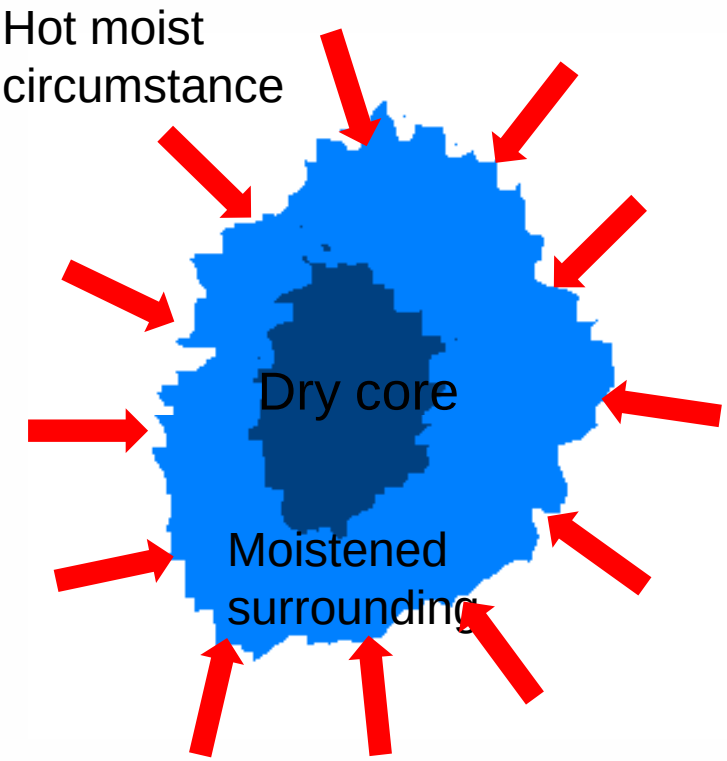
2). Extrusion elements improvement

3). Sinking feed process method

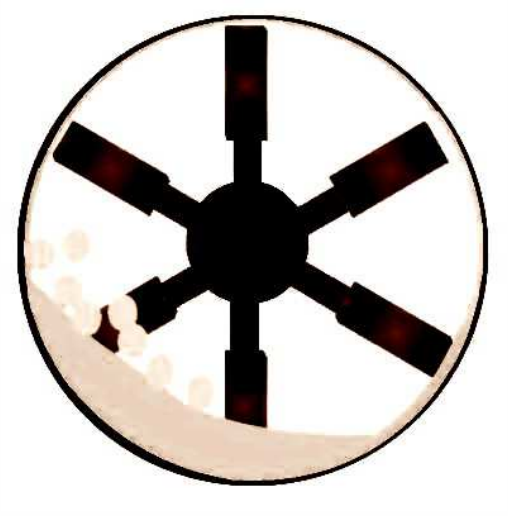
4). Muyang single screw extruder category

1) Preconditioner

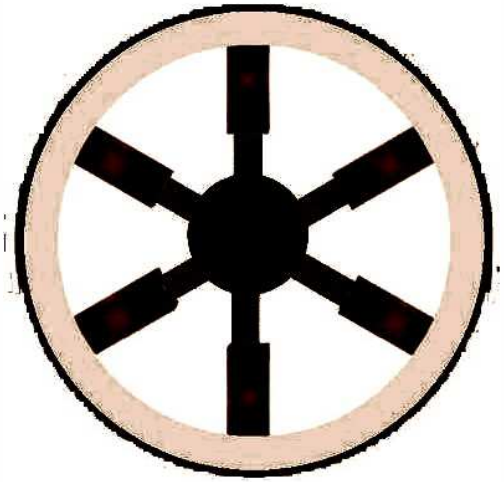
1. The objective of preconditioning is to completely moisten raw material particles, eliminating the dry core
2. High temperature to pre-gelatinize the raw material
3. Complete mixing of steam and raw material to keep stable quality



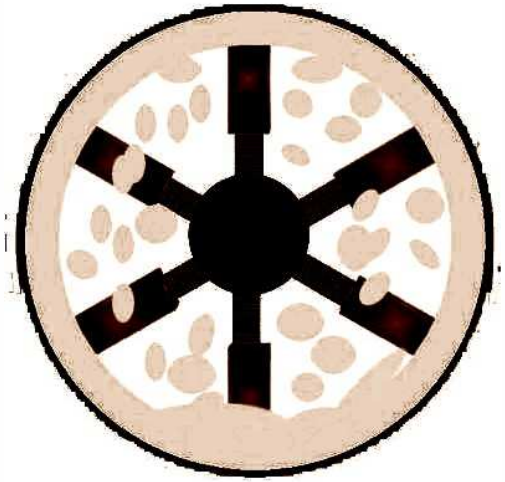
a) Single-cylinder conditioner



✘ low rotating speed



✘ too high rotating speed



✓ correct rotating speed

So the right linear speed of the conditioner paddle should be 220-250 rpm (say MUTZ 600 conditioner for fresh water fish feed production)

b) Two-pass single-cylinder conditioner

✓ high speed mixing

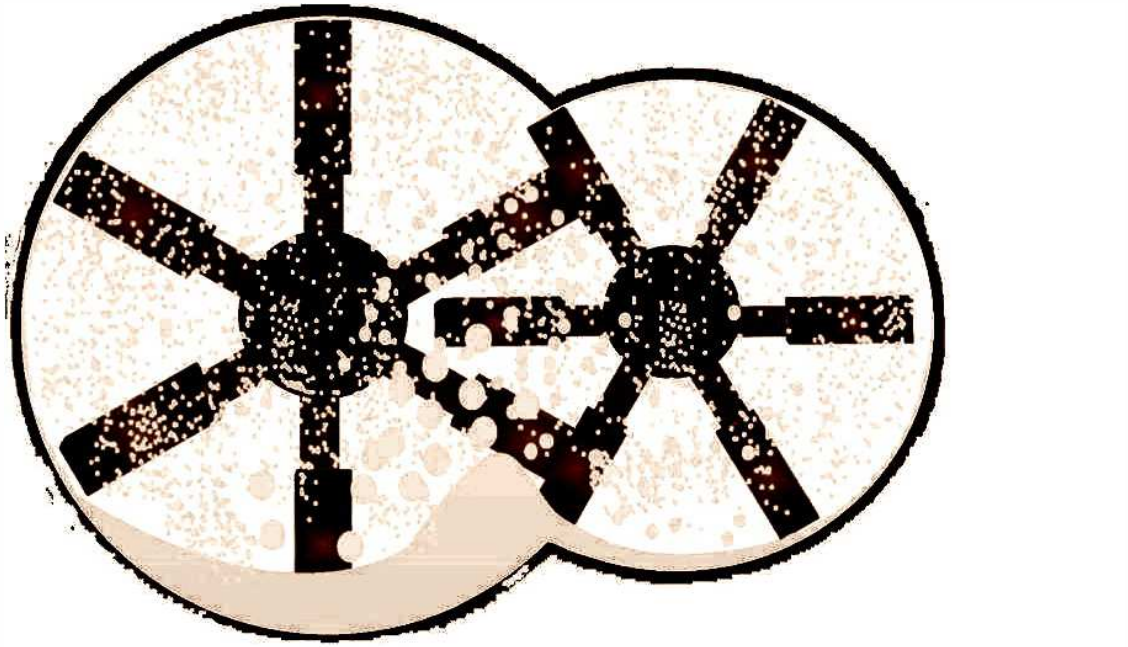
Low speed heat preservation

Contradictories for heat conservation in the second pass:

✓To increase fill rate, rotating speed must be reduced;

✓To improve mixing homogeneity, rotating speed must be increased.

c) Double-shaft Differential Conditioner (DDC)

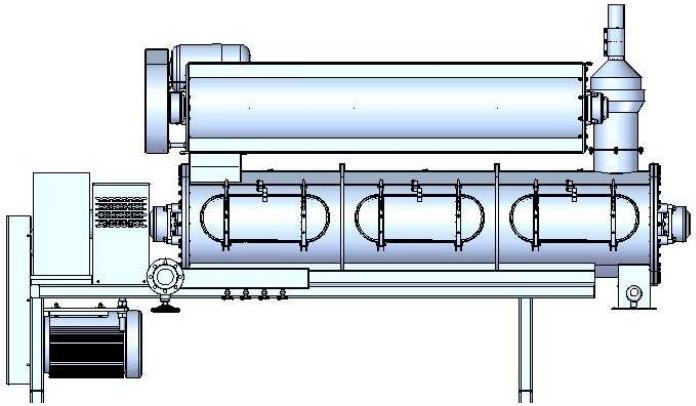


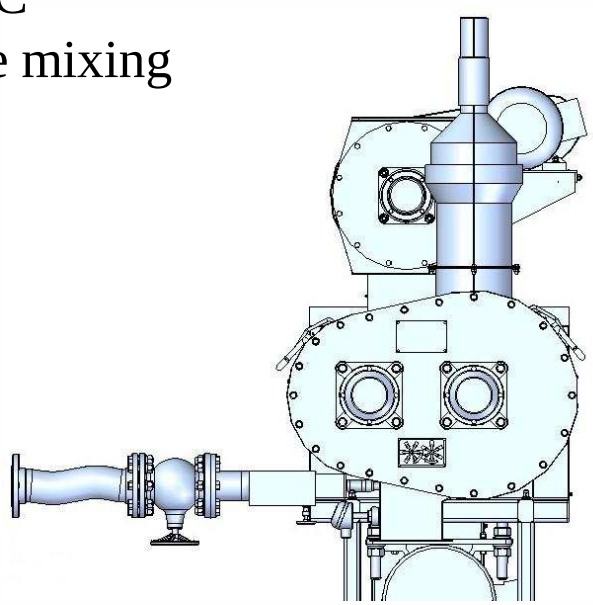
- Mixing can be well done by a DDC.

d) SPTZ The conditioning result of SPTZ series tri-shaft series Complex conditioner

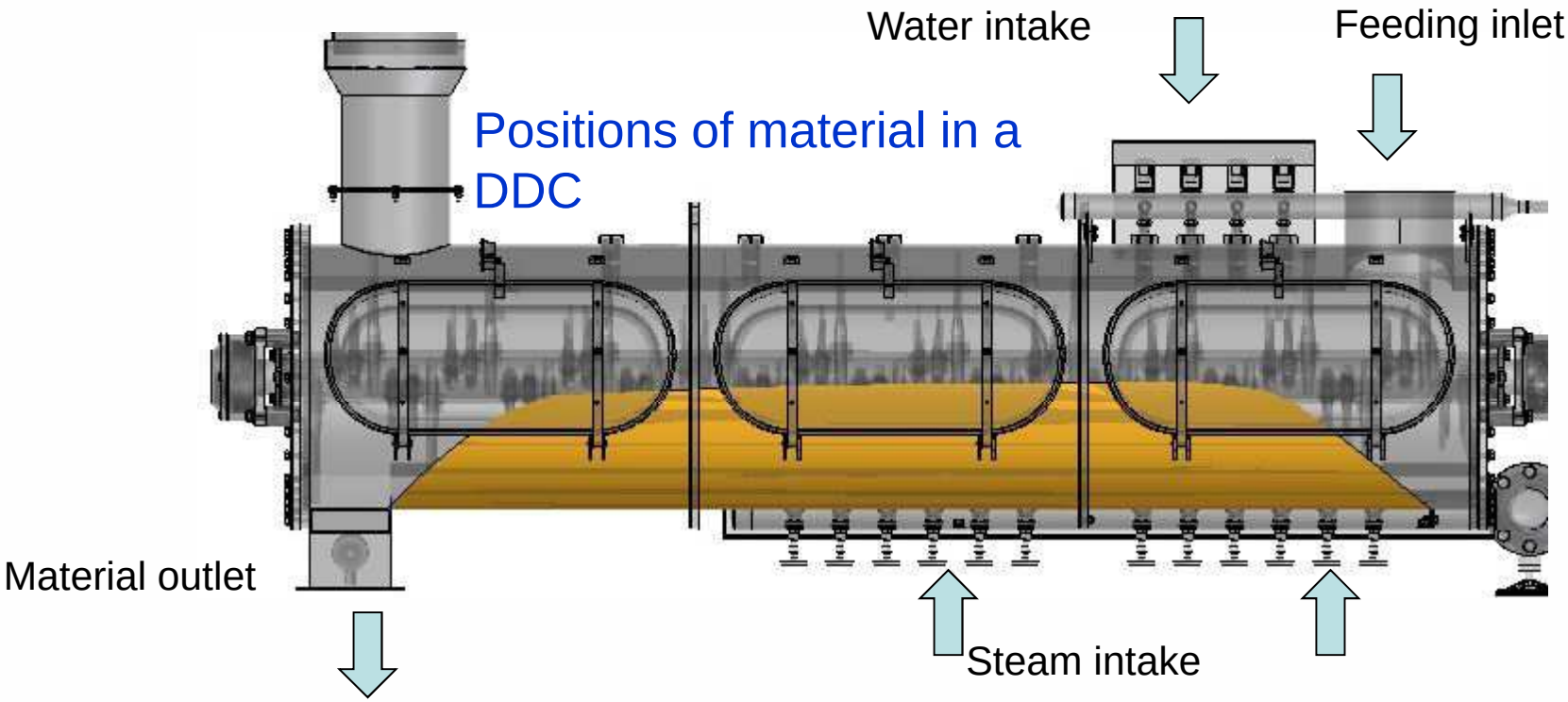
conditioner is superior than that of the forementioned 3 types of conditioner.

- Intensified mixing function of the single-cylinder conditioner for water, steam and mash;
- Through adjusting the paddles, fill rate of the DDC increased, conditioning time extended, meanwhile mixing function is also performed.





e) Comparison of DDC and Tri-Shaft conditioners



- Increased fill rate→prolonged conditioning time→improved material gelatinization →increased production rate of extruder
- **Can we further increase the fill rate through adjusting paddles on the present conditions?**

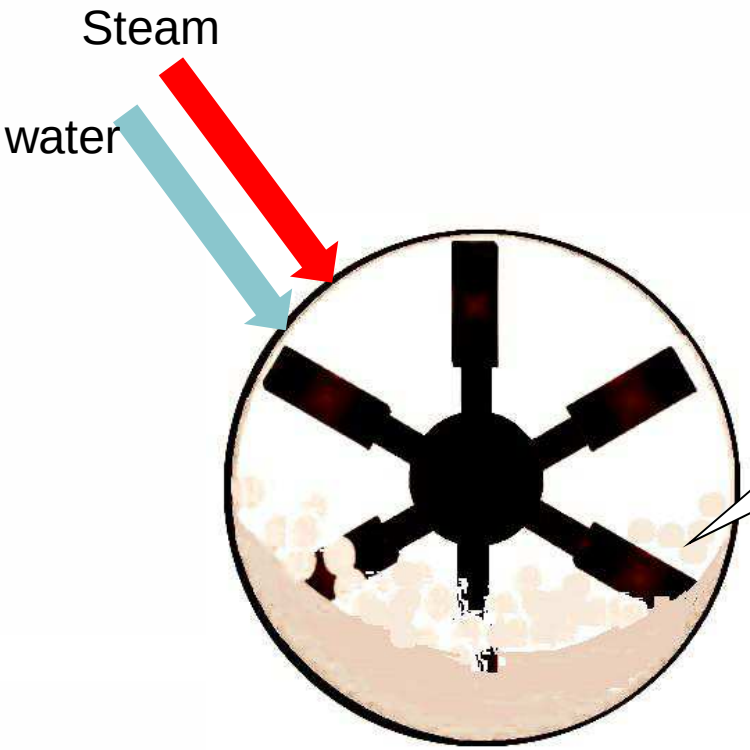
Existing DDC

The existing DDC can not be more filled, otherwise the mixing of mash material with water and steam will become worse!

Complex conditioner

Upper pass：single cylinder conditioner

(addition of water and steam)



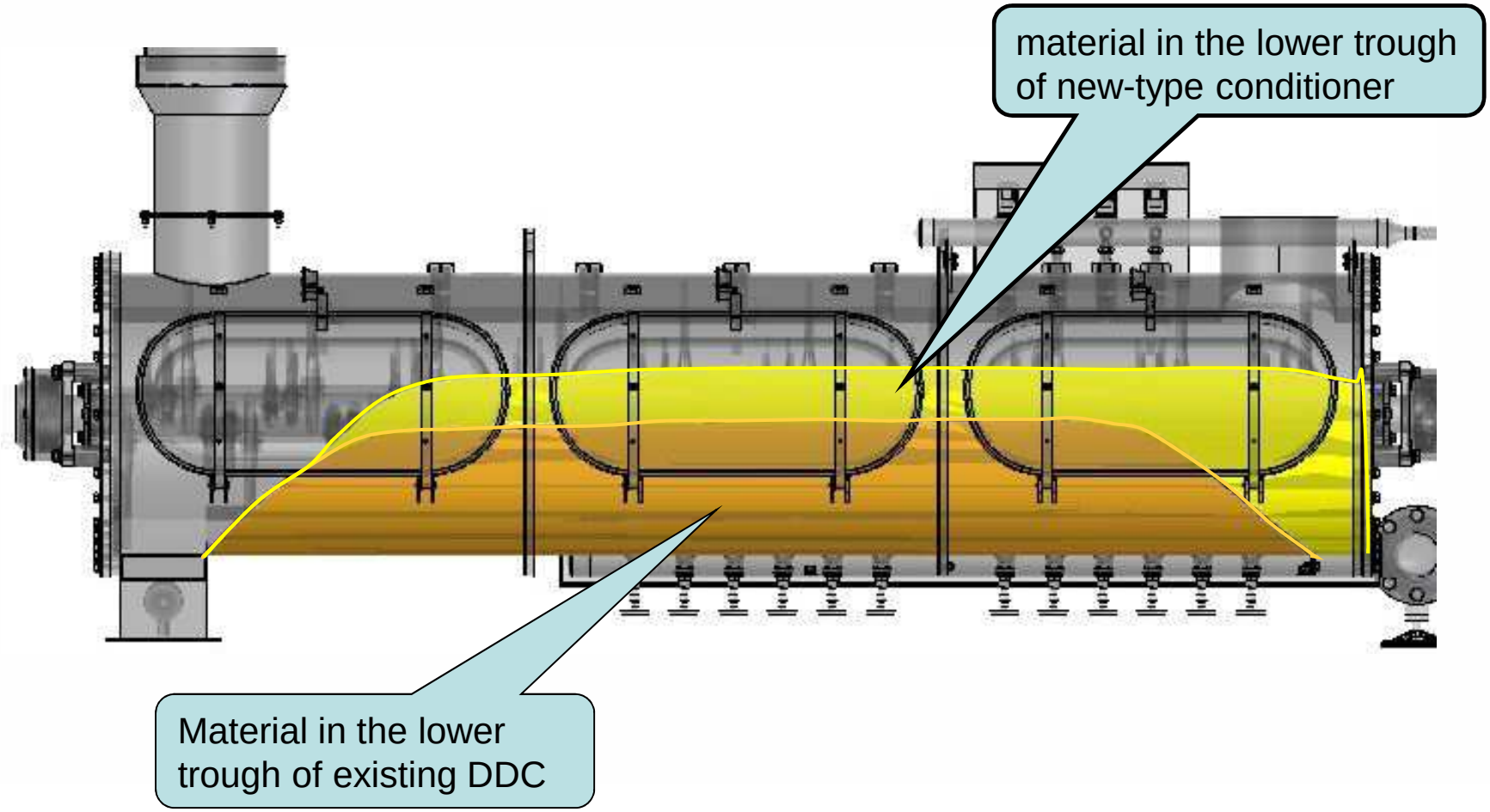
Fill rate of the material in a single cylinder conditioner:**40-45%** ;

The fill rate over **40-45%** shall impact the penetration effect of water and steam. 。

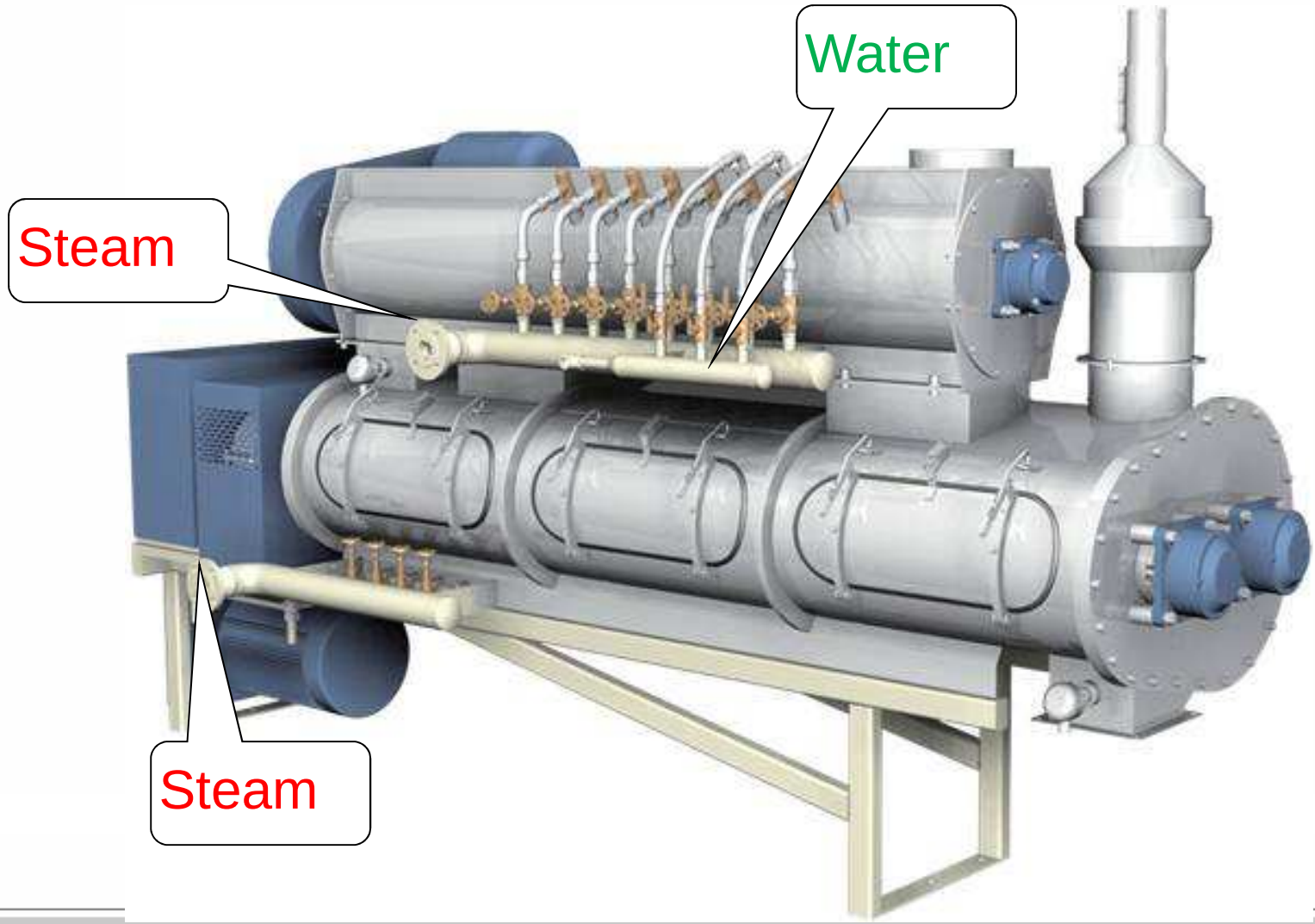
Complex conditioner

The lower trough of SPTZ series conditioner can be further filled with more material.

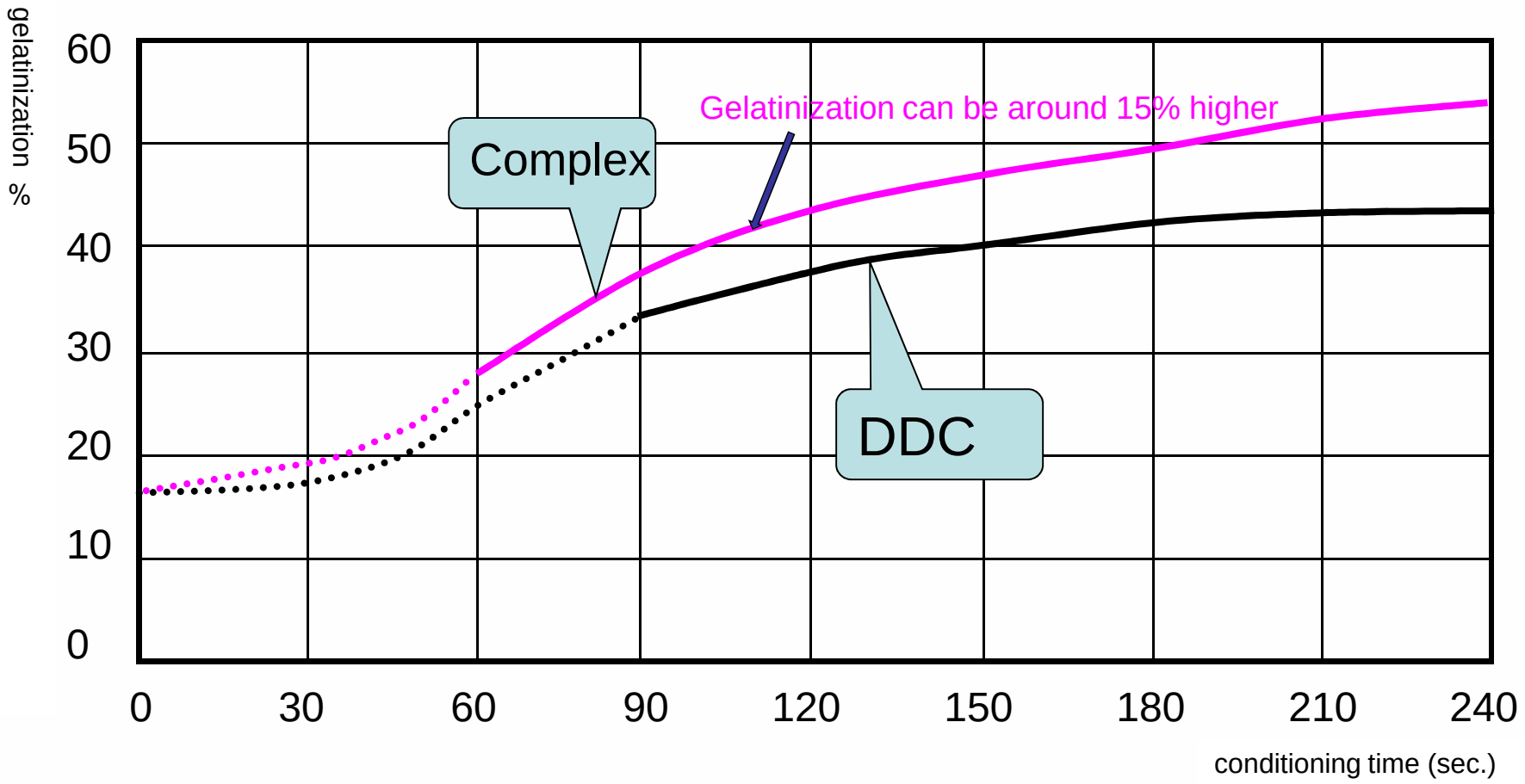
Filling level comparison



Mainly put in water and steam on upper pass



Comparison of gelatinization



Note: fresh water fish formulation, conditioner temperature 98 ℃, conditioning water 24%.

f) Determination of conditioning time

- Accurate determination method:

$$t = \frac{A}{S} \times 3600$$

In which: t = conditioning time, s

A = the amount of material filled in the conditioner, kg

S = material flow rate, kg/h

g) Conditioning time with different conditioner

Category	Conditioning time (s)	Temperature (℃)	Moistrue (s)	Gelatinization (%)
2 pass single MUTZ-600x2J	82	98	24	38.1
DDC SCTZ33	125	98	24	47.2
Complex conditioner SPTZ33	175	98	24	54.5

* Same capacity as for 6 t/h floating fish feed

Part 2

Full-fat Soybean Extrusion Technology

Producing expanded soybean with a raw material extruder

- ✓ Machine type ：TPH200
- ✓ Throughput ：3.0～3.5 T/h
- ✓ Urase ：$U_A \leq 0.2$

Producing expanded soybean with a raw material extruder

- ✓Machine type：TPH260
- ✓Throughput：6.0～7.0 T/h
- ✓ Urase：U_A≤0.2

FQAs that expanded soybean manufacturers always concern about

1.1 Extruding soybean with steam or without steam

1.2 How to control the urase activity of the extruded soybean

1.3 How to detect the urase in expanded soybean quickly

1.4 Are there any other issues we must be pay attention to when extruding soybean

1.1 Extruding soybean

With steam

or

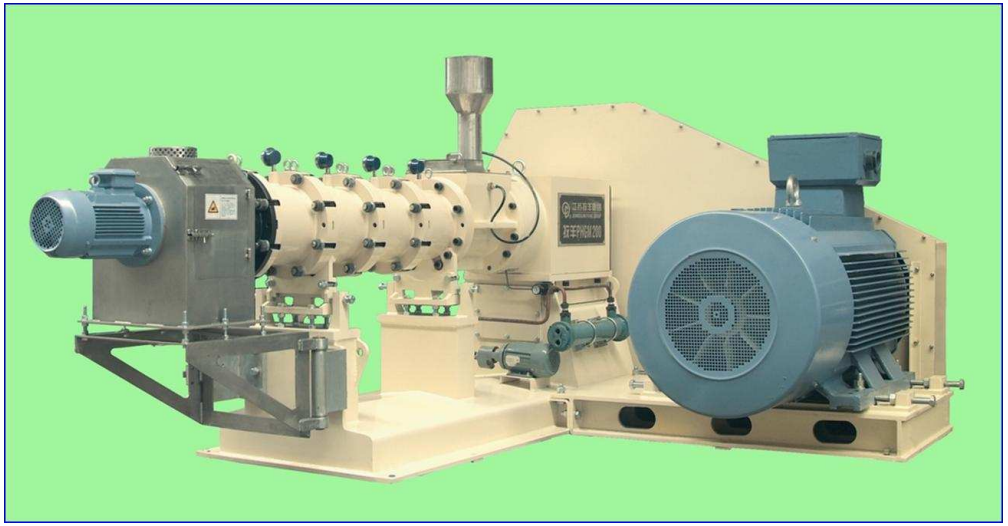
Without steam

With Steam Extrusion

- ✓ First pre-ripen the materials with steam in the conditioner then further ripen the materials by extruding them in the extruder.
- ✓ The extruding in the extruder is a gentle one.
- ✓ Energy that make material ripeness：specific thermal energy (STE), specific mechanical energy SME

Without steam extrusion

- The materials are directly ripened in the extruder without pre-ripening with steam in the conditioner ;
- Material ripened mostly by the Specific Mechanical Energy (SME during extruding.



Comparison of Without steam Extrusion and With steam Extrusion

No.	Methods	Throughput	Max. temperature	Color	Smell	Protein solubility
1	Without steam extrusion	Slightly Lower	150 ~ 160	Super good	Super good	Low
2	With steam extrusion	Slightly Higher	130 ~ 145	Good	Good	High

Evaluation standard for expanded soybean

- ✓ Is it ripe ?
- ✓ Is it overripe ?

Two indexes must be considered when extruding soybean

- Urase activity：the index used for evaluating soybean ripeness；
  Standard 1：0.1 < UA < 0.2
  Standard 2：0.04 < UA < 0.1

- Protein solubility：the index for evaluating soybean overripe status。
  Low standard：C ≥60%
  High standard：C ≥75%

ra e a t ty ea ur ng et o : G Method for the determination of urase activity in soybean products
rote n o u ty ea ur ng et o : ota u y ro e o u ty Met o

The conditioner with good conditioning efficiency can help in increasing the expanded soybean protein solubility

Conditioner volume	V	1.5V	2.4V	2.8V
Urase activity	0.1~0.15			
Protein solubility	60~65%	65~70%	73~75%	78~82%

- ✓ • Measurement for urase activity：GB/T 8622 Method for the determination of urase activity in soybean products
- • Measurement for protein solubility：potassium hydroxide solubility method
- ✓ • Laboratory machine: TPH200 extruder
- ✓ • Conditioner: MUTZ350, MUTZ350J, MUTZ420, MUTZ420JC
- ✓ • Conditioning temperature: 90℃
- ✓

Summary

- Extruding soybean with steam is the best choice

- ✓ Only wet-extrusion can guarantee no nutritional ingredients “burned” during extruding. ;
- ✓ Conditioning with steam can not only increase the output per unit time but also the strength in destroying anti-nutritional factors, which will further enhance the nutritive value of soybean mash;

- The soybean protein solubility can only be improved just by maximizing the conditioning efficiency.

1.2 How to control soybean urase activity?

How to control soybean urase activity

1.2.1 To control urase activity by adjusting SME ;

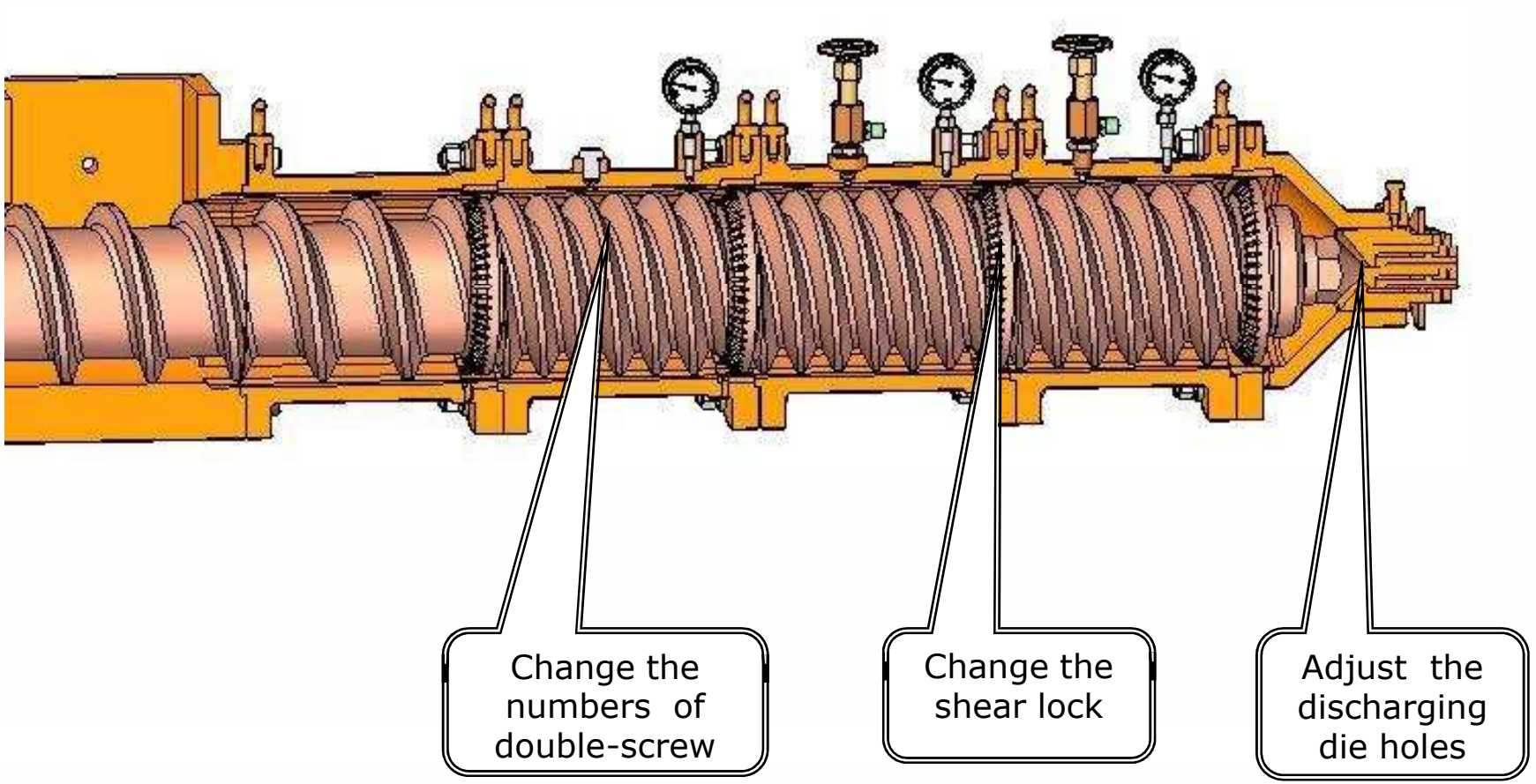
1.2.2 To control urase activity by adjusting technical parameters during production ;

1.2.3 To control urase activity by installing and using the steam pipeline correctly ;

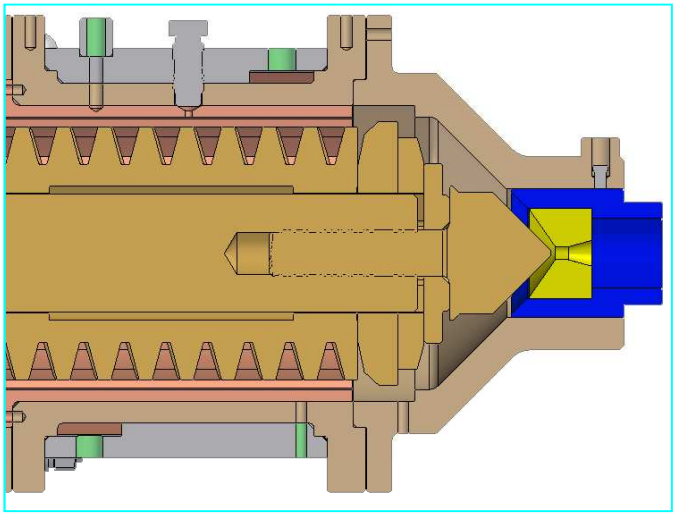
1.2.4 How to improve the soybean unrase activity effectively at the beginning of starting up an extrusion ;

1.2.5 A new method of improving production capacity while reducing the urase activity.

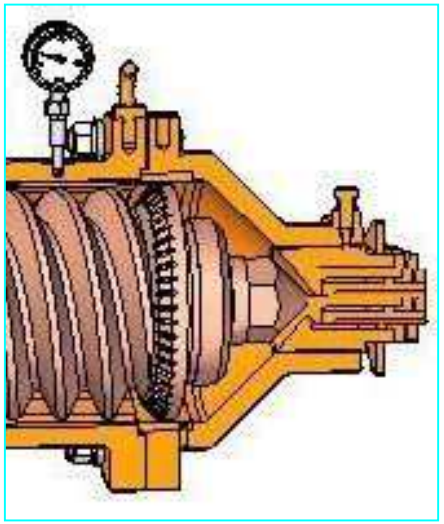
1.2.1 To control urase activity by adjusting SME



Change the discharging die

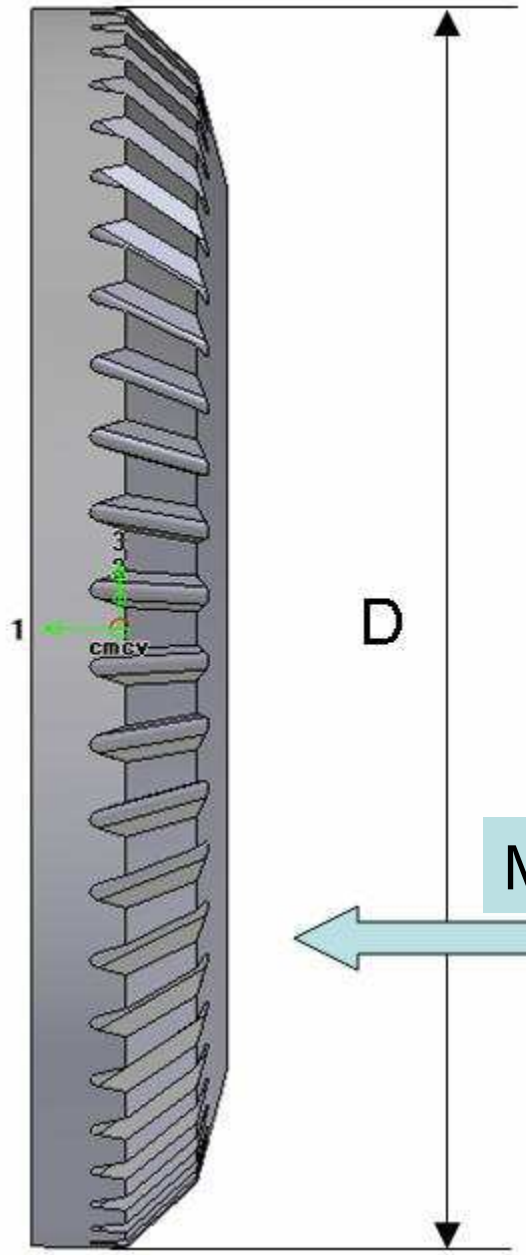


The old discharging die



The new discharging die
Muyang patent

- The new discharging die which the die holes are adjustable during production :
- ✓ is more convenient in controlling urase activity ;
- ✓ can eliminate machine blockage problem caused by error operating.



Change the shear lock with different diameter so as to adjust SME

Mash flow

Shear lock
Steam Lock

1.2.2 To control urase activity by adjusting technical parameters during production

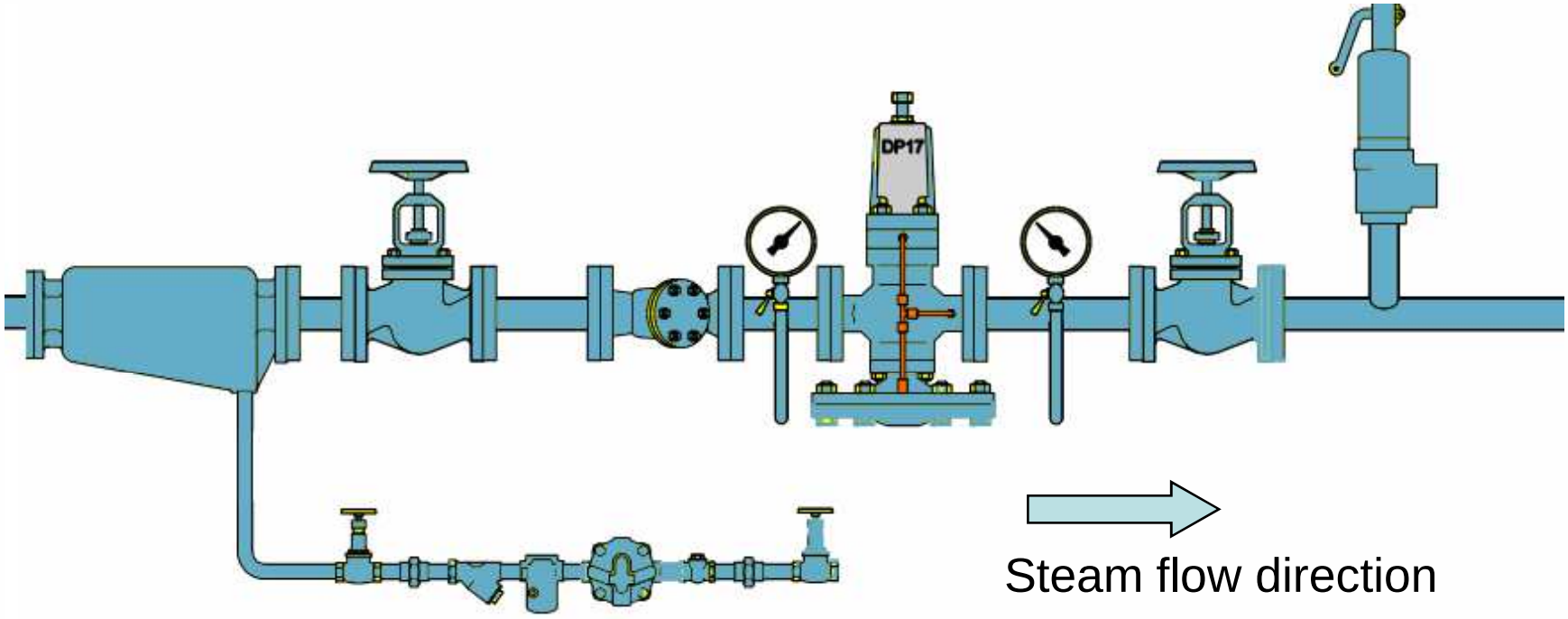
- Controllable parameters：
  - ✓ Feeding rate of soybean mash ；
  - ✓ Steam adding rate under the max. conditioning temperature ；
  - ✓ Steam pressure-relief valve：upstream pressure, downstream pressure ；
- Observable parameters：
  - ✓ Temperature of each barrel section：which is related to the configured screws and shear locks of the extruder ；
  - ✓ Discharging temperature.

1.2.3 To control urase activity by installing and using the steam pipeline correctly

- Good pipeline design can remove the un-wanted moisture in the steam pipeline so as to improve conditioning efficiency ;

- Steam pressure :
  - ✓ Upstream stream pressure > 0.6MPa (6bar)
  - ✓ Steam pressure for conditioning : 0.15 ~ 0.25MPa (1.5 ~ 2.5bar)

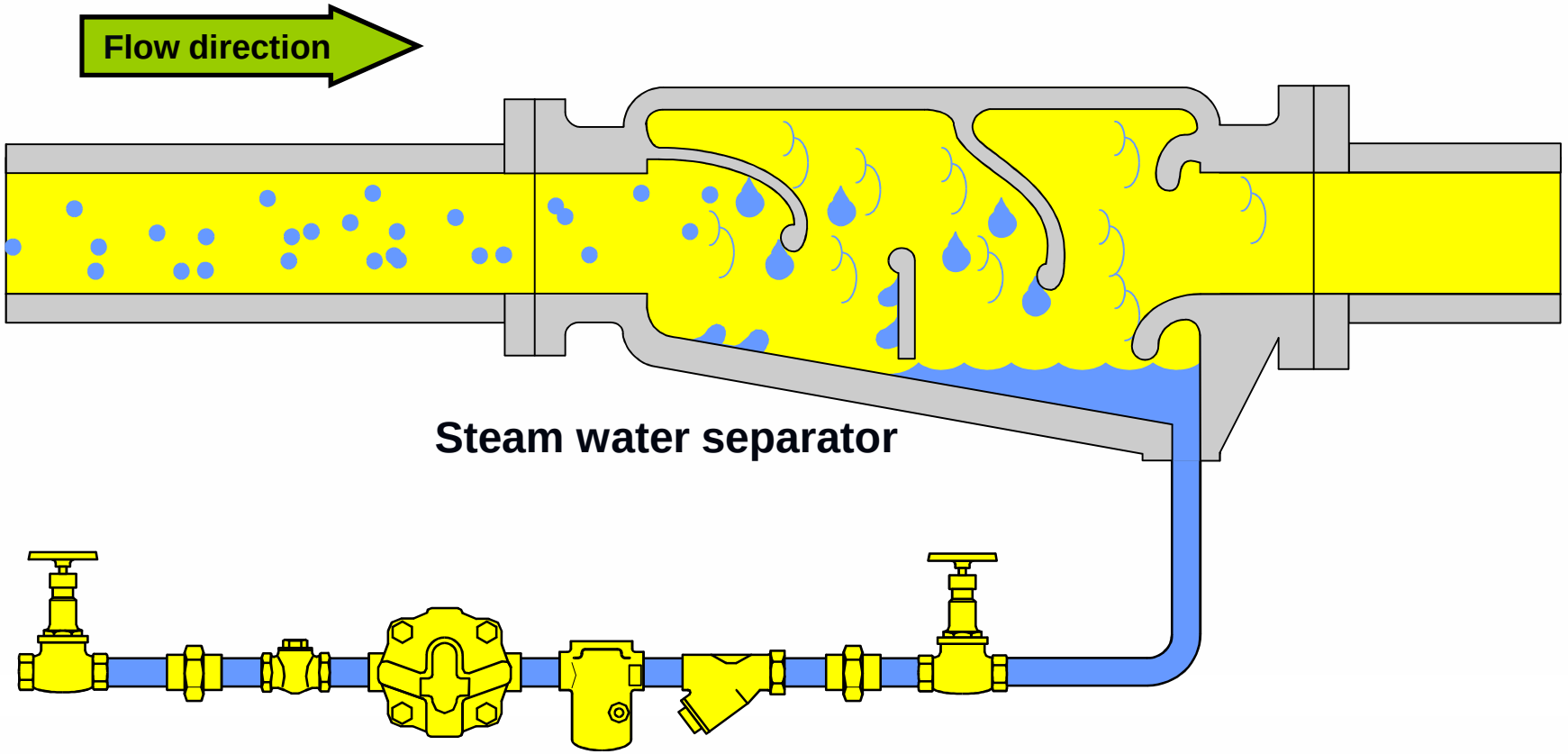
Recommended steam pipeline



1 steam-water separator 2 cut-off valve 3 filter
4 pressure gauge 5 pressure-relief valve 6 safety valve
7 steam trap

Use of a steam water separator

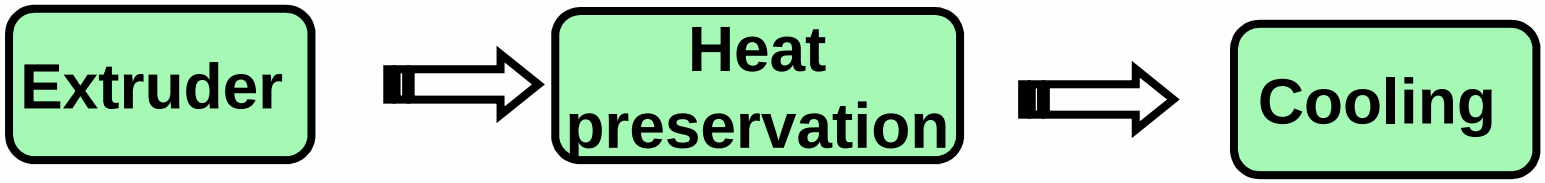
Which can effectively reduce water contained in steam flow and provide high quality steam for steam using equipments



1.2.4 How to improve the soybean unrase activity effectively at the beginning of starting up an extrusion?

- Pre-heat the principal machine：preheating temperature and preheating time ；
- Steam：applied only after draining out water, and please note the temperature difference between the start-up and stabilized running of the machine；
- After the extrudates begin to be discharged out of the barrel：gradually increase the feeding rate, adjust the die holes to a small diameter and then increase the pressure of the extruding chamber.

1.2.5 A new method of improving production capacity while reducing the urase activity



Discharging temperature: 80～85℃

Appropriate time

- Keep the materials stating in the heat preservation equipment for five minutes to finish final ripeness;
- The materials in the heat preservation equipment should be keep in the order of “FIFO” ;
- Throughput can be increased by 30～50%。

1.3 Fast methods for detecting urase during production

Conventional methods for detecting urase activity

- pH value-added method：
- ✓ The measured pH value of the soybean urase activity defined by the China Feed Standard is： < 0.2　The old standard is: < 0.4

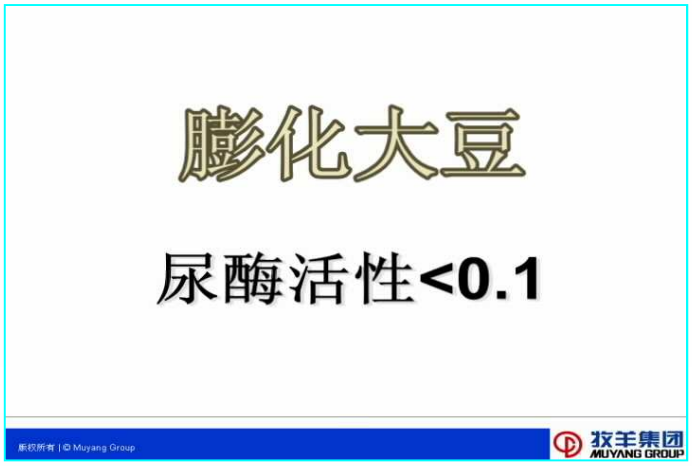
- Phenol red method：
- ✓ Examine the urase activity by qualitative detection.
- ✓ Can make an initial determination about whether the urase activity qualified or not in a short time.

Relationship between phenol red method *qualitativ detection)* and pH value-added method *quantitative detection*

Sample	1	2	3	4	5	6
Phenol red method min	5	10	15	20	30	40
pH value-added method	0.4	0.1 ~ 0.15	0.08 ~ 0.12	0.06 ~ 0.1	0.03 ~ 0.05	0.01 ~ 0.02

- Adopt phenol red method for qualitative detection and pH value-added method for quantitative detection ;
- *Qualitative detection* in the above table indicates the time that 10~15% expanded soybean mash take to turn red by adopting phenol red method to detect soybean urase;
- *Quantitative detection* in the above table indicates adopting pH value-added method to detect urase activity ;
- Test sample：expanded soybean that have been discharged out barrel within one hour.

Determine expanded soybean urase activity base on experience



$0.2 > U_A > 0.1$

1.4 Other relevant matters that should be concerned when producing expanded soybean

The soybean mash to be extruded should have an appropriate granularity

- Too coarse soybean mash：

✓ Too coarse soybean mash will result in insufficient conditioning which will cause hard friction when the soybean mash go into the extruder chamber, and then the temperature will rise up rapidly, the protein solubility will be reduced thereby.

- Too fine soybean mash：

✓ Too fine soybean mash is apt to slide in the extruder chamber, so that the shear effect generated by the screw to shear materials will be minimized, which will result in further decrease in the urase activity. And also it is easy to result in regurgitation problem and make the machine to be stopped.

✓ When extruding fine soybean mash with a worn screw and worn shear locks, it will be easy to result in regurgitation and blockage problems.

- Generally, expanded soybean is ground by a hammer mill with a 2.5～3.0 mm screen. However, there are also some feed mills that produce expanded soybean with a 1.5mm screen.

Post treatment for the expanded soybean

- After extruding the temperature of expanded soybean mash is usually 80～85℃；
- Cooling is needed. If the expanded soybean have not be cooled down for a long time, it will be browned and part of the expanded soybean will be overripe, and the protein deteriorated which will influence the availability as well as the palatability of the product；
- After extruding with steam, the product is of high moisture content, which in the cooling process will be taken off, then the product will finally obtain a safety moisture content for storage.

THANKS FOR YOUR TIME

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