Keda Suremaker, Maanshan City, Anhui Province, China

Research on heat consumption in the production of B05 grade AAC products

In accordance with its mission “Green Solution, Greener Life”, Keda Suremaker is permanently focusing on environmental protection and energy conservation issues. In order to investigate its practices to this effect, Keda Suremaker decided to analyze its heat consumption figures pertaining to AAC products to determine possible methods of heat loss reduction during the production process of AAC and correspondingly lower atmospheric carbon emission as much as possible.

The calculation of the autoclaved heat balance that this article addresses is based on data obtained from a Keda Suremaker AAC block production line with the following features:
Annual block production capacity: 300,000 m³;
Mould size: 6 × 1.2 × 0.6 m; 4,32 m³
Autoclave specification Φ 2.68 × 38 m;
Final product: B05 grade block;
Good quality product rate: 100 %.

Recipe design

Other production data: The water/solid ratio is at 0.60 and the total water content of green cake amounts to 21,489 kg/autoclave. When 2 % moisture is volatilized during pre-curing, the real water content of green cake is 21,059 kg/autoclave. The theoretical crystal water content is at 48.31 kg/m³ whereas total crystal water is at 3,121 kg/autoclave. The water content of white cake is at 38 %, and the total water content of white cake at 14,804 kg/autoclave. The volatile water content in the pore structure of the cake is 3,134 kg/autoclave. Actual dry density is 501 kg/m³.

Autoclaving

Autoclave curing system:

- Vacuuming: 45 min (0 ~ -0.06 MPa)
- Pressure up (heating period): 150 min
- Constant pressure: 360 min (1.2 MPa)
- Pressure down: 90 min (1.2 ~ 0 MPa)
- Saturation temperature: 187.96 °C
- Discharge of condensate water: 8,000 kg/autoclave
- Initial temperature of autoclave: 70 °C;
- The temperature of autoclave after vacuum extraction: 50 °C
- Initial autoclaving car temperature: 20 °C
- Initial autoclaving bottom plate temperature: 30 °C
- Initial cake temperature into autoclave: 80 °C
- Workshop ambient average temperature: 20 °C
- External autoclave insulation layer surface temperature at constant temperature stage: 25 °C.

Table 1: B05 Product recipe (equivalent to European PP4-0,50 AAC)

Raw material	Containing waste slurry [%]	Without waste slurry [%]	With waste slurry feed [kg/module]	Without waste slurry feed [kg/module]
Quartz sand	49.02	60	1,174	1,174
Lime	18.04	22.1	432	432
Cement	12.17	14.9	291	291
Gypsum	2.46	3	59	59
Waste slurry	18.31	—	439	—
Total	100	100	2,395	1,956

Table 2: Heat balance table

		Expenditure item		Income item		
Number	Project content	Enthalpy/kJ	Proportion/%	Steam volume/kg	Enthalpy/kJ	Proportion /%
1	Energy consumption for heating of dry material	3,208,635	10.60	1,617	4,499,725	14.86
	Energy consumption for product moisture heating	9,518,770	31.44	4,797	13,348,930	44.10
2	Thereof: Energy consumption for crystalline water heating	1,410,648	4.66	711	1,978,265	6.54
3	Energy consumption for autoclave heating	4,828,324	15.95	2,433	6,771,144	22.37
4	Energy consumption for autoclave curing car heating	510,481	1.69	257	715,888	2.36
5	Energy consumption for curing plate heating	1,636,663	5.41	825	2,295,223	7.59
6	Energy consumption for heating and vacuum extraction of residual air in autoclave	7,716	0.03	4	10,821	0.04
7	Enthalpy of heat dissipated in surrounding medium during pressure up heating stage	65,561	0.22	33	91,942	0.30
8	Enthalpy of heat dissipated in surrounding medium at constant temperature stage	261,683	0.86	132	366,978	1.21
9	Enthalpy of steam filled in autoclave at maximum temperature	2,170,926	7.17	780	2,170,926	7.17
10	Enthalpy removed by condensate discharged from autoclave	6,387,440	21.10			
11	Enthalpy of condensation water stored in cake and exiting as gas	1,675,378	5.53			
Total	30,271,577	100	10,878	30,271,577	100	

Keda Suremaker analyzed the heat consumption of AAC production by conducting a study on autoclaved heat balance phenomena.

Table 3: Steam consumption during autoclaving

Autoclaving stage	Steam consumption [kg/autoclave]	Steam consumption [kg/m³]	Proportion/%
Heating stage	10,747	138.20	98.79
Constant temperature stage	132	1.70	1.21
Total	10,879	139.90	100.00

Heat balance

Technical parameters

1. Energy consumption for one autoclaving cycle: 30,271,576 kJ/m³;
2. Steam consumption for one autoclaving cycle: 10,878 kg/m³;
3. Autoclave thermal efficiency Qη: 15.26 %;
4. Heat consumption per product unit: 389,295 kJ/m³;
5. Steam consumption per product unit: 140 kg/m³;
6. Units of product coal consumption: If the calorific value of each kilogram of coal is 5,000 kcal/kg, i. e. the equivalent of 20,934 kJ/kg, and the thermal boiler efficiency (including pipeline loss) is 80 %, then: G (coal consumption) = (389,295/20,934)/0.8 = 23.25 kg/m³.

Remarks

- The utilization of waste steam and condensate water is not considered in this balance calculation. If appropriate methods are employed, product heat consumption can be reduced.
- The energy consumption of slurry heating and/or external water heating and pre-curing kiln before autoclaving has not been considered. This increases product heat consumption.
- According to this balance calculation, the good quality product rate is 100 %. Any product waste rate will increase product heat consumption.

The Keda Suremaker study on its AAC block production line of B05 grade products indicates the following in terms of energy saving from the perspective of the autoclave heat balance:

(1) Energy consumption for different dry densities differs when the difference of dry density is 100 kg/m³ and the difference of energy consumption is 16.5 kg steam heat (disregarding the corresponding change of product qualification rate and water / material ratio). When the dry density decreases and energy consumption of products decreases, attention must be paid to controlling the decreasing range of product qualification rate.

(2) When the difference of water-material ratio per mould is 1 %, the steam energy consumption difference is about 1 kg/m³ and energy consumption can be reduced by reducing the water-material ratio to meet the gasification requirement.

(3) To heat a B05 grade product by 1 °C, an energy consumption of 1,515.3 kJ/m³ and a steam consumption of 0.7636 kg/m³ is required. Compared with the initial cake temperature at 80 °C, the initial cake temperature at 50 °C consumes 23 kg/m³ more steam, and the initial cake temperature at 30 °C consumes 38 kg/m³ steam. From the point of view of reducing energy consumption, the static chamber in front of the kettle should be equipped. To reduce energy consumption, the heat preservation room should be considered.

(4) In the process of entering and exiting the autoclave, it is necessary to prevent the temperature in the autoclave from decreasing. When the initial temperature of the autoclave drops by 1 °C, the steam volume of the autoclave needs to be increased by 0.2268 kg/m³. Compared with the initial temperature of the autoclave at 70 °C, the increase of steam volume is 11.33 kg/m³ for the cold autoclave (set at 20 °C) and 6.8 kg/m³ for the autoclave (set at 40 °C).

(5) A comparison of two thicknesses of mineral wool as a protective autoclave layer, namely 200 mm and 100 mm, shows that in the case of the thicker insulation, the relative autoclave steam loss is about 2 kg/m³.

(6) The exhaust waste steam comprises the steam in the autoclave, the condensate stored in the cake and the excess ingredient water stored in the cake pore structure. When the exhaust steam discharge pressure decreases, the latter two are converted from a liquefied to a gaseous state. For B05 grade products, the combined heat energy of the three is equivalent to 29.25 kg/m³ steam heat energy.

(7) For B05 products, the heat of the condensation water is at 6,387,440 kJ/autoclave, that is, the heat energy of condensation water produced by each product cubic meter amounts to 29.5 kg/m³ steam heat energy. If only used to keep up the curing room temperature, thermal efficiency is about 12 %. ●