The Development and Implementation of Alcohol Plant Fan Drying Control System

Shuyu Di and Shumei Di

***Abstract*—Feed contains adequate moisture,and feed moisture is very important quality indicator in the food administrator all over the world. Based on the research on the dynamic changes and their related factors of the waterage in the various feed drying stages,this article has put forward the automati control methods and designed the automatic control system based on PLC. he development and implementation process of fan drying control system, using Step 7 programming software to control system design. it has solved many problems such as low accuracy,large damages,high cost and so on.By optimizing the design and debugging to improve the accuracy of the control system and to improve the efficiency of the drying unit,reducing the operator's operational difficulties**.

***Index Terms*—Drying control, DDGS, step 7 .**

I. Introduction

DDGS (including dry corn distiller soluble) is mainly refers to the symbiotic products that is remaining fermentation residues by low-temperature drying with the mixed fermentation of corn seed and selected yeast after producing fuel ethanol and carbon dioxide. It is the mixture of concentrating other nutrition except for diastase and sugar in the corn [1]. It includes DDS (soluble dry distiller) and DDG (dried distiller) two parts. So compared with original corn kernel about its nutritional value, it has lower starch higher protein, higher digestible fiber and higher phosphorus and many characteristics [2].

With the increasing development of technology, the automation of drying equipment is gradually increasing, alcohol industry and DDGS Production Company faces many problems such as process equipment obsolete, low productivity, pollution of the tube bundle dryer. Steam flows through the pipes, while material flows through the shell in the opposite direction. After the wet material flows into the drying machine, it is sent continuously from the bottom to the environment these problems seriously affect economic benefits of alcohol industry, so more advanced and optimized drying technology and control system is the major issues in this field [3]–[5].

II. Process

The flow chart for the fan drying control process is shown in Fig. 1, and 0.6MPa fresh steam is used as heat source for upper situation by the lifting plate, then it drops among the heat transfer tubes under the force of gravity..

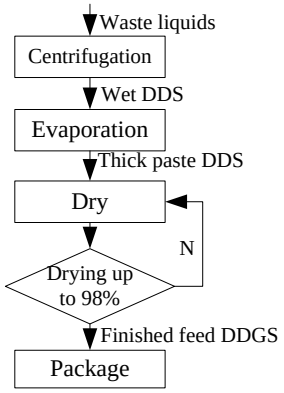

Fig. 1. Flow chart of fan drying.

Next, the material will be pushed from the inlet toward outlet by the spirally arranged feed-shovel, and finally it is sent out the drier by the outlet-board. Resident time of the material staying in the dryer should be long enough to exchange heat sufficiently with the steam in the exchanger tubes so as to evaporate water in the wet DDG. The remaining steam after evaporation will be extracted out by the centrifugal blower and sent to the evaporation procedure as supplement of the heat source. Dried feed contented in the exhausted air will be separated by a cyclone separator to be recycled. The wind speed at the exhausted outlet of drier is 5m/s, wind speed in the pipeline 28m/s, and wind speed at the inlet of cyclone separator 20m/s. The dust concentration of the discharged air into the air should be less than 120mg/m3. The clean condensate water generated in the dryer is sent back to the boiler room through the trap, and the flash steam generated by condensate water are used through the air heater to supply the hot air in the dryer and as the hot source for warm-keeping of cyclone insulation, which reduces the humidity in the air duct and avoid gas condensation of the dust in the flue entering the cyclone dust remover [6]–[11].

The thermal efficiency and drying rate are related to the amount of Wet air in the drying fan. The more is the wet air, the faster is the wind along the material surface. This situation is good to the improvement of the drying rate because air carries away moisture and heat simultaneously. In addition, high wind speed along the material surface will lead to spraying of small particle, so we need to control the win speed.

III. Design of System

A. Determine the Control Scheme

By research into the flow chart of fan drying,we determine the control scheme can be listed as follows:

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1) Control loop: respectively they are into the steam pressure loop, secondary steam temperature control loop, condensate tank level control loop, swing valve frequency control loop and the material flow control loop.
2) Interlocking control: main dryers interlocking control, preheating to the dryers. While preheating open the condensate discharge bypass valve; the preheating time is not less than 60 minutes, while preheating the working pressure is not higher than 0.6Mpa, start the dryer at the same time start the automatic oil supply system, start the feed auger and exhaust fan, mixer, discharge auger, interlocking anti-feed auger and control[12].
3) Adjust the feeding quantity, back to feeding quantity, addition of concentrated slurry to the specified value, adjust into the steam and volume of gas extracted, control the water of dry feed within the scope of the provisions.
4) Shutdown feed auger, back to the feed auger, mixing device, when the material is all discharged, close the inlet valve, open condensate discharge bypass valve. After stopping the materials and steam, dryer and exhaust fan continue to run, when exhaust gas temperature reduced to below 50 ℃, stop the exhaust fan, if there is no condensate to discharge, stop the dryer.

B. Hardware Configuration

According to the control program, it requires the following configuration, and calculates module power consumption, they can be listed as follows:

TABLE I: CONTROL SYSTEM HARDWARE

Template	Specification	Quantity	current drawn from backplane bus (mA)	current drawn from power supply (mA)
CPU Template	CPU 315-2/DP	1		800
Analog Input	SM331 4AI	1	50	200
Analog Input	SM331 8AI	2	60	50
Analog Output	SM331 4AO	2	60	240
Digital Input	SM32116×24DV	1	100	0
Digital Output	SM32232×24DV	1	110	160
Total		9	500	1740

Table I Control system hardware Power consumption of all templates:

$$24\ W\times 0.8\ W+1\ W\times 1+1.5\ W\times 2+3\ W\times 2+1.5\ W\times 1+6.6\ W\times 1=37.3W$$

CPU 315 can provide maximum current 1.2A. The total current the template draws from backplane bus is 0.5A, it does not exceed the maximum current 1.2A that the CPU provides; the current every template drawn from power supply is 1.74A, in consideration of the 20% to 30% margin, so the total power consumption of the system is 55.3w.

C. Design of Frequency Converter

The safety of liquid alcohol must be ensured in drying process of DDGS and over-temperature phenomenon, even if short-term, is not allowed. Because the power of the drier is very high, the cost will be high if direct speed governor is used, so that control algorithm for fans of transporting equipment which surrounds the drier using frequency converter. This strategy can not only ensure the safety of Ethanol, but also be convenient to the centralized control of the production line, so as to achieve the purpose of energy saving.

Control scheme diagram is shown in Fig. 2 the steam temperature signal is converted to 4~20mA analog signal firstly by the temperature transmitter and then is collected into the PLC by the PLC analog module. Thirdly, the signal is converted into a digital signal and ERROR e is obtained by subtracting with the temperature set value (which can be set through the PC or HMI). Fourthly, ERROR e is used for proportional, integral, differential operation and the operation result (digital signal) is converted into analog signal by the analog output module. This standard electrical signal is the input signal of the frequency converter and is used to control the output frequency of the converter in order to control the fan speed. The fan speed will be revised by the inlet temperature when it deviates from the set value, thus closed-loop control of inlet steam temperature for the dryer is obtained [13]–[15].

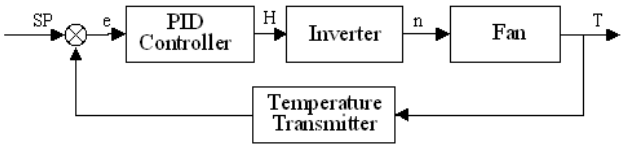

Fig. 2. Block diagram of converter PID closed-loop control the meaning of symbols in the Fig. 2 is as follows: SP－temperature setting; T—steam temperature; h－frequency signal; e－Deviation；n—fan speed

The realization of the control scheme is achieved by using one frequency converter to control the soft starting and soft stopping of three fans (see the dryer electrical control main circuit Fig. 3(a). QF1A~D are air switches with power frequency for the converter and three motors, namely, M1 to M3. The power of three-phase motor is 180kW. Normally-closed thermal relay FR1~3 are used to protect the motor from overloading. KM1A ~ KM3A are AC contactors and used to control the M1~M3's running. Each of the three fans has two driving mode, that is, power frequency and converting frequency which has the functions of power frequency starting, power frequency stop, and converting frequency soft-start, converting frequency stop. The electrical circuit for power frequency and converting frequency starting should comply with conditions as follows: power frequency and converting frequency starting should have double protection, that is, mechanical interlocking and logic interlock; The output of converter cab only control a fan at a time in order to prevent system from anti

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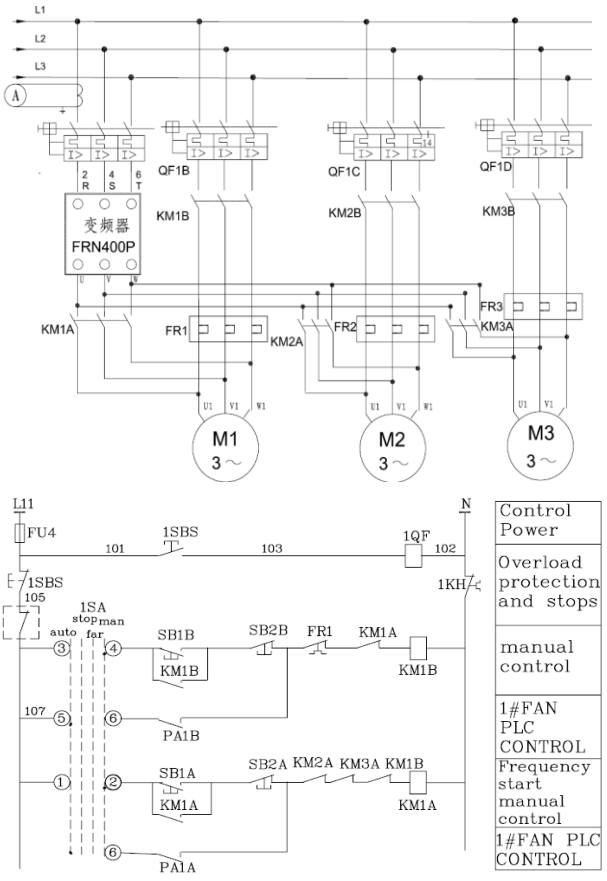

Fig. 3. (a). Electrical control of the main circuit (b). Control loop.

1SA in the Fig. 3(b) is the control switch used for automatic, manual, remote, stop. There are two ways for manual starting: one is SB1B and SB2B are used as manually start and stop switch for the No. 1 fan in power frequency when the change-over switch is in the manual position; the other is SB1A/AB2A are used for the start and stop of the fan motor by the manually frequency converting way. Protection is divided into two kinds: one is the interlock between the KM1B/KM1A power frequency and the manually frequency converting, the other is the interlock among 1/2/3 fan motor by cascading KM2A/KM3A in the 1st line in the frequency converting mode to avoid supplying 3 fan motors simultaneously in this state, which will lead to the large load of converter. When the transfer switch is in the automatic position, the soft PLC control mode of KM1B/KM1A is used to achieve the same functionality [16]–[18].

D. The Control Loop Programming

Program design. Create a data block and symbol table in the design. Under the effect of the vapor pressure control loop, the signals are respectively converted through FC105, PID regulate the regulation of subroutine FB58, control datas are converted by subroutine FC106, they are sent to the control field, thus monitoring data that collected by the above process were provided to monitor, it provides the reference data for the manual control, and provides data foundation for automatic loop control. Among the use of module FB58,it creates input variable settings DB3.DBD2,DB3.DBD22 in the case of automatic operation and manual operation respectively, meanwhile it creats switch input variable settings DB3.DBX0.0 between manual control and automatic control. The following programs are designed for steam pressure control loop.

```
A(
A    M   9.0
=    L   20.2
BLD  103
CALL FC  105
IN   :=PIW272
HI_LIM :=1.300000e+002
LO_LIM :=0.000000e+000
BIPOLAR:=L20.2
RET_VAL:=MW6
OUT  :=DB1.DBD12
A    BR
)
JNB  _001
CALL FB  58 , DB3
PV_IN  :=DB1.DBD12
LMN    :=DB2.DBD4
SP_INT :=DB3.DBD2
MAN    :=DB3.DBD22
MAN_ON :=DB3.DBX0.0
_001: NOP  0
  A    M    9.0
=    L    20.0
BLD  103
CALL FC  106
IN: =DB2.DBD4
HI_LIM: =1.000000e+002
LO_LIM: =0.000000e+000
BIPOLAR: =L20.0
RET_VAL: =MW28
OUT: =PQW30
NOP  0
```

E. Interlock Control Programming

Control scheme has identified a number of interlocking, the following procedures are for the system boots back to feed auger and start the design process.

```
A    Q    0.3
L    S5T#10S
SD   T    21
A    T    21
=    L    0.0
A    L    0.0
L    S5T#2H
SD   T    22
A    T    22
R    Q    0.3
A    L    0.0
BLD  102
S    Q    0.4
A    Q    0.4
```

```
L    S5T#13S
     SD   T    23
     A    T    23
     S    Q    0.2
     R    Q    0.4
```

IV. Results and Analysis of Experimentation

After the designed control system is used in the plant of related enterprise, field testing and assessment are verified successfully, Analysis results of the test data showed that the margin air of fan flow when the dryer runs normally and the actual current of normal drying is of 28% to 65% of rated current with the average 42% which means 45.5% energy savings.

The curve of the moisture content of the feed varies with the drying time is the test conditions are that the dry matter content in the wet mash is 25% -40%, the dry matter content in the thick slurry is 28%-34%, the amount of feeding-back dry is 0.8-1.8t/h, the dry matter content of the mixed wet material is 35% -40%, the moisture content drops from 35% to about 10%. The hot air temperature is set to 92℃, the sample interval of control system is 16 seconds.

The results showed that the moisture content of the feed declines sharply with drying time increasing. In the first 10 minutes of the drying process, the water content of the wet feed drops quickly, the temperature of hot air is higher. The faster drying speed is, the greater is the decreasing of the moisture content.

V. Conclusion

Make use of the charastics of STEP 7 procedure to write software, and combine with the system's hardware configuration, realizing the design of fan drying control system. In the process of commissioning, it is in strict accordance with the requirements of process control, the system is in normal state, the data conversion is accurate, the control loop can run smoothly, interlocking control is accurate, realizing the control design of a combination of manual control and automatic control, it avoids the probability hidden and the existence of accidents caused by human factors, the system automates the operation and running.

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