Design of the Control System for the Biomass Briquette Fuel Production Line

Song-Li SUN1,*, Le-Ying ZHANG1, Jing ZHU1 and Dian-Xiang ZHU1,2,b,*

1 School of Intelligent Manufacturing, Taizhou Institute of SCI. & TECH., NUST., No. 8, East Meilan Road, Taizhou City, 225300, Jiangsu Province, China

2 Department of Wood Science and Technology, Nanjing Forestry University, Nanjing, 210037, Jiangsu Province, China

*a) sunsongli75@163.com b) dixiang@163.com

*Corresponding author: Dian-Xiang ZHU, professor of Nanjing Forestry University, Ph.D. supervisor & professor of School of Intelligent Manufacturing, Taizhou Institute of Sci. & Tech. NUST., vice dean

Abstract. This paper studies the craft of the biomass briquette solid molding fuel, and determines the overall layout of the small-sized wood-pellet briquetting production line with an annual output of 6000 tons. Based on PROFIBUS-DP field bus and S7-300 PLC as the main station, the overall architecture is proposed and the detailed design is carried out of control system. By means of MCGS configuration software, the remote monitoring system of the upper computer is designed. Finally, the automatic operation of the briquetting production line is realized.

1. Introduction

Development and utilization of energy has been the human direction of effort and exploration, with the rapid development of economy and the large consumption of energy, environmental protection and renewable clean energy source, and has gradually become the mainstream of new energy development. Biomass solid molding fuel, commonly known as wood pellet, refers to all kinds of biomass raw materials through specialized equipment will be dispersed after the drying, crushing, to a certain particle size in a certain temperature, humidity and pressure conditions, a dense solid fuel with a regular shape is formed, such as biomass pellet fuel and biomass bulk fuel[1]. As a kind of biomass energy, wood pellet has high combustion efficiency, and the emission of combustion substances such as dust, SO₂ and CO₂ is greatly reduced compared with coal. As a "green substitute" for traditional coal[2], it is being widely used in North America and Europe.

China has abundant wood pellet resources. Adequate resources and support from national policies have provided a broad platform and basis for the development of wood-pellet fuels. The country's first independent research into the production of 200,000 tons of wood coal pellets has been accepted and mass-produced in 2012. In order to improve the automation and production efficiency, based on the existing technologies and processes of the biomass pellet fuel, this paper proposes the design of the control system for the automatic wood-pellet briquetting line with an annual output of 6000 tons. The system takes Siemens S7-300 PLC as the main station, and the hammer mill, water spraying and
auxiliary injection device, briquetting machine and so on as the slave station. Through PROFIBUS-DP field bus, distributed control is carried out, and through the monitoring system of the upper computer, automatic operation of the whole system is realized.

2. The process flow of wood-pellet briquette production
There is a big difference between the molding process of wood-pellet particles and wood-pellet briquette. For the molding process of wood-pellet briquette, the water content of the material is generally 10%~20%, and the particle size of raw materials should be generally less than 50mm. A single crushing can meet the technical requirements. The crushed material is usually transported by belt conveyors. Because the material with large size is easy to form the phenomenon of bridge, the screw forced feeding device should be set when entering the hopper. The briquette can be naturally cool\cite{3}. Because this line mainly processes these raw materials, such as the furniture waste and woodchips, the characteristic of this kind of raw material is dry, low moisture content. Therefore, this production line does not need to set up the drying link, but should add water spraying device. In addition, vibration screening device should be set up because the raw material will be mixed with impurities such as gravel and iron. Therefore, the production process of the wood-pellet briquette is mainly as follows: raw material\rightarrow crushing \rightarrow vibrator screening \rightarrow entering the qualified clean crushing hopper \rightarrow spraying water, adding additives and stirring \rightarrow briquetting \rightarrow packing and storage.

3. The structure of wood-pellet briquette production line
Combined with the production process, the main equipments required are: hammer mill, vibration screening device, tempering water spraying device and auxiliary additive device, briquetting machine, conveying system, etc. For 500 series of briquetting machine, the amount of briquette per hour is (300 ~ 450) kg. In terms of 12 hours of working time every day, the line with an annual output of 6000 tons needs to be equipped with 4 500 series compressors. At the same time, two hammer mills are provided to ensure the crushed materials. Vibration type stone and iron removing machine was selected as vibration screening. The water content of the material is more uniform by pressurizing water to a certain pressure and spraying it with atomization. The addition of additives (flour is more common) can effectively reduce the forming pressure and improve the forming quality. Conveyor belt motor 4 is used to drive the feed transportation pipeline 5 to complete the crushing transportation. The inlet of the hopper is equipped with a screw forced feeding device, driven by motor 6.

Figure 1 shows a layout of the wood-pellet briquette production line. Put the raw materials into the hammer mill 1 and the hammer mill 2. After the shredding treatment, the crushed materials will enter the vibration type stone and iron removing machine 3. The selected crushed material enters hopper 7 through the conveyor line 5. The main function of hopper 7 is to store the crushed material, which is equipped with an internal motor. The motor stirs up the crushed materials while the water spraying and auxiliary injection device 17 is working. Finally, the forming work of wood-pellet briquette is completed by 4 briquetting machines.
Figure 1. Layout of wood-pellet briquette production line
1~2-hammer mill; 3- vibration type stone and iron removing machine; 4-conveyor line motor; 5- feed conveyor line; 6-screw feeder motor; 7-hopper; 8~11- delivery line; 12~15- briquetting machine; 17- water spraying and auxiliary injection device

4. The architecture of control system

The upper computer of this control system is a configuration monitoring system based on industrial PC and MCGS. The lower computer is based on Siemens S7-300 PLC as the master. The slave stations include the hammer mill, the briquetting machine, water spraying and auxiliary injection device and so on, which are based on S7-200 and conveyor line motor which is controlled by the frequency converter. Through the PROFIBUS-DP fieldbus, decentralized control and centralized monitoring are realized.

Figure 2. PROFIBUS-DP network structure

The industrial PC is installed in the general monitoring room and communicates with S7-300PLC through Ethernet. The main station is set in the main control cabinet, using PS-307 10A power module and CPU315-2DP central processing unit. The slave stations including hammer mill, briquetting machine and so on are controlled by separate control systems based on S7-200PLC, which perform the PROFIBUS-DP fieldbus communication with the main station via EM277 module. The motors are speed controlled by means of the MM440 converter, and because the MM440 converter itself does not have the PROFIBUS-DP communication function, it is required to add the communication card, and use the PROFIBUS module of the MICROMASTER 4 PROFIBUS.
5. The detailed design of control system

5.1 Hardware configuration

When the S7-200 is in PROFIBUS-DP communication with the S7-300 via EM277, there is no need to configure or program the communication in S7-200. Simply store the data collation that will communicate in the specified V storage area, and then set the EM277 slave address through the dial code switch of EM277. The programming software of the S7-300 is step 7, and the hardware configuration should first be performed before the programming. After establishing the project and PROFIBUS network in STEP7, first install the EM277 slave station configuration file siem089d.gsd, then find EM277 PROFIBUS-DP under the PROFIBUS DP menu of STEP software and double-click to add EM277 to the network, then select a configuration based on the number of communication bytes, and finally set the DP slave address of EM277 (This address should be the same as the EM277 address). The hardware configuration method of frequency converter slave station is similar.

5.2 Software control process

The main idea of programming is embodied in the software control process. After starting the machine, the material level of the main hopper is judged first. If it is higher than the upper limit, the hopper mill, the feeding conveyor line and the water spraying and auxiliary injection device are closed. Otherwise, the equipments are running. Then, check whether the additive amount is normal. If it does not meet the requirements, alarm prompt of artificial assistant addition appears. Check whether the water spraying effect meets the requirements. If it is normal, start the briquetting machine. Otherwise, shut down the hammer mill, feed line, water spray and additives and alarm. After the briquetting machine is started, first check whether there is material in the finished material bit of the briquetting machine. If any, first remove the material. In the whole process, it is necessary to monitor the working condition of each equipment and give alarms in time. The alarm sources of this system mainly include three sensors: material level of main hopper, the water content of crushed material and amount of auxiliary agent. If they are abnormal, the monitoring system will alarm.

6. The design of MCGS monitoring system

MCGS is the Monitor and Control Generated System, and is a configuration software developed by Beijing Kunlun Tongtai automation software co., LTD. It has high cost performance and is widely used in domestic industrial control field.

Before the configuration design of MCGS monitoring system, the first thing to do is to analyze the requirements of the system, clear control object and operation object and other specific design content, and then do the following procedure: (1) open the MCGS configuration environment, establish a project - > (2) to define data object, establish real-time database to (3) through the user window design human-machine interface, (4) animation connection - > (5) device connection. The process of creating a real-time database is actually the process of defining system data objects. After step (2) (3),the graphics object is stationary, needed to the step (4) animation connection, a correlation connection is established between the graphical objects in the man-machine interface and the data objects in the real-time database, and set the corresponding animation properties, can make the human-machine interface of the animation. This is also the main method for MCGS to implement graphic animation design.

According to this design idea, the designed main monitoring interface is shown in figure 3.
Figure 3. Monitoring system main interface

7. Conclusion
China is rich in biomass resources, and the production cost of wood pellet is low, which can replace about 10% of the raw coal and is easy to be popularized, and the market potential is huge\(^4\). The application of this control system can effectively improve the automation degree and production efficiency of the wood-pellet briquette production line, and has good promotion value.

References
[1] Zhu D 2014 The research and development of biomass fuel pellets production line and key manufacturing technology J. Engineering Sciences 16(04) 13-16+44
[2] Zhu D and Guo D 2009 Wood coal - a new energy source with great development potential J. Forestry Machinery & Woodworking Equipment 37(01) 37-40
[3] Zhang L and Hou S 2012 Molding process research on densified biofuel J. Chinese Agricultural Mechanization (05) 87-91+100
[4] Wang J and Zuo Z 2012 A brief analysis of the wood coal technology principle and application prospects J. The Journal of Hebei Forestry Science and Technology (04) 95