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牵引式甜菜联合收获机自动对行系统研制

Development of auto-follow row system employed in pull-type beet combine harvester

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中文摘要:

为了提高甜菜联合收获自动化水平、降低收获损失，该文结合垄作甜菜种植模式，以牵引式甜菜联合收获机为载体，采用液压技术、传感器信号采集技术和微处理器控制技术设计了一套甜菜联合收获机自动对行控制系统。该系统具体包括对行探测机构、偏移牵引调整机构、液压控制系统、电子控制系统和控制软件。标准信号跟踪试验显示，跟踪最大延时小于1 s，超调量小于15%，最大误差为2.5°，表明系统具有快速响应特性和稳定性。田间收获对比试验显示，采用该自动对行控制系统后，甜菜联合收获机漏挖损失率降低2.03%，根体折断率降低1.48%，根块损伤率降低2.64%。该研究可为其他土下果实收获机械对行系统研发提供有效借鉴。

英文摘要:

Abstract: The sugar beet is one of the major sugar crops in China, accounting for about 17% of Chinese total sugar production. As a seasonal operation, sugar beet harvesting in China is still mainly manual work, characterized by high labor intensity, low efficiency, great harvest losses, and huge occupation of farming, all of which constraine the further development of the sugar beet industry. Mechanized harvesting is the inevitable development trend of sugar beet harvesting. The current domestic sugar beet harvesters are basically simple sectional operating machinery. Sugar beet combine harvesters are mainly imported from abroad, having high automation and intelligence and advanced performance. The domestic beet combines are still in the prototype development stage, having a great gap with the advanced foreign technology. Auto-follow row technology is one of the key features of beet combine harvesting, having great influence on machinery performance. Although domestic researchers have performed lots of studies on the automatic control of agricultural machinery, research on control systems for auto-follow harvesters is still scarce, which greatly affects the automation level and operation performance of domestic beet combine harvesters. In order to improve the automation level and reduce harvesting loss, a set of auto-follow row system for a pull-type beet combine harvester was designed by adopting hydraulic technology, sensor signal acquisition technology, and microprocessor control technology, which was based on the ridge-planting cultivation of sugar beets. The system includes a row detection mechanism, an adjustment mechanism for traction offset, a hydraulic control system, an electronic control system, and control software. The row detection mechanism detects the position of the ridge top beetroot block, converts the offsets of excavation forward locus to angle quantity, and then sends the information to the offset angle acquisition sensor. The offset angle acquisition sensor converts angle information to a digital signal and sends it to the controller. The controller handles the angle signal and outputs a control signal for the solenoid valve, through the control software, opening the hydraulic cylinder drive oil line. The hydraulic cylinder drives the traction biasing mechanism, adjusting the digging position. The angle feedback sensor installed on the traction-offset mechanism feeds back the adjusted angle signal to the controller. The controller adjusts output control signals in real time, ensuring the excavation forward locus always consistent with the beetroot block position. The entire control system is a closed-loop feedback system. The controller is a single-chip microprocessor μPD78F0525. Control software adopts Keil C language, using a fixed double dead zone control algorithm, because it increases system noise immunity, avoids frequent shocks of control action, and improves control stability. Standard signal tracking tests showed that the system had fast-response characteristics and high stability. The results of comparison experiments showed that the harvesting indexes of the beet combine were improved by employing the control system of auto-follow row, in which the loss rate of un-harvested beets, the root body fracture rate, and the root block damage rate were reduced by 2.03%, 1.48% and 2.64%, respectively. This study can provide effective reference for the development of auto-follow row systems employed in similar harvesting machinery.