气吸式膜上精量播种装置排种过程的仿真研究

刘汉涛, 窦卫国, 王竹瑛, 赵士杰, 赵满全
(内蒙古农业大学)

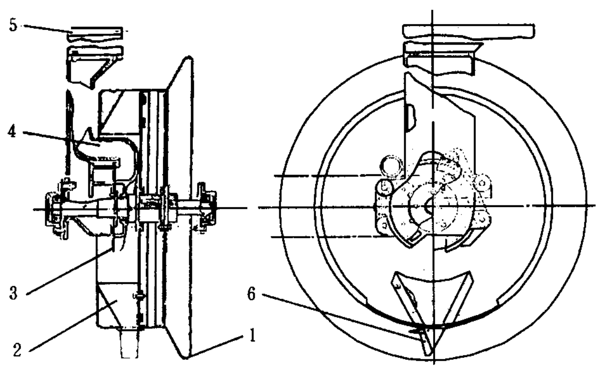
摘 要: 对 2BQM 22 型气吸式精量铺膜播种机的膜上开穴、取种、投种过程及其工作机理进行了分析, 建立了种子运动轨迹的数学模型, 在此基础上运用计算机仿真技术, 动态模拟了膜上穴播的工作过程, 找出了机组前进速度、投种角、接种漏斗偏置角变化时对种子投种精确度的影响规律, 优化了相关设计参数, 可为同类型精播装置的深入研究提供参考。

关键词: 计算机仿真; 气吸式播种机; 铺膜播种机; 排种装置

中图分类号: S223. 2+ 3 **文献标识码**: A **文章编号**: 100226819 (2002) 0120074204

1 播种滚筒结构和仿真目的

2BQM 22 型气吸式精量铺膜播种机的特点是将气吸式取种装置安装在播种滚筒内的有限空间内。滚筒结构如图 1 所示。



1. 滚筒焊合 2. 接种漏斗 3. 取种盘
4. 吸室 5. 种子箱 6. 鸭嘴

图 1 播种滚筒单体结构图

Fig. 1 Structure of single sowing wheel

排种装置工作时, 与播种滚筒同步转动的取种盘依靠一侧吸室提供的负压将另一侧的种子吸在取种盘的吸种孔上; 转动到吸室外缘处, 负压消失, 种子落入鸭嘴, 完成播种。

2BQM 22 型气吸式精量铺膜播种机排种装置的仿真软件主要设计目标有: 1) 从理论上研究滚筒和种子的运动规律, 以求找出影响播种机排种装置性能的主要因素; 2) 对给定机构参数的播种滚筒的工作过程进行动态模拟, 预测种子的运动轨迹; 3) 找出各参数变化时对投种精确度的影响规律。

为达到以上目的, 忽略各种随机因素的影响, 作出以下几点假设:

1) 机具的运动是平稳的, 即机具的前进速度没有波动; 2) 滚筒作纯滚动; 3) 吸种是可靠的, 即 100% 单粒; 4) 种子总是从吸种盘的同一位置下落; 5) 种子在下落过程中不考虑阻力的影响; 6) 当种子碰撞到漏斗或鸭嘴时, 将沿着漏斗壁或鸭嘴壁下滑; 7) 种子落到穴孔内不发生弹跳。

2 数学模型的建立

2.1 问题的提出

2BQM 22 型气吸式精量铺膜播种机以单粒精密穴播良种玉米为主, 更换相应元件可播其他作物。种箱、吸室固定在机架上, 播种滚筒外圆周上均布 n 个鸭嘴, 相应内侧边缘上对应安置 n 个接种漏斗, 底部与开穴鸭嘴相通。与播种滚筒同步转动的取种盘上也均布相同数量的圆形吸孔。当取种盘转动时, 依靠一侧吸室提供的负压吸住另一侧种箱中的种子于吸孔上, 经清种装置清种只留一粒种子被携带出种子箱; 到达吸室外缘后, 负压消失, 种子作具有一定初速度的自由落体运动落入接种漏斗中进入鸭嘴; 待鸭嘴入土开启后, 种子被播到穴孔中。建立模型必须考虑播种过程中滚筒式穴播器的参数如何选择; 吸室外缘与水平轴线的相对位置怎样确定, 即种子偏离水平轴线多大角度摆脱负压开始自由下落; 以及吸种孔与其相应的接种漏斗如何配置, 才能确保种子落入相应的接种漏斗中, 并在鸭嘴入土后打开、出土关闭前及时地将种子播入鸭嘴形成的穴孔中。

2.2 数学模型

投种是一个排种与落种的种子运动过程, 是种子伴随着碰撞和滚动的空间飞行过程。由文献[3]可知, 由于种子的物理特征不同等因素的影响, 虽然有

收稿日期: 2001207213 修订日期: 2001209213
基金项目: 国家自然科学基金资助项目 (59765001)
作者简介: 刘汉涛, 硕士, 呼和浩特市 内蒙古农业大学机电工程学院, 010018

少数种子的排种位置不一, 但大部分种子还是从排种器内同一点, 沿排种盘吸孔分布圆的切向排出。

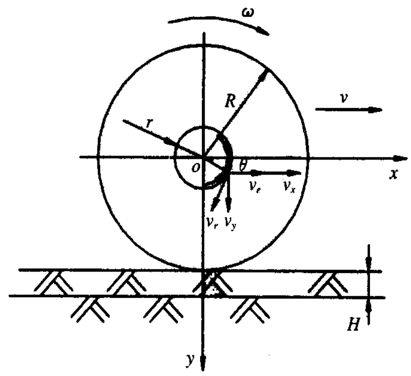


图 2　种子在滚筒内的速度分析

Fig. 2　Analises of the seed velocity in sowing wheel

如图 2 所示, 设滚筒半径为 R, 取种盘吸孔分布半径为 r, 机器前进速度为 v, 落种角为 H, 鸭嘴高度为 H, 可导出种子脱离吸种孔后的运动方程为

$$v_x = v - \mathrm{X} r \sin \mathrm{H} \qquad (1)$$

$$v_y = \mathrm{X} r \cos \mathrm{H} + g t \qquad (2)$$

式中　v_x —— 种子运动速度的水平分量; v_y —— 种子运动速度的垂直分量; X —— 滚筒角速度, X = vöR; t —— 种子从下落点开始到任意位置的时间; g —— 重力加速度。

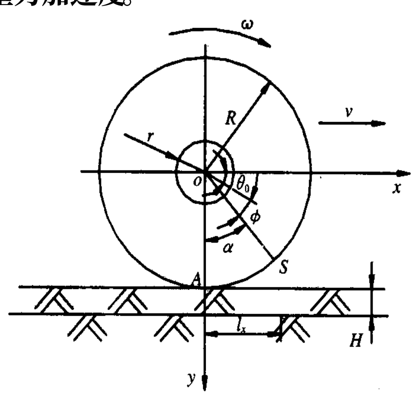


图 3　临界落种角 H0 的分析

Fig. 3　Analyses of the critical seed drop-off angle

根据排种装置设计要求, 种子脱离吸孔后应正好落入相应的鸭嘴内, 在满足这一要求下, 排种盘开始排种的转角为 H0。若鸭嘴装于 S 处(见图 3), 则 $\overset{\frown}{AS} = vt = l_x$, 即滚筒滚过的距离与临界落种角 H0 时种籽的初始水平位置及种子下落到穴孔内时经过的水平距离之和 l_x 相等。

由式(1) (2) 可导出

$$\mathrm{H}_0 = \arcsin\left[\frac{r\mathrm{X}^2 + \sqrt{r^2\mathrm{X}^2 + 2g(R + H)\mathrm{X}^2 + g^2}}{2(R + H)\mathrm{X}^2 + g}\right] \qquad (3)$$

从式(3) 可以看出, 临界落种角 H0 与前进速度 v 和滚筒尺寸(R, r, H) 有关, 只要 v, R, r, H 给定, 则 H0 角就是一个确定的值。

为了有最佳的投种效果, 有时吸种孔与接种漏斗(或鸭嘴) 不是配置在同一中心线上, 该二中心线间的夹角称为接种漏斗偏置角 ` 。

当选定落种角 H时, ` 的最佳值随 v 的改变在一定范围之间变化, 正值在吸孔中心线的右侧, 负值在其左侧(顺时针, 沿滚筒转动的方向)。

滚筒前进时, 当动鸭嘴尾部接触地面, 土壤支反力克服弹簧弹力作用打开鸭嘴。其打开的时间, 以鸭嘴到达最底部时, 种子能落下来为最好。此时就能把种子投放到穴孔底部, 达到正位投种。鸭嘴的开度应尽量大, 以便于种子的下落。

3 计算机仿真、结果及讨论

排种装置工作过程计算机仿真的程序流程如图 4 所示。输入的初始值有: 滚筒半径 R、吸种孔分布半径 r、鸭嘴个数 n、鸭嘴高度 H、漏斗圆半径 r_f、开始吸种位置、落种角 H、偏置角 ` 等。显然, 这些参数均为基本设计参数。改变这些参数意味着单体结构的变化。输入的初始值还有: 作业速度 v、种子尺寸等。改变上述参数, 计算出不同时间 t 时的瞬时状态, 即可对播种结构的性能作出评价或预测, 从而寻找到最佳结构。

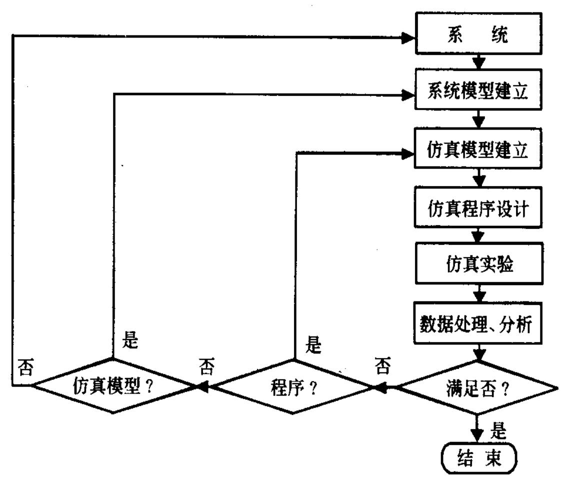


图 4　计算机仿真程序流程图

Fig. 4　Computerized simulation flow chart

3.1　仿真实验

1) 为找出机具前进速度、落种角、偏置角三者基本关系, 进行以下实验。在进行仿真实验时, 机具前进速度的极值按照以下原则判断:

(1) 以种子落到地面时, 漏斗中线不越过垂直位置作为判断机具最大前进速度的依据;

(2) 以种子刚好落入对应漏斗的最小速度作为

机具最小前进速度。

各参数的选取按照以下原则确定:

(1) 机具前进速度 v = 1 m ös 是 2BQM 22 播种机最适宜的工作速度。

(2) 偏置角 ` = 0 °是考虑生产实际的需要, 提高工艺性、方便制造选取的。

(3) 落种角 H= 38.21 °是按照机具最常用前进速度 v = 1 m ös 时的临界落种角 (H = 38.21 °) 而选取的。仿真实验结果如图 5、6。

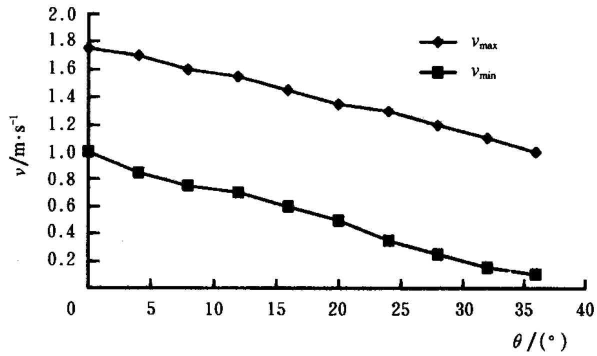


图 5 偏置角 ` = 0 °时, 落种角 H与机具前进速度 v 的关系

Fig. 5 The relation of implement forward speed v between seed drop-off angle H at bias angle ` = 0 °

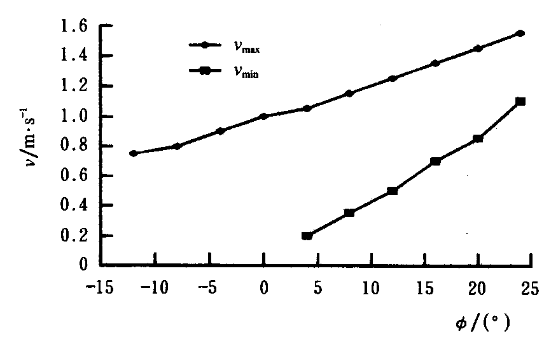


图 6 落种角 H= 38.21 °时, 偏置角 ` 与机具前进速度 v 的关系

Fig. 6 The relation of implement forward speed v between bias angle ` at seed drop-off angle H= 38.21 °

2) 在上述得出的有关前进速度、落种角、偏置角三者的基本关系的基础上, 又对落种角的取值范围, 进行了针对性实验。

在进行仿真实验时, 判断播种质量的原则为: 最佳的状态是使种子无碰撞的落到地面; 次之, 使种子不碰撞漏斗(可碰撞鸭嘴); 再次之, 使种子只碰撞左侧漏斗下部 30～40 mm 处。由实践经验可知, 种子以不碰撞右侧漏斗壁为好。仿真实验结果如图 7。

图中 v_{0max} 种子不碰撞漏斗或鸭嘴, 直接落到地面时的最大速度; v_{0min} 种子不碰撞漏斗或鸭嘴, 直接落到地面时的最小速度; v_{1max} 种子不碰撞漏斗(可能碰撞鸭嘴), 落到地面时的最大速度; v_{1min} 种子不碰撞漏斗(可能碰撞鸭嘴), 落到地面时的最小速度; v_{2min} 种子碰撞左侧漏斗壁, 且碰撞点在距滚筒壁 40 mm 以内, 落到地面时的最小速度。

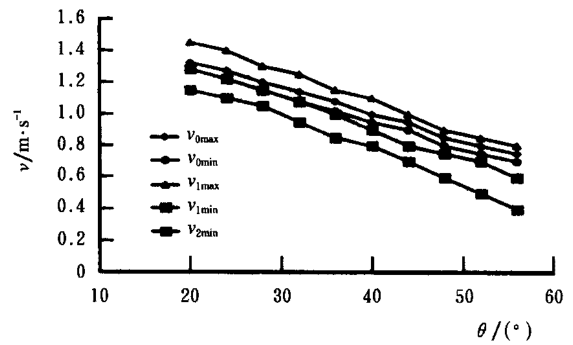


图 7 偏置角 ` = 0 °时, 落种角 H与选取最佳前进速度 v 的关系

Fig. 7 The relation of optimal implement forward speed v between seed drop-off angle H at bias angle ` = 0 °

3) 为得出当偏置角 ` 不同时, 落种角 H与前进速度 v 的关系, 又作了以下实验。图中的数据均为种子不碰撞漏斗和鸭嘴时的前进速度。结果如图 8。

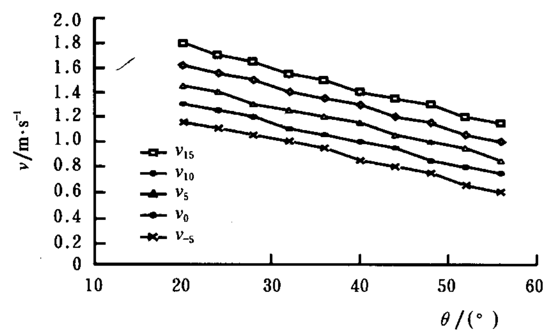


图 8 当偏置角 ` 不同时, 落种角 H与选取最佳前进速度 v 的关系

图 8 The relation of implement forward speed v between seed drop-off angle H at different bias angle `

图中 v_{-5}、v_0、v_5、v_{10}、v_{15} 为偏置角取 - 5 °、0 °、5 °、10 °、15 °时种子不碰撞漏斗或鸭嘴, 直接落到地面时的速度。

3.2 分析及讨论

各个参数对播种性能的影响是不同的, 特别是不同参数组合时对性能的影响不同。

1) 从图 5 可以看出, 当设定偏置角 ` = 0 °时, 随落种角 H的增大, 适宜的机具前进速度将降低。

2) 从图 6 可以看出, 当设定落种角 H= 38.21 °时, 随偏置角 ` 的增大, 适宜的机具前进速度将增大。

3) 由图 7 可以看出, 当取偏置角 ` = 0 °、落种角 H= 40 °～ 44 °时, 在机具前进速度 v = 0.7～ 1.1 m ös 范围内, 均具有良好的适应性。

4) 图 8 说明, 偏置角只对适宜前进速度的大小有影响, 而对前进速度的范围影响不大。所以, 通过调整偏置角来提高播种质量的价值不大。

5) 随着播种速度 v 的增加, 只要适当地减小落种角 H以提高种子相对地面的下落速度, 就能够使滚筒对种子的下落不发生干涉。但是在排种器的设计上, 要想使投种角随着机具前进速度的变化而相应地改变是难以实现的。因此, 只能按照最常用的播种速度来确定投种角的大小。

6) 若考虑种子从吸孔下落延迟和空气阻力的影响, 则种子的下落还要滞后, 此时, 若要种子及时、正位下落, 或者减小落种角, 或者加大偏置角。

4　结　论

1) 计算机仿真结果表明, 前进速度 v、落种角 H 和偏置角 ` 3 参数对播种性能的影响最为明显, 不同的参数组合对性能影响不同, 且有不同的变化趋势。

2) 当机具处于适宜的铺膜播种速度 v = 0.7～1.0 m ös 时, 落种角选取 H= 44°, 偏置角选取 ` = 0°, 有较好的播种效果, 而且此时对前进速度 v = 0.6～0.7 m ös 及 v = 1.0～1.1 m ös 也有良好的适应性。

3) 该仿真软件对气吸式膜上精量播种装置的深入研究有一定参考作用, 特别是在各参数对性能影响规律尚未明了之前, 直接使用本程序指导设计具有实际意义。

4) 该仿真软件在对系统的和随机的干扰因素影响作用尚需深入研究。

[参　考　文　献]

[1] 王竹瑛, 赵满全, 麻硕士等. 种子在新型气吸式膜上精量播种装置中的运动分析[J]. 内蒙古农牧学院学报, 1999, 20(2): 91～95.

[2] 马瑞峻. 2BQM 系列气吸式精密播种机理论与研究[D]. 呼和浩特: 内蒙古农业大学, 1997.

[3] 张建平, 李飞雄. 气吸式排种器排种均匀性的Monte Carlo 模拟[J]. 农业工程学报, 1994, 10(1): 56～62.

[4] 赵　匀. 农业机械计算机辅助分析和设计[M]. 北京: 清华大学出版社, 1999.

[5] 马　旭, 马成林, 于海业. 精密播种机田间植株分布动态仿真[J]. 吉林工业大学学报, 1998, 28(4); 16～21.

[6] 王正中. 系统仿真技术[M]. 北京: 科学出版社, 1986.

‘

Key words: spiral flow; transport; sediment; energy consumption

Bai Dan, Li Zhanbin (*Xi'an University of Technology, Xi'an* 710048, *China*)

Abstract: The equation for friction loss along the plastic pipe of micro2irrigation is presented adopting the multiple2regression analysis according to existing friction loss equation. The new equation is superior to existing equation in calculated results owing to considering pipe diameter, flow velocity and water temperature at the same time. The calculated result is more precise. The error analysis shows that the equation is satisfied with the requirement of project design. The developed equation can be employed in the design of micro2irrigation pipe system.

Key words: plastic pipe; micro2irrigation; friction loss computing

Wu Jianhua[1], Zhang Xu[2], Jia Jinxia[3] (1. *Xi'an University of Technology, Xi'an* 030024, *China*; 2. *The Supple2Water Corporation of Datong, Datong* 037000, *China*; 3. *The Remote Sensing Center of Shanxi, China*)

Abstract: The pressure2type stage sensor, float2type stage sensor and capacitance2type stage sensor are widely used in agricultural water conservancy project in China. However, there exists some drawback when they are equipped in the project with hyper2concentration of sediment and swift flow, in which collecting message requires remote telemetry. It is an inevitable tendency to use modern computer technologies to explore the higher accuracy and highly adaptable devices of water2level measurement in the agricultural water conservancy project. TC2301 new type stage sensor is presented in this paper, it practices new thought of simulative nerve theory, which succeeds in achieving new breakthrough in measuring water2level of agricultural water conservancy project, and the application effect is good.

Key words: agricultural water conservancy; computer; digital water2level transmitter

·Agricultural Machinery and Mechanization Engineering·

Zhang Xingchang (*Institute of Soil & Water Conservation, Chinese Academy of Sciences and Ministry of Water Resources, Yangling* 712100, *China*)

Abstract: Compared with conventional tillage, level trench might reduce 7% in average of runoff amount on different slope land, the ammonium concentration in runoff increases 19%, its loss amount reaches 13.01 kgö(km^2·a), also increases by 1.11 kgö(km^2·a), the nitrate concentration in runoff reduced 27%, its loss amount is 16.18 kgö(km^2·a) with reduction of 7.68 kgö(km^2·a), in conclusion, the soil available nitrogen loss in level trench might reduce 6.57 kgö(km^2·a) than that of conventional tillage. Level trench might retain 25% of soil loss, increase 13% of total nitrogen enrichment in sediment than that of conventional tillage, accordingly, soil nitrogen loss amount reaches 457 kgö(km^2·a), it also reduces 13% of nitrogen loss than that of conventional tillage. Five years' rotation experiments show the erosion modules of rotation systems with a season black soybean, a season soybean, and two seasons black soybean, a black soybean, reach 896 and 984 tö(km^2·a) respectively, their modules are twice less than that of rotation system with broom millet and potato.

Key words: level trench; crop rotation; soil nitrogen loss

Liu Hantao, Dou Weiguo, Wang Zhuying, Zhao Shijie, Zhao Manquan (*Mechanical & Electrical College, Inner Mongolia Agricultural University, Huhhot* 010018, *China*)

Abstract: An analysis of the process of punching holes on the plastic film, grasping at the seed through suction holes, dropping off the seed and the operation mechanism of the 2BQM22 model plastic film mulch

pneumatic precision planter is carried out and a mathematical model for seed motional locus is established based on which the operation process for plastic film mulch dibbling function is simulated dynamically by use of computer simulation technology, the influence of the change of implement forward speed, seed drop2off2angle and the bias angle of seed receiving funnel on the seed metering accuracy is found out and the relevant parameters are optimized. The results of this research can be taken as a reference for the design of similar implements
Key words: computerized simulation; pneumatic planter; plastic film mulch planter; seed metering device

Adaptability Test and Key Technology Research on Conservation Tillage ··············· (78)

Jia Yanming[1], Shang Changqing[1], Zhang Zhenguo[2] (1. *Changzhi Farming Machinery Management Bureau, Changzhi, Shanxi* 046000, *China*; 2. *Extending Station of Agriculture Machinery of Shanxi Province, Taiyuan* 030007, *China*)
Abstract: Around the sustainable develepment of dryland farming, it has been testing and researching for a long period in the world. The advanced Australian conservation tillage method was introduced in 1991, and was tested in Shanxi Province experimental plots. The test showed that: the conservation tillage has the comprehensive profits of conserving water, improving soil, increasing production and income, and improving ecological envionment. But the planting quality is not so good, which held back further test. Although it can increase the adaption by improving the machine, when the stalk covering rate reaches 80%, a series of problems would appear, e. g. in winter, it is difficult to prevent wind and fire; in spring, the soil temperature goes up slowly, and it is difficult to clean the weeds growing in the crops. By the further test, shallow rotary tillage or shallow harrow of the surface soil, can solve all the problems. Stalk covering, surface soil shallow tillage, and stubble planting make up the matured technical system of conservation tillage method.
Key words: dryland; conservation tillage; surface tillage; sustainable development

Design of Device for Raising Seedling and Seeding in Aperture Disk ····················· (82)

Xu Jinda[1], Yu Wenwei[2], Lü Meiqiao[3], Lou Miaoliang[1] (1. *Jinhua Research Institule of Farm Machinery, Zhejiang Province, Jinhua* 321017, *China*; 2. *Jinhua Office of Rural Energy, Jinhua Zhejiang, China*; 3. *Jinhua Station of Machinery Management, Jinhua Zhejiang, China*)
Abstract: According to demands for rice seedlings throwing, the device for raising seedling and seeding in aperture disk was designed and developed. Its working principle and design of rubber belt for conveying seeds were mentioned in the paper. The design scheme was superior after tested by experimentation. Under the condition of superior parameters, best factors combination for seeding in aperture disk with small quantity of seeds can be singled out and optimal seeding performance of the device can be obtained.
Key words: raising seedling in aperture sisk; rubber belt for conveying seeds; appending seeds; throwing seeds

Research and Development of Portable Apparatus for Power and Fuel Consumption Test of Small Tractors ··· (85)

Wang Huiming, Jing Shuhong, Hou Jialin, Lü Zhaoqin (*Mechanical & Electronics Engineering College, Shandong Agricultural University, Tai'an* 271018, *China*)
Abstract: The paper introduces an intelligent test system for power and fuel consumption test of small tractors. The system was developed by use of the microelectronics and single chip computer interface technique, based on single chip computer AT89C51 and inspecting the shape of signal wave by technique on dynamic display of data, which came from HBR21 type pressure sensor and HY21 type flow sensor. The measurement accuracy of power is ±0. 10% (kW). It can measure power and fuel consumption of small tractors continuously, rapidly and accurately.
Key words: engine; power; fuel consumption; single2chip computer; test

· Protected Agriculture and Environmental Control Engineering ·

Preliminary Experimental Research on Effect of Aluminized Thermal Screens in Greenhouse