

# 生态植树机松土机构运动特性分析\*

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**摘要** 首先定性分析了生态植树机的总体设计原则, 随后对生态植树机松土机构悬挂系统采用线修正逼近理论——牛顿-罗夫森(Newton-Raphson)法作了运动分析. 最后运用 MATLAB 对所讨论的问题进行了仿真. 本文有助于设计者在正式生产前对其开发的产品样机机构的运动特性、结构特性有更清晰的认识, 以提高产品开发的成功率.

**关键词** 生态植树机, 动力分析, 机构, 松土机构

## 前言

我国现有林地面积 13370 万  $\text{hm}^2$ , 森林蓄积量 10137 亿  $\text{m}^3$ . 人均占有森林面积和蓄积量分别只有世界人均水平的 16% 和 12%. 我国的森林覆盖率仅有 16.55%, 远低于亚洲的 22%、世界的 32%, 更是大大低于绿色王国日本的 68%. 而且, 土地沙漠化是我国面临的严重问题, 预计今后 50 年内全球将有 2 亿人因沙漠化而被迫迁徙<sup>[1]</sup>. 因此, 提高森林覆盖率, 保护生态环境, 防风固沙, 必须从植树造林开始. 因而, 利用机械化植树造林绿化国土的“21 世纪中国亚马逊工程”, 是中国实现现代化的重要一环<sup>[2]</sup>.

## 1 植树机性能及设计理论研究的回顾

植树机是机械化植树造林的主要设备, 生态植树机 (Ecoplant) 生态适应性好, 对生态破坏极小<sup>[3]</sup>. 首先, 这种植树机对土壤的破坏是最小的, 它避免了大多数植树机所采用的开沟器连续开沟植树造林, 这也就减少了营养流失、土壤破坏及地表生态环境的破坏, 能用于原始森林和人工林内种树, 并不破坏现有的树木. 该机用无机土和腐质土混合物包裹树苗根部, 树苗有更高的成活率和生长率. 此外, 可使得植树机在工作时能避开地面障碍物, 而且有选择的在适宜的植树点挖坑、植树, 提高了机器的机动性和对不同地面的适应性及机械化程度, 也降低了机器的损伤率<sup>[4]</sup>.

图 1 为生态植树机结构图, 其工作过程为: 种植时, 容器树苗先被置于植树机的转动苗盘的苗筒内, 当树苗转到种植位置, 即落入植树头中, 这样树苗就准备好了. 松土机构在指定位置进行松土, 以得到土质疏松, 无机土与腐质土混合的土壤. 之后, 植树头在四杆机构的作用下, 将树苗置于植苗点, 植树头再被抬起来, 最后由压实机构, 将树苗压实, 树苗被植得很深, 能更好的和深层潮湿的土壤接触. 同时, 苗盘转动, 新的树苗又被送入植树头中以备下次使用. 如此, 完成一次种植过程<sup>[5]</sup>.

## 2 植树机松土机构悬挂机构运动分析的基本假设

在研究植树机松土机构悬挂机构的运动分析之前, 首先对其提出几点基本假设, 以简化模型, 便于建立动态方程及后续的分析. 基本假设如下:

1) 设油缸由缸筒和活塞杆 (此件含活塞) 两个构件组成, 两者组成一移动副;

2) 设油缸的缸筒和活塞杆的质心和质量不随进油量的多少而改变;

3) 设油缸的活塞杆为主动件并分别以恒定的速度  $v_1$  和  $v_2$  伸出 (即下行) 和缩回 (即上行) 运动;

4) 设松土机构的钻头组件在其工作时为下端受一向上恒力  $F$  的构件.

5) 为了分析不同杆长对坑形的影响, 设四杆机构 ADEB 为一般四杆机构, 而非平行四杆机构.

通过上述 5 项假设, 生态植树机松土机构的悬挂系统可简化为一等效六杆机构. 如图 2 所示:

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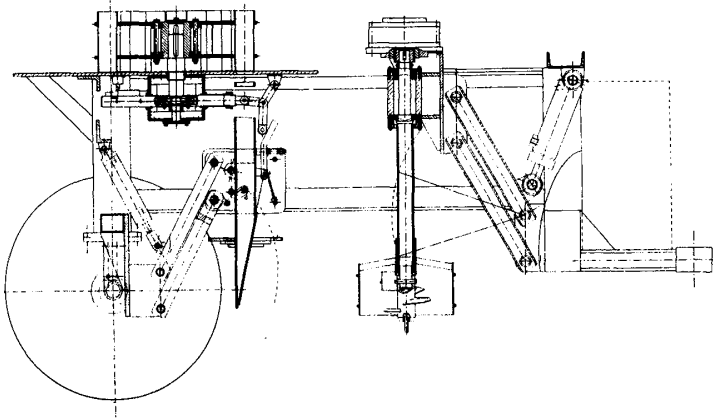


图 1 生态植树机结构

Fig.1 Structure of ecological planting tree machine

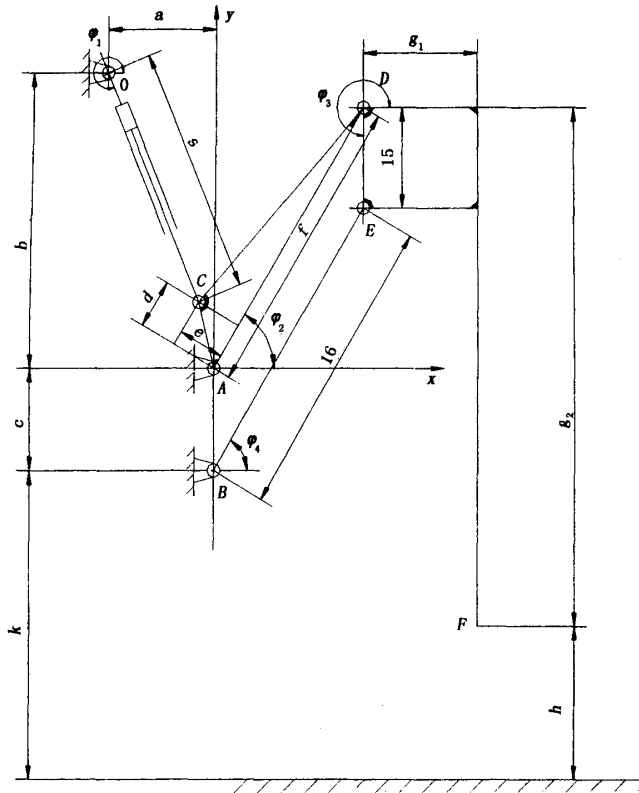


图 2 生态植树机松土机构悬挂系统的等效六杆机构

Fig.2 Six equivalent mechanisms of the hangs system that the ecological planting tree machine organization for loosens the soil

目前对于四杆机构及串联形式的六杆机构,即阿氏分类的二级组,求解位置问题并不困难,可以写出广义坐标的显函数表达式<sup>[6]</sup>.但是对于复杂的机构,例如闭链数  $L=2$  的杆组所组成的六杆机构,即阿氏分类的三级组、四级组,位置分析就得不

出显函数关系的精确解,出现非线性方程式,因之需引用数值解法.这一问题可应用线修正逼近理论进行迭代求解的方法,这方面的著作在前苏联有齐诺维也夫,而在西方国家中则有牛顿-罗夫森 (Newton-Raphson)法等,他们的思想方法是一致

的<sup>[7]</sup>.

在本论文中所研究的植树机松土机构悬挂系统由于油缸为主动件,所以在求解位置时,不易得出显函数关系的精确解.故本论文采用线修正逼近理论——牛顿-罗夫森(Newton-Raphson)法求解机构位置问题.

### 3 线修正逼近理论——牛顿-罗夫森(Newton-Raphson)法分析机构位置

建立杆机构的拉氏坐标,在机构中有5个拉氏坐标,机构的自由度为1,于是5个拉氏坐标中有1个输入参数,令其为  $s$ ,即为油缸伸长量.其机构如图2所示.

在位置分析中,对于具有2个闭链的机构可以建立  $2 \times 2$  个约束方程,在5个拉氏坐标中有1个一级坐标,其二级坐标则有4个,用  $\phi_1, \phi_2, \phi_3, \phi_4$  表示,并写成下式

$$f_i(\phi_1, \phi_2, \phi_3, \phi_4; s) = 0 \quad (i = 1, 2, 3, 4) \quad (1)$$

由上式(1),令  $s$  为输入,  $\phi_1, \phi_2, \phi_3, \phi_4$  用  $\varphi_1, \varphi_2, \varphi_3, \varphi_4$  表示,于是

闭链方程式

$$\begin{cases} f_1 = s \cos \varphi_1 - d \cos \varphi_2 + e \sin \varphi_2 - a = 0 \\ f_2 = -s \sin \varphi_1 + d \sin \varphi_2 + e \cos \varphi_2 - b = 0 \\ f_3 = f \cos \varphi_2 + l_5 \cos \varphi_3 - l_6 \cos \varphi_4 = 0 \\ f_4 = f \sin \varphi_2 + l_5 \sin \varphi_3 - l_6 \sin \varphi_4 + c = 0 \end{cases} \quad (2)$$

即可得位置方程组,求解  $\varphi_1, \varphi_2, \varphi_3, \varphi_4$

$$\begin{cases} f_1 = s \cos \varphi_1 - d \cos \varphi_2 + e \sin \varphi_2 - a \\ f_2 = -s \sin \varphi_1 + d \sin \varphi_2 + e \cos \varphi_2 - b \\ f_3 = f \cos \varphi_2 + l_5 \cos \varphi_3 - l_6 \cos \varphi_4 \\ f_4 = f \sin \varphi_2 + l_5 \sin \varphi_3 - l_6 \sin \varphi_4 + c \end{cases} \quad (3)$$

F点(钻尖)位置坐标为

$$\begin{cases} x_F = f \cos \varphi_2 - g_1 \sin \varphi_3 + g_2 \cos \varphi_3 \\ y_F = f \sin \varphi_2 + g_1 \cos \varphi_3 + g_2 \sin \varphi_3 \end{cases} \quad (4)$$

对式(3)求导后写出雅可比矩阵

$$A = \begin{bmatrix} \frac{\partial f_1}{\partial \varphi_1} & \frac{\partial f_1}{\partial \varphi_2} & \frac{\partial f_1}{\partial \varphi_3} & \frac{\partial f_1}{\partial \varphi_4} \\ \frac{\partial f_2}{\partial \varphi_1} & \frac{\partial f_2}{\partial \varphi_2} & \frac{\partial f_2}{\partial \varphi_3} & \frac{\partial f_2}{\partial \varphi_4} \\ \frac{\partial f_3}{\partial \varphi_1} & \frac{\partial f_3}{\partial \varphi_2} & \frac{\partial f_3}{\partial \varphi_3} & \frac{\partial f_3}{\partial \varphi_4} \\ \frac{\partial f_4}{\partial \varphi_1} & \frac{\partial f_4}{\partial \varphi_2} & \frac{\partial f_4}{\partial \varphi_3} & \frac{\partial f_4}{\partial \varphi_4} \end{bmatrix} =$$

$$\begin{bmatrix} -s \sin \varphi_1 & d \sin \varphi_2 + e \cos \varphi_2 & 0 & 0 \\ -s \cos \varphi_1 & d \cos \varphi_2 - e \sin \varphi_2 & 0 & 0 \\ 0 & -f \sin \varphi_2 & -l_5 \sin \varphi_3 & l_6 \sin \varphi_4 \\ 0 & f \cos \varphi_2 & l_5 \cos \varphi_3 & -l_6 \cos \varphi_4 \end{bmatrix} \quad (5)$$

$$[A]^{(i)}[\Delta \varphi] =$$

$$\begin{bmatrix} -s \sin \varphi_1 & d \sin \varphi_2 + e \cos \varphi_2 & 0 & 0 \\ -s \cos \varphi_1 & d \cos \varphi_2 - e \sin \varphi_2 & 0 & 0 \\ 0 & -f \sin \varphi_2 & -l_5 \sin \varphi_3 & l_6 \sin \varphi_4 \\ 0 & f \cos \varphi_2 & l_5 \cos \varphi_3 & -l_6 \cos \varphi_4 \end{bmatrix} \times$$

$$\begin{bmatrix} \Delta \varphi_1 \\ \Delta \varphi_2 \\ \Delta \varphi_3 \\ \Delta \varphi_4 \end{bmatrix}^{(i)} = \begin{bmatrix} -f_1 \\ -f_2 \\ -f_3 \\ -f_4 \end{bmatrix}^{(i)} \quad (6)$$

在迭代中

$$\begin{cases} \varphi_1^{(i+1)} = \varphi_1^{(i)} + \Delta \varphi_1 \\ \varphi_2^{(i+1)} = \varphi_2^{(i)} + \Delta \varphi_2 \\ \varphi_3^{(i+1)} = \varphi_3^{(i)} + \Delta \varphi_3 \\ \varphi_4^{(i+1)} = \varphi_4^{(i)} + \Delta \varphi_4 \end{cases} \quad (7)$$

如果用消元法直接求解<sup>[8]</sup>,可得

$$\begin{cases} \Delta \varphi_1 = \frac{(-f_1 d + f_2 e) \cos \varphi_2 + (f_1 e + f_2 d) \sin \varphi_2}{s(-d \sin(\varphi_1 - \varphi_2) + e \cos(\varphi_1 - \varphi_2))} \\ \Delta \varphi_2 = \frac{-f_1 \cos \varphi_1 + f_2 e \sin \varphi_1}{-d \sin(\varphi_1 - \varphi_2) + e \cos(\varphi_1 - \varphi_2)} \\ \Delta \varphi_3 = [(ff_1 + df_3 - ef_4) \sin(\theta_1) + (df_3 + ef_4) \sin(\theta_2) - ff_1 \sin(\theta_3) + (ff_2 - ef_3 - df_4) \cos(\theta_1) - (ef_3 - df_4) \cos(\theta_2) - ff_2 \cos(\theta_3)] / [el_5 \sin(\theta_7) - el_5 \sin(\theta_8) + dl_5 \cos(\theta_7) - dl_5 \cos(\theta_8)] \\ \Delta \varphi_4 = [(ff_1 + df_3 - ef_4) \sin(\theta_4) + (df_3 + ef_4) \sin(\theta_5) - ff_1 \sin(\theta_6) + (ff_2 - ef_3 - df_4) \cos(\theta_4) - (ef_3 - df_4) \cos(\theta_5) - ff_2 \cos(\theta_6)] / [el_5 \sin(\theta_7) - el_5 \sin(\theta_8) + dl_5 \cos(\theta_7) - dl_5 \cos(\theta_8)] \end{cases} \quad (8)$$

式中设

$$\begin{cases} \theta_1 = \varphi_1 - \varphi_2 + \varphi_4 \\ \theta_2 = \varphi_1 + \varphi_2 - \varphi_4 \\ \theta_3 = \varphi_1 - \varphi_2 - \varphi_4 \\ \theta_4 = \varphi_1 - \varphi_2 + \varphi_3 \\ \theta_5 = \varphi_1 + \varphi_2 - \varphi_3 \\ \theta_6 = \varphi_1 - \varphi_2 - \varphi_3 \\ \theta_7 = \varphi_1 - \varphi_2 - \varphi_3 + \varphi_4 \\ \theta_8 = \varphi_1 - \varphi_2 + \varphi_3 - \varphi_4 \end{cases}$$

$$\begin{bmatrix} -f\sin\varphi_2 & -l_5\sin\varphi_3 & l_6\sin\varphi_4 \\ f\cos\varphi_2 & l_5\cos\varphi_3 & l_6\cos\varphi_4 \\ f\cos\varphi_2 & -g_1\sin\varphi_3 + g_2\cos\varphi_3 & 0 \end{bmatrix} \quad (11)$$

$$[B]^{(i)}[\Delta\varphi] = \begin{bmatrix} -f\sin\varphi_2 & -l_5\sin\varphi_3 & l_6\sin\varphi_4 \\ f\cos\varphi_2 & l_5\cos\varphi_3 & -l_6\cos\varphi_4 \\ f\cos\varphi_2 & g_1\sin\varphi_3 + g_2\cos\varphi_3 & 0 \end{bmatrix} \times$$

生态植树机等效六杆机构任意点绝对位置分析可以由 F 点(钻尖)距地面的高度及绝对位置得到

$$\begin{bmatrix} \Delta\varphi_2 \\ \Delta\varphi_3 \\ \Delta\varphi_3 \end{bmatrix}^{(i)} = \begin{bmatrix} -f_3 \\ -f_4 \\ -f_5 \end{bmatrix}^{(i)} \quad (12)$$

$$\begin{cases} x_F = x_F + s_c = (f\cos\varphi_2 - g_1\sin\varphi_3 + g_2\cos\varphi_3) + v_s \cdot t \\ h = c + k - y_F = c + k - (f\sin\varphi_2 + g_1\cos\varphi_3 + g_2\sin\varphi_3) \end{cases} \quad (9)$$

$$\begin{cases} \varphi_2^{(i+1)} = \varphi_2^{(i)} \\ \varphi_3^{(i+1)} = \varphi_3^{(i)} + \Delta\varphi_3 \\ \varphi_4^{(i+1)} = \varphi_4^{(i)} + \Delta\varphi_4 \end{cases} \quad (13)$$

上式中  $t = \frac{s - 370}{v_g} = \frac{s - 370}{\dot{s}_g}$

文中

$$v_s = 0.4 \text{ km/h} = 111.11 \text{ mm/s}$$

$$v_g = \dot{s}_g = 80 \text{ mm/s} \quad (\text{油缸下行,工作时})$$

$$v_g = \dot{s}_g = 160 \text{ mm/s} \quad (\text{油缸上行,回程时})$$

本部分主要是分析 F 点(钻尖)触地点位置及其时刻,以确定钻土坑形. F 点(钻尖)触地点位置时  $h = 0$ , 即  $h = c + k + y_F = c + k + (f\sin\varphi_2 + g_1\cos\varphi_3 + g_2\sin\varphi_3) = 0$

建立位置方程组

$$\begin{cases} f_3 = f\cos\varphi_2 + l_5\cos\varphi_3 - l_6\cos\varphi_4 \\ f_4 = f\sin\varphi_2 + l_5\sin\varphi_3 - l_6\sin\varphi_4 + c \\ f_5 = c + k + (f\sin\varphi_2 + g_1\cos\varphi_3 - g_2\sin\varphi_3) \end{cases} \quad (10)$$

同理,由线修正逼近理论——牛顿-罗夫森(Newton-Raphson)法<sup>[9]</sup>,得式(10)的雅可比式为

$$[B] = \begin{bmatrix} \frac{\partial f_3}{\partial \varphi_2} & \frac{\partial f_3}{\partial \varphi_3} & \frac{\partial f_3}{\partial \varphi_4} \\ \frac{\partial f_4}{\partial \varphi_2} & \frac{\partial f_4}{\partial \varphi_3} & \frac{\partial f_4}{\partial \varphi_4} \\ \frac{\partial f_5}{\partial \varphi_2} & \frac{\partial f_5}{\partial \varphi_3} & \frac{\partial f_5}{\partial \varphi_4} \end{bmatrix} =$$

$$\begin{cases} \Delta\varphi_2 = [(f_3g_1 - f_4g_2)\sin\psi_1 + (f_3g_1 + f_4g_2 - 2f_4l_5)\sin\psi_2 - (f_3g_2 + f_4g_1)\cos\psi_1 - (f_3g_2 - f_4g_1)\cos\psi_2] / [f(l_5 - g_2)\sin\psi_7 - g_2\sin\psi_8 - l_5\sin\psi_9 - g_2\cos\psi_7 + g_1\cos\psi_8] \\ \Delta\varphi_3 = [f_4\sin\psi_3 - (f_4 - 2f_5)\sin\psi_4 + f_3\cos\psi_3 + f_3\cos\psi_4] / [(l_5 - g_2)\sin\psi_7 - g_2\sin\psi_8 - l_5\sin\psi_9 - g_2\cos\psi_7 + g_1\cos\psi_8] \\ \Delta\varphi_4 = [(f_3g_1 - f_4g_2 + f_4l_5)\sin\psi_5 - (f_3g_1 + f_4g_2 + f_4l_5 - 2f_5l_5)\sin\psi_6 - (f_3g_2 - f_3l_5 + f_4g_1)\cos\psi_5 - (f_3g_2 - f_3l_5 - f_4g_1)\cos\psi_6] / [l_6((l_5 - g_2)\sin\psi_7 - g_2\sin\psi_8 - l_5\sin\psi_9 - g_2\cos\psi_7 + g_1\cos\psi_8)] \end{cases} \quad (14)$$

上式中设

$$\begin{cases} \psi_1 = \varphi_3 + \varphi_4 \\ \psi_2 = \varphi_3 - \varphi_4 \\ \psi_3 = \varphi_2 + \varphi_4 \\ \psi_4 = \varphi_2 - \varphi_4 \\ \psi_5 = \varphi_2 + \varphi_3 \\ \psi_6 = \varphi_2 - \varphi_3 \\ \psi_7 = \varphi_2 + \varphi_3 - \varphi_4 \\ \psi_8 = \varphi_2 - \varphi_3 - \varphi_4 \\ \psi_9 = \varphi_2 - \varphi_3 + \varphi_4 \end{cases}$$

便可求出  $\varphi_2, \varphi_3, \varphi_4$

再由

$$\begin{cases} s \cos \varphi_1 - d \cos \varphi_2 + e \sin \varphi_2 - a = 0 \\ -s \sin \varphi_1 + d \sin \varphi_2 + e \cos \varphi_2 - b = 0 \end{cases}$$

解得

$$\begin{cases} s = \sqrt{(d \cos \varphi_2 - e \sin \varphi_2 + a)^2 + (d \sin \varphi_2 + e \cos \varphi_2 - b)^2} \\ \varphi_1 = \arcsin \left( \frac{d \sin \varphi_2 + e \cos \varphi_2 - b}{s} \right) = \\ \arcsin \left[ \frac{d \sin \varphi_2 + e \cos \varphi_2 - b}{\sqrt{(d \cos \varphi_2 - e \sin \varphi_2 + a)^2 + (d \sin \varphi_2 + e \cos \varphi_2 - b)^2}} \right] \end{cases} \quad (15)$$

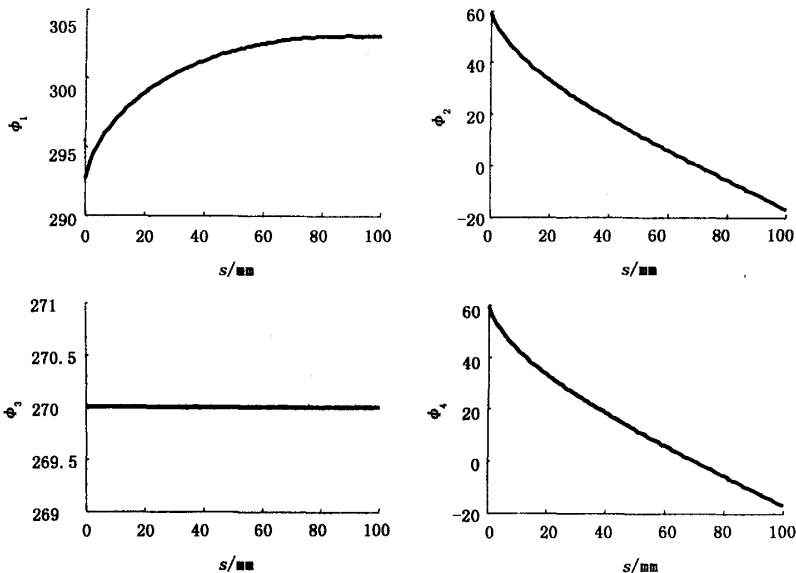


图3 各杆转角变化

Fig.3 Change of every pole corner

## 4 结论

1)对生态植树机的松土机构悬挂系统提出了几点基本假设,并采用线修正逼近理论——牛顿-罗夫森(Newton-Raphson)法分析了机构位置及钻尖的相对位移、绝对位移,这对下一步的动力分析作好了准备。

2)采用 MATLAB 语言计算了上述内容,得到了各构件的转角,并用数值仿真计算了各个点的结果。

3)研究各个曲线分析不同参数时对悬挂系统第二杆组 ADEB 采用平行四杆机构及油缸的推行速度 80 mm/s 时坑形可满足要求,并应用到实际植树机的设计中。

由式(12)~式(15)即可求得 F 点(钻头)触地时(即  $h = 0$ ),整个等效六杆机构此时的位置及时刻。

设计的生态植树机松土机构悬挂系统等效六杆机构各杆尺寸为: $a = 165.5 \text{ mm}, b = 440 \text{ mm}, c = 150 \text{ mm}, d = 73 \text{ mm}, e = 70 \text{ mm}, f = 450 \text{ mm}, l_5 = 150 \text{ mm}, l_6 = 450 \text{ mm}, g_1 = 175 \text{ mm}, g_2 = 766 \text{ mm}, k = 455 \text{ mm}$ ,油缸的变化范围  $370 \leq s \leq 470 \text{ mm}$ 。当取  $s = 370 \text{ mm}$  时,由式(3),(7),(8)经过迭代便可得机构在此时刻的位置图。以此类推,便可得到等效六杆机构在任意时刻的位置(如图3所示)。

4)本文提出了对植树机松土机构悬挂机构的运动分析的一种研究方法,这也为今后对该类机构的改进设计、参数确定指明了方向。

## 参 考 文 献

- 姜爱林.西部沙漠的开发、利用与保护.国家行政学院学报,2000,4:46~49(Jiang Ailin. Development, using and protecting in the western desert. *Journal of National Administrative Institute*, 2000, 4:46~49(in Chinese))
- 潘天丽,王蓝.在退耕还林中应大力发展林业机械.陕西林业科技,2000,4:59~64(Pan Tianli, Wang Lan. Develop forestry's machinery in a more cost-effective manner in conceding the land to forestry. *Science and Technology of*

- Forestry of Shanxi*, 2000, 4: 59~64 (in Chinese))
- 3 王玉霞,郭连生,邹受益,等.科尔沁沙地杨树深松插干造林技术研究.内蒙古林学院学报(自然科学版), 1999, 21(3): 38~43 (Wang Yuxia, Guo Liansheng, Zou Shouyi. Research on the technology that poplar looses and inserts deeply for afforesting in Horqin sand. *Journal of Forestry Instioute of the Inner Mongol (Natural Science Edition)*, 1999, 21(3): 38~43 (in Chinese))
  - 4 俞国胜,顾正平,钱桦,等.半干旱沙地深栽造林钻孔机的性能试验与研究.林业科学, 2001, 37(3): 112~117 (Yu Guosheng, Gu Zhengping, Qian Hua, et al. Performance testing and research on afforest holing deeply machine for half arid sand. *Forestry's Science*, 2001, 37(3): 112~117 (in Chinese))
  - 5 俞国胜,顾正平,陈劭.半干旱沙地机械化造林试验研究及其前景.林业机械与木工设备, 2000, 28(10): 9~11 (Yu Guosheng, Gu Zhengping, Chen Shao. Experimental study and prospect of afforesting mchaniarily in half arid sand. *Forestry's Machinery and Woodwork Equipment*, 2000, 28(10): 9~11 (in Chinese))
  - 6 Bertil Axelsson. Ecoplanter scarifies and plants at the same time. *Holmen Insikt*, 2003, 5: 124~126
  - 7 Helenius P, Luoranan J, Rikala R, Leinonen K. Effect of drought on growth and mortality of actively growing norway spruce container seedlings planted in summer. *Scandinavian Juornal of Forest Research*, 2002, 17. : 16~19
  - 8 孟宪举,黄永强.具有刚性运动的弹性梁单元动力学微分方程的精确表达式.河北理工学院学报, 1998, 20(3): 34~41 (Meng Xianju, Huang Yongqiang. Accurate expression formula with elastic roof beam unit dynamics differential equation of the rigidity movement. *Journal of Hebei Instioute of Technology*, 1998, 20(3): 34~41 (in Chinese))
  - 9 冯志友,李晶,邢传波.含间隙机械系统 KED 分析的计算机仿真.佳木斯大学学报(自然科学版), 2000, 18(4): 333~334 (Feng Zhiyou, Li Jing, Xing Chuanbo. The computer emulation that KED analyses of mechanical system including interval. *Journal of University of Jiamusi (Natural Science Edition)*, 2000, 18(4): 333~334 (in Chinese))

## ANALYSE ON THE DYNAMIC ATHLETICS CHARACTERISTIC OF ECOPLANTER \*

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**Abstract** Firstly, we discussed the general design principle of an ecoplaner qualitatively. Then, we applied the linear modification approximation theory-the method of Newton-Raphson to perform the kinematics analysis on the hanging system of the scarification mechanism of the ecoplaner and discussed its pit shape. Finally, we carried out the numeral simulation on the pit shape and the Elasto-Dynamics with the business software - MATLAB. The results were helpful for the designer to have more distinct knowledge about the mechanism motion property and the structure property of the developed product prototype before formal production, and therefore raising the successful rate of the product development.

**Key words** ecoplanter, elasto-dynamic analysis, organization, loosening soil organization

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