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Research Article

Using SIMULINK to Design and Simulate the Peanut Flattening Rolls

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Abstract: Building up two systems for the peanut flattening rolls in the peanut cold rolling process according to SIMULINK, is imitating to solve the radius of the peanut flattening rolls. It includes the deformation resistance system (kf_Subsystem) and the radius of the peanut flattening roll's calculation system (R_Subsystem). These two systems are used to alternately compute the radius of the peanut flattening rolls. What to adopt is the percentage difference between the radius less than 3% and calculation times less than 10 are the termination condition.

Keywords: Peanut flattening rolls, resistance system, SIMULINK

INTRODUCTION

SIMULINK is a block diagram environment for multi-domain simulation and Model-Based Design. It supports simulation, automatic code generation and continuous test and verification of embedded systems (Zhang *et al*., 2013; Marın *et al*., 2014). SIMULINK provides a graphical editor, customizable block libraries and solvers for modeling and simulating dynamic systems. SIMULINK provides a set of predefined blocks that you can combine to create a detailed block diagram of your system. Tools for hierarchical modeling, data management and subsystem customization enables you to represent even the most complex system concisely and accurately (Xiong *et al*., 2012; Suh *et al*., 2012).

Simulink is used for the multi domain simulation of dynamic systems and embedded systems and model-based design tools (Trikande *et al*., 2014; Docquier *et al*., 2010; Hameed and Mohamad, 2014). For a variety of time-varying systems, including communications, control, signal processing, video processing and image processing system, it is closely integrated with the MATLAB, can directly access the MATLAB a lot of tools for algorithm research, simulation analysis and visualization, batch script creation, modeling environment customization and signal parameters and the definition of test data. SIMULINK provides an interactive graphical environment and can be customized module library to carry on the design, simulation, implementation and testing (Li *et al*., 2014a; Saleh *et al*., 2010; Coman and Lonescu, 2009).

Using SIMULINK can realize the modeling and Simulation of peanut cold roll radius. It's not only in the calculation of the process of modular iterative complex between rolling force and roll deformation. In this environment, the process of creating just click and drag the mouse operation can be done. It provides a more convenient, direct and clear way and users can immediately see the results of the simulation system (Li *et al*., 2014b; Yi *et al*., 2014; Shuang, 2013; Ferretti *et al*., 2012).

MATERIALS AND METHODS

Work roll flattening: Since the peanut properties of the work rolls, under the action of the work rolls of the rolling force will peanutally be compressed. Rolling force is calculated by the simplified formula and Hitchcock formula used to calculate the peanut flattening roll. Because the calculation of rolling force and roll deformation radius between each other premised, it must be iterative calculations.

Simplification rolling force equation:

$$f_w = k \left(1 + \frac{\mu \quad l_B}{4 \quad h_A}\right) b \quad l_B$$

$$l_B = \sqrt{\Delta h_G \times R}$$

$$\Delta h_G = \left(\sqrt{(h_E - h_A) + \frac{h_A \cdot k}{E_B}} + \sqrt{\frac{h_A \cdot k}{E_B}}\right)^2$$

Hitchcock formula: Hitchcock proposed an equation on a "roller deformation radius." Contact arc mainly relies on its peanut region. Thus, equation expands to:

$$R_i = R\left[1 + \frac{crb \cdot f_W}{b \cdot \left(\sqrt{\Delta h + \Delta h_{el}} + \sqrt{\Delta h_{el}}\right)^2}\right]$$

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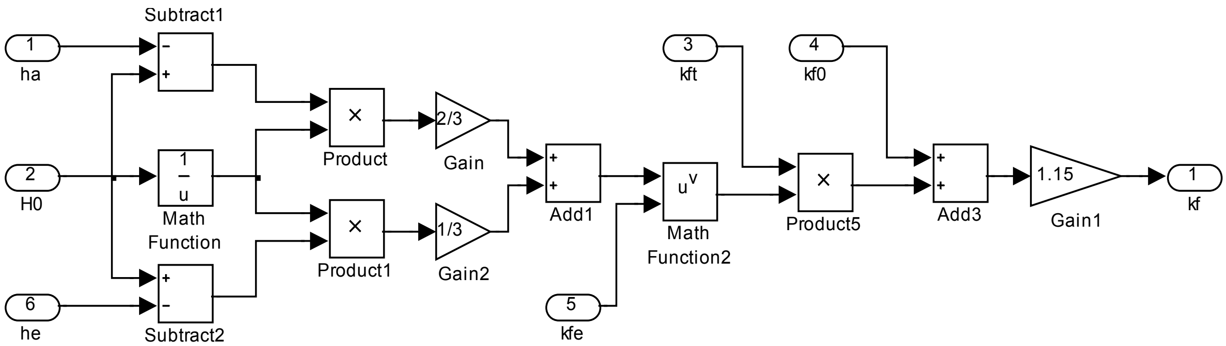

Fig. 1: Deformation system (kf_subsystem)

The above equation:

f_w = Rolling force
k = The horizontal stress
l_B = Deformation zone length
μ = The coefficient of friction, here take a fixed value μ = 0.07
b = For strip width
$\triangle h_G$ = Total amount of deformation
crb = Pressure flat coefficient R
Ri = The work roll before deformation and after the roll diameter
h_A = Export strip thickness
h_E = Entrance strip thickness
E_B (emod_strip) = Strip peanut modulus

Since the calculation flattening radius depends on the rolling force, we must use an iterative approach to calculate it, until the difference is calculated before and after the rolling force of less than two iterations of a suitable fixed value before termination iteration. Used here is the percentage of the difference between two iterations is less than 3% or the radius of the number of iterations is less than 10.

SIMULINK roll radius to achieve peanut cold rolling process modeling and simulation: Both systems were established using SIMULINK, including the deformation resistance system (kf_Subsystem) and roll radius Computing System (R_Subsystem) two subsystems. And the deformation resistance of deformation of the overall system, including the subsystem $\triangle h_G$ (deta_h_G), these two systems are used to calculate the horizontal stress k. Roll radius Computing System (R_Subsystem) contains a rolling force computing system (fw_Subsystem) used to calculate these two systems to calculate the roll radius.

Deformation resistance system (kf_subsystem), shown in Fig. 1 (kf_subsystem): Tandem peanut cold rolling is a producing technology with high efficiency and quality for peanut cold rolling strip. It has a lot of equipment and the control process is complex. The deformation resistance equation is one of the fundamental equations, which described the process of tandem peanut cold rolling, but an accurate quantitative expression has not been given at present. In the peanut cold rolling process, deformation resistance k_f and the total compression ratio ε_Σ have the equation relation:

$$k_{f_i} = k_{f_0} + \varepsilon_\Sigma^{\,k_{f_e}} k_{f_t}$$

k_{f_0} is the material's yield strength (when the reduction of area is zero); k_{f_e} is the strain-hardening exponent (Fig. 2).

$\varepsilon_\Sigma = \frac{1}{3}(H_0 - h_e)/H_0 + \frac{2}{3}(H_0 - h_a)/H_0$ ε_Σ adopted approximate methods; k is for the horizontal stress; fza is the exit tension; k = kf -fza.

R_subsystem for the cold work roll radius (shown in Fig. 3): R_Subsystem is the core of the simulation process. The cold work roll radius was calculated by the use of the numerical iterative algorithm with do-while module and memory module at last. Based on the conclusion of peanut theory, the R_Subsystem module of flattening between roll was built, so that the flattening between rolls can be treated more rationally.

To avoid an infinite loop, the reasonable termination condition should be sets. The percentage of the difference between two iterations is less than 3% or the radius of the number of iterations is less than 10.

fw_subsystem (Fig. 4): The quality requirements for thickness accuracy in peanut cold rolling continue to become more stringent. In peanut cold rolling mill, it is very important that the rolling force calculation considers rolling conditions. The rolled strip thickness was predicted using calculated rolling force. However, the prediction of strip thickness in peanut cold rolling is very difficult. With rolling force increasing, the deformation of the peanut flattening rolls increased. The work roll shifted gradually from a round to an oval.

Joint simulation (Fig. 5): Subsystem all encapsulated then built the total module and loaded in SIMULINK. Using SIMULINK method based on Lagrange's

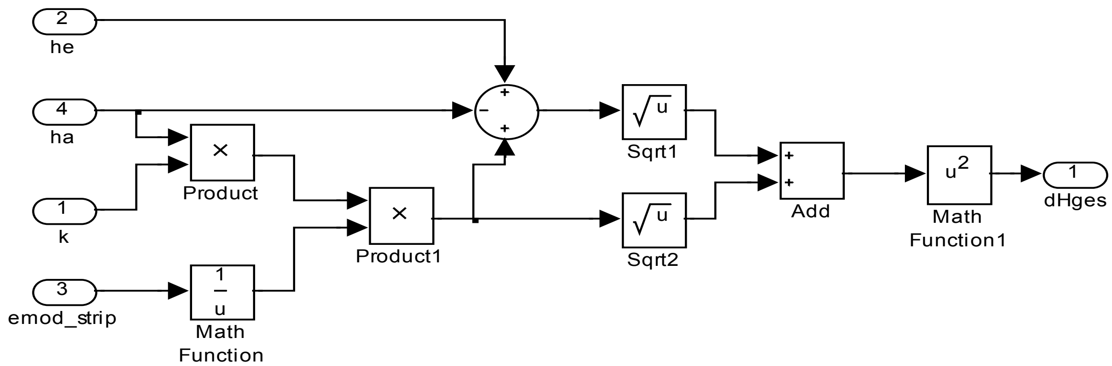

Fig. 2: Deformation ⊿h_G subsystem

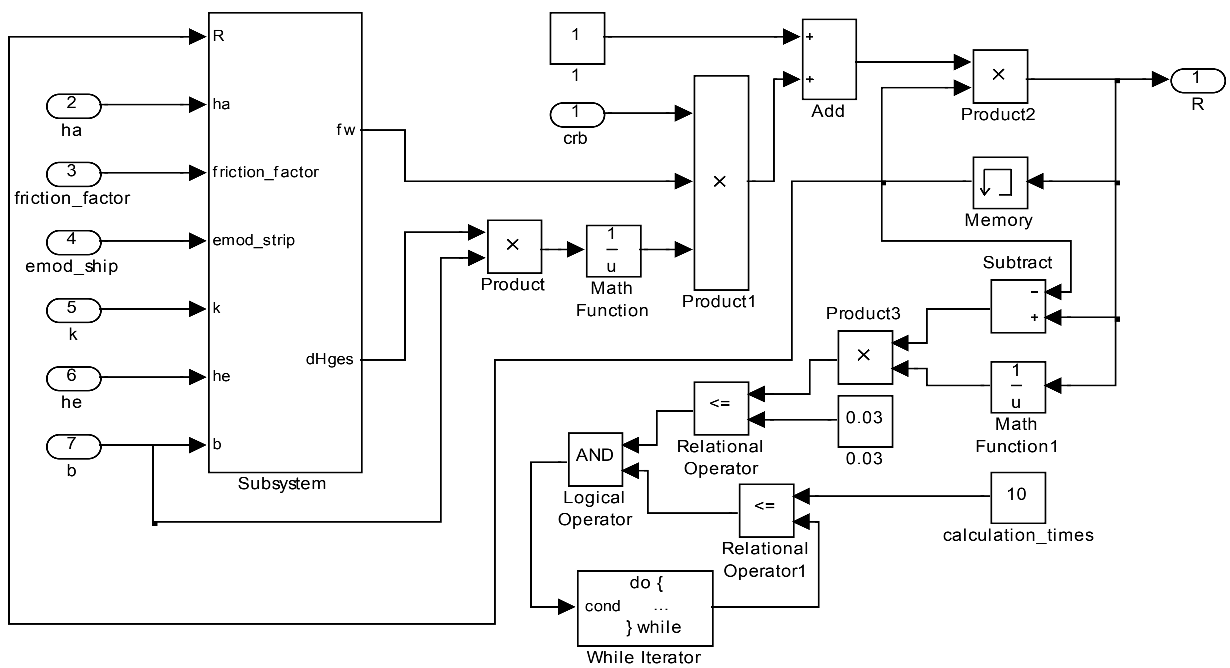

Fig. 3: The peanut flattening rolls calculate system (R_subsystem)

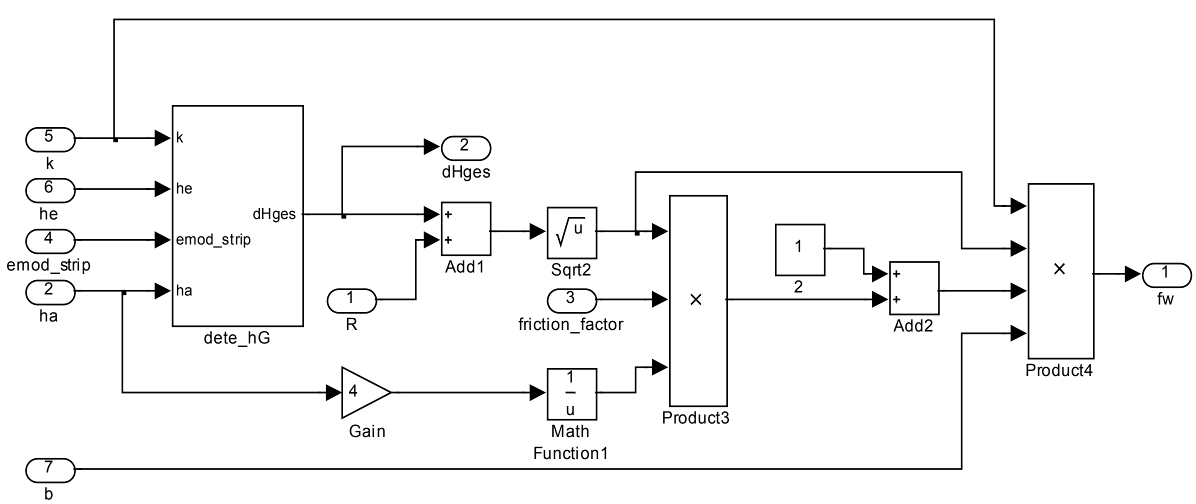

Fig. 4: Rolling force calculation system (fw_subsystem)

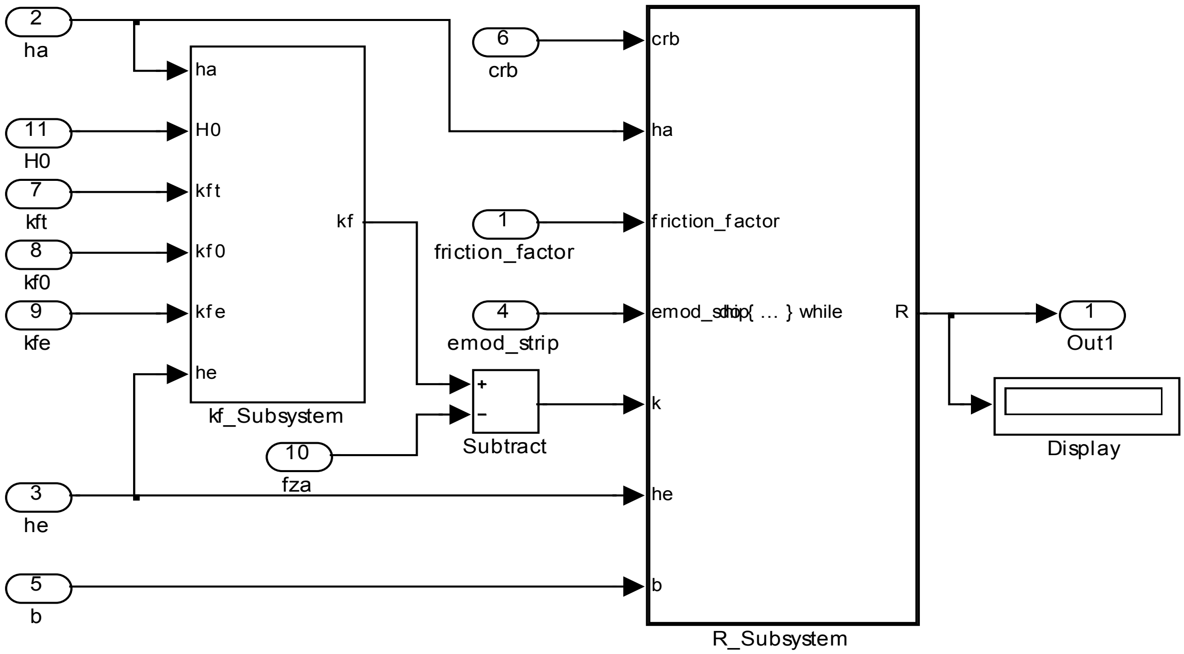

Fig. 5: Joint simulation

Table 1: Measured data

Parameter	ha (m)	he (m)	R (m)	Sita-μ	kfe	kft	kf0 (Pa)	E_B (Pa)	Fza (N)
Value	0.0018	0.00225	0.225	0.07	0.505	429645376	357652480	2.0e+11	8.0e+7

Table 2: Simulate result

Parameter	kf (Pa)	Fw (N)	Ri (m)
Value	6.413e+8	6.949e+6	0.2871

multiplier to analyses the deformation of strip, influence function method to calculate the peanut deflection of rolls and analyses the flattening deformation between work roll and strip, a joint simulation was established with an iteration way.

RESULTS AND DISCUSSION

As for the peanut cold rolling plant data is used to joint simulation. Initial strip thickness (H0) is 2.50 mm; width (BB) is 1000 mm, as shown in Table 1.

Results of the joint simulation as shown in Table 2. The SIMULINK result shows that simulate values are close to the actual measured values.

CONCLUSION

- The powerful operation function of SIMULINK realized the solution of peanut cold rolling roller diameter. Through modeling, simulation, in the process of operation can be seen clearly and directly calculating process unit rolling force and roll radius iterative.
- Using the simplified calculation of rolling force simulation calculation equation and accumulative deformation degree equation, the results represent the actual production operation process, improve the analog operation speed.
- By SIMULINK iteration rolling force and roll radius between the simulation will calculate the implicit relationship manifested intuitive.
- The simulation results agree with the actual production and has important reference value.

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