Investigating the behaviour of the welding manipulator tip

Svetlana Gerganova-Savova

Abstract – **The most important element of the welding robot is the powering and moving of the manipulator units. This is why, upon designing the system for positioning of the welding head, it is necessary that the input parameters are specified.**

Keywords – **Roots, Process, Welding robot.**

I. Introduction

The systems for robot controls calculate the trajectory of movement of the weld nozzle by interpolation; they produce signals for execution of commands and control the movement by taking into account the specific parameters of the manipulator. They set the static and dynamic accuracy, as the width of the arc weld differs – from 5 mm in the automotive industry to 30 mm in the ship-building industry [3]. The most important element of the welding robot is the powering and moving of the manipulator units. The speed of motion, depending on the type of welding, may start from a millimeter per second. This is why, upon designing the system for positioning of the welding head, it is necessary that the input parameters are specified. Such a system is displayed on the diagram [2].

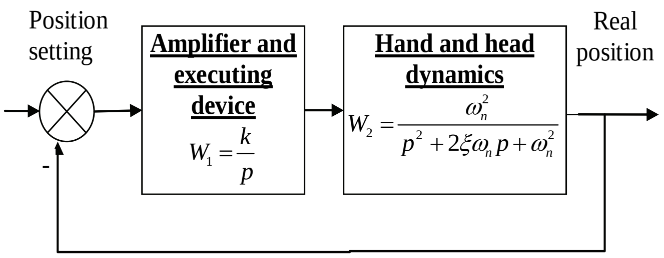

Fig. 1. The system

The dynamics of the hand and the head of the welding manipulator is described as follows:

$$W_2 = \frac{\omega_n^2}{p^2 + 2\xi\omega_n p + \omega_n^2} \qquad (1)$$

Svetlana Gerganova-Savova is with the Automation of Manufacturing Department, College in the Structure of the Technical University of Varna, 1 Studentska, Varna 9010, Bulgaria, E-mail: gerganova-savova@lycos.com.

The amplifier and executing device is described as follows:

$$W_1 = \frac{k}{p} \qquad (2)$$

For an open system:

$$W_{oc} = \frac{k\omega_n^2}{p^3 + 2\xi\omega_n p^2 + \omega_n^2 p} \qquad (3)$$

ω_n- systems deviation frequency, $\xi=0.2$

The combined transient function of a closed system is:

$$W_{зс} = \frac{k\omega_n^2}{p^3 + 2\xi\omega_n p^2 + \omega_n^2 p + k\omega_n^2} \qquad (4)$$

The researches on the threshold of stability [1] show $k_{гр}=0.4\omega_n$, where the recommended ratio for the system is: $0.1<k/\omega_n<0.3$ [2].

When the ration k/ω_n is at its lowest value, where k=1, $\omega_n=10$, the roots are:

$p_{1,2} = -1.4842 \pm 9.7332i$

$p_3 = -1.0316$

The process is slow, the transient response is: $t_p \approx 5\sec$, as shown on Figure 2.

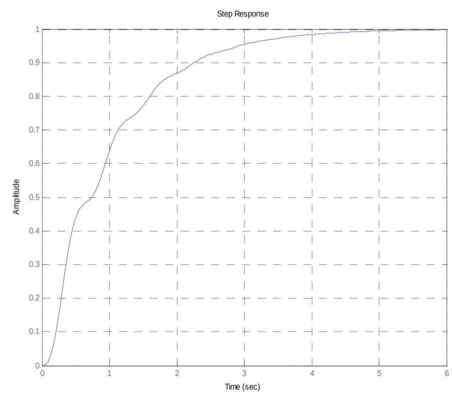

Fig. 2. The process

The same ratio, but with higher k=10, leads to the transient response, as shown on Figure 3.

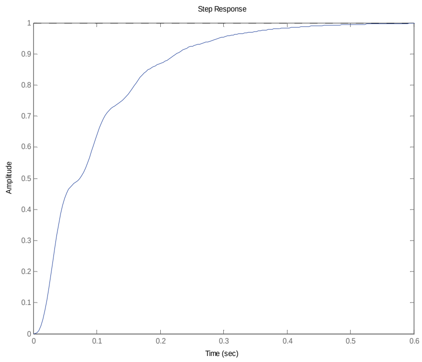

Fig. 3. The process

The result is a faster process. In both cases the transient response features a nice curve. The two real components have close to each other values.

The test for stability by frequency criterion in the middle of the recommended interval k/ω_n =0.2 (k=2; ω_n=10) is shown on figure 4. The system is stable and has a good stability margin: $\Delta L \approx 10dB, \Delta\varphi \approx 80°$.

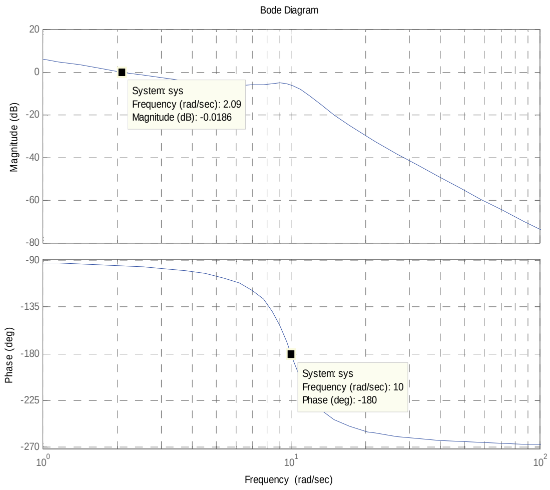

Fig. 4. The test for stability

The roots of the closed system in this case are:

p1,2 = -0.9584 ± j 9.7513

p3 = -2.0832

The imaginary part is tenfold bigger than the real one.

By Δ=±3%, the transient response is 2.2 , according to the formula $t_p \approx \dfrac{4}{\xi\omega_n} \approx 2\sec$, which could also be seen on figure 5. It is recommended that the time value at the first peak in these processes is 1 [2].

The transient function has the form of an oscillating process, monotonous without overregulation. Here the deviation of the complex component with frequency $\omega_n\sqrt{1-\xi^2}$ is added to the a-periodic component. This corresponds to a faster moderating oscillating component in comparison to a slower moderating exponential component of the real parameter, which is close to the imaginary axis. With the decrease of the imaginary component the amplitude is increased and the frequency of deviations is reduced – the process becomes oscillating with overregulation. The real root should correspond to the real component of the complex root, at the most 2-3 times bigger than the latter, then being a monotonous process, where the periodic component can be observed.

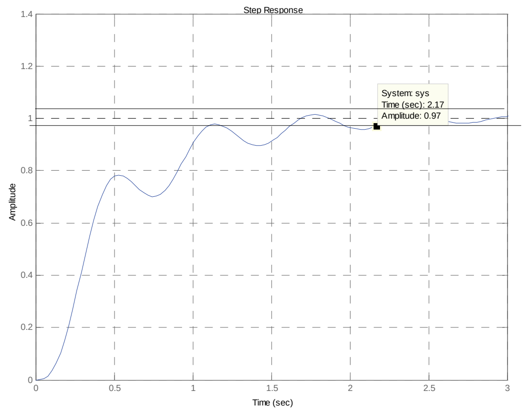

Fig. 5. The transient response

If the ratio stays the same, but there is a change in parameters: k=20 at ω_n=100, the result is displayed on figure 6.

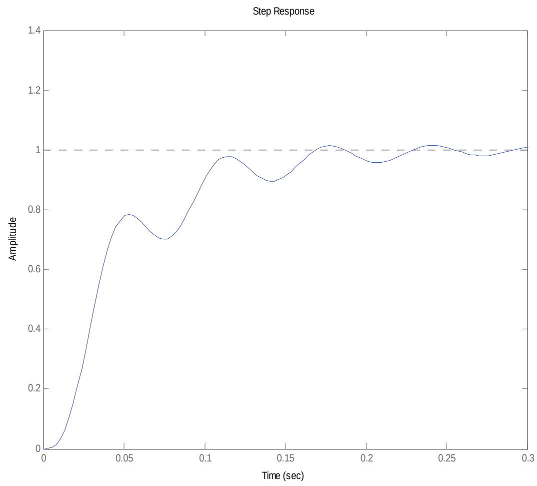

Fig. 6. The transient response

The process becomes faster, the amplification coefficient is increased, but its curve is still the same: oscillating monotonous, without overregulation.

If the ratio at the upper limits $k/\omega_n=0.3$ ($k=3$, $\omega_n=10$) is changed, the roots become:

$p_{1,2} = -0.4565 + 9.8475i$

$p_3 = -3.0870,$

and the transient response is presented on figure 7.

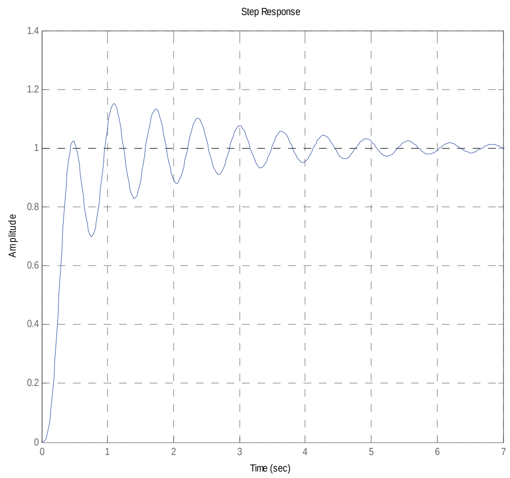

Fig. 7. The transient response

The process here becomes oscillating with overregulation of approx. 18%, which for real processes is up to 1 mm for a welding seam of 5mm width, and up to 6 mm for a welding seam of 30mm width, taking into account that a diagram of a stabilized power supply is reviewed.

The test for stability by frequency criterion (in the lowest value, middle of the recommended interval, at the upper limits) is shown on figure 8.

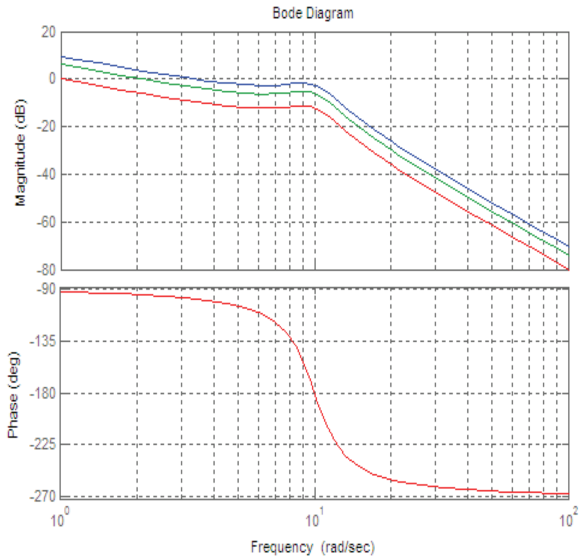

Fig. 8. The test for stability

By the simulation tests from the system at figure 1 a transient response is achieved, which is closest to the aperiodic one at values of $k/\omega_n=0.1$. With the ratio growth the oscillating character becomes even clearer – the real component of the complex roots decreases, i.e. the oscillation indicator increases (the ratio imaginary to real component of the dominant root). The influence of the real root weakens – it distances from the imaginary axis.

REFERENCES

[1] Gene Franklin, J. David Powell, Abbas Emami-Naeini, Feedback Control of Dynamic Systems, Pearson Education Inc., New Jersey, 2006.

[2] Richard Dorf, Robert Bishop, Modern Control Systems, 2008.

[3] http://info-svarka.ru/oborudovanie/svarochnye-protsessy-kak-obekty-avtomaticheskogo-upravleniya