A systematic approach to developing the control system of an AL-250G Bench Lathe

And later generalisations of the design approach to accommodate a wider range of machinery.

The purpose of the following document will be to describe and apply a design approach to the control system of a hobbyist-level manufacturing machine, the AL250G bench lathe from Hare & Forbes Machinery House in Brisbane. The aim of the document is to produce an intelligent control system for this machine and provide a generalised design approach to develop intelligent control systems for general manufacturing machines, which all can operate on the same control system hardware. A reference for the AL250G machine is shown in Figure 1 below.

A large metal lathe with many screws

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Figure 1: AL-250G Bench Lathe as sold by Hare & Forbes. Image Retrieved: (Hare & Forbes Machinery House)

**Section 1: Modelling the system dynamics**

The first step in modelling the system dynamics of the lathe is to find the 1st order control parameters for the simplest ‘black box’ representation of the system. The 1st order control parameters refer to the inputs of the system that are directly controlled by any external force (be that a human operator or an electromechanical controller etc). Note that since the 1st order control parameters of the system can be controlled by systems external to that which we are modelling, a precursor step to modelling these dynamics is a full subsystems analysis that enables the separation of any electromechanical control subsystem from the remaining ‘operational’ subsystems. The operational subsystems refer to the subsystems in the machine that perform the actual work (e.g. in the context of a lathe, the turning subsystem which rotates the workpiece, the positioning system that positions the tool, etc.). Below is a subsystem diagram that describes the lathe at a high level.

A diagram of a system

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Figure 2: Top-level subsystem diagram of the AL-250G Lathe

Using this subsystem analysis, we can break down the subsystems further toward the component level. In this context where we are generating a control system, most of the subsystem components can be left alone grouped into their respective black boxes, excepting only the parts at the component level that are directly responsible for the control parameter inputs of the system. Below are several subsystem breakdowns that identify the control components of the machine.

A diagram of a process

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Figure 3: User Interface Subsystem Breakdown showing inputs, disturbances, outputs and output disturbances.

A diagram of a mechanical scheme

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Figure 4: Mechanical Subsystem Breakdown showing inputs, disturbances, outputs and output disturbances.

A diagram of a component

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Figure 5: Thermal Subsystem Breakdown showing inputs, disturbances, outputs and output disturbances.

A diagram of a safety system

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Figure 6: Safety Subsystem Breakdown showing inputs, disturbances, outputs and output disturbances.

A diagram of power supply

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Figure 7: Power and Electrical Subsystem Breakdown showing inputs, disturbances, outputs and output disturbances.

A diagram of a system

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Figure 8: Actuation Subsystem Breakdown showing inputs, disturbances, outputs and output disturbances.

From the above subsystem breakdowns, a list of all control parameters in the system and their dependencies are identified:

A diagram of a system

Description automatically generated

Figure 9: List of control components, control parameters and controlled components.