SESSION IV

Paper (c)

LOGIC IN MACHINERY DESIGN

John Stulen
LIRA

In the logging industry, the effective use of heavy machinery has always been important. Over the years a number of productivity gains have been realised through technological improvements to various machine components. These gains have primarily resulted from reductions in downtime and reduced cycle times - however, very little attention has been focused on the most important control element in the machine : the man operating it. This paper discusses problem areas with respect to the man/machine interface in heavy machinery and outlines the considerations necessary for improving that relationship.

"Ergonomics is the study of the work design. Applied to man/machine systems, the field gives attention to design that improves the safety, health, comfort and efficiency of the operators and maintenance workers. It also aims at reducing the system requirements for human ability and skill, so that a larger proportion of the total population could become satisfactory workers". (Cottell, P., 1976). Put simply, for the purposes of this paper, ergonomics requires the application of logic in machinery design.

To begin, consider a comparison between the operator's compartment of an average cable skidder and the driver's compartment of a modern automobile. Theoretically, both vehicles should be designed to accommodate operators of various shapes and sizes. In the automobile we find adjustments to the following areas are generally available : seat-steering wheel distance, mirror angle and sometimes, steering wheel position/angle. In addition, to carry out the job of driving more effectively, aids to maintain good visibility are available, such as : windscreen wipers, defogging aids, and sunlight deflectors. Adjustable body restraint devices are now common place on automobiles. On the other hand, skidders are without most of these adjustments or facilities. Poor means of access and egress are common. Despite the fact that during the work cycle a skidder operator has to withstand more forces than an automobile driver, no adequate body restraint devices are fitted. All shapes and sizes of operators are expected to cope with fixed control placements and no seat adjustments.

Recently, a study was conducted in Canada on a number of skidder operations to evaluate the human factors involved with them. (Hope, P., Webb, R.D., 1983). An ergonomic checklist (Aminoff, et al, 1980) was used to evaluate cab entrance measurements, cab dimensions and seat characteristics. The following tables display the results:

Table 1 shows the number of machines meeting the recommendations of standard checklists for cab dimensions (Aminoff et al. 1980; Purcell 1980). Ten different models from 5 manufacturers were assessed.

Measurement	Recommendation	Acceptable
Cab width	90 cm min.	10/10
Cab height	160 cm min.	1/10
Cab depth	130 cm min.	3/10
SRP - Right wall	45 cm min.	9/10
SRP - Left wall	45 cm min.	10/10
SRP - Front	65 cm min.	10/10
SRP - Floor	40-50 cm	7/10

TABLE 1: Cab Dimensions
(SRP - Seat Reference Point)

The seat reference point was taken as the intersection point of the seat backrest and the seat reference plane.

Table 2 shows the number of machines meeting the checklist recommendations for seat characteristics.

Measurement	Recommendation	Acceptable
Backrest		
Width	40-50 cm	4/10
Height	40-50 cm	1/10
Angle	95-110°	0/10
Adjustability	required	0/10
Cushion		
Width	44 cm min.	10/10
Thickness	4-10 cm	7/10
Movement		
Vertical	10 cm	0/10
Forward	16 cm	3/10
Armrest	required	0/10

TABLE 2: Seat Characteristics

Cab Entrance

Table 3 shows the number of machines meeting the checklist requirements.

Measurement	Recommendation	Acceptable
Door Height	160 cm min.	1/10
Door Width	162 cm min.	0/10

Measurement	Recommendation	Acceptable
Height		
Step 1	40 cm max.	0/10
Step 1-2	20-30 cm	2/10
Step 2-3	20-30 cm	2/2
Step width	30 cm min.	5/10
Step depth	10 cm min.	5/10
Left grab rail	160 cm max.*	0/10
Right grab rail	160 cm max.*	0/10

(*Base-ground)

TABLE 3: Entrance dimensions

The above table highlights the fact that attention to operator comfort and efficiency has suffered a lot of neglect. Further to this, the conditions for maintenance workers on skidders and other heavy equipment are also, in general, far from being suitable. However, to continue listing examples of poor work-place design would only be negative. It is more appropriate to outline considerations which must be taken into account in future design of this type of equipment.

"Design should aim at a partnership between man and machine to achieve the system goals. Man acts in the system mainly as an adaptive control device". (Cottell, P., 1976). To meet the system goals there are two main areas of consideration for machinery design : the movement or processing of the tree or log, and the motions required by the operator to carry out this work. Technological improvements in mechanical, electrical and chemical processes are readily available to the machine designer to reduce cycle times with respect to doing work on the tree or log. However, because the human involved is an adaptive control device the factors relating to them can be ignored and a machine design may still be considered successful. Table 4 outlines the elements which must be considered in designing a satisfactory work place for a man in a machine.

Table 4 : Elements of Man/Machine Systems

Equipment	Work place Environment	Tasks	Personnel
- controls - displays - dimensions - components - test and service points	temperature illumination visibility vibration noise ventilation	procedures duration feedback response requirements • frequency • accuracy • speed • force	intelligence sensory capability motor capability training experience motivation

(Meister, D., 1971).

The interactive functions of a man and a machine can also be laid out graphically to demonstrate what factors are involved, as shown below :

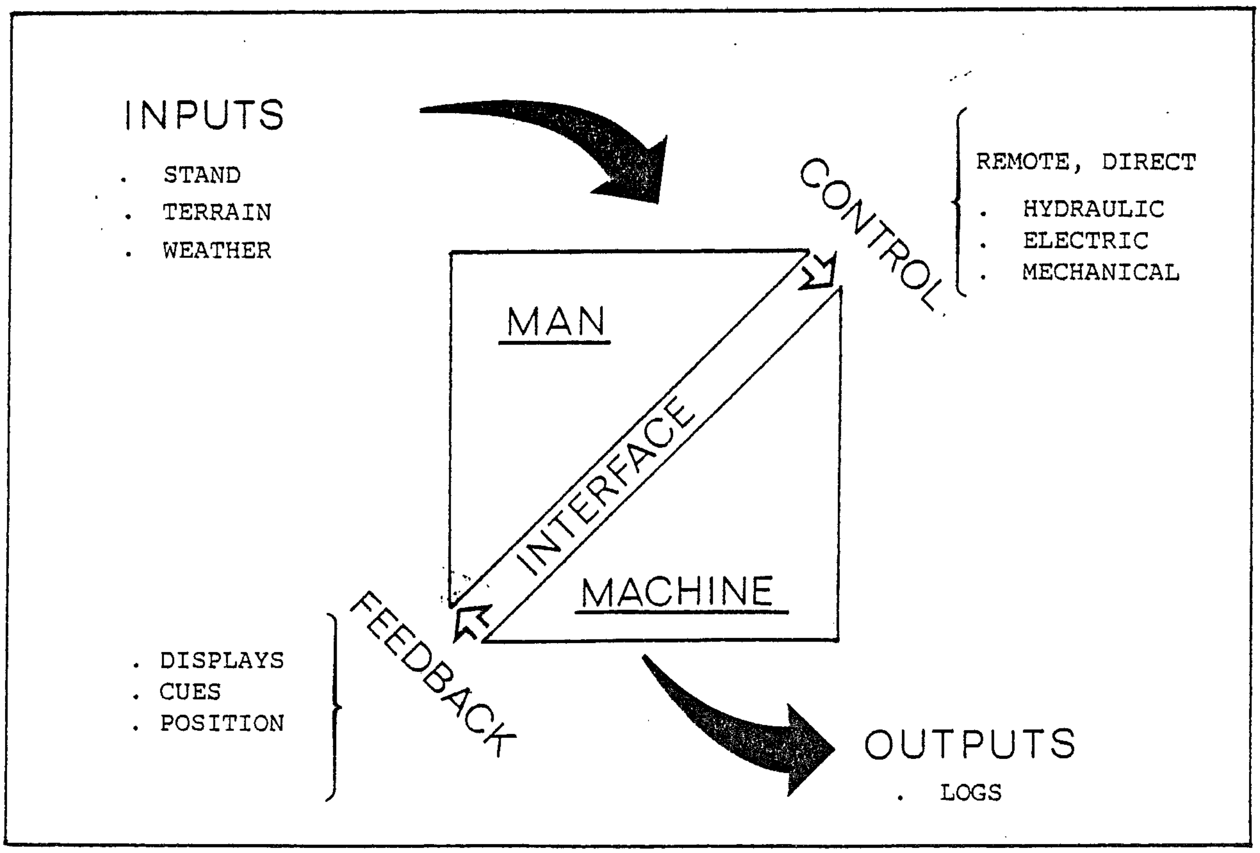

Figure 1

A logical approach to designing control functions in a machine is to follow the progression of events involved in the normal operation of that machine. This principle can be applied to any type of logging machine which requires one or more operators, regardless of whether it is a skidder, forwarder or harvester. Following through the flow diagram of figure 1 the events occur as follows: the machine operator receives inputs from the stand, terrain, weather, etc; after assessing these input conditions he interacts with it by moving or activating certain control functions. Having acted, he then receives feedback information from machine gauges and displays, cues around himself and the machine and from the position of the machine tool(s). The events of assessment, control and feedback occur continuously and repeatedly during work cycles with the eventual output being the movement or processing of trees or logs.

Control placement, force requirement to operate it and feedback received while using it are all very important aspects in the design of controls. Knowing the details of control useage during a cycle or day affects the above factors regarding its design. A control which only is moved once a day need not be as easy to actuate or reach as one which is repeatedly used during one work cycle. For control placement it is also important to ensure that controls which activate machine motion or whose tool movement momentum can affect the operators seating position. (i.e. boom swing controls) are located so the operator can brace himself (i.e. via armrests) while making a controlled movement.

Examples of good and bad control design can be found in the area of hydraulic knuckle-boom crane applications. The options are 6 lever or 2 lever (joystick) controls. Problems with 6 lever controls are as follows: a high degree of skill is required to quickly and efficiently actuate more than two controls at once; the operator cannot firmly brace his body in the seat as the arms are extended to reach control levers, and some levers (directly connected to hydraulic spool valve banks) provide little feedback.

Newer two-lever controls provide solutions to these problems. Through either electric or hydraulic pilot control they can provide feedback of a more subtle type than the direct control. Multidirectional movement of each control allows each lever to control more than one function to be activated by each lever. Figure 2 shows well designed 2 control layouts. Both are from forwarders.

Note the combined electrical (white buttons) and hydraulic control levers at the end of the armrest. The operator can brace himself against the seat and armrests to remain stable while making control movements. The control levers are designed to fit the human hand so that they remain comfortable to operate through the work day.

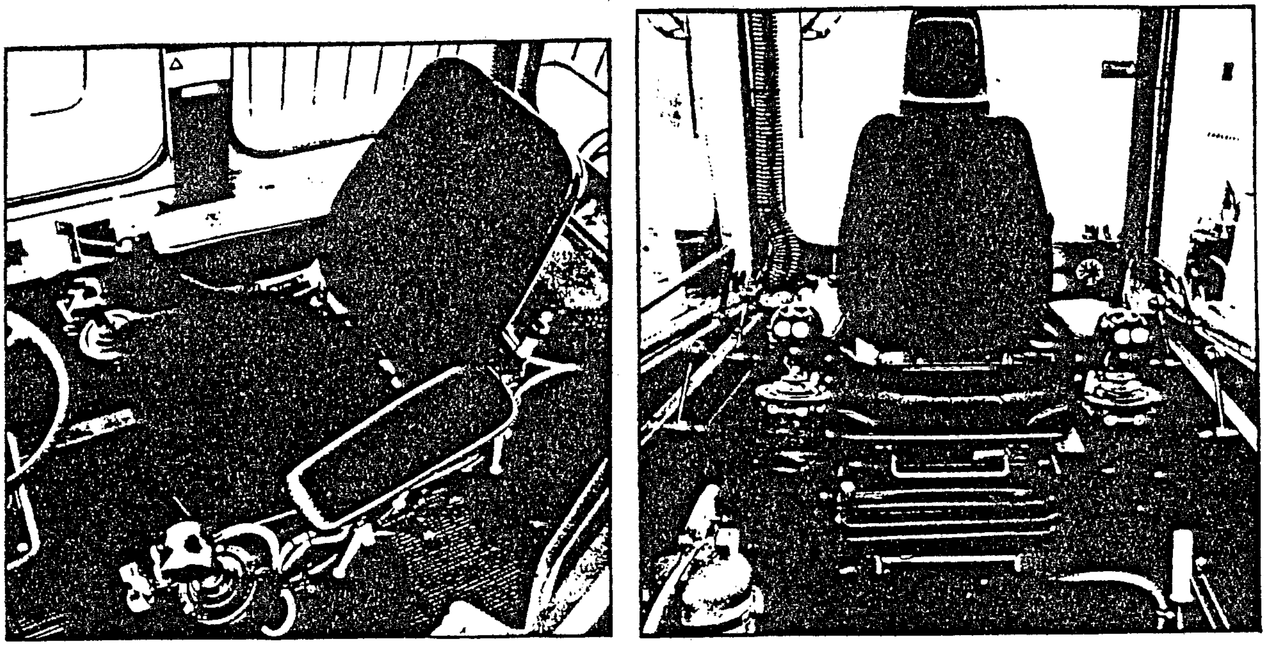

Figure 2 - Cab/control layouts using 2 lever joystick control design (Above left: Osa forwarder; right: Brunnett forwarder).

Design changes to facilitate logical and comfortable machine control and operation can only be brought about through operator/ owner and manufacturer communication. Often the process of changes is slow. To avoid problems operator requirements and comfort levels should be checked thoroughly when choosing machinery in the first instance. The human factor is very important in the design and selection of logging machinery and this point is only slowly becoming apparent to manufacturers of logging equipment. Attention to logic when designing the equipment will help.

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