XVII^th World Congress of the International Commission of Agricultural Engineering (CIGR)

Hosted by the Canadian Society for Bioengineering (CSBE/SCGAB)
Québec City, Canada June 13-17, 2010

WORKLOAD ASSESSMENT IN AGRICULTURE – INTEGRATION IN A WORK BUDGET SYSTEM

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CSBE100313 – Presented at Section V: Management, Ergonomics and Systems Engineering

ABSTRACT The use of a contemporary model-based work budget allows the comparison of work and production processes up to total-farm level under otherwise equal conditions. The inclusion of physical load is ensured via expanded OWAS codes with a mass-related load index as well as with the average physically strenuous working-time requirement. Consequently, sectoral statements on manpower potential and workload in farming are also possible. The continuous traceability of the data is ensured, so that expansions and corrections of errors are easily carried out. Data may be exported from the program via interfaces. The software, which is modular in design, is available in four languages. The computer-based work budget therefore represents an internationally applicable tool both for the improvement of work organisation and time planning, as well as for the measurement of workload.

Keywords: Working-time measurements, modelling, work budget, work record chart, workload.

INTRODUCTION The use of model calculation systems allows calculating the working-time requirement of work processes, to production processes, up to total-farm level. At the same time, the element-oriented approach with its clear-cut beginning and end points for each work element also facilitates the inclusion of body postures, masses moved, and workload groups. Within the “Farm” work system, concrete time planning must be carried out in addition to the accurate calculation of the expected working times. The purpose of time planning is to determine what tasks the workforce deals with at what times, and how these tasks are prioritised. The computer-based work budget can serve as a tool here, both for work organisation and time planning.

MATERIAL AND METHODS In Agroscope Reckenholz-Tänikon ART’s “Work Economics Planning Bases” project, work-economics key figures and the workload components affecting them (e.g. masses and posture) are recorded, edited and statistically analysed on the element level, and made available as planning times and influencing variables to a model calculation system for further calculations, for the purpose of compiling work budgets. On each participating farm, a detailed questionnaire for recording the farm labour organisation (e.g. number of workers, state of labour force) and important influencing variables (e.g. number of pigs, stages per year, feeding methods, distances travelled, etc.) is compiled. In this connection, an initial work observation is also performed to prepare the participating workforce and timekeepers for the time measurements.

The time measurements are carried out with electronic time-recording systems (hand-held PC and built-in recording software). They are performed exclusively as a direct work observation with individual time measurements on the element level. The essential influencing variables “masses moved”, “body postures”, “distances travelled”, “feed quantities” and “driving speeds” are determined and recorded electronically during the time measurements. All other influencing variables (e.g. stall width, stall length, trough length) are to be recorded before and after the time measurements.

With cyclical workflow steps such as ‘Lifting straw bales”, “Placing straw bale in wheelbarrow’ and ‘Setting straw bales down in pen”, determination of data quality takes place during measurement via the so-called Epsilon test. For this test method, the absolute value of the half confidence interval is applied to the mean, with an Epsilon of <10% judged to be good. Using the determination of data quality as a starting point, the expected sample size n’ can also be determined after the recording of just a few measuring points. This makes it possible to plan the effort for the data recording.

For further processing, the recorded data is first prepared in tabular form, and then examined with non-problem-oriented test procedures (normal distribution, outlier, coincidence). In the absence of normal distribution, a one-sided logarithmic transformation is carried out as a basis for the following problem-oriented test procedures and regression calculations.

Next, the analysed data are transferred in the form of planning-time values and functions to a planning-times database table, with each element being assigned a unique alphanumeric code, a name with beginning- and end points, and the appropriate statistical parameters, including contents description, author and creation date.

The continuing calculation of working-time requirement values on the level of work processes is performed with the built-in model calculation system. This involves the logical linking of work elements with the quantitative and qualitative influencing variables affecting them. All influencing factors are entered in the model calculation system as variables, and can be altered at any time within the upper and lower bounds. A warning message is automatically displayed in the event of entries falling outside these limits.

The calculation system is modular in construction, and in addition to the planning-times database consists of the modules “list of influencing variables”, “interconnection area”, and “output area”. For each work process of interest, a separate extract is created from the planning-times database. All data are available for further processing in freely selectable formats.

In order to assess workload, the load index L (according to Lundquist, 1990), the mass-related load index (according to Riegel and Schick, 2005) and the physically strenuous working time (BMPh) are enlisted (Equation 1).

$$B_{MPh} = W_P * \sum WT_P + W_{PM} * \sum WT_{PM} \qquad (1)$$

WT = Working-time requirement per work process
WT_P = Working-time requirement per work process with measure classes MCL 2, MCL 3 and MCL 4
WT_{PM} = Working-time requirement per work process with MCL 2, MCL 3 and MCL 4 and masses >= 2 kg
W_{PM} = Weighting of body posture with masses
W_P = Weighting of body posture without masses

The advantage of the workload indices lies in their ease of handling, as well as in the accurate qualitative comparison of individual working processes. On the other hand, the use of the physically strenuous working time makes available a facility for quantitative comparison. In addition to allowing consideration from an ergonomic viewpoint, this approach also permits an objective monetisation of the effort and benefit of measures designed to make work easier.

MODEL CALCULATION SYSTEM AND WORK BUDGET Using the model calculation system as a point of departure, work and production processes can be compiled. In this context, a work process is a self-contained sequence of operations spanning all necessary work subprocesses or work elements and influencing variables for achieving the work objective (e.g. ploughing or feeding). By contrast, a production process consists of a possible and logical combination of different work processes for producing a product (e.g. grain cultivation) or rearing a production unit (e.g. dairy-cattle husbandry). The overall farm working-time requirement is calculated through the combination of different production processes, bearing in mind circumstances of the individual farm, as well as the available fieldwork days for the individual activities. On the one hand, overall working-time requirement values for production, special tasks and management activities may be represented on this level. On the other hand – using this level as a starting point – detailed analyses up to the "work process" level can be compiled.

An initial overall work budget is available as a result, which shows the working-time requirement for the whole farm as a function of the selected work and production processes as well as of the chosen influencing variables. In addition, this also allows us to determine how many labour units are required for the farm (Fig. 1).

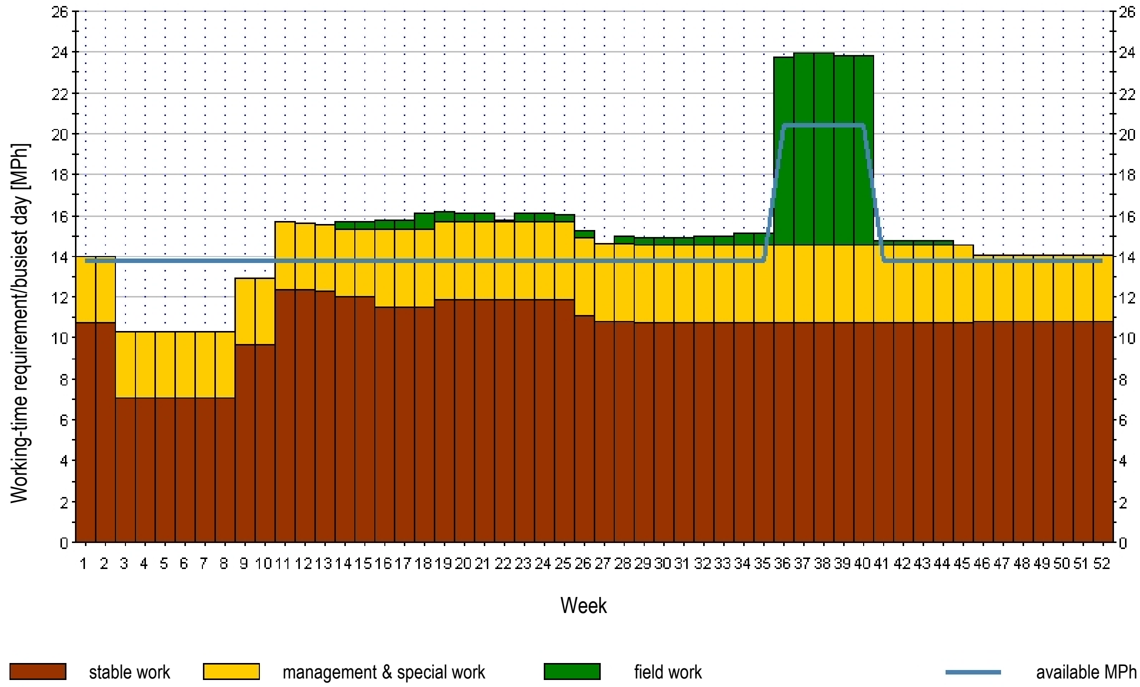

Figure 1. Work record chart showing the daily working-time requirement of the whole farm throughout the year taken the busiest day of the week as standard (MPh = Manpower hours).

ASSESSMENT OF WORK VIA "WORK-RELATED PHYSICAL STRAIN" GROUPS On the "work budget" level, the objective degree of physical strain experienced by the workforce owing to the individual work and production processes is illustrated. Also possible at this level, however, is a subjective appraisal on the basis of "work-related physical strain" groups (e.g. driving a tractor without significant manual labour, light manual labour, heavy manual labour). These are groups of tasks with comparable work sequences. Using these "work-related physical strain" groups as a starting point, the performance per group is allocated for each labour unit. Ultimately, this allows us to calculate the performance per farm branch, or for the entire farm.

SELECTED RESULTS FROM THE PIG-FATTENING HUSBANDRY The following assumptions are made as an example for calculation on fattening farms:

Farm A keeps fattening pigs in stalls with partially slatted floor constructed for 20 animals including an outdoor run. There, stalls are swept out once daily, and 100g straw per animal from small bales is scattered. Feeding is carried out three times daily, with liquid feed being automatically distributed into the troughs (Fig. 2).

Farm B has the same requirements as farm C, but no straw is scattered (Fig. 3).

With farms A and B a clear decrease may be observed, which becomes less pronounced with increasing herd size. The time requirement for routine work per fattening place and year stands at 1.4 MPh for farm A, and 1.1 MPh for farm B. From this the time requirement per herd and year is calculated. For an assumed size of 400 fattening places, this comes to 549 MPh for farm A, and 428 MPh for farm B. This yields a difference of 121 MPh between straw bedding and strawless housing (22%, with three cycles per year being assumed).

Looking at the daily working-time requirement, there is a difference of 0.06 MPh (7.7%, 50 fattening places) to 0.8 MPh (24.7%, 800 fattening places) per herd and day. Per fattening pig and cycle a difference of 0.1 MPh is calculated for all herd sizes (0.12 to 0.10 or 9.3% to 24.4% in the case of herds with 50 to 800 fattening places).

The working-time requirement for special work is the same for both types of farms (0.6 MPh per fattening pig and year in the case of pre-fattening and finishing, 0.4 MPh per fattening pig and year in the case of the in-out process) and was therefore not taken into account for the comparison here.

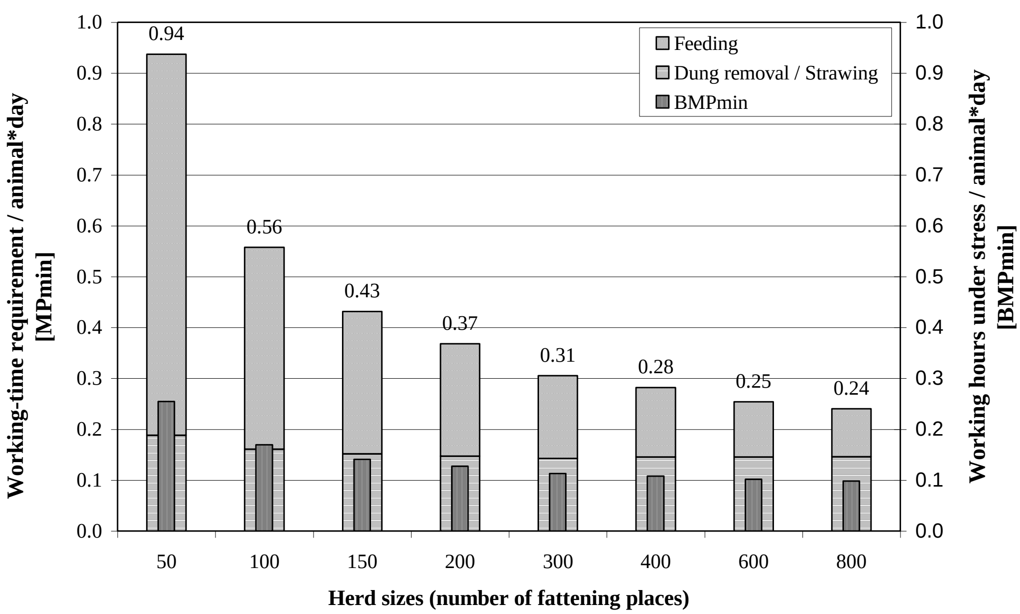

Figure 2. Daily working hours of various herd sizes on Farm A (MPmin = Manpower minutes, BMP_{min} = loaded working minutes)

The workload scarcely decreases from farm A to farm B, which can be attributed to the fact that strawing is performed with an upright posture, so there is no stress. The slight difference results from the work elements ‘Lifting straw bales / placing in wheelbarrow’ and ‘Setting straw bales down in pen’, for which a stooping posture is required, and which do not occur with farm B.

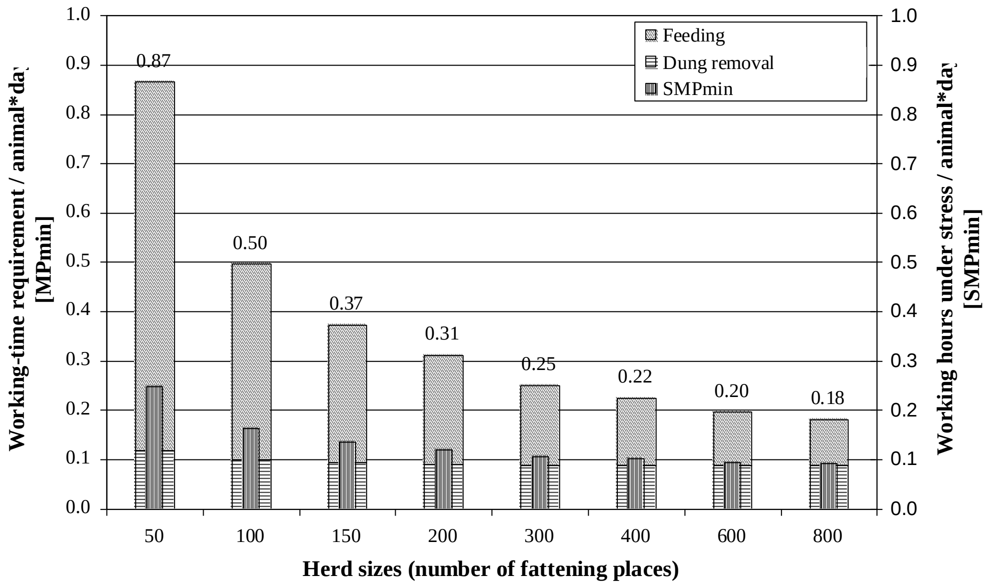

Figure 3. Daily working hours of various herd sizes on Farm B (MPmin = Manpower minutes, BMP_{min} = loaded working minutes).

CONCLUSION In combination with the need to move masses by hand, unfavourable body postures have a negative influence on work quality. Up till now, simple tools for the ergonomic analysis and assessment of work processes and whole farms have been lacking. In association with the calculation of working-time requirement values, a work-estimate system that includes workload indices and physically strenuous working times may constitute a useful tool for qualitatively and quantitatively assessing workload.

REFERENCES

Lundqvist, P. 1990. Wopalas - A method for ergonomical analysis and practical improvements - examples from Swedish industry and agriculture. Advances in Industrial Ergonomics and Safety II: 827-832

Pinzke, S. 1999. Towards the good work. Dissertation, Swedish University of Agricultural Sciences. Agraria: 155

Schick M. and M. Riegel. 2003. Arbeitsqualität in der Milchviehhaltung. Agrarforschung Nr. 10 (4): 155-157

Schick, M. 2005. Arbeitszeit und Management auf dem Landwirtschaftsbetrieb. 51. Kongress der Gesellschaft für Arbeitswissenschaft GFA, Personalmanagement und Gestaltung, Heidelberg: 341-344

Schick M., M. Riegel M. and R. Stark. 2009. Bewertung der körperlichen Arbeitsbelastung in einem computergestützten Arbeitsvoranschlagssystem.16. Arbeitswissenschaftliches Kolloquium des VDI-MEG Arbeitskreises Arbeitswissenschaften im Landbau. Potsdam, 9.-10. März 2009: 157-162