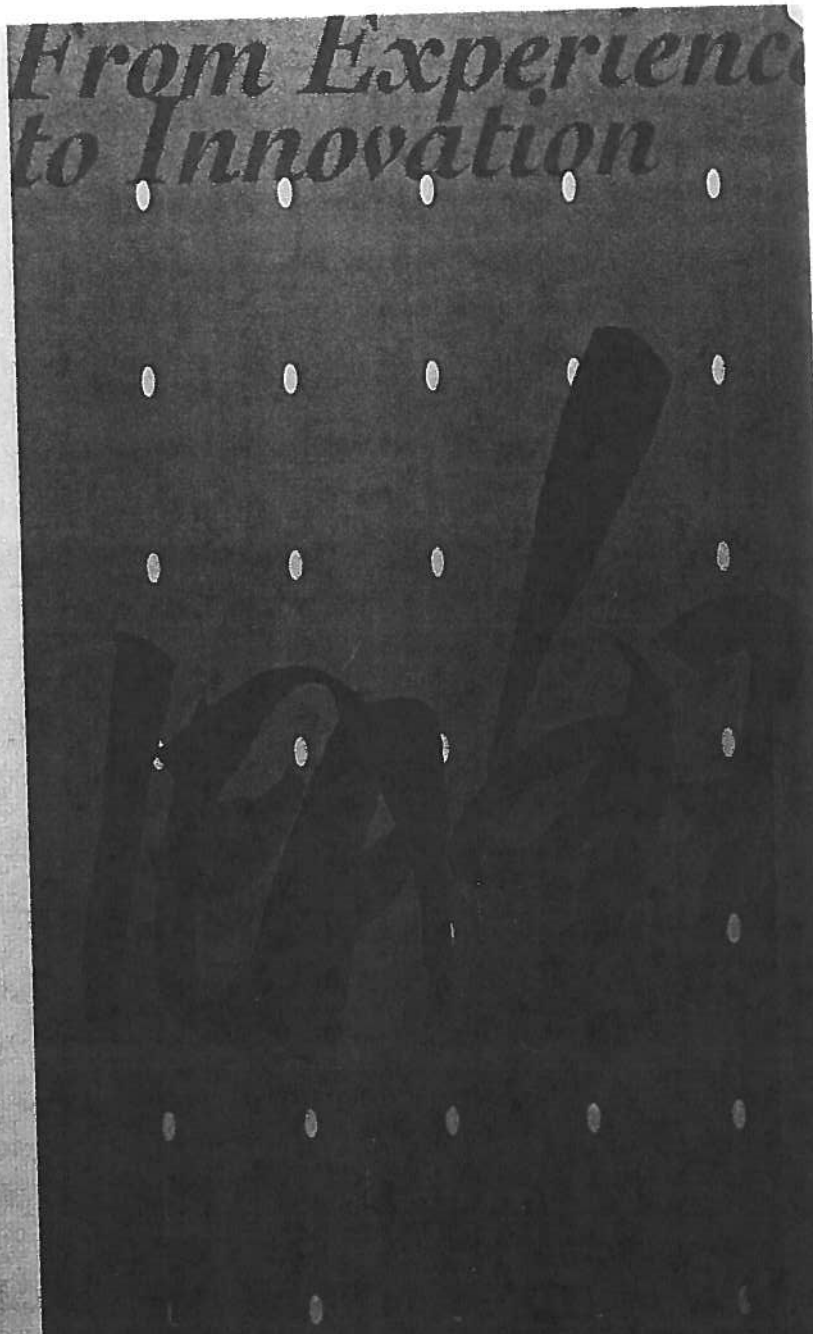
VOLUME 1

From Experience to Innovation



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A Swedish industrial research program 'Co-operative for Optimization of industrial production systems regarding Productivity and Ergonomics' (COPE) Presentation of the program and the first case study

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1. Background: 'Traditional' ergonomic intervention often seems to have a low impact on musculoskeletal health (Westgaard & Winkel, in press). This is interpreted as a consequence of ergonomic interventions usually being: (1) based on contemplation of past situations, i.e. retrospective; (2) performed by external experts; (3) focused on details in the production system.

Based on this recognition, four Swedish research groups (Affiliations A-D above) have initiated a six year programme named COPE (cf. heading). A main goal is to investigate and develop intervention models integrating productivity and ergonomic issues. The programme focuses shop floor work in industry. It currently engages 25 researchers (approximate 15 full time researchers/year).

This paper presents the theoretical framework for the COPE program, our main methods which are going to be further developed within the programme, and some principal procedures used in our initial case study.

2. Theoretical framework: Ergonomics intervention research has traditionally emphasized risk factors related either to isolated elements in the production system (e.g. non-optimal tool design) or to the individual (e.g. gender or fitness). The resulting practical shop floor interventions have therefore aimed at mitigating these risk factors. However, primary risk factors may rather be derived from the structure of the production system, e.g. technical dimensions or work organization. Thus, efficient ergonomic intervention requires these risk factors to be identified and described in terms of their influence on mechanical or psychosocial exposures. Furthermore, the ergonomist should consider that production systems generally undergo continuous improvements guided by efficiency considerations; so-far the ergonomic consequences of this process are largely unknown.

During the recent decade, market conditions have changed from a 'mass market' focusing low prices towards a more 'fragmented market' focusing e.g. customers demands, product variety and quality and short delivery time. Accordingly, many new models for production system design have been discussed in the literature; 'Total quality management', 'Lean production' and 'Integrated production system'. Several of these models seem to contain a potential not only for improved productivity, quality and efficiency but also for improved ergonomics. However, some studies suggest that the realization of these models may not always lead to good ergonomics. This dichotomy is a key research issue in COPE.

3. Field studies: COPE aims at acting as a partner in the continuous improvement process in a number of assembly industries in western Sweden. Thus, the primary initiative lies within the company rather than among ergonomic experts, and efficiency is the primary focus. Consequently the interventions attack complete work processes of the production system rather than isolated details. COPE documents the production system, using a multidisciplinary approach including production engineering and ergonomics (see 'Methods' below). Data are, in

a participative process, fed back to stakeholders in the companies, who may then decide upon the next intervention step. The consequences will be recorded and reported to the company by COPE. Thus, ergonomic assessments are made prospectively as part of the development of the production system. This approach will hopefully increase the compliance, sustainability and efficacy of the ergonomic changes compared to 'traditional' ergonomic interventions.

Several of the case studies which are prepared at present focus on a few work processes which are common in most assembly systems. Here we aim to (1) optimize solutions for such entities regarding technical, organizational and ergonomic issues, (2) investigate proper procedures for the development and implementation of such solutions.

4. Methods: In COPE *efficiency* in production systems is quantified by so-called 'zero-based analysis' (Engström & Karlsson, 1981). The basic idea of such a 'loss analysis' is to decompose the resource consumption of the production cycle into 'necessary work' (a utopian loss-free system only dependent on the product) and production inefficiencies ('losses'; Fig. 1). This approach focuses primarily on value-adding activities. It allows for a determination of the potentials for rationalization as well as comparisons between systems. The loss analyses are based on video recordings of different operators performing all activities included in a production cycle. A PC synchronized video recording equipment is used (Engström & Medbo in press).

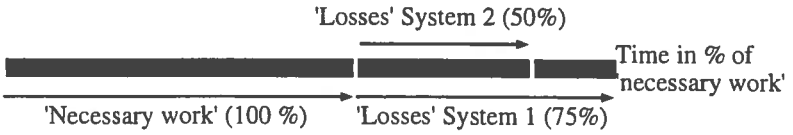

Figure 1: Comparison of efficiency between two systems based on 'loss analyses'.

An intervention based on a 'loss analysis' will focus on minimizing the documented losses. This may imply improved, unchanged or impaired ergonomic exposures in terms of risk. Ergonomic assessments should therefore investigate mechanical as well as psychosocial exposures related to activities denoted as 'losses' as compared to the exposures offered by the 'necessary work'.

The first step in loss analysis is to decompose the filmed work into activities. This basic information is then used in the loss calculations (time domain), as well as in the mechanical and psychosocial analyses (exposure domain).

Mechanical exposures are assessed by continuous recordings of postures and movements using electrogoniometers (Hansson et al., 1996) and inclinometers (Hansson et al., 1992). Moreover, muscular activity is recorded using electromyography. This data is stored in data loggers (Asterland et al., 1996) and synchronized off-line with the video recordings used for 'loss analysis'. In order to obtain an exposure profile of the production system (a 'product cycle exposure') rather than of the individual operators, new concepts and operational methods are needed, as described in a separate abstract (Mathiassen & Winkel, present conference)

Psychosocial exposures are assessed with regard to both job demand and decision latitude (Karasek & Theorell, 1990). Job demands and sources of irritation are at present integrated in the computer program of the VIDAR method described below (see Fig. 2).

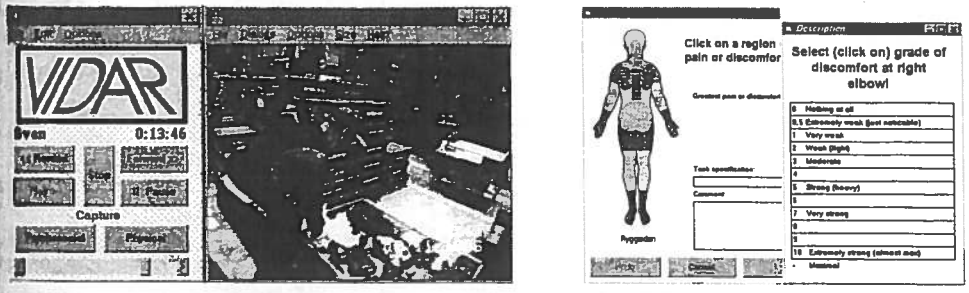

Figure 2. The filmed operator makes an ergonomic assessment of his/her own work, while looking at the video film on a VDU. Localization and grade of pain is marked by the operator; long video recordings may be reduced to a library of a few prioritised problem situations.

The intervention process is partly based on worker participation. It is facilitated throu visualization using a CAD-program (Sundin et.al., present conference) and the VIDA method (Kadefors & Forsman, present conference; Fig. 2).

5. An initial case study: The first case study is conducted at a Volvo plant producing abo 1,500 automobiles a year. It focuses on materials supply for assembly of individual specime of special vehicles, i.e. police automobiles, taxies and limousines. This so-called compone kitting is of general significance for the automotive industry. Thus, the knowledge a experience gained from this case study will be of future relevance, since kitting is expandin The kitting process studied engages a group of 12 operators. The work process main comprises (1) kitting of materials along a stand of plastic containers (see picture Fig. 2), (picking of small components into sub-kits and (3) picking of materials from a store, using fork truck. Data collection was performed during three weeks in November - December, 199 involving researchers from all research disciplines as indicated above.

Figure 3 presents an example of data from a 'loss analysis' of the kitting process, togeth with the corresponding time fractions of trapezius 'muscle rest', i.e. muscular activity belo 1% of maximal effort. As indicated, several other activities are performed in excess of t minimal 'necessary work'. The company may decide to reduce the duration of several of the 'losses' in order to increase efficiency. If, e.g., the duration of administrative work eliminated and exchanged by more 'necessary work' this will reduce the duration of musc rest. Previous studies have indicated that a reduction of such rest may increase the risk f shoulder-neck complaints.

6. Conclusion: The present example (Fig. 3) illustrates one procedure for interdisciplina data analysis as a basis for intervention.

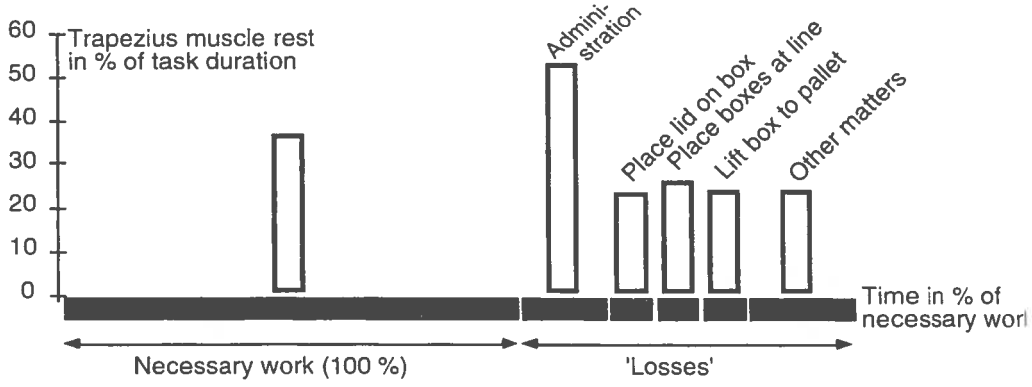

Figure 3: 'Loss analysis' for kitting work and fraction of 'muscle rest' for the different activities included in kitting work. One subject.

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