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Improving Ergonomics in the Meat Industry: A Case Study of an Italian Ham Processing Company

Lucia Botti*. Cristina Mora**
Alberto Regattieri**

** Department of Management and Engineering, University of Padova, Vicenza, Italy (Tel: +39 051 2093418; e-mail: lucia.botti5@unibo.it)*
*** Department of Industrial Engineering, University of Bologna, Bologna, Italy (e-mail: cristina.mora@unibo.it; alberto.regattieri@unibo.it)*

Abstract: Meat processing is a labor-intensive industry dealing with manual handling of heavy loads of meat at high frequency. Meat processing workers are under pressure to maintain high rates of work, performing arduous repetitive motions while keeping awkward postures. Ergonomic risk assessments reveal that manual material handling and repetitive tasks expose meat-processing workers to high physical risk. This paper investigates the impact of automated technology on manual ham-deboning lines in the meat-processing industry. The aim is to study the effects of automation on the work system and layout, analyzing the economic and ergonomic impact of semi-automatic ham deboning lines. The study introduces a non-safety cost model for the comparative and sensitive analysis of manual and semi-automatic ham deboning systems, including the cost of non-safety. The model is tested with a case study from an Italian ham processing company. The reference manual ham-deboning line is introduced, together with a new layout proposal involving the adoption of a semi-automatic ham-deboning machine. Results reveal the positive impact of the semi-automatic ham-deboning system on the company's profitability and workers' ergonomics. As a consequence, automated technology leads to economic and ergonomic benefits for workers, employers and customers.

Keywords: Ergonomics, automation, safety analysis, risk assessment, food processing.

1. INTRODUCTION

Work activities in the meat processing industry are both technically and physically demanding. Meat processing workers perform a wide range of tasks, involving manual handling of heavy loads, e.g. whole carcasses, at high frequency. Common activities include lifting, moving, turning and twisting heavy carcasses among the workstations. Other tasks involve laborious and frequent movements to cut the carcass, whilst holding the loads. Such repetitive motions are a common cause of occupational diseases, as the well-known musculoskeletal disorders. In addiction, the work environment is characterized by noise, humidity, cold and offensive odors. These characteristics make the meat processing industry both physically and emotionally demanding. As a consequence, slaughterhouse work is not an attractive option for prospective employees, particularly young people. To improve the working environment and hinder the potential insufficiency in the labor force, the meat processing industry is automating the most labor-intensive parts of the work process (Purnell, Caldwell 2012, Clarke, Nielsen & Madsen 2014). Automated meat processing reduces arduous repetitive work, whilst replacing some heavy activities with less-intensive tasks, e.g. planning and controlling the new technology (Nielsen, Fertin & Christensen 2005, Barbut 2014). Furthermore, the increasing international competition is pressuring the meat processing industry to automate the meat process and develop more efficient production methods. A recent study on the European meat industry reveals that the per capita meat consumption has stabilized in the last 20 years (Kanerva 2013). This static overall consumption increases the pressure on the meat processing companies to adopt more efficient production methods, e.g. automated technology. At the same time, automation offers consistent benefits for safety and hygiene of the meat processing work, providing higher process controllability and better working conditions (Wadie et al. 1995, Purnell, Caldwell 2012, Purnell, Grimsby Institute of Further and Higher Education 2013). For example, the reduction of manual handling and the more efficient tool sterilization in the clean slaughter line reduce the cross contamination between carcasses, improving the food hygiene and safety. Robot technology is widely used in manufacturing industry, when products are well-defined and properly designed. Furthermore, the high investments in automation require industries with high production volumes ensuring a reasonable payback time. Pork, poultry and lamb slaughtering are fully or partially automated, e.g. poultry lines work at high speeds, while the lamb production is partially automated (Madsen, Nielsen 2002, McMurray 2013). Nevertheless, several projects failed after trying to automate the whole beef slaughtering process (Purnell 1998, Madsen, Nielsen 2002), i.e. fully automatic slaughtering is more complex in beef and pork production, due to greater dimensions and weight of the carcasses. Particularly, manual workers typically perform ham-deboning work.

This paper focuses on the improvement of health and safety of meat processing workers through ergonomics and automation. The following study introduces a comparative and sensitive analysis of manual and semi-automatic ham-

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deboning systems. The aim is to investigate the effects of automation on the work system and layout, analyzing the economic and ergonomic impact of semi-automatic ham deboning lines. The comparative analysis includes a non-safety cost model for the study of non-safety cost due to accidents and injuries. The non-safety cost model is tested with a case study from an Italian ham processing company. The study of the existing meat processing plant and the work system analysis reveal critical situations posing serious risks to the workers' safety and health. The study introduces the new layout proposal for the ham production process, replacing laborious manual ham-deboning activities with automated technology. The remainder of this paper is as follows. Section 2 presents the non-safety cost model, analyzing direct and indirect non-safety costs. A brief overview of the Italian Region Emilia Romagna meat industry is introduced in Section 3, together with the detailed description of an existing ham production plant and the ergonomic risk assessment among deboning line workers. Section 4 introduces the new layout proposal, while the comparative and sensitive analysis is in Section 5. Finally, Section 6 and Section 7 discuss the results, providing directions for future developments.

2. NON-SAFETY COST MODEL

The following Section 2 introduces the non-safety cost models for the economic evaluation of the both the manual ham-deboning system and the semi-automatic ham-deboning system. The non-safety cost model analyzes the cost of the work system, c_s, together with the cost of non-safety, c_n.

Companies quantify the value of c_s including labour costs, plus investment, power supply and maintenance costs, in case of semi-automatic ham-deboning systems. Non-safety cost c_n is due to the neglected investments in safety procedures and equipment. Despite the high cost of accidents and injuries, companies frequently neglect the cost of non-safety. Workers, companies and community pay the consequences of non-safety work. Particularly, occupational accidents cause direct costs and indirect costs to the companies. The former include quantifiable costs due to the accident event, e.g. workers' compensation payments, medical expenses, and costs for legal services etc. The latter are frequently underestimated and include lost productivity, recruitment and training of new employees, costs associated with lower employee morale and absenteeism, etc. The following Equation (1) shows the overall non-safety cost.

$$c_n = (c_d + c_i) \cdot n \quad (1)$$

Given n as the number of injuries in the reference time period, c_d as the unit direct non-safety cost and c_i as the unit indirect non-safety cost, c_n is the overall non-safety cost. Studies show that the ratio of indirect costs to direct costs, k, varies widely, from a high of 20:1 to a low of 1:1. The less serious the injury, the higher the ratio of indirect costs to direct costs (Business Roundtable 1982). As a consequence, the value of k is related to the type of injury, i. Furthermore, statistics show the incidence rate of injuries as equal to h events every 100 meat-processing workers. The following Equation (2) introduces the final formulation for the overall non-safety cost.

$$c_n = \frac{h}{100} \cdot t \cdot \sum_{i=1}^{l} [\, w_i \cdot c_d \cdot (1 + k_i)] \quad (2)$$

Given the number of worker w_i exposed to the risk of injury i, the overall c_n in the reference time period t is as in the Equation (2). The following Section 3 introduces the overview of the Italian Region Emilia Romagna meat industry, together with the detailed description of the reference ham production plant and the ergonomic risk assessment among deboning line workers.

3. MEAT PROCESSING PLANT ANALYSIS

3.1 Meat processing industry in Emilia Romagna, Italy

The pork and beef slaughterhouse and processing industries play an important role in the economy of the Emilia Romagna Region (Regione Emilia Romagna 2014). The Local Occupational Health and Safety Agency (AUSL) reports that meat processing is one of the most hazardous industries in the Emilia Romagna Region. Meat and poultry workers sustain a range of injuries, including hernia and repetitive stress injuries. According to the American Bureau of Labor Statistics, injuries in the American meat industry declined from 29.5 per 100 full-time workers in 1992 to 14.7 in 2001, but the rate was among the highest of any industry (United States Government Accountability Office 2005). Nevertheless, Italian statistics show higher incidence rates, reporting 24 injuries per 100 meat-processing workers (ASL Mantova, USL Modena 2000).

Meat processing work typically requires manual workers to keep up with the high speed of processing lines. Employment policies and practices of this industry result in serious physical and mental harm to meat processing workers, preventing them from reporting injuries or drawing attention to unsafe working conditions. Furthermore, several workers are recent immigrants and face additional economic and social pressures increasing their vulnerability in the workplace (Monforton 2013). As a consequence, the meat processing is one of the most hazardous industries, as it poses a serious risk to workers' safety and health.

3.2 Reference meat processing plant

The meat processing plant of this study is from an Italian company situated in the Emilia Romagna Region. Figure 1 shows the ham processing steps in the reference meat processing plant, highlighting the hazardous manual handling activities. About twenty tractor trailers a day reach the plant, where manual workers unload the hams with a 1,800 hams per hour pace. Two different lines typically move the pork legs towards different processes. The first line is for the ham salting before the aging process and it is conventionally called "salt line". The latter is the "deboning line" and it moves the pieces towards the speck and ham steak production processes. The hams processed in the salt line are delivered to further processing plant for the aging process, whilst ready-to-eat specks and hams are packed as whole pieces or sliced packs, then delivered all over the world. Salt line workers trim about 1,300 hams per hour, whilst manual deboning line workers prepare about 3,000 hams per hour. Particularly, the hams for the deboning line are manually arranged on specific hanging racks and moved towards the processing phases.