Biosystems Engineering (2005) **92** (1), 59–68
doi:10.1016/j.biosystemseng.2005.05.007
AP—Animal Production Technology

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Neural Network Modelling and Sensitivity Analysis of a Mechanical Poultry Catching System

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(Received 30 July 2004; accepted in revised form 9 May 2005; published online 18 July 2005)

Mechanical poultry catching equipment has been under development for a number of years. Producers on the Delmarva Peninsula have begun to move towards mechanical catching equipment. For this study, the Anglia Autoflow mechanical catching system was observed on 11 occasions from January 2002 to July 2002. The data collected were used to create a predictive time artificial neural network (ANN) of the catching process. In the study, an ANN model with a network with seven input nodes, one hidden layer of four nodes and one output node was used. The model was used to determine the sensitivity of the process to changes in the system. The system was most sensitive to changes in house configuration and least sensitive to changes in the mechanical catching system operating characteristics.

1. Introduction

1.1. *Mechanical poultry catching*

Mechanical poultry catching systems have been investigated for a number of years. The cost and complexity of mechanical catching systems has been a factor in the relatively slow adoption of mechanical catching equipment. Mechanical catching systems have the potential to reduce the physical labour demands of catching, the number of personnel, and the number of person-hours required for catching. Technology has started to advance to the point where the mechanical catching technology is feasible for poultry integrators (Kilman, 2003).

The position of hand catching is frequently rated as one of the worst jobs in the organisation (Lacy & Czarick, 1998). During an average shift, a typical hand catcher will lift 5–10 tonnes of broilers. The physical demands and working environment have made it difficult to recruit or retain hand catching crews. Mechanical poultry catching requires less physical labour, but more skilled operators than hand catching. A typical hand catching crew may have between seven to ten catchers while a typical machine catching team has four people. Mechanisation decreases the activity level of the operator and reduces the inhalation rate of dust and other airborne contaminants (Morris *et al*., 1991; Zhou, 1996).

Several studies have made comparisons of bird bruising between hand and machine catching. Wabeck (1973) found that bruising was 4–8% less for birds caught with a vacuum system than by hand. May and Hamdy (1966) found that bruise severity was directly proportional to the force that was applied and was greater when inflicted near bones. Jewett and Saunders (1960) reported that the type of crate and method employed in handling the birds had a substantial effect on bruise intensity. They also found that bruising is significant concern to broiler producers from an economic and bird welfare viewpoint. Average bruising rate for hand-caught birds could reach up to 25%. Estimates show that in the UK, up to 20% of bird downgrades were incurred during catching (Kettlewell &

Notation

A_{ij}	area for a given combination of length and width, m^2
$A_{typical}$	area of a typical 2280 m^2 poultry house, m^2
E	sum of the squared error
e_s	error
k	sample index number
N	total number of samples
R_{at}	ratio of normalised floor area over normalised time required to mechanically catch a chicken house
T_{ij}	overall catching time, s
$T_{typical}$	catching time for a typical 2280 m^2 poultry house, s
x	input to the neural-network activation function
y	output from the neural-network activation function
$\hat{y}_k$	estimated output from the neural network at iteration k
y_k	actual output from the system at iteration k

Turner, 1985). Mechanical catching and manual catching have differing injury frequency distributions, with mechanical catching more likely to cause wing damage, but less likely to cause leg damage (Ekstrand, 1998). More recent studies indicate that mechanical catching has a lower injury and dead on arrival (DOA) rate than manual catching (Knierim & Gocke, 2003). Ekstrand (1998) and Knierim and Gocke (2003) differ on overall injury frequency and injury distribution.

Catching of poultry is a major concern due to injury to the bird and manual handling, regardless of intensity, is stressful to the bird (Duncan, 1989). Pre-slaughter activity, including feed withdrawal, catching, crating, and transport, affect bird welfare (Savenije *et al.*, 2001). Higher pre-slaughter stress levels can influence thigh meat colour (Kannan *et al.*, 1996). Feed deprivation, required to reduce faecal contamination, reduces available energy, potentially leading to muscle contraction at deboning and consequential increased toughness (Savenijie *et al.*, 2001). Research has shown that both hand and machine catching are stressors, but a higher stress level occurs during hand catching than mechanical catching and more damage occurs to hand-caught birds (Scott, 1993). Although maximum heart rate for machine-caught birds is initially higher than hand-caught birds, heart rate declines faster for machine-caught birds (Duncan *et al.*, 1986). Herding or conveying induces less stress than hand catching and carrying. The development of mechanical catching machines would minimise periods of human-to-bird contact, and lead to improvements in bird welfare by lowering both stress and injury levels (Scott, 1993).

In the last 15 years, improvements have been introduced in the mechanical catching of birds, but a satisfactory mechanical catching method has yet to be fully accepted by the industry (Berry *et al.*, 1990). Kettlewell and Turner (1985) reported on mechanical catching units that used large foam rubber paddles to catch the birds. These paddles rotated down on top of the birds from above and then pushed the birds onto a conveyor belt, which carried them back to a loading platform where they were deposited into crates. The catching unit was a track-powered vehicle, which made it quite manoeuvrable and capable of operating on any type of litter. Several firms have tested this system, but unfortunately, the machine was slow, unreliable and required expensive maintenance (Lacy & Czarick, 1998).

Lacy and Czarick (1992) reported on a mechanical chicken catcher propelled by a 52 kW diesel engine. The catching unit was front wheel drive for increased traction and rear-wheel steered for manoeuvrability. The drive system was hydraulic and operated in forward or reverse. When catching, the catching unit was driven slowly through the poultry house. The pick up mechanism used three pairs of counter-rotating, soft rubber-fingered cylinders to capture the birds and gently lift them onto the conveyors. The conveyors carried the birds to a caging system at the rear of the machine. During field tests, the catcher was extremely efficient at picking birds up off the ground. However, the caging process damaged birds and was inconsistent. The catcher was designed to catch and cage 7000–8000 birds per hour, similar to hand catching rates (Lacy & Czarick, 1994).

The poultry industry is faced with considerable capital investment for mechanical catching (Shane, 2001). The mechanical catchers should be compatible with a range of house configurations and should operate effectively in pole and clear span houses. The equipment should also operate at a rate greater than the 7000–8000 birds per hour typical for a hand-catch crew. Catching and transfer modules should be reliable, offering at least 95% operational time with minimal routine and preventative maintenance. The mechanical catching equipment should enable rapid mobilisation and demobilisation to attain high efficiency rates. Since most of the feasibility studies conducted to test the mechanisation are based on the replacement of one catching crew