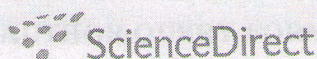
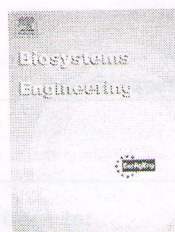


Available at [www.sciencedirect.com](http://www.sciencedirect.com)journal homepage: [www.elsevier.com/locate/issn/15375110](http://www.elsevier.com/locate/issn/15375110)

## Research Paper: PH—Postharvest Technology

# Specific energy consumption for reducing the size of alfalfa chops using a hammer mill

Z. Ghorbani, A.A. Masoumi\*, A. Hemmat

Department of Farm Machinery, Faculty of Agriculture, Isfahan University of Technology, Isfahan 84156-83111, Iran

## ARTICLE INFO

## Article history:

Received 10 May 2009

Received in revised form

16 August 2009

Accepted 14 September 2009

Available online xxx

Measuring the energy requirement for alfalfa size reduction could be important for downstream processing such as densification. Alfalfa chops passed through sieve sizes of 18 mm (SS<sub>18mm</sub>), 15 mm (SS<sub>15mm</sub>) and 12 mm (SS<sub>12mm</sub>) were ground using a hammer mill (1.1 kW) with four screen sizes of 1.68, 2.38, 3.36 and 4.76 mm. Results showed that alfalfa chops with sizes of SS<sub>18mm</sub> and SS<sub>12mm</sub> had the highest and lowest specific energy (30.96 and 5.06 kJ kg<sup>-1</sup>), respectively. Exponential relationships between the specific energy requirement and the hammer mill screen sizes were obtained with coefficients of determination (R<sup>2</sup>) values ranging from 0.94 to 0.98. The data on specific energy was fitted to Bond, Rittinger and Kick models. The Rittinger model was the best fitted model with R<sup>2</sup> > 0.94 for the three sizes of alfalfa chop. A linear model between the specific energy and the ratio of initial to final screen sizes predicted more accurate specific energy values than all three models for the combined data.

© 2009 IAgrE. Published by Elsevier Ltd. All rights reserved.

## 1. Introduction

Alfalfa (*Medicago sativa*, L.) contains digestible fibres and useful range of minerals, vitamins and protein in animal feed (Haiqing, 2004). Alfalfa leaves are high in protein and carotenoids, low in fibre and are useful to feed monogastric animals such as poultry and swine or as a protein supplement for ruminant ration. Alfalfa stems are high in fibre content and can be used for ruminant feed, paper and hardboard, and energy production (biofuel/ethanol) (Adapa et al., 2007).

Size reduction is crucial to the densification process. Particle size reduction increases the total surface area, pore size of the material and the number of contact points for inter-particle bonding in the compaction process (Mani et al., 2004). For size reduction, mechanical energy is needed to break the materials and also to overcome friction between the moving parts of the machine. Mohsenin (1986) concluded that almost

all of the energy in the grinding process is wasted as heat, and about 0.06–1% of the input energy consumed for disintegration of the material. Measuring the energy requirement for alfalfa size reduction could be very useful in developing the strategies to reduce input energy in process of converting to bioenergy.

In the forage industry, hammer mills are widely used for grinding alfalfa chops to produce pellets. Hammer mills are relatively cheap, easy to operate and produce the wide range of particle sizes which are required for densification of ground materials (Mani et al., 2004). Hammer mills reduce the particle size of solid materials by shear and impact actions. The performance of hammer mills is measured by energy consumption and the particle size distribution of the ground product. Lopo (2002) reported that the energy consumption of grinding biomass depends on the ratio of particle size distribution of materials before and after milling, moisture content,

\* Corresponding author.

E-mail address: [masoumi@cc.iut.ac.ir](mailto:masoumi@cc.iut.ac.ir) (A.A. Masoumi).

1537-5110/\$ – see front matter © 2009 IAgrE. Published by Elsevier Ltd. All rights reserved.

doi:10.1016/j.biosystemseng.2009.09.006

58  
59  
60  
61  
62  
63  
64  
65  
66  
67  
68  
69  
70  
71  
72  
73  
74  
75  
76  
77  
78  
79  
80  
81  
82  
83  
84  
85  
86  
87  
88  
89  
90  
91  
92  
93  
94  
95  
96  
97  
98  
99  
100  
101  
102  
103  
104  
105  
106  
107  
108  
109  
110  
111  
112  
113  
114