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Cost Economics for Drying of Paddy Coupled with Gasifier

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A B S T R A C T

Harvested paddy grain with high moisture content must be dried to about 12 per cent (w.b) within 24 hours for safe storage and milling. Approximately 9 per cent of paddy was lost due to outdated drying methods, milling, unscientific method of storage, transport and handling (Basavaraj *et al.*, 2015). Mechanical drying is essential to maintain the quality of grain during storage to prevent the growth of bacteria and fungi and the development of insects and mites. The economic feasibility of the on-farm paddy dryer coupled with a gasifier was analyzed by considering the initial investment of the gasifier, dryer, repairs and maintenance cost, cost of raw material. Present conditions, economic factors are the strongest augment for considering gasification for drying of paddy because the price of petroleum fuels is high. Break-even point for on-farm paddy dryer was calculated as 23.27 months. Benefit cost ratio for developed on-farm paddy dryer coupled with a gasifier was found to be 1.36.

Introduction

Drying paddy is one of the major problems in India. Often grains become deteriorated due to improper drying which results in a poor germination. The use of mechanical drying is an alternative method to dry grains in order to assure good quality. Drying of paddy by other methods like hot air drying, dielectric energy and wood is expensive. Hence, drying by bio-energy through gasification process is economically a viable solution for drying high moisture content of paddy.

Kumar *et al.*, (2009) reviewed the current status of use of thermochemical biomass gasification for producing biofuels, bio-power and chemicals. Biomass gasification is a promising technology to displace use of fossil fuels and to reduce CO_2 emission.

Recently, the focus of its application has changed from production of combined heat and power to production of liquid transportation fuel. The challenges with gasification are to understand the effects of operating conditions on gasification reactions for reliable predictive and optimizing the product composition for obtaining maximal efficiencies.

Purohit (2009) studied economic potential of biomass gasification projects under clean development mechanism (CDM) in India. The results indicate that in India around 74 million tonne agricultural residues as a biomass feedstock can be used for energy applications on an annual basis.

Cost of drying

Drying cost is comprised of fixed costs and variable costs. Fixed cost includes depreciation, cost of interest, repair cost, and opportunity cost. Variable costs consist of fuel, labour and electricity costs. Depending on the purpose drying cost can be stated as either annual cost or cost per unit of weight.

Total drying costs are composed of two components, fixed cost and variable cost (IRRI, 2013).

$$C_D = C_F + C_V \quad \text{...(3.31)}$$

where,

C_D = Total drying cost,

C_F = Fixed cost,

C_V = Variable cost,

Variable costs

The variable cost or operating cost mainly consists of the expenditure that only occur when the dryer was operated, namely fuel, electricity, labourcost and potentially other minor cost of items.

$$C_{var} = C_{fuel} + C_{electricity} + C_{labor} + CV_{others} \quad \text{...(3.32)}$$

where,

C_{var} = Variable cost,₹ /t

C_{Fuel} = Fuel cost,₹ /t

Fuel cost

Cost of energy for the fuels used in the air heater was computed using the following equation

$$C_{fuel} = \frac{FC \times c_{fuel}}{m_{dry}} \quad \text{...(3.33)}$$

where,

C_{fuel} = Fuel cost, ₹ /t of dried grain

FC = Fuel consumption, kg/batch

c_{fuel} = Cost of fuel, ₹ /kg

m_{dry} = Weight of dried grain per batch, kg/batch

Electricity cost

$$C_{electricity} = \frac{P \times lf \times t_{op} \times C_{kWh}}{m_{dry}} \quad \text{...(3.34)}$$

where,

$C_{electricity}$ = Electricity cost, ₹ /t

P = Power rating of motor or component, kW

Lf = Load factor, (usually 0.7 for motors)

t_{op} = Operating time of component, h/batch

C_{kWh} = Cost of one kWh electricity, ₹ /kWh

m_{dry} = Weight of dry grain per batch, t/batch

Fixed cost

The fixed cost consists mainly of investment costs for a system and depends highly on dryer capacity, state of technology and local content.

$$C_f = \frac{C_{depr} + C_{repair} + C_{interest} + C_{others}}{U} \quad ...(3.35)$$

where,=

C_F = Fixed cost, ₹ /t

C_{depr} = Annual depreciation, ₹ /year

C_{repair} = Annual repair cost, ₹ /year

$C_{interest}$ = Annual interest cost, ₹ / year

C_{others} = Other annual cost, ₹ / year

U = Annual utilization, tonnes/year

Depreciation

For simplicity a linear depreciation is used. Usually a salvage value is used in the calculation of the depreciation but in many cases this is not realistic since dryers typically are used in one location until they fall apart.

$$C_{depr} = \frac{C_{inv} + SV}{EL} \quad ...(3.36)$$

where,

C_{depr} = Annual depreciation, ₹

C_{inv} = Investment cost, ₹

SV = Salvage value, ₹

EL = Economic life, year

Cost of interest

The cost of interest averaged over the years was computed using the following equation

$$C_{int} = \frac{C_{inv}}{2} \times \frac{R_{int}}{100} \quad ...(3.37)$$

where,

C_{int} = Annual cost interest, ₹ / year

C_{inv} = Investment cost, ₹

R_{int} = Interest rate, %

Cost of repair

A certain budget needs to be allocated to maintenance and repair needs. Based on manufactures recommendations this can be expressed in percentage of investment

$$C_{repair} = \frac{C_{inv} \times R_{repair}}{100} \quad ...(3.38)$$

where,

C_{repair} = Annual repair cost, ₹ / year
C_{inv} = Investment cost, ₹
R_{repair} = Rate of repair in % investment cost, %

Break-even point

The break-even point in batches per year calculated as follows

$$BEP = \frac{C_{inv}}{(m_{dry} \times \Delta P) - C_V} \quad ...(3.39)$$

where,

BEP = Break-even point per, batch/ year
C_{inv} = Investment cost, ₹
m_{dry} = weight of grain per batch after drying, kg/batch
ΔP = Price difference of wet and dry grain, ₹ /kg

C_v = Variable cost, ₹ /t

Benefit–cost ratio

The benefit-cost ratio (BCR) is the ratio of the gross benefits divided by the initial investment costs plus costs of operation.

For an investment worthwhile, BCR should be greater than one to indicate that the investor is recovering every worth of investment.

Conversely, a BCR lees than one implies that the assumed interest rate, the investment being evaluated is not profitable. The benefit-cost ratio is calculated as

$$BCR = \frac{B_{total}}{C_{total}} \quad ...(3.40)$$

where,
BCR = Benefit–cost ratio
B_{total} = Sum of discounted annual total benefit, ₹

C_{total} = Sum of discounted annual total cost, ₹

Results and Discussion

Economic analysis of on-farm paddy dryer coupled with gasifier

Economic analysis of the system was estimated by annualized cost and life cycle savings. The life cycle saving of the system analysed for a total life span of 5 years. Table 1 comprises the data about the factors like the initial investment, salvage value annual savings, operating and maintenance cost, expected life of asset and annual cash benefit for the paddy dryer. Break-even point and benefit cost ratio for on-farm paddy dryer was calculated by considering total cost of operation which includes fixed cost and variable cost

Break-even point

Investment cost = ₹ . 54425.00

weight of dried grain = 0.890 t/batch

Price difference of wet and dry grain = ₹ . 3.25 kg^{-1}

Variable cost = ₹ . 554.00 t^{-1}

$$BEP = \frac{54425.00}{890 \times 3.25 - 554.00}$$

= 23.27 months

Benefit-cost ratio

The benefit-cost ratio (BCR) is the ratio of the gross benefits divided by the initial investment costs plus costs of operation. The benefit-cost ratio is calculated as

Gross benefits = ₹ . 1,06,241.52

Initial investment costs plus costs of operation

= ₹ . 77,749.00

$$BCR = \frac{106241.52}{77,749.00}$$

= 1.36

Table.1 Total operational cost of on-farm paddy dryer

I.	**Fixed cost**		
	a) Depreciation Cost		
	Investment cost	=	₹. 54425.00
	Salvage value @ 10% of Investment cost	=	₹. 5442.50
	Economic life	=	5 years
	Sub total	**=**	₹. 1**1973.50 peryear**
	b) Repair cost		
	Investment cost	=	₹.54425.00
	Rate of repair @ 10% of Investment cost per year	=	₹ 5442.50 ₹
	Sub total	**=**	₹. **5442.50** per year
	c) Cost of interest		
	Investment cost	=	₹.54425.00
	Rate of interest @ 16% of investment cost year	=	₹ 8708.00
	Sub total	**=**	₹. 4354.00 per year
	Fixed cost total	**=**	₹. 21,770.00
II.	**Variable cost**		
	a) Fuel cost		
	Fuel consumption	=	12 kg batch-1
	Cost of fuel	=	₹. 4.00 kg-1
	Weight of dried grain	=	0.890 t batch-1
	Sub total	=	₹. 54.00 t-1
	b) Electricity cost		
	Power required	=	2.237 kW
	Load factor	=	0.7
	Operating time	=	8 h/batch
	Cost of one kWh electricity,	=	₹. 1.45 per kWh
	Weight of dry grain per batch,	=	0.890 t batch-1
	Sub total	=	₹. 20.00 t-1
	c) Labour cost		
	Labour requirement for loading and unloading @ 1 man day/batch	=	₹. 400.00
	Labour requirement for drying @0.2 man day/batch	=	₹. 80.00
	Sub total	=	₹. 480.00 per batch
	Variable cost total	=	₹. 554.00
Grand total cost (Fixed + Variable cost)		=	₹. 22324.00

Economic analysis based on benefit-cost ratio

Cost of on-farm paddy dryer coupled with a gasifier benefit cost ratio was 1.36. It was considered that the on-farm paddy dryer coupled with a gasifier adoption is economically viable in addition to environmental benefits.

Due to its cost effectiveness, the paddy dryer can play vital role in bringing sustainable energy to the paddy farmers in rural community of India. Gasifier assisted paddy dryer can be proposed as a suitable alternative to mechanical dryers.

Harvested paddy grain with high moisture content must be dried to about 12 per cent (w.b) within 24 hours for safe storage and milling. Approximately 9 per cent of paddy was lost due to outdated drying methods. The economic feasibility of the on-farm paddy dryer coupled with a gasifier was analysed by considering the initial investment of the gasifier, dryer, repairs and maintenance cost, cost of raw material Break-even point for on-farm paddy dryer was calculated as 23.27 months. Benefit cost ratio for developed on-farm paddy dryer coupled with a gasifier was found to be 1.36. Hence, gasifier adoption is economically viable

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