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Design and Development of an Innovative Mobile Fish Vending Unit for Retailers

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Abstract- The purpose of this study was to design and develop a low cost mobile fish vending unit in urban/municipality areas with proper waste disposal. The prototype model was designed and fabricated using locally available materials at a cost of Rs.52780/-. The main feature of this prototype is that its100 and 70 L insulated chilled crates; utility box; Cutting and processing area; storage of water and waste disposal. Necessary effort has been made to maintain the possible market quality of fish and fish products in the form of raw and semi-processed/processed chilled products. Test trial of ergonomics evaluation indicated that the working heart rate (HR work) of the male operator ranged from 123.8 to 134 beats/min with a mean value of 131.9 ± 1.6 beats/min. The corresponding values with women were 119.0 to 149.6 and 131.2 ± 1.0 beats/min, respectively. The heart rate was lower with male as compared to the female. The forces on the pedal are 161.84 N and 377.6 N in case of first and second condition. The calculated mechanical advantages for first and second condition are 0.278 and 0.276, respectively. The design of mobile fish vending unit is stable. The operators both male and female have found the unit to be conducive both in terms of ergonomically as well as operationally.

Keywords: Human powered utility vehicle (HPUV), Fishvending, Fish Hygiene, Fish retailers; Value added fish products, Rolling and Gradient resistance

I. INTRODUCTION

Hygienic fish marketing has been a bottleneck in the whole fish marketing channel. Hygienic fish product increases the consumer satisfaction and repeat buying. Fish vendors both male and female under take fish retailing within a radius of 5-10 km.Traditional fisherman and women carry a load of 15-20 kg fish in locally made bamboo baskets and income generated from selling is around Rs.60-100/- per day.Limited mobility, poor investing capacity, communication, perishable nature of the commodity and seasonal fluctuations are factors mostly faced by the poor fish retailers. Production and vending of value added products, like semi processed fish, ready to cook and ready to eat fish products etc. can be taken up as the livelihood by the fisher folks.

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In tropical and warm country like India the quality of fish can better be controlled and shelf-life substantially increased through the introduction of a uniform cold-chain system from harvesting to marketing. (Upare *et al*., 2008).

However during fish retailing the shelf life can substantially be increased through introduction of insulated boxes during the retailing period.Pedal operated Mobile fish vending unit has addressed mainly to those concerned with the planning, development and administration of urban fish marketing operation. It is useful for those concerned with formal fish vending and expansion of development or expansion of hygienic fish marketing in municipal areas (*Indian Farm Machine for the Month-December, 2012*). To make fish available to consumers at the right time and in the right place requires an efficient marketing system. Urban marketing of live, frozen fish, fresh fish and shell fish defined as products that have not been subjected to any process of preservation, except chilling (5 ±1° C).Street vending supplies fish to low and medium income group and is a source of income for many others including women.

The development of mobile fish vending unit has several benefits like hygiene and fish quality management. The mobile fish vending unit act as storage and supply of fish. Street vendors occupying permanent place are regarded as illegal entities that encroach on public space; hence they should not be provided any facility to enhance their business (Bhowmik and Saha, 2002). Due to these difficulties faced by the retail vendors a prototype has been developed looking into those problem. Trolley Rickshaw is the major means of transport of goods in municipal areas. It is maneuverable, completely non-polluting and hence, anenvironment friendly means of transport. In the narrow lanes of the town and cities probablyare the only transport system to provide point to point transport of goods/passengers (Chetanand Mahalle, 2012). Information regarding mobile fish vending units are scanty, however few authors have reported on human powered utility vehicle (HPUV). Paola et al., (2002) developed the new prototype of the pedal crank. The main feature of this prototype is that its pedal crank length changes as a function of the crank angle being maximal during the pushing phase and minimal during the recovery one. Jeffery and Neptune (2008) studied to determine cycling performance (i.e., maximal power output) could be improved by optimizing the chainring shape to maximize average crank power. Danny and Landwerdiscussed about the factors affecting performance in human powered vehicles (HPUV). A major problem in developing communities is a lack of transportation infrastructure (Njenga and Davis 2003; Darrow andSaxenian 1986). The absence of reliable roads, vehicles, and other transport facilities in such areas stalls economic growth. Because goods and services cannot be effectively moved from one point to another, the trade thereof cannot occur.

In many areas, appropriate mechanisms for even general tasks are non-existent, or of inadequate design. Appropriate technology (AT), as its namesake implies, is simply an application oftechnology with an emphasis on the direct societal and cultural needs and limitationslikely to be encountered. Appropriate technology provides an effective alternative where modern technology and "indigenous technology", as referred by Schumacher (1973), cannot meet specific needs.While designing the vending unit following points are to be addressed

- Small-scale capital investment
- Using locally available materials and technologies.
- Labour-intensive in its operation.
- Affordable to the local populace.
- Understandable to local people for construction, maintenance and modification.
- Adaptable for different uses, locations and circumstances.
- Environmental friendly and sustainable.

The vehicle is human-powered and fabricated using locally available parts, materials and technologies. Development included input from local end-users, customers in rural fish market in and around Bhubaneswar.

Objectives

The main purpose is to develop a mobilefish vending unit which can be used for transportation, storage and delivery of live, raw, semi processed and processed fish to the customers.

II. MATERIALS AND METHODS

2.1 Trolley rick construction

A trolley rickshaw is a three-wheeled vehicle. In Asia and Africa, trolleys are used mainly for commercial transportation either of passengers in pedicabs or of freight and deliveries (Wikipedia, 2009). The design of the trolley rickshaw hasbeen improved year by year for getting the convenient vehicle that meets the customer or user expectations in term of mobility, maneuverability, performance, operating comfort and safety. Vehicle construction beganwith a standard tri-cycle purchased from local market. Rear wheel was replaced by one pair of tyre and tube R325 mm) and rim was fabricated according to the size of the tyre. Before fabrication, layout design was made for providing working facilities like chill box; cutting and processing area; storage ofwater; Waste disposal; utilityspace andoffal disposal. The rear base platform of 1450 mm length and 790 mm widthwas made using MS angles, flat, rods and GI sheet etc and all the joints were welded (Fig.1). The work for providing facilities began from the rider seat. The utility box is made of 40cm^3 volume with three chambers. Three HDPE trays (20ltrs each) can be kept inside the chamber. The trays can be used for multiple functions, where it can be kept for small fish/ semi or processed fish or may be used as tool box. Above the utility box a 100 ltrs Polyethylene insulated (PUF) crate was placed for keeping fresh fish. Another Polyethylene insulated (PUF) crate of 70ltrscapacity was placed below the cutting and processing area. Three plastic tubseach 8 l capacity was placed at the rear end for waste disposal, which can be easily lifted when it is full. The cutting and processing areas of 0.42 m^2 were made using 4 mm thick polypropylene materials to avoid fish contamination. Lighting facilities were made through solar lantern, it will charge during the day and will be used for fast food selling at night. The driving mechanism is simple chain drive. The cutting knife which is popularly known as *Paniki* fixed with nut and bolt at the centre of the waste disposal area. The *Paniki* was fitted in such a way that while fish dressing it should be in position and downwards when not in use. The weight of the unit is approximately 150 kg without gadgets. The cost to produce the cycle (Human powered utility vehicle-HPUV) was nearly Rs. 52780 (Fig.2). The list of materials used is presented in Table 1.

Fig.1. View of the structure of trolley rickshaw

Fig.2. View of the innovative mobile fish vending unit for retail fish marketing

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Table-1: List of materials used for fish vending unit

Sl.No.	Description of items	Quantity	Unit cost (Rs.)
1	Std. Tri-cycle	01	9185
2	Rear tyre & tube-325 mm, Nylon –grip/MRF make	02	4150
3	MS angles and flat in different sizes	39 kg	2379
4	GI Sheet (16 gauge)	42 Sq. feet	4200
5	Rear axle, ball bearing including lathe work	LS	4000
6	Poly propylene sheet-6 mm	16 Sq. feet	1760
7	Insulated containers-100 l	01	4700
8	Insulated containers-70 l	01	3800
9	HDPE plastic trays-15 Lts capacity	03	1125
10	PP waste disposal bin (8 Lts each)	03	375
11	Chopping board Hard wood/PVC	01	200
12	Filleting knife	01	50
13	Plastic container for carrying water-10 l	02	140
14	Price board	01	100
15	Plastic basket (20 lts)	01	120
16	Weighing scale (Plastic)	01	250
17	Weighing scale manual/ indigenous	01	300
18	Business calculator	01	100
19	Solar lamp	01	1500
20	Chopping knives, Fin gripper and scale remover	01set	600
21	Paniki-2 feet length	01	500
22	Cutting board PP	02	1500
23	Fish scales for different …	03	30
24	Garbage bags	01 pkt	60
25	Umbrella	01	2500
26	Misc. items *viz*., paint, nut and bolts and other fittings etc	LS	3200
27	Labour charges for fabrication of retail trolley rickshaw	LS	6000
		Total	52780

2.2 Design consideration

Different designs of trolley rickshaw are available in India. We have selected conventional drive system, which is available in local market and can easily be fabricated (Fig.3). The details of design dimensions are as follows:

i) Weight of cycle rickshaw = 1470 N
ii) Drive used:- Roller chain drive
iii) Chain used:- Riveted roller type with single strand (simplex)
iv) Gear ratio or speed ratio (front chain wheel/freewheel) : 2
v) Crank arm length : 180mm
vi) No. of teeth on chain wheel: 48
vii) No. of teeth on freewheel: 24

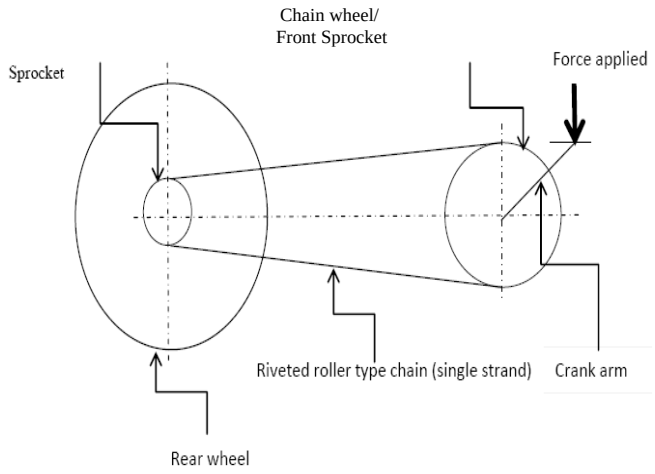

Fig3. View of the conventional chain drive used in trolley rickshaw

B. Design Calculations for speed vs. load

The drive used in trolley rickshaw is conventional chain drive; the speed ratio of the drive train is fixed i.e 2. Force required on the pedal is more with this speed ratio forcing the puller to get down and pull it on the foot. Hence it is required to analyse the speedvs. load to find out the optimal one.

The experiment is conducted with the following assumption

- Vehicle at zero load with zero gradient
- Vehicle at full load with zero gradient

Considering the first loading out of two conditions, the total tractive effort required on the rear wheel of the trolley rickshaw is calculated based on the following design inputs.

Design inputs

i) Gross weight of the tricycle acting on the rear wheels:(W)= 1470 N
ii) Radius of the rear wheel r_w = 325 mm
iii) Measured speed of the tricycle (V_{max}) = 1.5 m/s
iv) Desired acceleration time (t_a) = 7.5 sec
v) Gradient (α) = 0
vi) Coefficient of rolling resistance between tyre and road, C_{rr} =0.0101(contact surface asphalt)

Total tractive effort (TE) is the addition of rolling resistance (RR), gradient resistance (GR) and acceleration force (FA)

$T = RR + GR + FA \ldots . (Eqn. 1)$(Chetan and Mahalle, 2012)

Rolling Resistance (RR): The force due to rolling resistance is mainly dependant on weight of trolley rickshaw, tyre inflation pressure and load. The effects of tyre and road surface characteristics are usually expressed as the coefficient of rolling resistance (C_{rr}). The value of C_{rr} = 0.0101 (Grappe et al., 1999). Hence, rolling resistance can be calculated using Eqn. (2)

$Rolling\ resistance\ , RR = W \times C_{rr} \ldots\ldots\ldots\ldots$ (Eqn.2)

Hence, Rolling resistance = 14.85 N

Gradient resistance (GR): The parameters required are the total weight of the vending unit and the road gradient (Rise by run) the GR is calculated from Eqn. (3)

$Gradient\ resistance, GR = W\ \tan^{-1}\alpha$ ..... (Eqn.3)

Gradient resistance= 0

Accelerating force (FA)

$Accelerating\ force = W \times \frac{V_{max}}{g \times t_a}$ = 29.79 N … (Eqn.4)

Total tractive effort (TE) = 44.82 N

TE is the force required at the rear wheels of the trolley rickshaw to drive it with the desired speed in desired time. In chain drive used in trolley rickshaw the force applied to the pedal is transferred to the rear wheel. Hence the force on the pedal is calculated by using (Eqn.5)

$F_R = \frac{F \times r_c}{r_w} \times \frac{r_2}{r_1} \ldots\ldots\ldots\ldots\ldots\ldots$ (Eqn.5)

Where F_R is force transmitted at the rear wheels of the trolley rickshaw

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r_c - the length of the crank arm.
r_2 - the radius of the rear sprocket
r_1 - the radius of the front sprocket or chain wheel
F - The force on the pedal
Therefore the force required on pedal is calculated as

$$F = \left(\frac{F_R \times r_w}{r_c}\right) \times \left(\frac{r_1 r}{r_2}\right) \quad \text{..... (Eqn.6)}$$

Here F_R is the total tractive effort TE.
Hence, the force on the pedal for the first loading condition is F= 161.84N

Mechanical advantage

The mechanical advantage of the drive is calculate using (Eqn.7)

$$MA = \frac{F_R}{F} \quad \text{..... (Eqn.7)}$$

The MA is0.278
The process is repeated for 2nd condition

III. RESULTS AND DISCUSSION

It is important that a trolley rickshaw design should be stable. For maximum stability, rear wheels were fitted (R325 tyre and tube) for stability, withstand more loads and better gripping on the ground. Criteria for appropriate technology were considered and revised according to the needs of the fish vendors. The design of the HPUV was successful both in terms of provision of useful gadgets for fish retailers. Our objectives are to develop sustainable technologies for the fish vendors, who need a ready to built product and will continue to use and for their livelihood. On the basis of the above calculation different parameters were calculated i.e. zero load with zero gradient and full load with zero gradient and it was compared. It was found that with zero loads the MA is 0.278. Whereas with increasing load (full load) the MA is reduced to 0.276. The forces on the pedal are 161.84 N and 377.6 N in case of first and second condition, respectively.

Preliminary road cycling trial was conducted at Krishi Vigyan Kendra-CIFA, Kausalyaganga Khurda on 11.01.2013. The surface of the test section was asphaltroad. A fixed distance was marked and maintained constant velocity. The ergonomical evaluation of mobile fish vending unit was conducted with male and female trainees, attended for skill development programme at KVK-CIFA, Khurda (Fig.3). The trolley rickshaw was operated with male for 10 minutes at a distance of 1.2 km. The ambient temperature and relative humidity during experiments period were 19.64.6 ± 0.63^0C and 69.0± 6.8 %, respectively. The Heart rate (HR) was measured by polar heart rate monitor (Model S-810) of Polar make with an accuracy of ± 1 beat/min. The polar transmitter detects the HR and transmits it to the wrist receiver. Five observations were taken between 3-15 minutes and the average was taken as the representative HR. At the end of each trial, the rider were given 15 minutes rest so that all the physiological parameters regained to their resting level. The heart rate data from 6th min onwards of work of each subject was considered for calculating the heart rate during rest and work period which reflects that the worker heart rate get stable after 3-5 min (Astrand and Rodahl, 1977). The working heart rate (HR work) of the maleoperator ranged from 123.8 to 134 beats/min with a mean value of 131.9 ± 1.6beats/min. The corresponding values with women were 119 to 149.6 and 131.2 ± 1.0beats/min, respectively. The heart rate was lower with male as compared to the female. The mean resting heart rate of the subject was found to be 70.3 beats/min with a range of 68 - 79 beats/min. The maximum heart rate was in the range of 171 – 185 beats/min with a mean value of 179.2 beats/min. In general, it was observed that the female has decreased heart rate with the increaseof age.

Fig.3. Ergonomical evaluation of trolley rickshaw by female operator

The HR work increased till 10 minutes of pedalling in both cases and stabilized thereafter. The peak HRs reached were 129 and 148 beats/min with male and female, respectively. The HR recovered to its pre-work stage after 13 minutes of rest in case of male whereas it was 23 minutes in case of female. This showed that a rest pause of 13and 23 minutes could be given to the male and female before restarting the job. However, more rest may be needed to sub side the muscular fatigue developed during the pedalling operation. Yadav and Pund (2007) reported a rest pause of 14 minutes while working with manual weeders to restart the work where the peak HR of the subjects ranged from 142 – 150 beats/min.

Economics

One of the key items in any trade is an analysis of the cost of a project that includes some consideration of both the cost and the payback i.e. in monetary. The variable cost of the prototype have been presented in Table-2 and profit from sale (Return) of the products are presented in Table-3

Table-2: Variable cost of the mobile vending unit

Sl.No	Types of products	Sale of Product (Avg.)	Cost (Rs.)
1	Fresh / chilled Indian Major carps	100 kg	10000
2	Weed fish	20 kg	1600
3	Dressed fish (Steaks, debones products etc.)	20 kg	4000
4	Municipal fees	Fixed	200
5	Packaging material	2 kg	200
6	Ice	2 blocks	200
7	Losses of fish products	10%	780
8	Man-days	01	300
		Total Operating cost:	19980

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Table-3: Returns from sales of products

Sl.No	Types of products	Sale of Product (avg.)	Cost (Rs.)
1	Fresh / chilled Indian Major carps	95 @140/-	13300
2	Weed fish	19 @100/-	1900
3	Dressed fish (Steaks, debones products etc.)	19 @ 250/-	5700
		Total	20900

Cost Benefits analysis:

Payback

This is literally the amount of time required for the cash inflows from a capital investment project to equal the cash outflows. The payback period is calculated by Eqn.8.The shorter the payback period, the better the investment, under the payback method. The main issue with this is that, even for a short period, there is a sacrifice to be made: an upfront investment with the hope that it will be "paid back" in the future.

$$Payback\ period = \frac{Initial\ payment}{Annual\ cash\ flow} \quad \text{……(Eqn.8)}$$

Hence, Payback period is 2.53years

Average Rate of Return (ARR)

The average rate of return is the profits arising from a project or business as a percentage of the initial capital investment. The most common method of ARR is as follows:

$$ARR = \frac{Average\ annual\ revenue}{Initial\ capital\ cost} \times 100 \text{……. (Eqn.9)}$$

Over the project's 2.53 year life the ARR is 39.60%

The business time of the trolley rickshaw for fish vending will be from morning for fresh fish marketing and same vehicle can be used for fast food product vending during evening hours. The details of cost-economics of the fish vending trolley rickshaw is as follows

- Operational cost: 200 kg fish @ 100/- = Rs.20,000/- (Rotational money/per day)
- Profit @10% of rotational cost = Rs.1000/-
- Profit on fast food product, Cost-Benefit ratio(1:1): 2250.00(15 kg fish @300/- per kg)

IV. CONCLUSIONS AND FUTURE WORK

The prototype ofHPUV was successful designed in terms of a useful gadget and facilities for fish vendors. From the above result it is concluded that speed is directly related to the load. The efficiency of the drive is decreasing due to increase of load. The benefits of HPUV includes Assured best possible market quality; Provide a proper form of semi-processed or final product; Assured health safety of products; Apply the most rational raw processing method. The product is suitable in urban/Municipality areas for proper waste disposal. Thevehicle with all the accessories is costly, cannot be afforded by the fish vendors, hence Government should come forward for financial support in the form of subsidy.The calculated pay-back period is 2.53 years, it is indicated that the mobile unit is highly profitable. The ARR calculatedover the project period is 2.53 year life is 39.60%.The retail vending of fish and fish products by the fisher folks are presently facing a large number of problems starting from a proper place in the fish market, waste disposal and fish marketing during the bad weather and night time. Most of the problems have been addressed during the designing and layout of the prototype. The mobile fish vending unit may be popularized in the municipality and NAC areas with Government subsidies to overcome the retail fish vending problems.

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