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ORIGINAL RESEARCH ARTICLE

FABRICATION OF MANUAL MATERIALS HANDLING MECHANISM FOR LIFTING AND FEEDING OF CASSAVA MASH

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ABSTRACT

Manual materials handling (MMH) devices like jigs and fixtures are required for transporting or positioning materials in large-scale operations. An MMH device was designed to feed cassava mash into fry pan during batch *gari*-frying. Flow is facilitated through the tapered outlet of a 40 kg-capacity hopper while lifting is achieved by turning a triple-start screwed shaft handle, housed in a u-steel channel framework with wide rigid base that can support holding content in position without buckling. Feeding is done until the content is exhausted ready for reloading. It can deliver more than 160 kg/hr depending on the fry pan capacity and working rate. The worker avoids stretching, bending and twisting the trunk or the neck, or move round more frequently for reloading, thus overcoming the stated ergonomic risk factors and slowness of the work process. The device is also adaptable to other tasks requiring similar feeding mechanism.

1.0 Introduction

Manual materials handling (MMH) is a component of many jobs and activities undertaken in life. Typically, it involves lifting, lowering, pushing, pulling and carrying objects by hand. Loading and unloading trucks, carts, boxes or crates; moving parts or assemblies from one place to another; loading paper to the copier or picking binders from an overhead shelf; lifting patients from a bed or transporting them in a wheelchair are typical MMH activities found in work settings.

In the *gari*-frying task, the work involves mainly collecting the grated cassava mash and pouring into the fry pan, fried/cooked while stirring and then discharge for bagging. Whether in sitting or standing posture during loading of the fry pan, the processor often bends, stretches and twists to get the mash usually by her side, then turns to pour into the fry pan. She does this for all batches required to be fried. Similar activity is involved in other unit operations prior to frying – peeling, washing, grating, pressing/dewatering, and pulverizing which results in rapid fatigue and body

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discomfort. The one thing all these tasks have in common is the potential to result in some adverse health effect, from simple cuts, bruises and sore muscles to more serious occupational health diseases of low back pain (LBP). Based on available statistics, almost half of all low back injuries are related to lifting, about another 10 per cent are associated with pushing and pulling activities, and another 6 per cent occur while holding, wielding, throwing or carrying materials (Kadikon and Abdol Rahman, 2016). MMH tasks can be found in most workplaces and they may constitute a risk factor for work-related musculoskeletal disorders (WMSDs) – Mohammadi *et al*, (2013)

Ziaei *et al*, (2017) assessed the postural risk and imposed forces due to manual handling and loading of sugar bags. The study was conducted on male warehouse workers of a sugar manufacturing plant using rapid upper limb assessment (RULA) to assess the risks of awkward postures using computer-aided three-dimensional interactive application to estimate the forces and moments. RULA final scores were estimated to be 7 and 3 before and after the virtual redesign, respectively. They identified the main risk factors as heavy weight and poor control of sugar bags. They posited that virtual redesign can diminish bending and twisting postures, and, therefore, some resulting forces and moments.

Material handling is the movement of material in any direction both vertically and horizontally. In the selection of material handling equipment, a systems approach with the aim of attaining the lowest overall cost for the system as a whole should be adopted. This allows for a trade-off of initial and operating costs, and higher costs in some parts of a system for lower costs in other parts. The net result is usually the lower costs. Hence, the objectives or requirements of materials handling are to save money, save time and save labour by using better methods and equipment (Rene *et al*, 2017).

Igbeka (2013) emphasized the need to mechanize as many material handling operations as possible, if the operation itself cannot be eliminated. For efficiency, there should be a good plant layout. According to him, an efficient plant layout might eliminate many material handling operations or improve them. Typical arrangements of plants include provision for receiving, disposing, processing and conveying. He further categorized factors that will influence plant layout to include methods of operation, lighting and human factors engineering

Nourani *et al* (2017) designed a harvesting aid, a portable dates cluster harvesting machine comprised of stabilizing platform, lifting device, lowering device and cutting device. The lifting device is a telescopic mast extendable with the use of reel and cables actioned by two manual winches and supported by the platform with two mobile joints to make it mobile and fixable. The device is used to raise and lower the cutting device and the basket made of metal ring holding a textile bag, mounted through the basket support at the upper end of the telescopic mast, while the cutting device equipped with a return spring and a draw wire, consists of a rechargeable electric chainsaw mounted on an articulated arm. This is mounted at the upper end of the basket support.

Choi *et al* (2012) examined physical workloads associated with manual lifting activities and translated the academic research into effective prevention “good practices” for the reduction of injury risks in the construction workplace, using fourteen different construction trades.

Mohammadi *et al* (2013) determined prevalence of MSDs in Iraninan casting workers who performed MMH tasks, using Nordic musculoskeletal disorders questionnaire and the Snook tables. His results showed that hand/wrist symptoms were most prevalent (84%). He, therefore, recommended redesigning the MMH tasks to reduce the identified WMSDs among workers.

Harvested cassava root cannot be stored for too long; it perishes soon after harvesting and mass processing into storeable products is the best way to extend the shelf life of the root. Arching, caking and segregation are commonly encountered flow problems in the pulverizing and sieving. They quantified the flowability of cassava mash on the basis of angle of repose of 28^{o} at a moisture content of 73% (wet basis) while the pulverized mash with moisture content of 45% (wet basis) had an angle of repose of 49^{o}. They posited that the angle of repose of cassava mash is moisture content dependent (Kolawole *et al*, 2010, 2014).

Loading constitutes problems in the sense that the processor has to improvise sometimes using a bowl containing less than 40kg of cassava mash. The processor goes through these problems culminating in fatigue due to the ergonomic risk involved. A lifting devise that would hold the load in position for a longer period, eliminate the risk of frequent movement in loading the fry pan, is what is needed for this task. This material handling devise is designed and fabricated to fulfill this purpose.

2.0 Materials and Methods

2.1. Requirements for Feeding Mechanism for the *Gari*-Frying Task

From the research conducted during pilot study, it was discovered that the *gari*-frying process material handling task could be divided into three main tasks excluding the activities that took place before and after frying which were mostly transportation, cooling, sifting and packaging activities. These tasks include loading, stirring and unloading.

2.1.1. Loading

This is the stage during which the grated cassava mash would be poured into the pan for frying. This task continues as long as there is still cassava mash available for frying. Normally for a batch, about 4-5 scoops are poured into the pan for frying depending on the size of the pan.

2.1.2. Stirring

This is the stage that usually comes after loading. It requires a continuous turning process of the *gari* in the pan while frying so as to avoid caking. This continuous process requires stirring for the period a particular batch in the pan would last to cook and dehydrate.

2.1.3. Unloading

This is similar to the loading task, but it involves removal of the fried *gari* from the pan into a container.

The aspect being investigated in this study is that of loading, using MMH method instead of the traditional way of using bowl or other handy container to do it.

3.0 Components of Lifting/Loading Device.

3.1. Hopper

Geometrically, the hopper is cuboidal trapezium (topmost part is cuboid, bottom part is trapezium). It is made of stainless steel sheet metal. The choice of the shape is informed by its flow characteristic such that the hopper would easily empty its content into the inlet end of the fry pan wherein the hopper gate opens for feeding the content in a bid to control the feeding of the fry pan. The hopper is situated on the frame via a u-steel channel framework with base. The hopper and its content is held in a vertical position using a triple-start screwed shaft with handle which the worker turns (anti-) clockwise to cause up-and-down movement.

Capacity of hopper is calculated as follows:

Volume of the cuboid part = 550 x 400 x 348 = 76,560,000 mm^3 = 0.76,560,000 m^3

Volume of the trapezoidal part = 210 (400+550)/2 = 99,750 mm^3 = 0.00099750 m^3

Total volume of the cuboid trapezoid hopper = 0.76560000 m^3 + 0.00099750 m^3 = 0.076659750 m^3

Bulk Density of Cassava Mash = 553 kgm^{-3} (Kolawole *et al*, 2014)

Mass of the hopper = density x volume = 0.076,659,750 x 553 = 42.396 kg ≈ 40 kg, since the hopper is not expected to be loaded to the brim at work for safe work ethics.

Note that hopper shape and the outlet was specially designed to aid 'free-flow' of the cassava mash which is controlled through the gate for each batch.

3.2. The Frame

The frame holds the hopper in position. The triple-start screw shaft, supported by the frame, lifts hopper content with a handle at the top for the processor to turn for the lifting operation after loading. It has a strong base to sustain the content of the hopper. This is made from 50 x 50mm U-channel and covers an area of 570 x 850mm and 1105mm high. The shaft which bears the hopper is held in-between two bearings within which it rotates to lift or lower the hopper. Provision for additional loading of weight was made at the base for balance and stability. There are supports at the side edges to hold the hopper rigidly in position. Figure 1 and Plate1 show the loading/lifting device. The height was made to suit the sit-stand posture of the *gari*-frying workers.

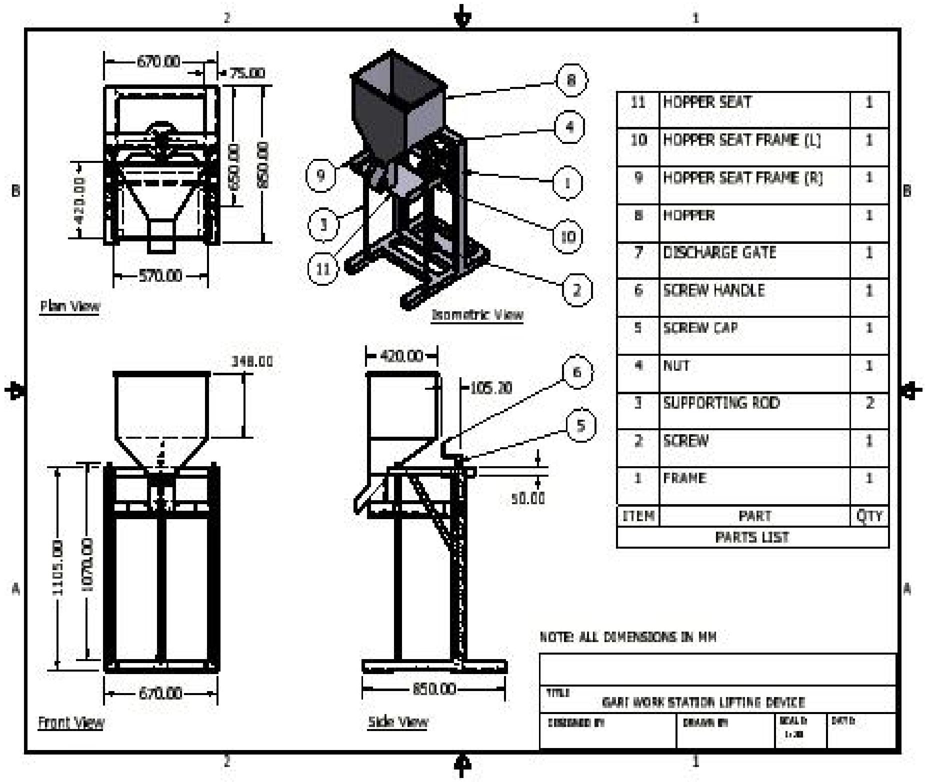

Figure 1: Lifting Device

Plate 1: Lifting Device

3.3. Lifting/lowering mechanism

This consists of a threaded shaft machined and erected on pillow bearings and supported by 12 mm diameter mild steel rod on both sides at the “cantilever” side of the hopper.

The advantage of this is in its high capacity hopper and the lifting activity that relieves the worker of unnecessary frequent movements and stress in lifting the material from the floor onto the platform as well as in having to reload the hopper often. All this add to the efficiency of the worker since this device delays the onset of fatigue unlike in the traditional method of directly manual loading.

4.0 Description of the Operation of the Lifting Device

The setting of the lifting hopper is at the floor (base of the frame) from where it is loaded with materials and then conveyed up the frame by anticlockwise turning of the handle at the top of the frame. Positioned close to the processor's seat and the fry pan to be supplied, the hopper is stopped at a height where the outlet of the hopper levels with the fry pan into where it discharges its content. This holds the content which is discharged for each batch of the frying operation when the gate provided is opened and closed for a batch operation. This hopper is designed to hold content more than required for one batch, say for five rounds or more, to minimize the frequency of loading and reloading, lowering and lifting. This process thus saves time and movement of the processor, who may have to complete five batches or more without having to reload, hence once discharge is made easy for the content to flow down a slopy framework provided at the other end of the fry pan, into which the processed cassava mash is emptied, the next batch is allowed into the fry pan without wasting time as in the traditional method where the processor may move from the seat to load the next batch. All that is required is to open the gate and let in the next cassava mash for the frying process.

5.0 Conclusion

A 40 kg capacity lifting device for feeding cassava mash into fry pan has been designed and constructed. Components include hopper, u-steel channel frame, triple-start screwed shaft with handle for up-and-down lifting on a wide rigid base, counterbalanced with weight. Using locally made materials and with simple construction, this has been made to assist the operator in manual feeding of the cassava mash into the fry pan. The simple operating principle of the mechanism and construction makes it possible to be replicated by artisans in the rural areas where this equipment is needed. The lifting device creates higher efficiency for the worker through efficient means of supplying materials as soon as possible as well as allowing more number of batches (5 times or more) to be done without unnecessary movement, transportation compelled to be in an awkward posture (bending, twisting or stretching) usually experienced before reloading the hopper. This saves time and preserves the health of the worker with the overall advantage of improved productivity. This equipment is also adaptable to other jobs with similar job flow.

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