Development of Manually & Solar power driven vehicle for Mobile vegetable & fruit vendors

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ABSTRACT: Short life of vegetables & fruits due to variation of temperature and the musculoskeletal disorders due to improper material handling & cooling practices are the most common problems to fruit vendors & farm workers in rural area. Typically, musculoskeletal disorders affect the low back, neck, shoulders which leads to several serious spine related disorders. Along with this they are majorly facing the problem about Short life of vegetables & fruits due to variation of temperature & un-availability of cost effective cooling storage system which leads to food quality & economic losses and waste. The paper presents a review & our development study which was carried out for farm workers and vegetable vendors in Vidharbha region and our development of ergonomically designed manually and solar power driven vehicle for Mobile vegetable and Fruit vendors with cost effective cooling storage system to solve the issues and provide the cost effective solution for rural & social development

Index Terms - Musculoskeletal disorders, Cooling Storage, Solar-powered vehicle, Vegetables, Rural development

I. INTRODUCTION

India is a country where agriculture is one of the major occupations on which the livelihood of the majority of people is depended. Despite of the new technologies being implemented in this field, the poor people yet perform many of the activities manually and not having adequate cost effective sources of storage and material handling, due to which they are affecting economically and medically. Thus it becomes necessary to maintain their occupational safety along with cost effective system for their goods storage. Activities like lifting excessive load from the ground and carrying it on head is not ergonomically safe and also it induces the risk of musculoskeletal disorders. Thus, an ergonomic intervention is designed so that it can reduce the head load etc. and subsequently suppress the prevalence of work related musculoskeletal disorders among the farm community also providing the cost effective system for vegetable storage since due to current practices like sprinkling water etc. detoriate the nutrients and vegetable life shorten.

1.1 Cooling System

Absence of sufficient storage facilities after harvest results in deterioration in the quality in fruits and vegetables that reach the market. This has an immediate impact on the distribution and availability of the required amount for human consumption. Immediate cooling is important to minimize quality loss when the produce is harvested at high temperatures or at an advanced stage of maturity. Preserving such commodities to remain fresh demands that the chemical, biochemical and physiological changes are restricted to a minimum by close control on temperature and RH. The high cost involved in developing cold storage or controlled atmosphere storage on a movable cart is a major problem in India and several developing countries. Evaporative cooling is an efficient and economical means for reducing the temperature and increasing RH in an enclosure.

Evaporative cooling is an environmental friendly air conditioning system that operates using induced processes of heat and mass transfer, where water and air are the working fluids. It provides an inexpensive, energy efficient, environmentally benign (not requiring ozone damaging gas as in active systems) and potentially attractive cooling system.

So in our proposed model we are using a solar-powered evaporative cooling system to preserve the food at lower cost.

1.2 Musculoskeletal disorders

Musculoskeletal disorders (MSDs) are injuries or pain in the human musculoskeletal system, including the joints, ligaments, muscles, nerves, tendons and structures that support limbs, neck and back. [9] The risk factors of MSDs at work place are termed as work-related musculoskeletal disorders (WRMSD) which are the combined effect of physical, psychological and psychophysical factors. Physical risk factors such as high forces, high repetition, working with arms overhead, long-term static postures, local contact forces and vibration are the most common reasons for WRMSD. According to a literature paper by Aoife Osborne [10], the spinal region is the most researched body part having MSD. The causes for spinal MSD being postural load as a work factor, age as a personal factor and poor sleep quality, geographic location as the psychosocial factor and many such other factors [11].

From the paper by M Joosab, it is noted that the cervical spine, being the most cranial and mobile part of the vertebral column, may be susceptible to spondylosis or disc degeneration in head loading [12]. As the workers carry weights as high as 50 kg on their head, the axial strain of load-carrying on the head exacerbates degenerative change in the cervical spine

1.3 Ergonomics

Ergonomics is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance [13]. Ergonomic risks present in agriculture and the resulting MSDs pose a physical and economic concern to both producers and workers. For agriculture, commonly used activities are lifting, lowering, carrying loads and moving. Figure 1. shows the basic limits for load lifting and lowering.

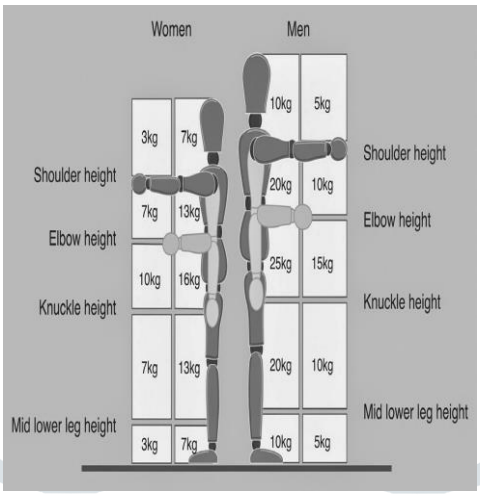

Figure 1. Ergonomic weight limits

M.F. Haisman has concluded in his paper that there is no easy solution in the definition of a maximal load, because of widely varying circumstances, but for healthy young males there appears to be some consensus for the traditional rule of one third body weight [14]. But there is an exception to this conclusion as the weight carried by a physically fitter person like soldier will be different. Load carriage in industrial and other civilian areas will also involve a similar compromise between the person's capabilities and requirements of the task which may in some circumstances have important implications for health and safety.

In another paper by Rohit Sharma [15], the authors have determined the safe limit of load for women who carry water on either head or shoulder. According to this paper, women can carry 15 kg maximum load safely on head. From all these inferences it is clear that we require to design a load carrying equipment that can sustain heavy loads without affecting the cervical spine and using this device the workers can lift weight on head which is more than the ergonomic weight carrying limits.

II. FIELD SURVEY

Before the design process for the study of existing problems and design of intervention, a field survey and sight visit was carried out. We visited 80 farms workers and vegetable vendors in vidharbha region where they were asked personal details and questions from the NMQ for assessment of risk of MSD among them. Majority of the population was female within the age group of 35 to 70 years. The data required like the distance travelled, amount of weight carried on head, Cooling methods using, difficulties etc. and type of activities performed, type of path travelled, etc. was gathered from the questionnaire. Other parameters required for the design of the equipment like the anthropometric data was also collected from the questionnaire. In order to design the equipment with cost effective cooling facility for storage. Some key findings are that age group workers & vendors in this is majorly 36 – 50 years old , also most of them are suffering from back related problems & others findings are follows.

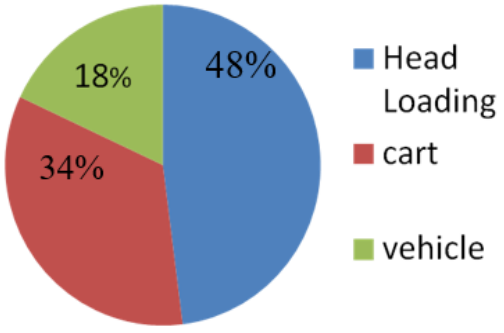

Figure. 2: Modes of material handling by vegetable vendors

Figure. 3: Daily waste Season wise

Figure 4(a) and 4. (b) Show the actual photographs clicked during the survey of farm workers and vegetable vendors carrying heavy vegetable baskets on their head.

Figure 4. (a) Farm worker carrying heavy crop Basket on head (at Mandhal)

Figure 4. (b) Vegetable vendor carrying vegetable crate on head (at Chandrapur)

At rural and urban area mobile vegetable and fruits vendors currently uses load on head, cycle, shoulder, and cart for material handling purpose which is not ergonomically good for human health which further leads to various disorders. Another issue observed is that all vegetables or fruits are perishable with respect to time and it affects the quality of that vegetable due to which that vendor have to suffer from huge loss. Also it affect by summer, winter and rainy season too.

Figure 5: Vegetables vending on Cycle

Figure 6: Vegetables vendor carrying load on shoulder

Figure 7: Difficulties occurred to Fruit seller

Figure 8: Vegetables vending in rain

Currently Mobile Vegetable Vendors use wet gunny bags or sprinkle water on vegetable or fruits to keep them fresh. This leads to spoilage of produce particularly leafy vegetables due to direct water sprinkling, less shelf life for leafy, tomato, cucumber and others and loss of income due to selling under compulsion and consumers disliking. To solve this issue to maintain the vegetable and fruits storage cool or fresh for longer time without affecting the quality we are going to design such storage system with user friendly handling vehicle.

Figure. No. 9:- Vendor sprinkling water on vegetables to keep it fresh

III. LITERATURE SURVEY

D. V. K. Samuel, P. K. Sharma* and J. P. Sinha designed in 2015 [1] solar-powered vending cart and developed for storage of fruits and vegetables. It was tested for its performance during summer season. The minimum and maximum drop in temperature ranged between 8.1°C and 11.2°C, and the increase in relative humidity was observed to be up to 15% and 25% inside the vending card chamber in June. The requirement of water ranged between 16.5 and 20.0 litre/day. Udayanga, H.L.T.U, Weeasinha, S., Kannangara, R.D., Ayaj, A.M., Guruge, Y.V., Priyadarshani in 2015[3] revealed that the minimum inside temperature varies between 17-18 °C when ambient temperature was 31 °C for the evaporative cooling system they developed. Further studies are in progress to develop the prototype evaporative cooler to achieve best cooling efficiency. Shashank Shekhar, Santosh Suman, Dr. H.S. Moharana, D. Sethy in 2016[4] investigates the comparative performance of Desert Coolers employing six different pads in terms of cooling efficiency, air velocity, and water consumption for a sustainable and economic application. In real practice, use wood wool, khus, coconut coir fiber, ceramic materials tubes, stainless steel, galvanized metal sheets as pads in desert coolers in 2016. Taye S. Mogaji, and Olorunisola P. Fapetu in 2011[5] developed evaporative cooling system for extending the shelf life of tomatoes and carrots and its performance was evaluated. Study was conducted to check the freshness of tomatoes and carrots, and data were observed daily. Results of the transient performance tests revealed that the evaporative cooling system chamber temperature and relative humidity depression from ambient air temperature varied over 16-26°C and 33-88% respectively. Ambient air temperatures and relative humidity during the test periods ranged over 26-32°C and 18-31% respectively. The shelf life of the vegetable produce inside the evaporative cooling system was extended by fourteen days relative to ambient storage. N. N. Khobragade[1], Dr. S. C. Kongre in 2016[6] done experimental performance of evaporative cooling pads of different materials based on weather data of vidharbha, India has been carried out. Saturation efficiency and cooling capacity of thickness 4 inch cooling pad materials were measured. Effect of air and water flow rate on saturation efficiency and cooling capacity has been investigated for different cooling pad materials like cellulose, khus-grass, and wood-wool material. It has been observed that cellulose material gives highest saturation efficiency of about 92.8% while Khus-Grass material gives lowest saturation efficiency of about 40.13%. The cooling capacity increases with air flow rate and is obtained between 1.1 to 6.72 kW for different materials. M. C. Ndukwu and S. I. Manuwa in 2014 [7] did review of evaporative coolers for the preservation of fresh agricultural produce in some countries was presented. Researches into novel technologies in evaporative cooling systems which can improve the cooling performances, such as membrane air treatments, dew point type and heat pipe type heat exchanger in indirect/direct evaporative cooling application, and their feasibilities in agricultural storage are either absent or scarce. Some kinds of materials especially agricultural residues have been used for air water contact in evaporative cooling in different climates, but most of the analyses focused on effect of air flow rate and pad thickness on the cooling effectiveness, and the energy efficiency and evaporation loss of these materials in most cases were not evaluated or presented. N. J. Ogbuagu, I. A. Green, C. N. Anyanwu and J. I. Ume in 2017[8] they review the tropical regions, postharvest losses of fruits and vegetables induced by high temperatures is a major challenge to agriculture, especially in places with poor or no electric power supply. The present study is on the comparative performance evaluation of a 92kg capacity storage bin for the preservation of fruits and vegetables, operating on the principle of evaporative cooling. The average temperature drop and saturation efficiency in the evaporative cooler during the no-load test were 5°C and 42%, respectively. The facility was able to sustain tomatoes, garden eggs and carrots stored in it for ten days. The weight losses at ambient temperature were found to be 70%, 30%and 45% for tomatoes, garden eggs and carrots, respectively; while those stored at cooler temperature were10%, 25%, and 40% for tomatoes, garden eggs and carrots respectively.

IV. DESIGN METHODOLOGY

The design of Manually & Solar power driven vehicle for Mobile vegetable & fruit vendors includes the development of concept based on the existing designs available, inputs from survey as well as analysis of spine. For that, firstly the CAD model of the apparatus and spine is prepared. FEA analysis of both the models is done. The working prototype of the apparatus also developed. After prototyping, the necessary changes are made and the apparatus is redesigned. Finally the fabrication is going on after selecting proper material and checking the design for vehicle with cooling system. The fabricated product will be given to the farm workers and vegetable vendors for real-time testing and their feedback is taken using NMQ form. Current work status is explained below.

Conceptual Design & Computer aided design

With respect to need and input of Vegetable & fruits vendors through survey we have developed conceptual design followed by prototype development and now fabrication process is going on. All the components and design of cart is explained in drawing so refer the figure of vegetable cart & Features of Project enlisted below.

Our Manually & Solar power driven vehicle for Mobile vegetable & fruit vendors will be having

1. Developing hybrid powered, ergonomically designed vehicle.
2. Achieving cost effective cooling for vegetables using evaporative cooling system
3. Provide electric charger port for mobiles and wifi systems.
4. Light utility for night and digital weighing and calculator arrangement for ease of vendor
5. The sound system should provide for announcement of vegetables and fruits.
6. Solar panels can be replace by solar sheet, this also reduces the weight of cart along with tracking system.
7. In rainy season, the cart should be disassemble and use for other works.
8. Able to do further simplification in cart structure for comfort in drive.

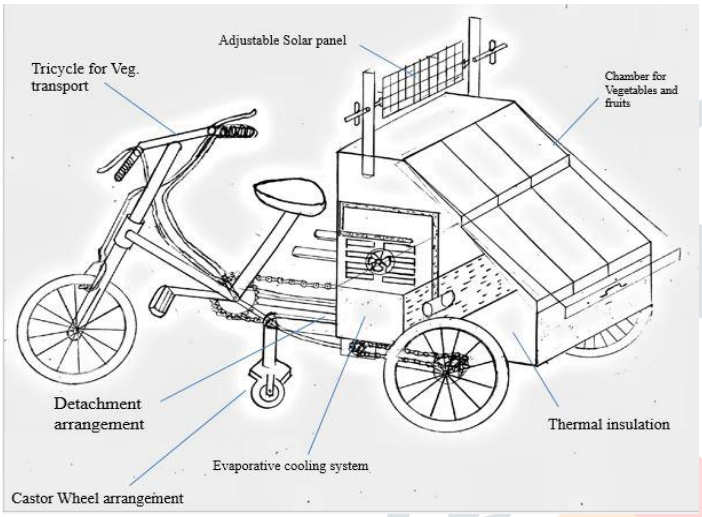

Figure. 10. The Conceptual design of proposed vehicle

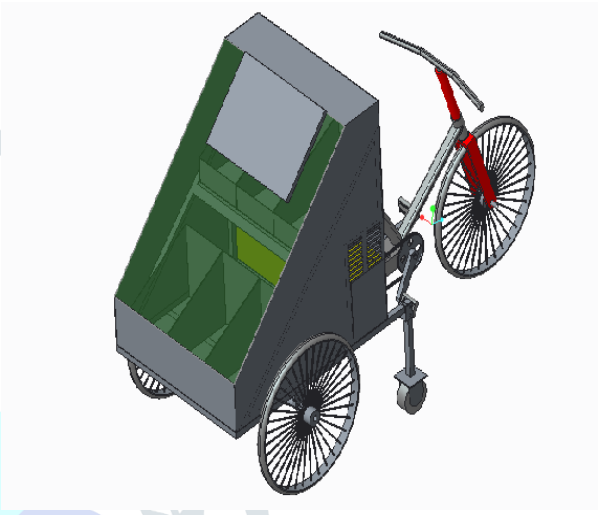

Figure. 11 CAD of proposed vehicle

Spine load assessment

As our main aim is to reduce the stresses on the spine, hence we are going to analyze the spinal region for different load carrying conditions. For that, the first step is to obtain CT scan of cervical spine in the DICOM format. The DICOM images are converted to STL format in MIMICS software. The MIMICS file is then imported into 3-Matic for meshing. In 3-matic software, the meshing is done and the file is imported back into MIMICS for assigning material properties. This file is saved in the format which is compatible with the solver software. We have saved the mesh file into Ansys Preprocessor format and then exported it in ANSYS workbench. The static structural analysis of cervical spine is carried out for 30 kg (294 N) load.

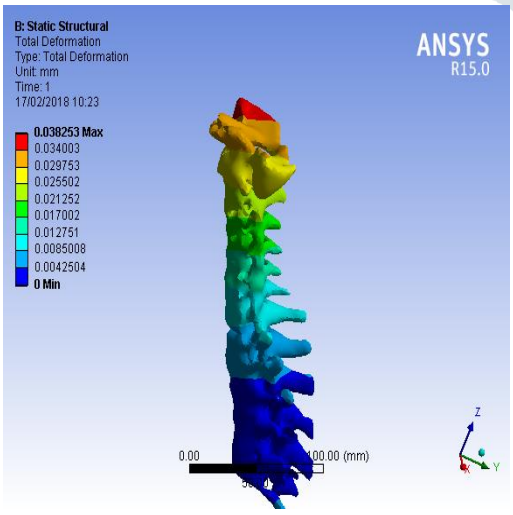

Figure 12 (a) Total deformation of Spine

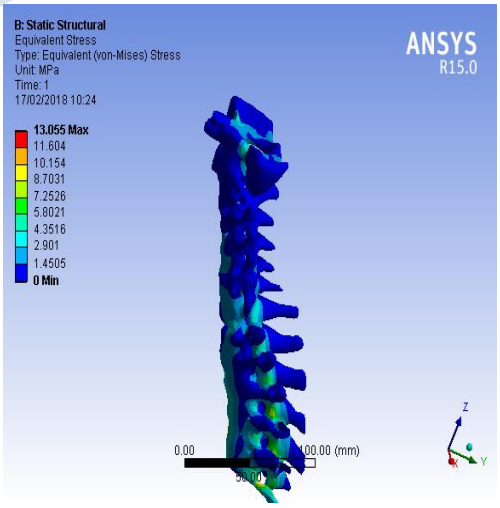

Figure. 13 (b) Equivalent stress on Spine

V. CONCLUSION

We are in Industry 4.O era and India is the vegetable and fruit basket of the world but still development is needed in rural area .through our development of Manually & Solar power driven vehicle for Mobile vegetable & fruit vendors our project we are trying to contribute towards the social innovation to increase the productivity of vegetable and fruits vendors. Approximately 23–35% of the horticulture produce goes waste due to improper post-harvest operations and due to lack of enough storage facilities. Evaporative cooling systems have a very large potential to propitiate thermal comfort at cheaper cost.

Mainly, the vehicle is developing for common vegetable vendor. This vehicle will be cost effective campared to other carts and so vendors can afford. The fabrication of cart is very simple and no need of any special skills. The assembly and disassembly of cart is very simple, and the person can used it for short and long distance. The system will reduce the temperature about 15-16 degrees than surroundings temperature, so that shelf life of vegetables will increases as compared to current conditions, due to which economic losses will reduced to much extent even though vendor is unable to sell all goods daily .Additionally vehicle is ergonomically designed with prior studies and analysis to avoid and reduced the musculoskeletal disorder problems which leads to productivity.

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