

Case 4: Load Carrying Device

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Project report

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Labour Statistic system in India

Manual labour in developing countries like India is still one of the most ignored and often abused sectors when it comes to workers' conditions and wages.

It is not only the Ministry of Labour and Employment responsible for making labour policy laws and their implementation. But agencies engaged in planning socioeconomic development, particularly, the Planning Commission, when it comes to collecting data on different aspects of labour.

Among the international users of Labour statistics, the principal stakeholder is the International Labour Organisation (ILO). ILO is responsible not only for compiling labour statistics but also to monitor progress in labour standards set by its conventions and recommendations, on that basis.

Looking at some of the reports on labour statistic system in India. Themes like informal and unorganized sector, employment and earnings in the rural non-formal sector, informal employment in the organized sector, are some of those in which research questions are being asked; yet data for their detailed analysis are not available.

(Information from the report presented by TS POPLA on Labor statistics system in India)

Looking at LPG Gas cylinders and 20 litre Water cans.

Gas Cylinders

Gas cylinders are extensively used for cooking purposes from a common household to large scale restaurant businesses. These cylinders are manufactured in factories and distributed all over the country.

These are distributed into two categories. One for domestic and the other for commercial. When it comes to domestic usage, people must register and apply to get a new gas connection at their house. The gas cylinder supplier delivers these cylinders in small trucks or hands the job over to Individuals.

Looking at how the LPG cylinders and Water cans are delivered to homes:

1. Lorries - Capacity over 400.

The lorries are used to transport the manufactured cylinders from factories to the supplier in city or rural areas. They can carry more than 400 cylinders at a time. The loading and unloading of these cylinders are done by manual labour. There are no special machines or cranes used to unload or load the cylinders onto the lorries. Most of the time, the loading and unloading is done by the factory workers or drivers for extra money. Specialized labour is not hired for this job.

(Observation recorded from a field visit to a cylinder manufacturing unit (2016 summer), on the outskirts of Bengaluru)

2. Tata ace (small truck) / Auto - Capacity 20-70

Small trucks like Tata ace and Autos can carry 20 -70 cylinders depending on the capacity of the vehicle. These are used to transport the gas cylinders from the supply store to domestic homes.

3. Two-wheelers - Capacity 3-5

The most dangerous way to deliver the cylinders is done on two-wheelers. One or two people on a scooter carry around 3 to 5 cylinders with ropes tied to them, so they don't fall while driving. This is an extremely dangerous way to carry a cylinder as they are flammable. The weight distribution is not equal across the vehicle and highly prone to accidents. This is not officially allowed by the government, but yet it is very commonly seen on roads in cities and rural areas.

20 L water cans

Just like a gas cylinder, the 20l water cans are delivered from water filtration plants to domestic homes or restaurants. The major difference being the manufacturing and materials of 20l water cans is different from that of gas cylinders.

A small palm-sized test tube-shaped plastic tube is filled with air at high pressure to expand. The tube expands into a 20 L water can, which is then distributed across the city/town. The weight of these plastic cans is considerably low compared to the cylinder which is made out of Iron. (Based on a field visit to a manufacturing unit)

Although there are water purifiers that can be attached directly to the water taps, buying drinking water in 20l water cans is still a very common practice in India because it is cheaper. New research shows that these 20L water cans over a period of time become carcinogenic. when the plastic degrades or overused they release toxic chemicals that are not healthy to consume. But nevertheless plastic is the major component used in these industries and unless there is a strict ban on plastic cans, the cans would be used widely.

The water cans are collected directly by people by going to the water filtration plant, or they get the cans home delivered. The filtration plant hires workers to deliver the cans to homes, this is done in small trucks (Tata Ace) or two-wheelers. The unloading and loading of cans are done by manual labour.

Commonalities between Gas Cylinder and Water Cans (20l)

The similarities between the gas cylinder and the water can are numerous, and they share common design problems

	Domestic gas cylinder	Water Can
Height	20 inches Excluding the top handle	17 inches
Diameter	13 inches	11 inches
Weight	30 kg filled	20 kg filled
Capacity	14.2 kg of LPG	19 l of water

The diameter, height, and weight of the gas cylinder are greater in every category. But the similarities are. Approximate height, weight, diameter, and cylindrical in shape. The gas cylinder has a handle of 10 inches from its cylinder top, which makes the handling of the cylinder easier than water cans.

Both these cylinders are delivered by labour, on their shoulders when they are not resting in a truck or a two-wheeler. Although the gas cylinder has a handle which makes it easier to lift and grip, It weighs 10kg more than the water can, so it is more difficult to carry. When the cylinders are empty, the metal gas cylinder weighs 10kg and the plastic can weigh nothing comparatively as it is made out of plastic.

Finding the right problem

- Hundreds of gas cylinders are loaded and unloaded onto lorries, without any help from cranes or machines at the manufacturing plants.
- Suppliers who hire two-wheelers to deliver the cylinders.
This is a very dangerous yet common practice in developing countries. People load their two-wheelers with 3 or more gas cylinders which are balanced by a rope and some metal plates. The vehicle is now overloaded with flammable gas and is prone to serious accidents.
- Home delivering the water cans and gas cylinders. The labour carries the cylinders on their shoulders to the doorstep. This is their full-time job and performing this act without any additional support could cause spine and shoulder injuries in the long term. Sometimes, in small towns, the labour is expected to climb up the stairs with the cylinder on his/her shoulder to the doorstep.
- New research shows that 20-liter water can be carcinogenic. The plastic wears over time and degrades. The plastic releases toxic chemicals that are harmful.

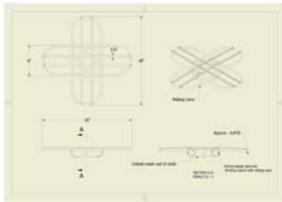
After studying both the Industries and listing down all the design challenges, we decided to focus on assisting those who home deliver the gas cylinders and water cans. Our research is focused on finding the right solution to address the problems faced by the labour who carry cylinders on their shoulders.

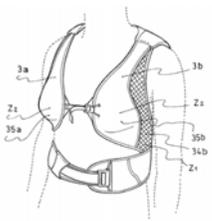
As a next step, we interviewed labour who home deliver 20-liter water cans.

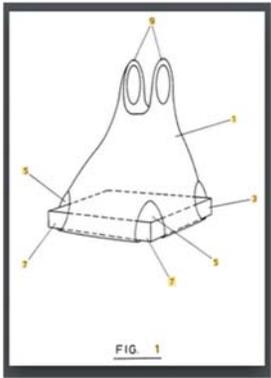
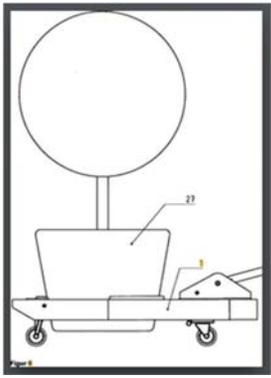
1. How many times in a day do you deliver the water cans to houses?
A. The whole day, from when the water plant opens until 6 in the night
2. How do you know you when you have to go deliver the water cans?
A. People call the boss requesting for a new can and we deliver
3. How do you deliver?

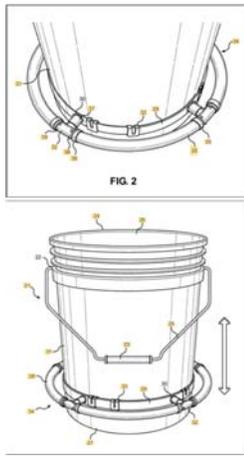
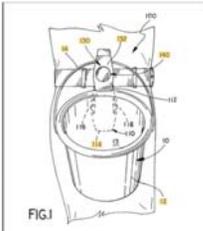
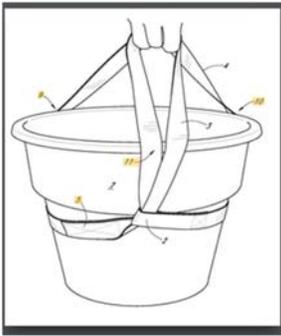
- A. Scooter
4. How many do you carry at a time?
- A. in the front and my friend holds 2 or 3 at the back
5. Do you have a license?
- A. No
6. How much do you get paid in a day?
- A. Depending on the number of requests. Each delivery each of us gets 15 rupees. Extra money at the end of the month
7. How many houses do you deliver to in a day?
- A. More than 50 sometimes less or more
8. How far do you go?
- A. Maximum 3 km
9. Did cops ever catch you?
- A. We don't go that far in scooter
10. How many cans do you deliver to a single house?
- A. Usually not more than one
11. How many times do you climb the stairs?
- A. If we are lucky there will be lift, if not we carry out on our shoulders
12. How do you know the address?
- A. We deliver to the same houses who ordered before, so we know it by memory. And if it's a new customer, the boss will have their address
13. Does your plant have trucks?
- A. No, our place is quite small, so we deliver in a scooter. But some big plants have delivered in Tata ace
14. Do you use any device to lift the cylinders?
- A. There is a handle at the plant which you can use to lift with one hand, but carrying on shoulders is easier while walking.

Existing models or previous attempts

	Design	Images
1	Load-carrying device http://www.ijirset.com/upload/2016/february/82_22_Assistive.pdf	

<p>2</p>	<p>Load-carrying protection of women</p> <p>http://www.freepatentsonline.com/20130185853.pdf</p>	
<p>3.</p>	<p>Load Carrying Device for Bricks By Rohit, Anshuman, Ankit, and Ajay - 2018</p> <p>https://www.ss.sristi.org/load-carrying-device-1</p>	
<p>4.</p>	<p>LOAD CARRYING DEVICE (v1.1)</p> <p>By - Aniket Singh, Arpit Kabra, Chintan Mehta and Rashi Jain May 2016</p> <p>https://www.ss.sristi.org/load-carrying-device-1</p>	
<p>5.</p>	<p>Improved Load Bearing Device by Sreenath Mallela, Sai Sidharth</p> <p>https://fairwallproject.wordpress.com/improved-load-bearing-device-by-sreenath-mallela-sai-sidharth/</p>	

<p>6.</p>	<p>Low-Cost Wearable Assistive Device For Carrying Heavy Loads In Mountainous Terrains S Vishnu Rajendran</p> <p>http://gyti.techpedia.in/project-detail/low-cost-wearable-assistive-device-for-carrying-heavy-loads-in/10746</p>	 <p>Figure 1: Women carrying load in baskets</p>
<p>7.</p>	<p>Device for carrying Gas Cylinders</p>	
<p>8.</p>	<p>Load-carrying</p> <p>https://patents.google.com/patent/EP0646086B1</p>	 <p>FIG. 1</p>
<p>9.</p>	<p>Load-carrying device for bucket-shaped objects</p> <p>https://patents.google.com/patent/DE102011122081B4/en</p>	

<p>10</p>	<p>Bucket Lifting Assembly</p> <p>https://patents.google.com/patent/US20140327258A1/en?q=B65G7%2f12&q=B65G7%2f12&page=2</p>	
<p>11</p>	<p>Belt clip for paint containers</p>	
<p>12</p>	<p>Carry strap</p> <p>https://patents.google.com/patent/US8061750B1/en?q=B65G7%2f12&q=B65G7%2f12&page=3</p>	
<p>13</p>	<p>Vikarm Panchal</p> <p>https://lapazgroup.net/2012/12/28/5-reasons-i-see-indias-potential-to-produce-a-stararchitect/load-carrier/</p>	

14	Sowmil Patra's Thesis	
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Studying all the previous patents and existing models gives a better understanding of all the prior work done in this field, this helps in building a better product and addressing existing design challenges. A major health problem that occurs to those working in labor sectors could be MSD. The following research is based on what causes MSD and the possible ways of tackling this issue.

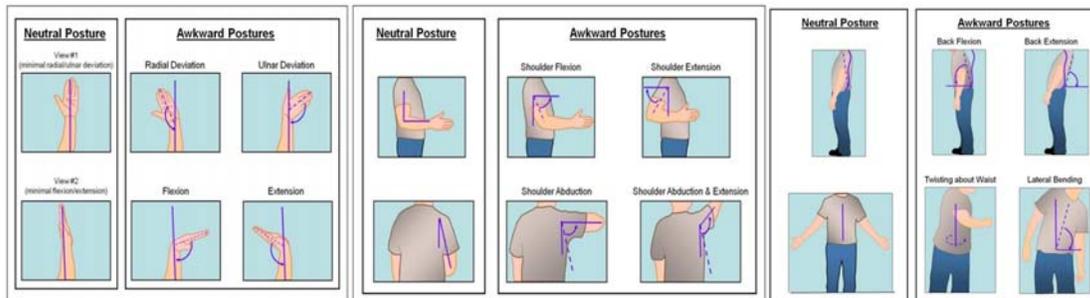
Ergonomics :

Benefits of good ergonomics in industries :

- Reduce ill-health
- Improve productivity
- Reduce ergonomic risks resulting from repetitive or manual handling tasks
- Ensure tasks are conducted in the easiest way possible

The following images are designed to highlight the effect that awkward postures have on muscle activity for the wrist, elbow, shoulder, and lower back.

Awkward Postures



Risk factors related to work activity and ergonomics can make it more difficult to maintain this balance. The major **workplace ergonomic risk factors** to consider are:

- **Forceful Exertions:** Many work tasks require high force loads on the human body. Muscle effort increases in response to high force requirements, increasing associated fatigue which can lead to MSD. Eliminating excessive force requirements will reduce worker fatigue and the risk of MSD formation in most workers. Using mechanical assists, counterbalance

systems, adjustable height lift tables and workstations, powered equipment, and ergonomic tools will reduce work effort and muscle exertions. Work process improvements such as using carts and dollies to reduce lifting and carrying demands, sliding objects instead of carrying or lifting, and eliminating any reaching obstruction to reduce the lever arm required to lift the

object. Workers should be trained to use proper lifting and work techniques to reduce force requirements.

- **Repetitive/Sustained Awkward Postures:** Awkward postures place excessive force on joints and overload the muscles and tendons around the affected joint. Joints of the body are most efficient when they operate closest to the mid-range motion of the joint. The risk of MSD is increased when joints are worked outside of this mid-range repetitively or for sustained periods of time without adequate recovery time. Eliminate or reduce awkward postures with ergonomic modifications that seek to maintain joint range of motion to accomplish work tasks within the mid-range of motion positions for vulnerable joints. Proper ergonomic tools should be utilized that allow workers to maintain optimal joint positions.

Work procedures that consider and reduce awkward postures should be implemented. In addition, workers should be trained in proper work techniques and encouraged to accept their responsibility to use their body properly and to avoid awkward postures whenever possible.

- **High Task Repetition:** Many work tasks and cycles are repetitive in nature, and are frequently controlled by hourly or daily production targets and work processes. High task repetition, when combined with other risk factors such as high force and/or awkward postures, can contribute to the formation of MSD. A job is considered highly repetitive if the cycle time is 30 seconds or less.

Eliminating excessive force and awkward posture requirements will reduce worker fatigue and allow high repetition tasks to be performed without a significant increase in MSD risk for most workers.

Providing safe & effective procedures for completing work tasks can reduce MSD risk. In addition, workers should be trained in proper work techniques and encouraged to accept their responsibilities for MSD prevention.

A lot of these solutions focus on training workers but a lot of the times the workers don't want to adapt, due to which a lot of well-intentioned programs fail. Therefore, apart from building a device for workers safety :

- Management needs to commit to worker safety too
- Workers' attitudes towards safety and compliance with safety norms need to be observed
- If there is a negative attitude towards safety, it needs to be changed and the right attitude needs to be enforced.

An ergonomics intervention may look great on the drawing board, it may be rendered ineffective if employees choose to perform the wrong behaviors. A powerful tool for getting employees to voluntarily, willingly, and enthusiastically execute desired behaviors is a behavioral-based safety process.

Understanding Biomechanics

The biomechanics effects of back and front load carriage for human locomotion (research by Han Yali Liu Yiyu Gao Haito Zhu SongQing)

Abstract - The paper describes an investigation into the biomechanical effects of a back and front load carriage on human locomotion preferences. Two young male subjects walked on a level under five conditions (10kg front pack, 20kg front pack, 10kg backpack, 20kg bag pack). The kinematic and kinetic effects were obtained with walking experiments.

The results on Joint Kinematics

For the backpack load the hip flexion was increasing, and more hip flexion with a backpack than the front pack. The hip angle increased in both cases when adding weights. The front-back exhibited greater hip extension than the backpack. The experiment also shows that difference in knee flexion is not notable when increasing weights and backpack with 10kg and 20kg load walking.

Trunk range and COM change

There is a forward lean with an increase in weight with the front pack as compared to the bag packs. Trunk posture was shifted backward while carrying a front pack. And carrying a front pack resulted in the head being moved backward relative to control condition without a backpack. The backpack load trajectory was lower than the front pack may be due to greater forward lean angles during backpack style walking. It was concluded that the use of the front pack results in a more upright posture in gait when compared to a backpack style carrying the same load.

Joint moment and power

The joint movement was larger with load increase during the same pack style walking, this was expected since the larger are present due to the additional mass on the body. The ankle knee and hip joint moment also increases with the load during front pack style walking, and greater than the backpack in the same mass load. Joint powers were increases with load increasing during the same pack style walking, this was expected since the larger forces were present due to the additional mass on the body. The joint power with the front pack greater than the bag pack, which may be due to the higher displacement of the front pack load walking

Choosing the right solution

There are existing trolleys with wheels that can carry cylinders up to 10 at a time. These devices are used in factories or manufacturing plants where moving 5 to 6 cylinders at a time is required.

There is also a single-cylinder carrier with wheels and metal handles. This device is used in household and worker to move a single-cylinder, however, this device does not help the labor to lift the weight

From the questionnaire and research, it is found that majority of people who require domestic gas cylinders or water cans order one at a time. The delivery van might have 20 or 30 cylinders at its disposal, but he/she only carries one cylinder to a household at a given time. Thus designing a device that could hold one cylinder was essential to help the labour who carry the cylinder from the vehicles to homes. This helps to keep the weight to a minimum. Sometimes the house could be 200 meters away and four floors up with no lift.

Form and Function

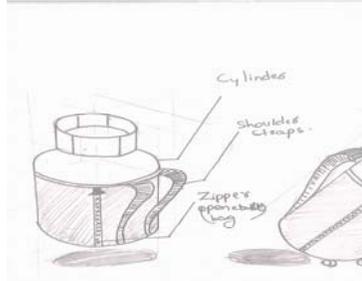
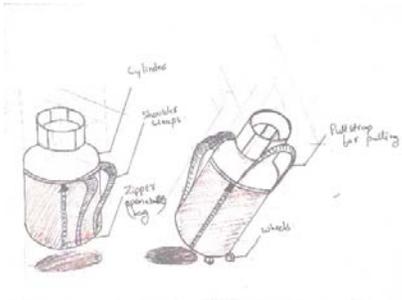
The load-carrying device for our project is a bag pack. A cylindrical bag pack with a top opening and the bottom covered. The bottom of the bag also has 2 tiny skate sized wheels. The bag pack has a side

zipper that covers the entire horizontal length when the zipper is open, when the zipper is closed it is back to its cylindrical shape. The bag pack has 2 shoulder straps, on the opposite side of the zipper, It also has a pull strap in between and above the shoulder straps, the above strap can be like a pulled like a handle. The backpack can be loaded with a gas cylinder or 20-liter water can. This helps significantly take the 20 to 30 kg of load on one shoulder and distributes the weight evenly on the back. This will increase the range of motion while carrying a gas cylinder and reduce the risk of potential injuries. A backpack that can withstand at least 50kg of weight when using materials like Jute and bamboo fibers. The design is kept to minimal cost adding only basic features. The bag pack has two wheels and a handle strap to pull like a trolley when needed. The backpack has a side zipper that opens the entire bag pack to cover the cylinder when laid on the ground horizontally. The backpack can be folded when not in use and kept with the user.

Function

1. The cylinder is laid horizontally flat on the ground
2. Opening the side zipper of the backpack and covering the entire cylinder
3. Roll the cylinder until the zipper is seen again
4. Close the zipper to have a snug fit
5. Lay the backpack with cylinder vertically on the ground
6. Pull using the hand strap
7. Use the shoulder straps to carry it on the shoulders.

The use of 2 small wheels does not affect the foldability of the product. The product is foldable when not in use and can be taken anywhere.



The device is ready to be carried like a bag pack while walking or climbing up stairs or pull using the handle straps while walking.

