Gas cylinder transfer system for a gas cylinder delivery person

Kamlesh Sawant
08613802

Guide: **Dr. G. G. Ray**

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Submitted in partial fulfillment of the
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Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/ source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Kamlesh Sawant

Roll No.08613802

Date:

Approval sheet

The Industrial Design Project-II, titled

"Gas cylinder transfer system for a gas cylinder delivery person"

by **Kamlesh Baba Sawant (08613802)**

is approved for the partial fulfilment of the requirement for the post graduate degree in Industrial Design.

Guide July 01. 2010

Chair Person

External Examiner

Internal Examiner

Abstract:

LPG gas cylinders have evolved as an important source of fuel for cooking needs in India. Apart from the projected increase demand; LPG gas cylinders have always been in news sometimes for rise in cost or shortage or for illegal uses. But, all these time nothing has been talked about the amazing system which works behind it, to keep the circulation going.

This project investigates the working of the system to find out how the LPG cylinders weighing upto 40 Kg are handled on daily basis. The analysis of the study is synthesized to find out the area where there is scope as well as need for design intervention.

Insights of the persons involved in gas cylinder delivery and observations done while studying the system, were helpful in formulating the design brief. The mock-up models were also used for validating and refining the concepts at every step.

The proposed solution needed to be feasible solution within the boundaries marked by concerned authorities. Keeping this in mind, after concept evaluation the final concept was further developed to meet the needs suggested by the earlier study.

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Acknowledgement

I would like to express my sincere thanks to my guide Prof. G. G. Ray, for his valuable guidance and support. It was an immense learning experience for me.

Furthermore, I would like to thank the IDC Faculty for their feedback and constructive criticism.

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I want to thank all my friends, for all their ever extending support, interest and valuable opinions.

Kamlesh Sawant

List of abbreviations

LPG – Liquefied Petroleum Gas

PNG – Piped Natural Gas

CNG – Compressed Natural gas

MMT – Million Metric Tonnes

HCV – Heavy commercial vehicle

LCV – Light commercial vehicle

RTO - Regional Transport Office

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Background

Background

The story so far:

"Minister of State for Petroleum and Natural Gas Jitin Prasada ,who is in-charge of fuel marketing, met the marketing heads of the firms on Tuesday in order to streamline supplies.

Prasada has directed the oil marketing companies to prepare a year-wise as well as state-wise road map for increasing the pace of **new LPG connections by releasing 5.5 crore (55 million) new connections by 2015.**

a statement from the ministry said.: Release of these new connections would raise **coverage from about 50 per cent of the population at present to 75 per cent in line with the Vision 2015** finalized by the ministry, recently.

Prasada emphasised that focus would be on states which as have very low LPG coverage. Governments endeavor is to take LPG to rural areas of the country," the statement said.

The minister also directed the three firms to improve supply time and customer satisfaction. He wants the **time between booking and delivery of LPG cylinders to come down to 48 hours."**

Rediff business, Date:15/07/2009;

http://business.rediff.com/report/2009/jul/15/new-lpg-connections-soon.htm

"India has over 150 million LPG cylinders and on an average seven million cylinders are circulated in the market every year."

The Hindu, Date:02/02/2008;

URL:

http://www.thehindu.com/2008/02/02/stories/2008020257272000.htm

What it means is:

Year	No. of cylinders in millions
2009	150
2015	(150 + 55x2) = **260***

* - assuming only one Gas cylinder for new connection

Table no. 1; Prediction for number of cylinders in year 2015

	LPG	**PNG**
Consumption or Import	11.7 MMT consumed during 2007-08 *Practical Guide to Energy conservation* *Petroleum Conservation Research Association* *Ministry of Petroleum & Natural Gas*	8.32 MMT import of LNG during 2007-08
Import scenario	2007-08 – 1.73 Million tonnes 2008-09 – 1.55 Million tonnes 2011-12 – 0.1 million tonnes (estimated) *Livemint.com* LPG imports may stop by 2009: *RIL Ibnlive.in.com – 13/03/2007*	
Country coverage	As on 1.10.2008, LPG customer population covers approximately 53% of country's total population, as per census of India, 2001	The cities covered under the Piped Natural Gas (PNG) network in the country are Delhi, Mumbai, Agartala,Surat, Hazira, Junagarh, Vasva, Mora, Damka, Bhatlai, Kawas, Rajgiri, Suwali, Icchapore, Ankleshwer, Bharauch, Vadodara, Ahmedabad, Vdyanagar, Anand, Morbi, Gandhinagar, Duliajan, Digboi, Dibrugarh, Moran, Naharkatiya, Sivsagar, Nazira, Simaluguri and Tinsukia.

Table no. 2, (continued); Comparison between LPG and PNG; [11]

With LPG new fuel is also emerging as a cooking solution. Comparison between LPG and Piped Natural gas (PNG) is as follows:

	LPG	**PNG**
No. of customers	1047 lakh (Domestic & Non-domestic)	7,75,119 domestic, 1287 Commercial and 64 Industrial consumers *Petroleum and Natural Gas Regulatory Board (PNGRB)*
Distributors	9376	398 CNG stations in the country.
	OMCs are in the process of setting up 1342 new LPG distributorship mainly in rural locations.	Integrated pipeline plans connecting various cities in India in next 10 years *Petroleum and Natural Gas Regulatory Board,* *Tender No. PNGRB/M(I)/PLCAP/NGPROD/OT/2008/02/01* *Hiring of Consultancy services to firm up process for determining capacity of pipelines (Petroleum Products and Natural gas)*
Cost	$ 802.00 /MT – Import Rs. 23 / Kg for domestic use	Rs 13.52 per cubic metre - 18% cheaper by heating value than LPG *Times of India 25th Feb, 2009* For end user - 8 % cheaper than LPG *16th Sept, 2009 – Pune times* PNG works out to be up to 7-10% cheaper than LPG *mngl.in/png-faq's.html – Mahanagar Natural gas Limited*
BTU	2500 *wisegeek.com*	1000 *wisegeek.com*

Table no. 2; Comparison between LPG and PNG; [11]

The other development in this segment is Reticulated Piping system. The details of which can be found in following news:

Image no. 1, Reticulated piping system

Image reference: *The Hindu, Date: Date:17/07/2004; URL: http://www.thehindu.com/thehindu/pp/2004/07/17/stories/2004071700020100.htm*

"In the reticulated system, supply to the hotplate is drawn from a `bank' of cylinders stocked in the ground floor of the complex. It contains two lines of cylinders — one that is in use and another that serves as a standby.

Success of the piped supply is largely dependent on the role of the resident's association and cooperation among the residents.

Moreover, for those purchasing new apartments the additional cost on the system is small, whereas in existing complexes it requires greater unity and investment from the residents…

The expenditure for installing the piped gas system is between Rs. 10,000 and 15,000 a house. But establishing a reticulated system in existing complexes is not easy, as most of them do not have the requisite facility for locating the cylinder bank…"

The Hindu, Date: Date:17/07/2004; URL: http://www.thehindu.com/thehindu/pp/2004/07/17/stories/2004071700020100.htm

Inference:

There is a need for heating source for cooking and not the cylinder which is used to store the source. But, it is very clear from the above facts and figures that LPG cylinders are inseparable part of the system - which caters the cooking demand of India.

The issues like shortage, price rise, ‘black-marketing’ of LPG cylinders are much talked about since they affect the end user i.e. customer. But the Gas Cylinder Delivery System which handles such loads (a filled domestic cylinder weighs 30 to 32 Kg and commercial cylinders weighs 40 kg) and keeps the circulation going is always kept in shadow.

With a panoramic view of the Gas cylinder delivery system, it was evident that manual labor is involved in each step of the system. A gas cylinder delivery person carrying a 30 kg LPG cylinder on his shoulder right upto top floor of a four story building is also part of that system. Imagining the physical stresses involved, the need was felt to investigate the details of the system to find a specific area where efforts can be channelized within the time constraints of this project.

This project was initiated with intentions to come-up with aids which reduces physical stress involved in gas cylinder delivery.

First few days

First few days

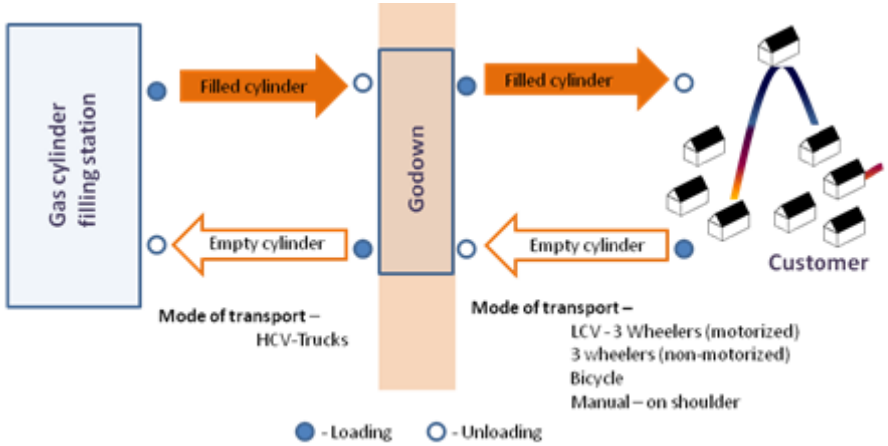


Fig 1 (a) – Gas cylinder delivery system overall

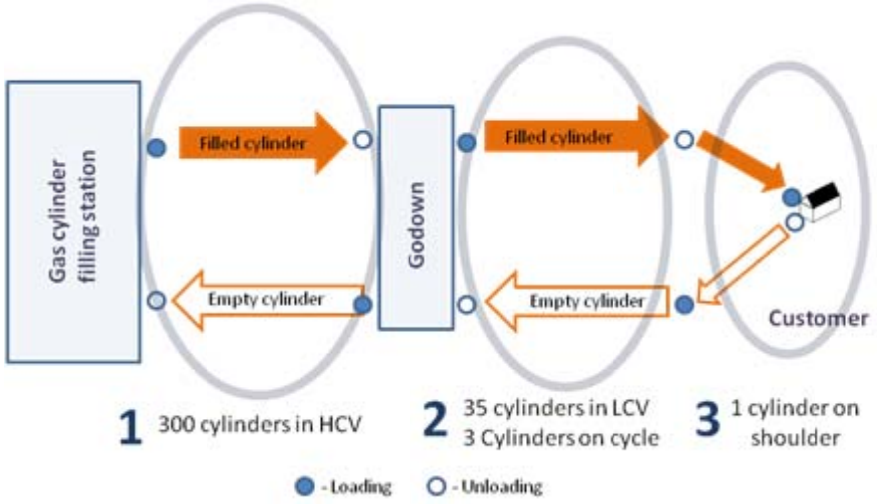


Fig 1 (b) – Three stages of Gas cylinder delivery stages

To understand the constituents of Gas cylinder delivery system, most of the time was spend to follow a cylinder right from the arrival at local godown till its delivery at the doorstep. The observations are shown diagrammatically in fig no-1 (a) and (b.:

Stage 1 – Transportation of filled cylinder from refilling station to local godowns for further distribution

Stage 2 – Transportation of filled gas cylinders from godown to location which is nearest to destination and easily accessible with vehicle.

Stage 3 – transportation of one cylinder from location to the customer's doorstep; this involves carrying one cylinder on shoulder.

Loading of empty Gas cylinders and Unloading of filled gas cylinders from HCV at godown

Unloading of filled gas cylinders from HCV:

A fully loaded HCV may carry about 300 LPG gas cylinders or more depending upon its tonnage.

The unloading and loading of HCV at godown is done by a team of Mathari workers. In this case a team of four mathari workers were responsible for this activity.

For unloading; one member of the team climbs up in the carriage of the HCV to push out cylinders one by one towards its gate. At gate the other team members take the pushed out cylinder turn by turn and carry it to the temporary storage space in godown. There they start arranging gas cylinders to form lines, stacking them ne over other (only one level is added on the cylinders which are kept on the ground).

Image no. 2; Unloading cylinders from HCV

Image no. 3; Stacking cylinders after unloading from HCV

Loading empty cylinders into the HCV:

For loading; one member of the team climbs up in the carriage of the HCV to arrange the gas cylinders ‘thrown in’ by the other team mate. On ground, other team mates form a chain to transfer cylinders one by one to a member of team who stands near the gate of HCV. This team member then swings the cylinder into the carriage of HCV while doing so he also takes support of HCV with one hand. The member in the carriage arranges the cylinders level by level (upto three levels including the bottom one).

Image no. 4; Loading cylinder in HCV

Use of cycle as a Gas cylinder transport vehicle:

Though it is a practice to carry three cylinders on a cycle carriage; occasionally five cylinders are also carried on a cycle.

Cylinders are hooked on the carriage from both sides and one cylinder is kept in horizontal position and held in position with a rope or a cycle tire tube or rope.

Image no. 6 (a); Cylinder transport with cycle.

Image no. 6(b); Cylinder transport with cycle.

Loading and unloading of LCV

Single person loading - unloading

The LCV is brought as near as possible to the stacked up cylinders. The driver who also performs the duty of gas cylinder delivery, swings in the cylinders one by one into the carriage of the LCV. This fills up the aft side of the carriage leaving an empty space towards cabin. The person climbs up into the carriage shifts the cylinders towards cabin and also stacks them one over other. Again he gets down from the carriage and continues to swing in the cylinders one by one into the carriage. At the same time he also starts arranging them to utilize the available space to the maximum.

Two persons loading – unloading

Though LCV loading and unloading is handled by only one person, occasionally two persons team up for the same. In this case one climbs up into the carriage and one works as a ground crew. While loading the person on grounds swings the cylinder into the carriage and the other one arranges them

Image no. 5; Loading cylinder in LCV;

From left to right – Swinging the cylinder with one hand, arranging the cylinder, Lifting a cylinder to put in the carriage

Carrying one cylinder on the shoulder – right upto the doorsteps:

Though serving regular urban area of buildings and nicely laid roads is part of the job; some areas like hill side and complex societis formed by chawls are very hard to access with any vrhicle. For providing service to those region a cycle is ususlly preferred to go to the location – a place very near to the desination and upto which a vehicle can come - and then cylinders are delivered one by one to the customers.

Image no. 8; Steep Steps

Image no. 7; Inaccessible area for vehicles

Image no. 9; The tough terrain

Inference:

By the end of these early days the assumptions –physical stress must be involved in handling gas cylinders - made at the commencement of the project had justification on qualitative grounds. As each observed activity demanded an extreme physical fitness it was very hard to zero down on a particular area which demanded a design intervention.

Hence it was decided to evaluate each activity on quantitative terms.

Following the heart beats

Following the heart beats

For this purpose apart from **observations and interaction** with users **Physiological** measuring technique was also required to quantify the stress.

Therefore, user's heart rate was monitored while doing the activity.

Instrument used: Polar heart rate monitor

Image no. 10; Polar heart rate monitor

Survey location Maharashtra gas agency – Depot, Powai

The activities were broken into following categories:

1) Loading and unloading vehicle – Loading and unloading of HCV was chosen. This activity involved more number of cylinders as well as more height of carriage from ground as compared with loading of LCV.
2) Monitoring heart beats of a gas cylinder delivery person who delivers cylinders and uses cycle as a transport vehicle.

Unloading filled gas cylinders from HCV:

For unloading the HCV, one out of four team members climbed up in the HCV carriage to push out the cylinders and other member worked as ground crew. The persons working on ground took the pushed out cylinders one by one, turn by turn and arranged it in the space of godown. One of the member working as ground crew is named Subject 1 here and the team member who climbed up in the carriage of HCV is called as Subject 2.

Subject 1; Age 30; height 5'6''; weight: 62 kg; heart beats (relaxed) 75

Subject 2; Age 22; height 5'3''; weight: 55kg; heart beats (relaxed) 74

Subject 3; Age 34; height 5'5''; weight: 68 kg; heart beats (relaxed) 67

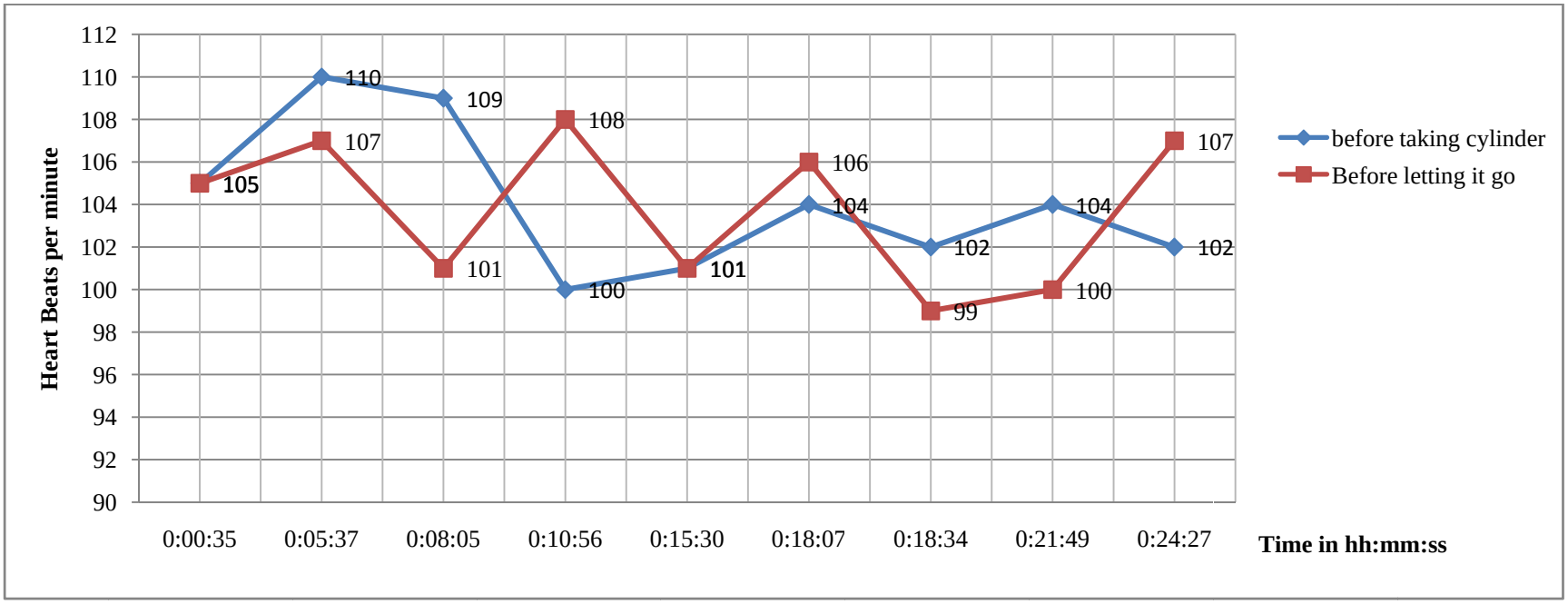


Chart no.1

Chart no. 1- Heart beats record for Subject 1; Unloading filled gas cylinders from HCV

Location of subject: team member working on ground; Total number of cylinders handled: 107

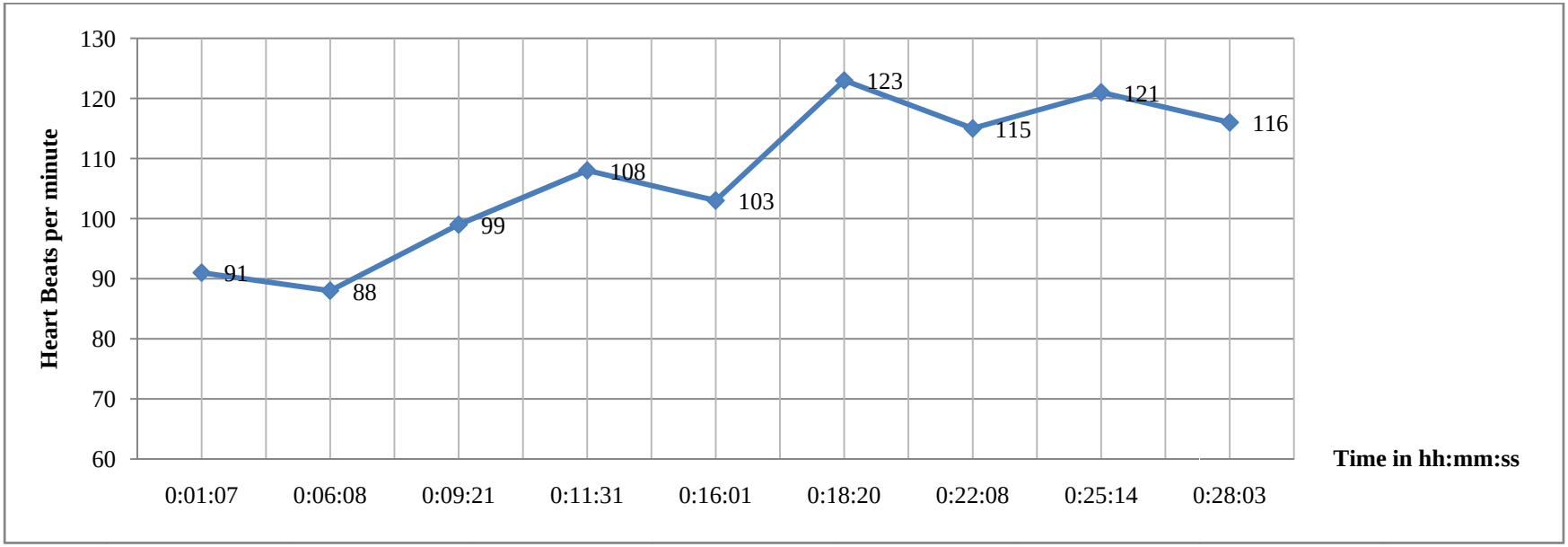


Chart no -2

Chart no.2 - Heart beats record for Subject 2; Unloading filled gas cylinders from HCV

Location of subject: team member working in carriage of HCV; Total number of cylinders handled: 250

It is very evident that out of two subjects, Subject 2 attained maximum heart beats per minute (123). The reasons may be:

1) Subject 1 was not lifting the load against gravity as adjusted himself with the HCV carriage height to take the pushed out cylinder directly on his shoulder.
2) Subject 1 was working with two other group members thus out of total 250 cylinders he only handled 107.

3) Subject 2 handled all 250 cylinders in the same time as taken by Subject 1 to handle 107 cylinders.

Heart beat readings of Subject 1 shows, after initial hike in the heart beats readings were stable. Readings of Subject 2 shows a progressive increment in heart beats and thus increasing physiological stress.

For loading empty cylinders in the HCV the four Mathari workers worked as a team. One member (Subject 1) was standing beside HCV carriage to swing cylinders in the carriage while taking support from HCV carriage. Other member (Subject 2) was on ground along with one more person to transfer cylinders from storage area to Subject 1. The remaining of the team member (Subject 3) climbed on the carriage of the HCV to arrange the cylinders swung-in by Subject-1.

Loading empty gas cylinders in HCV:

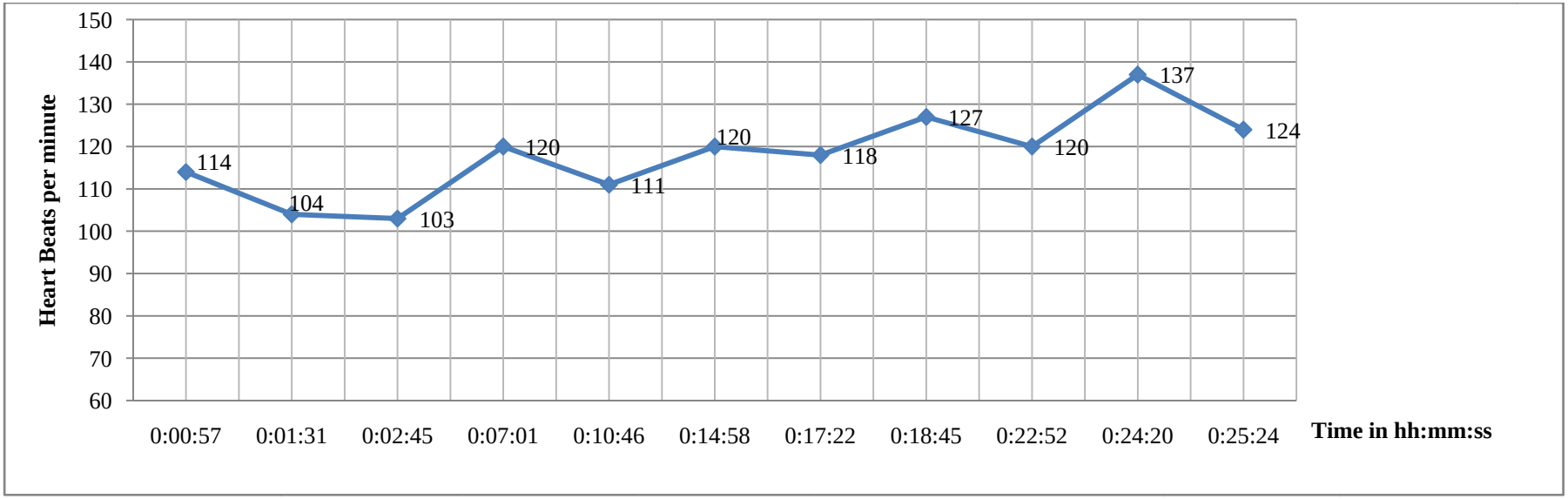


Chart no. 3

Chart no.3 - Heart beats record for Subject 2, loading empty gas cylinders in HCV

Location : On ground beside HCV; Number of cylinders handled: 242

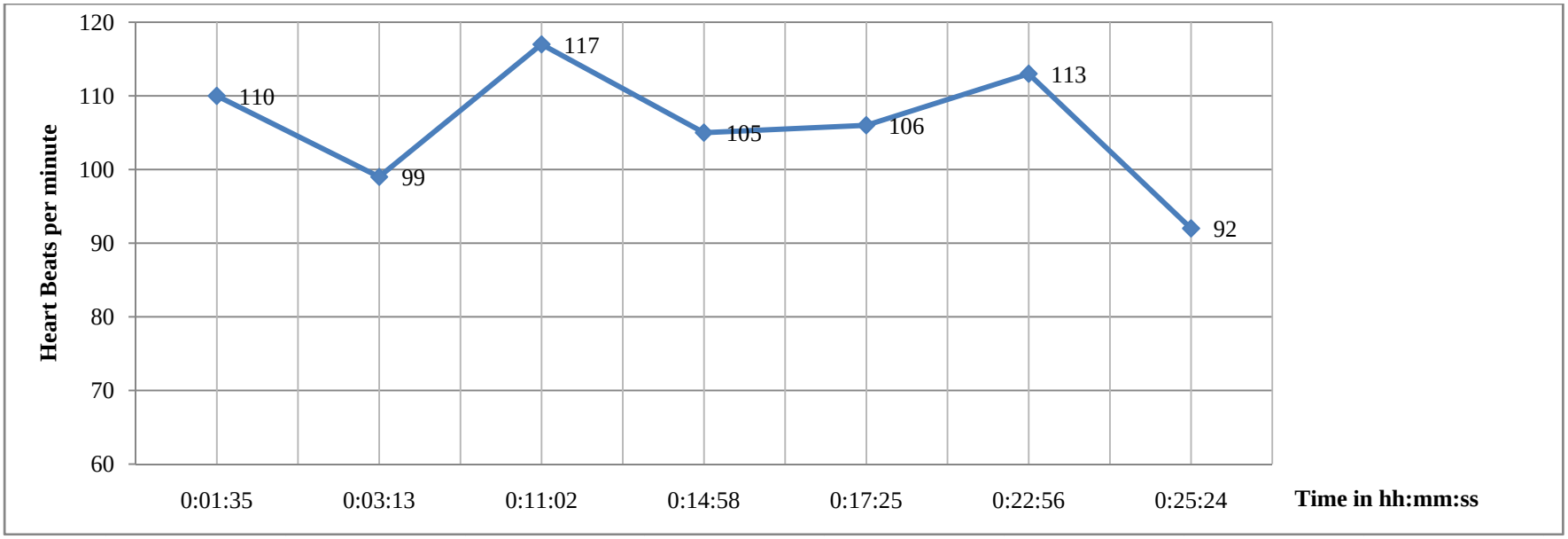


Chart no. 4

Chart no. 4 – Heart beat readings for subject 1; Loading empty gas cylinders in HCV

Location: On ground between Subject-1 and godowm ; Number of cylinders handled: 242

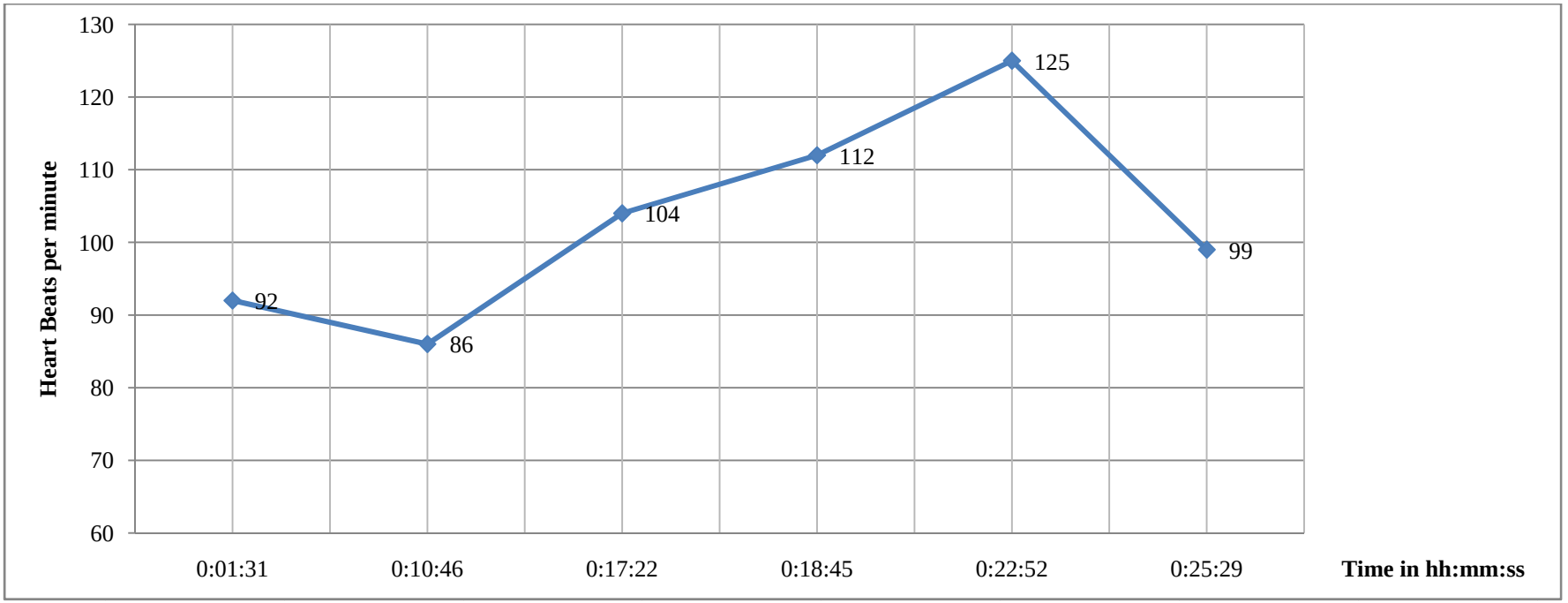


Chart no. 5

Chart no. 5 – Heart beat readings for subject 3; Loading empty gas cylinders in HCV

Location: on carriage of HCV; Number of cylinders handled: 242

As Subject-1 was working against gravity, the increased heart beats monitored in the readings can be reasoned. Also there is increase in the heart beat readings of Subject-2 who has to carry the cylinder, sometimes two at a time. Rise in the readings of Subject-3 also shows the physical stress involved in arranging the cylinders and stacking them in the carriage. Drop in readings at the end of the run can be argued as false reading but at the end of the run Subject-1 was doing most of the work by

throwing cylinders directly in position. But the maximum heart beats were monitored in Subject-1's readings as he was lifting load.

Summary of Loading and unloading activity is given in table 3:

Activity	Subject	Heart beats per minute					
		In truck		Transfer of cylinders on ground		Lifting of cylinder (from ground into truck)	
		Average	Maximum	Average	Maximum	Average	Maximum
Unloading	Subject-1 (Sham)			104	110		
	Subject-2 (Mama)	107	123				
Loading	Subject-1 (Ganesh)					118	**137**
	Subject-2 (Sham)			106	117		
	Subject-3 (Mama)	103	125				

Table no. 3, Summary of loading and unloading activity

Monitoring heart beats of a gas cylinder delivery person who delivers cylinders and uses cycle as a transport vehicle:

This involved following a gas cylinder delivery person, right from godown to the doorsteps of a customer and back till data for atleast four such consecutive journeys was recorded. The summary of the recorded heart beats per minute is shown in table -4

Though the activity of cycling with three filled cylinders shows maximum recorded heart beats, the second highest recorded heart beat readings in activity of delivering one filled cylinder uphill is also equally stressful.

Subject 1; Age 39; height 5’2’’; weight: 78 kg, heart beats (relaxed):81

Subject 2; Age 43; height 5’6’’; weight: 55 kg; heart beats (relaxed): 67

Activity	Subject	Average heart beat rate per minute	Maximum Heart beat rate per minute
Cycling - with filled cylinder	Subject -1	126	130
	Subject -2	132	146
Pushing cycle uphill	Subject -1		
	Subject -2	145	**164**
While delivering cylinder	Subject -1	115	129
	Subject -2	106	121
While delivering cylinder uphill	Subject -1	142	160
	Subject -2		161
Cycling - with empty cylinder	Subject -1	120	122
	Subject -2	111	115

Table no. 4, Summary of heart beats readings of gas cylinder delivery person

Note: Three numbers of cylinders handled while cycling; one cylinder handled while delivering.

Inference

The activity of Cycling with three filled gas cylinder is found most stressful along with the activity of delivering one cylinder uphill on shoulder. This does not mean that heart beats recorded in other activities are under physiological limits. According to reference [10] safe working load for activity like loading and unloading of cylinder is 13 Kg, which is three times less than the weight of the commercial cylinder.

Deciding direction

Deciding a direction

Options

After contemplating the complete process of Gas cylinder delivery process and recollecting the initial intent to reduce physical stress following two directions were available:

1) Reduce the weight which is handled

2) Introduce mechanization at various levels – keeping the weight of the cylinder same

Exploring Option -1

Reducing the weight of the cylinder directly means redesigning and reengineering the gas cylinder. And while doing so if, the LPG contents are also reduced then in long run it will mean stressing the delivery chain as number of booking in a month will proportionally go up. Before earnestly thinking to take this option as a further direction, the current scenario was studied which revealed some interesting facts.

"For LPG in fiberglass cylinders

NEW DELHI: Lightweight and transparent composite cylinders for liquefied petroleum gas, termed the 21st century LPG cylinders, are all set to hit the Indian market. Attracted by the expanding Indian market, a Norwegian company, **Ragasco,** has obtained the approval of the Chief Controller of Explosives to set up business in the country.

Petroleum and Natural Gas Minister Murli Deora, who met a representative of the company during a recent visit to London, said he had **asked the oil marketing companies to examine the feasibility of introducing the advanced technological innovation in India. Ragasco, the pioneer of this technology, is contemplating setting up a joint venture in the country.** … "

The Hindu, Date:02/02/2008; URL: http://www.thehindu.com/2008/02/02/stories/2008020257272000.htm

"**Fibre body LPG cylinders coming soon**

CHENNAI: **Chennai is among the three cities in south India where Indian Oil Corporation will introduce lightweight fibre body liquefied petroleum gas cylinder for domestic consumers**, but without any subsidy.

"It will be non-subsidised domestic LPG cylinder … only for a niche market," N. Srikumar, Executive Director (Branding, Corporate Communications and Planning) of the company, told The Hindu from Mumbai. Besides Chennai, the company would be test marketing the product in Hyderabad and Bangalore. …

The fibre body cylinder would come in different colours, and would be easy to maintain and handle. It would suit households laying emphasis on aesthetics and opting for modular kitchens. The total weight of the cylinder, inclusive of 10.5 kg of LPG, would be around 16 kg. It would have a transparent panel for users to monitor the level. … "

The Hindu, Date:23/05/2008; URL: http://www.thehindu.com/2008/05/23/stories/2008052358000100.htm

"**Coming soon: LPG in fiberglass cylinders**

State-owned oil marketing companies plan to procure 1,00,000 composite translucent fiberglass cooking gas cylinders, which are expected to be launched for test marketing in Apr-Jun 2010, Petroleum and Natural Gas Minister Murli Deora said in Lok Sabha on Thursday.

"Oil marketing companies have reported that necessary approval of chief controller of explosives has been obtained for use of composite cylinders for LPG," Deora said in a written reply.

He said the composite cylinders are estimated to cost Rs3,000-3,200as against around Rs1,050 for the 14.2 kg steel cylinder currently in use.

The minister said the government has granted "in principle" approval for introduction of composite cylinders to market domestic cooking gas.

The translucent cylinders would improve customer's satisfaction about quantity of LPG, as it would be visible. "Composite cylinders are proposed to be marketed at non-subsidized price. This will bring down the subsidy burden on the government to that extent," Deora said."

DNA, Date:07/08/2009; URL:http://www.dnaindia.com/india/report_coming-soon-lpg-in-

“Domestic LPG cylinders to have radio tags

… Along with RFID (radio frequency identification) tags, a smart card is likely to be introduced to ensure the subsidized fuel reaches the intended consumer.

IOC, BPCL and HPCL are working in tandem for the same and a system of inter-company detection is being planned. “

New Delhi / Press Trust of India, Date: 22/08/2009;
URL:http://newsx.com/story/24411

As it is clear from the preceding mentioned news that the cylinder design; for the near future, with existing technology- is explored fair to middling. Now it needs a practical trial in market. Only then the problems with the existing new proposed designs will be surfaced.

After analyzing the scenario Option-1 of redesigning and reengineering of Gas cylinder was not considered further as the scope of the project.

As it is clear from the news that the cylinder design; for the near future, with existing technology- is explored fair to middling. Now it needs a practical trial in market. Only then the problems with the existing new proposed designs will be surfaced.

After analyzing the scenario Option-1 of redesigning and reengineering of Gas cylinder was not considered further as the scope of the project.

Option 2: Introduce mechanization at various levels – keeping the weight of the cylinder same

This meant following three things:

i. **Automation in loading unloading – Use of forklifts, jacks, etc.**
   - This will involve huge initial investment, training, maintenance, supporting devices and dealing with space constraints.

ii. **Mechanization of manual transport (also includes loading and unloading at godown) of more than one cylinder with a vehicle from godown to location of delivery**
   - Heart beat rate analysis also shows that this area needs attention
   - Even in the LPG Reticulated piping scenario this problem remains.

iii. **Mechanization of manual transport from vehicle to the doorsteps**
   - This will largely depend upon the gas cylinder design
   - In LPG Reticulated piping scenario this factor is not prominent.

Inference

As automation in loading unloading with forklifts, pallets and jacks will involve huge investment and demands a system level intervention; this option was left out from the scope of this project because of the time constraint.

Mechanization of manual transport from vehicle to the doorsteps is mainly dependent on the weight of the cylinder and thus redesigning the same. Also other factors like the diverse terrain and sometime hard to access destinations, narrow passages, uphill, uneven or lack of steps also adds to the antecedently present main problem of weight. Hence, this option was also not considered in the scope of this project.

Mechanization of manual transport (also includes loading and unloading at godown) of more than one cylinder with a vehicle from godown to location of delivery – As the previous analysis of heart beat readings also showed this is a physically stressful activity, this option was considered for further exploration.

Focused study

Focused study

As the direction was now clear; that the manual transport (also includes loading and unloading at godown) of more than one cylinder with a vehicle from godown to location of delivery; this segment was observed and studied to obtain more user insights.

First thing done was to break-up the cycling activity to get the stressful events in it. For this one Subject's heart beats were monitored all the way in the while he was working. The results are tabulated below in table no.:

The readings again showed the region of pushing a cycle with filled cylinder uphill is most physiologically stressful region, along with the activity of delivering one cylinder uphill.

As transport was also focused; the option of carrying cylinder with LCV which is practiced by some gas cylinder delivery persons was also investigated.

	Heart beats per minute		Time for the activity (hh:mm:ss)	
	Max	**Average**	**Max**	**Average**
Loading 3 cylinders	129	110	0:00:45	0:00:38
Cycling	154	146	0:03:30	0:02:01
Pushing cycle	**175**	**152**	0:03:00	0:01:40
One cylinder delivery	163	132	0:04:00	0:02:13
Cycling back to godown	133	128	0:05:00	0:03:20
Unloading	124	121	0:00:30	0:00:28

Table no. 5, Summary of heart beats readings of gas cylinder delivery person – focused study

Date: 14th Sept, 09, Subject name: Mr. Sarvan, Age: 39, Height:5'9'', Place: Powai Mumbai

Activity break-up: This step of focused study also involved understanding users and the micro level of activity.

i. Loading :

- Cylinders are loaded from -
- Ground - only one level
- Ground - stacked one level above ground level
- From HCV directly into LCV

ii. Manual Loading (Single person)

- Lifted to the carriage height with both hands
- Swung into the carriage by one hand, other hand takes support from the carriage body
- First four single rows are filled up in LCV, near to the carriage door with space left at far end toward driver's cabin.
- Then the person enters the empty space of the carriage He then starts stacking the cylinders in the empty area, thus filling up the space at far back of LCV
- The activity is repeated to fill up the LCV

iii. Manual loading (Two persons)

- One person stands inside the carriage to stack the cylinders
- Other person lifts/swings cylinders into the carriage (holds the carriage body while swinging)

iv. Transport:

- Held in position by
- Hooks in case of cycle for vertical cylinders.
- Cycle tube for holding horizontal gas cylinder on cycle carriage.
- Cylinder weight, when no. of cylinders does not fill the LCV completely.
- Cylinder weight, stacking when LCV is filled to its capacity.
- The body work of carriage also works as a limiting boundary.

v. Unloading cylinders:

Cylinders are taken out from vehicle one by one at the delivery location

- Cycle – All three cylinders are delivered at only one delivery location
- LCV – Cylinders are taken out one by one according to location

vi. Loading-unloading pattern

- Cycle – to keep the balance
- Side cylinders must be placed first before loading horizontal cylinder
- Horizontal cylinder must be removed first to unhook the side cylinders
- LCV – After every delivery to make space for new empty cylinders and to reach the filled cylinder in last row last column, the filled cylinders in vehicle from a row are unloaded at location. The empty cylinders are then loaded at the far back followed by the loading of filled gas cylinders which were unloaded earlier. And this repeats at each location.

Some insights – (HP Gas)

1) LCV is not owned by Gas agency.
2) LCV is usually hired for Rs. 200 per day.
3) Gas cylinder delivery persons with LCV get Rs.5 per cylinder as commission as against normal Rs. 3 per cylinder. i.e. Rs.2 allowance per cylinder delivery.
4) With LCV daily 100 cylinder deliveries are possible. (with two persons) i.e. additional income of 100 x 2 = Rs. 200 = hiring cost per day for LCV.
5) Company pays the petrol allowance of Rs. 150 per day to persons with LCV.
6) Approximately petrol of Rs. 100 required per day (case of Maharashtra Gas Agency).
7) Maintenance cost is barred by the person who uses the LCV.
8) Company pays for getting the vehicle certified for LPG transport.
9) At night vehicle is parked near user's home.

Daily income of a gas cylinder delivery person is approximately **Rs. 500**

Some insights – (Bharat Gas)

1) LCV is not owned by Gas agency.
2) LCV is usually bought and owned by the user.
3) LCV cost details : Rs 20K down payment + EMI of Rs 3500 per month for next four years = Rs 1,84,500 /-
4) Gas cylinder delivery persons with LCV get Rs.4 per cylinder (independent of number of cylinder deliveries) as commission as against normal:
   - Rs. 2.50 per cylinder – if total cylinder deliveries are less than 750
   - Rs. 3.00 per cylinder – for cylinder deliveries above 750
5) With LCV daily approximately 20 cylinders are delivered and the LCV inaccessible areas and adjacent areas near godown are catered with cycles and tricycles (mainly to save petrol).
6) Company does not pay any additional petrol allowance.
7) Maintenance cost is barred by the person who uses the LCV
8) Company does not pay for getting the vehicle certified for LPG transport
9) At night vehicle is parked near user's home.

Insights – (HP Gas and Bharat Gas combined)

- In their opinion LCV is best suited for the job.
- But, they also say that for some locations cycles are more preferred than LCV because of the terrain and accessibility issues.
- Everyone do not buy LCVs because of the cost
- And not everyone hires it because of the fixed Rs. 200 per day charges as against their daily fluctuating income.
- The one who owns a LCV do not use it extensively for all scenarios mostly for saving on fuel cost.

Inferences:

- Cost is a major issue while making a decision of buying or hiring a vehicle as it is clear that users have approximate income of Rs. 500 per day.
- Though LCV serves a purpose of carrying around 20 (for Bajaj model) 32 cylinders (for Force's Minidor) the activity of loading and unloading and 'in-vehicle' arranging activity increases.
- LCV does not solve the problem of gas cylinder delivery persons who are supposed to work in areas inaccessible to LCV and who do not deliver more than 20 gas cylinders in a day.
- Use of TVS Excel was also attempted to deliver 6 cylinders in one journey. But, because of stringent RTO control the moped was grounded.
- Loading and unloading of gas cylinders should be free from any bar.
- The loading height should be as low as possible. Manual mode of load transport should be reduced as much as possible or tried to be kept within physiological and bio-mechanical limits. (After comparing cycle hook height and LCV carriage height)

Working towards design brief

Working towards a Design brief

Extraction of findings of the focused study meant:

1) A motorized vehicle is required which can replace cycle.
2) The vehicle should be small enough to access the areas which are currently served with cycle.
3) The vehicle should carry 6 cylinders to reduce the trips as against 3 cylinders carried by cycle.
4) The vehicle should also follow rules set-up by regulatory authorities for safety reasons.

This led to following Vehicle Specification:

- Single sitter
- Three wheel vehicle
- Payload - 350 Kg (Max 6 Gas cylinder + Driver)
- Minimum ground clearance – 150 mm
- Footprint of vehicle should not exceed 900 x 2000 mm
- Turning radius as small as possible (Cycle's turning radius 1.5m)
- Space on body for RTO's flammable goods transporter stamp and dealer's details as per norms
- Space on body for Company's branding

At this point there were two options:

1) Design a new chassis to suite the requirements and propose a new vehicle.
2) Search existing vehicle which suits the requirement

As option-1 of designing a new chassis involves a lot of unknown factors and the project enters into a completely new domain; demanding a different set of study; this option was not considered as a scope of project because of time constraints of the project.

Vehicles available in market were studied and compared with their features against the set requirements; the comparison is as shown in table no. 6 – on following page.

					
Model name	Bajaj GC 1000	Minidor Pickup	Ape	Alfa cargo	Pick-up
OMC	Bajaj Auto	FORCE Motors ltd	Piaggio	Mahindra & Mahindra	Atul Motors
Gross vehicle weight	990 kg	1350 kg	975 kg	995 kg	990 kg
Kerb weight	425 kg	725 kg	415 kg	460 kg	437 kg
Payload	565 kg	625 kg	560 kg	535 kg	553 kg
Overall length	2960 mm	3595 mm	2930 mm	3015 mm	2960 mm
Max width	1375 mm	1490 mm	1490 mm	1460 mm	1310 mm
Max height	1810 mm		1635 mm	1700 mm	1810 mm
Cargo bed length	1500 mm	1960 mm	2040 mm	1590 mm	1520 mm
Cargo bed width	1325 mm	1430 mm	1470 mm	1460 mm	1300 mm
Cargo bed side wall	250 mm	330 mm	300 mm	320 mm	400 mm
Wheel base	2025 mm	2492 mm	1920 mm	2005 mm	1845 mm
Rear wheel track		1330 mm		1260 mm	1140 mm
Turning radius	2.75 m		2.75 m	3.5m	
Ground clearance	170 mm	140 mm	165 mm		130 mm

Table no. 6, Comparison of LCVs

Conclusion after comparison:

Available vehicles are oversized and overpowered for the laid requirements.

Option 2 offers no direct solution, but knowing that some of the vehicles which are listed in comparison table are currently used for gas cylinder delivery an alternate solution can be thought.

This alternate solution involves modifying carriage of existing vehicle to minimize the efforts required in loading and unloading and other issues which also involves accessibility.

The advantage of the alternate solution: As more number of cylinders can be carried, number of trips to and from godown will decrease.

Limitation of alternate solution: As minimum turning radius available is 2.75m (Bajaj GC 1000) these vehicles can only reach to areas where road width is 4m.

Design brief:

Design a loading unloading aid for LPG gas cylinder delivery person to load and unload LPG gas cylinders to and from LCV (Model: Bajaj GC 1000) carriage. Also, redesign a carriage of a LCV (Model: Bajaj GC 1000) for LPG gas cylinder delivery application considering attributes mentioned in the table no. 7.

Focus area	**Description**
Accessibility	Loading and unloading of gas cylinders should be free from any bar.
Loading and unloading	Manual mode of load transport should be reduced as much as possible or tried to be kept within physiological and bio-mechanical limits.
Safety	There should be a provision to firmly hold the cylinders in their position whilst transporting (rope or rubber tube used now)
Security	Quick locking provision for load space to safeguard against possible theft whilst delivering one cylinder.
Unrestricted use	It should be able to hold varying sizes of cylinders – Domestic and Commercial
Branding	Space on body for Company's branding
Affordability	Low tech modifications
Maintainability	Availability of spare parts and service
Compliance with rules	Gas cylinder rules 2004, reference -[10]
Additional weight as less as possible	As any additional weight will eat away a share from payload capacity.

Table no. 7, Part of design brief

Ideation

Ideation

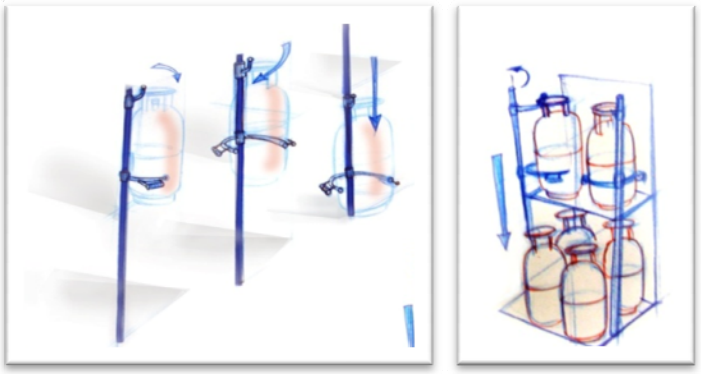
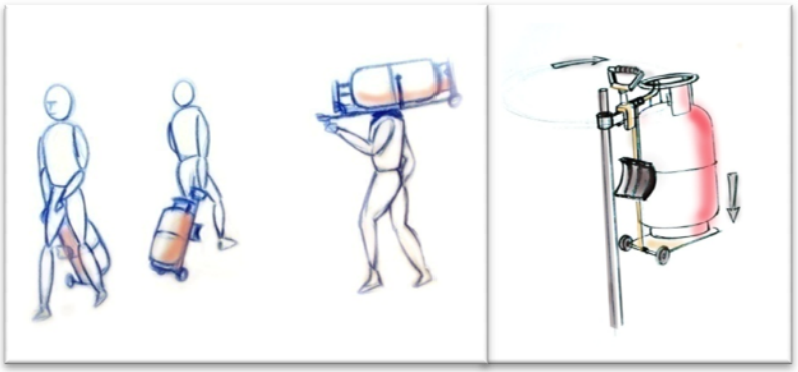
As the chosen vehicle cannot replace cycle with existing maneuvering characteristics; a separate trolley for one cylinder, is also proposed with the vehicle. The trolley will be collapsible and can be placed in drivers cabin. The LCV can take cylinders to the nearest possible location of delivery and then one cylinder will be carried on trolley to the maximum possible stretch of the remaining road.

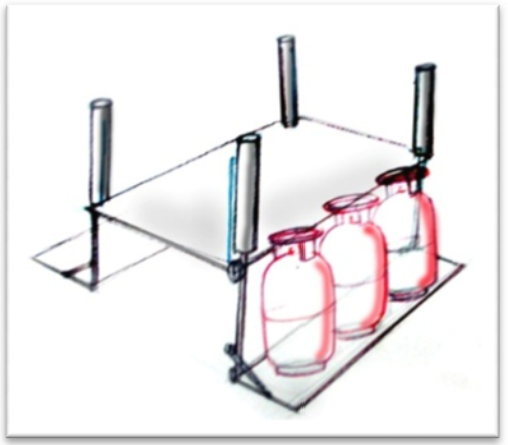
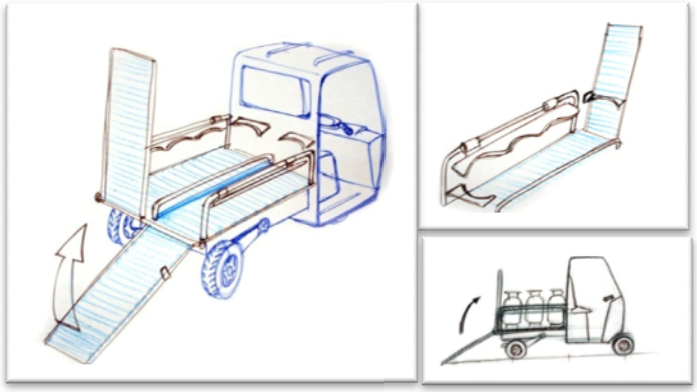
The following ideas consist of loading and unloading aids and carriage modifications required for gas cylinder delivery purpose. Each of t:he idea was judged in two categories –

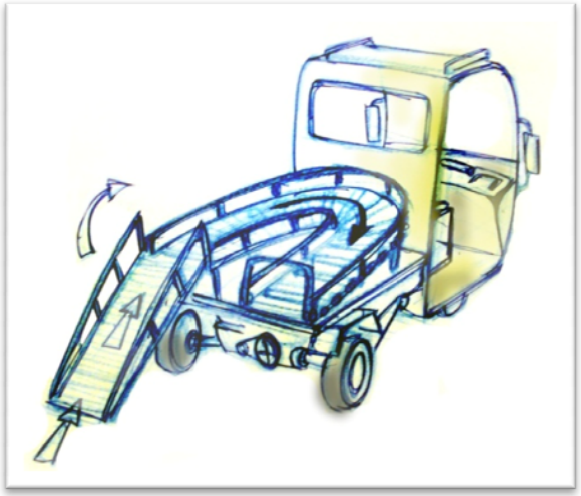
1) Affordability: as the customer of the vehicle has a daily income of Rs. 500; it is very important to keep initial cost, running cost and maintenance cost in mind.
2) Effectiveness: this comprises of the ability of the aid to reduce the physical stress on the user; and the other mentioned issue in design brief like accessibility, safety, security.

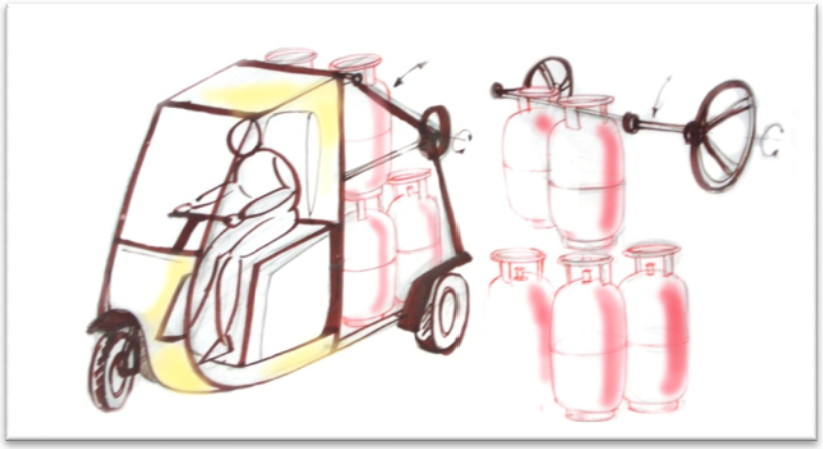
The points are given on 1 to 10 scales, 10 being most suitable. For an idea to be a developed as a concept the perquisite was that it should score high in each of the both categories

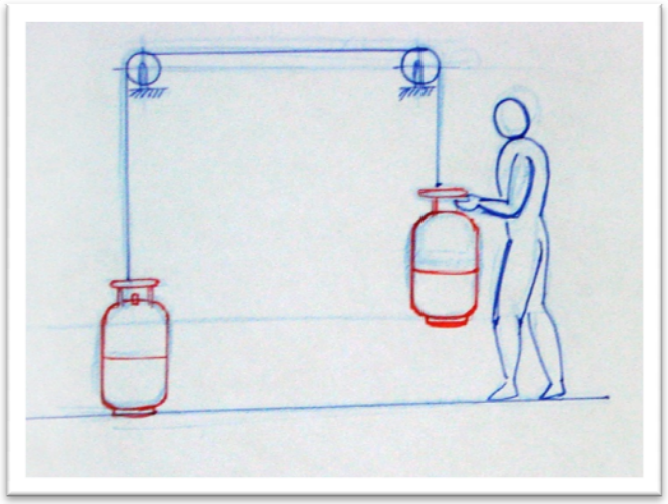
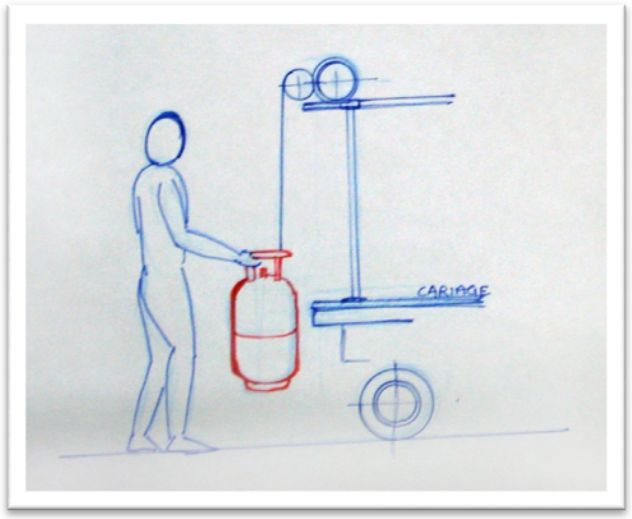
Idea no.	Idea	Description	Affordability	Effectiveness
1		As the weight of the cylinder is only distributed on both shoulders, this idea of transporting cylinder may turn out better than the existing routine in reducing localized physical stress. But, the load of 30 Kg is beyond the results of studies about physical capacity of human beings. Not directly linked with brief.	5	2

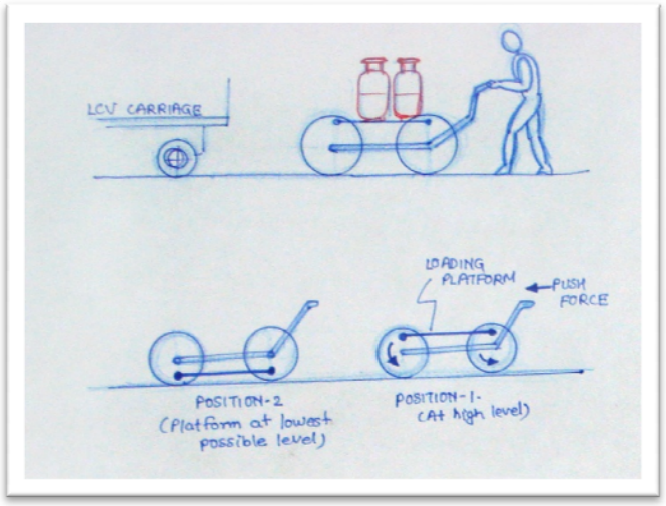
Idea no.	Idea	Description	Affordability	Effectiveness
2		Stacking cylinder – on levels, with a guiding mechanism while lifting and lowering the cylinder from top level. The top level cylinder will be hard to access by a person, especially while pushing it up.	3	3
3		A removable trolley – which can be mounted on carriage and removed with cylinder. The efforts required to load and unload the carriage in which all these trolleys will be placed will be manual. Even the hardware increases.	4	3

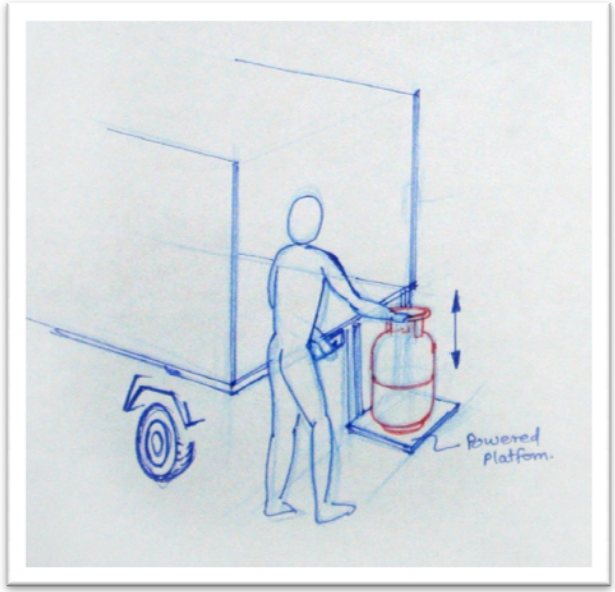
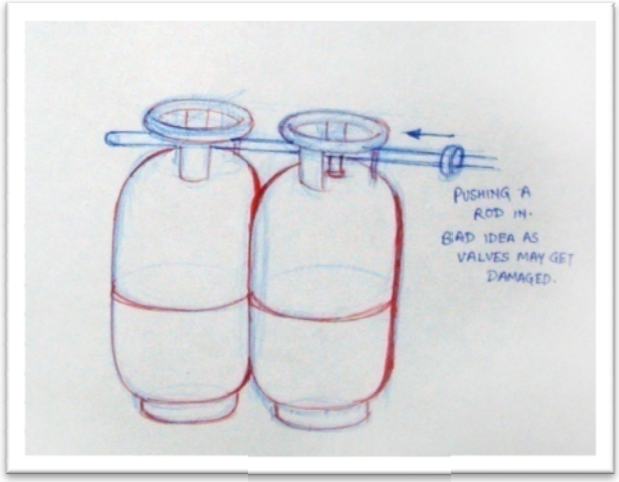
Idea no.	Idea	Description	Affordability	Effectiveness
4		Pneumatic / Hydraulic lifting aids • High cost of actuators • Additional requirement of compressor driven by engine and air tank • Maintenance issues • High running cost	1	5
5		A ramp integrated with carriage and rollers for easy sliding of the cylinders.	5	5

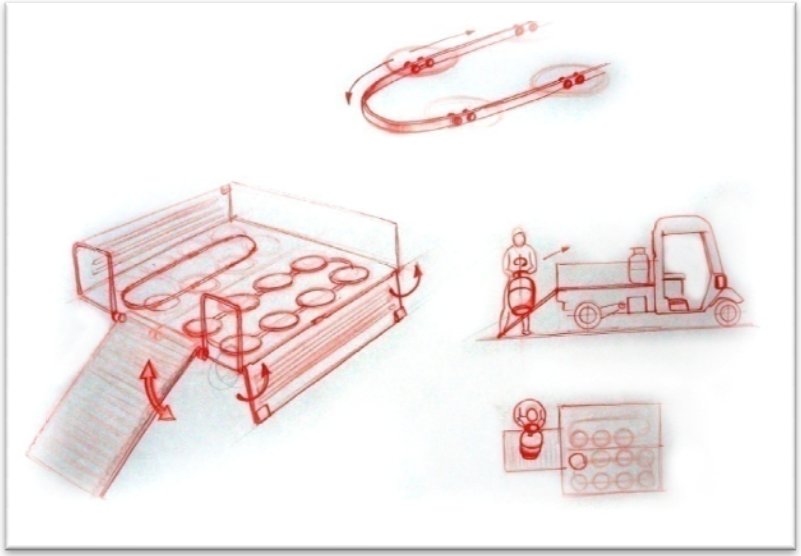
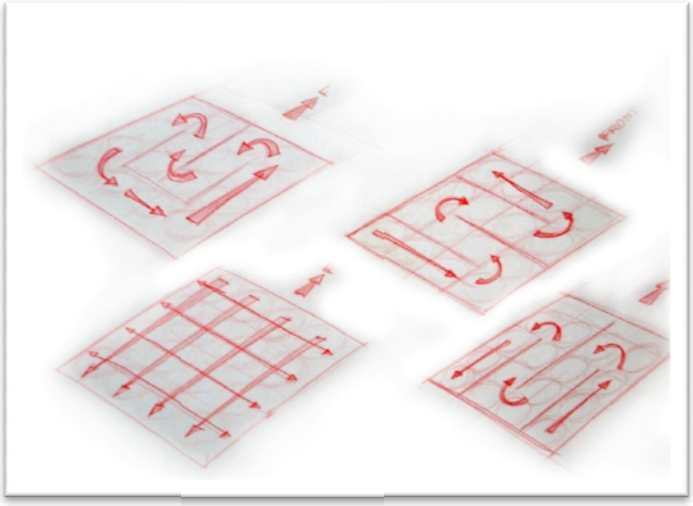
Idea no.	Idea	Description	Affordability	Effectiveness
6	  	Spiral – Loading cylinder filled from one end and unloading empty cylinders from other end The geometry itself increases the loading height of the cylinder.	5	2

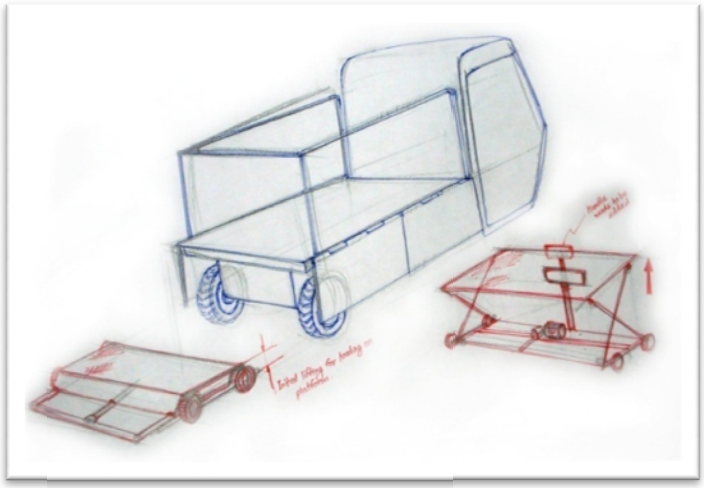
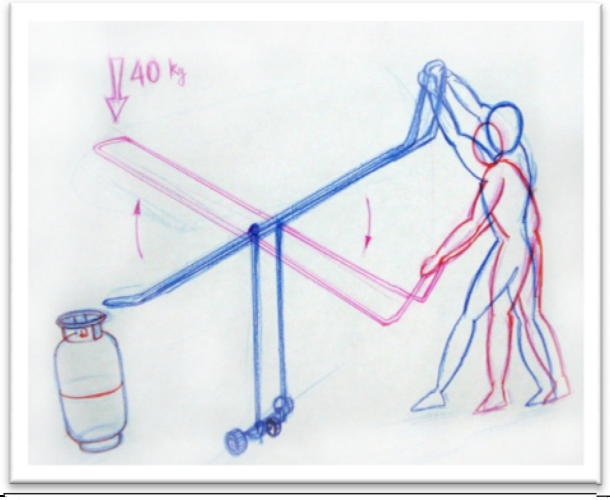
Idea no.	Idea	Description	Affordability	Effectiveness
7		Electric assistance: Overhead motor with reduction gear and ropes with hook. Electricity source: Vehicle battery and/or plug point. Affordability and maintainability are main concerns. Running cost will also be high	2	5
8		Swinging arm to load and unload cylinders; operated by a manually rotatable wheel. Compared with the involved load and the load that can be managed safely by a person, a reduction gear box will be required to increase the applied torque. But that will directly mean more no. of rotations of wheel to lift the load and thus more fatigue.	5	2

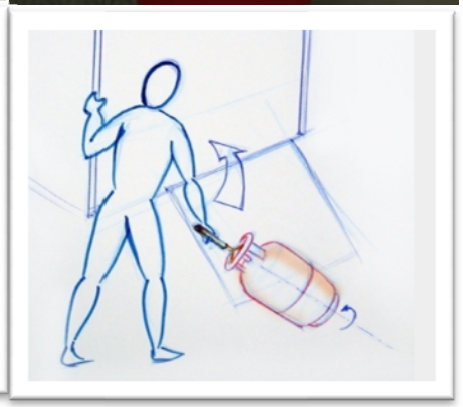
Idea no.	Idea	Description	Affordability	Effectiveness
9		Counterbalance – using dead weight or a cylinder While using counterbalance for lifting loads the height of the counterbalance will come down by same amount. To use counterbalance for loading it has to be placed it higher height to start with and thus it will be no different than the actual scenario.	7	1
10		Storing energy while unloading cylinder; so that it can be used while loading cylinders Unloading activity with LCV is generally for empty cylinders which weigh half of that of filled cylinders. Considering that even the energy of unloading empty cylinders cannot be stored completely with losses in system; the option does not seem feasible.	2	2

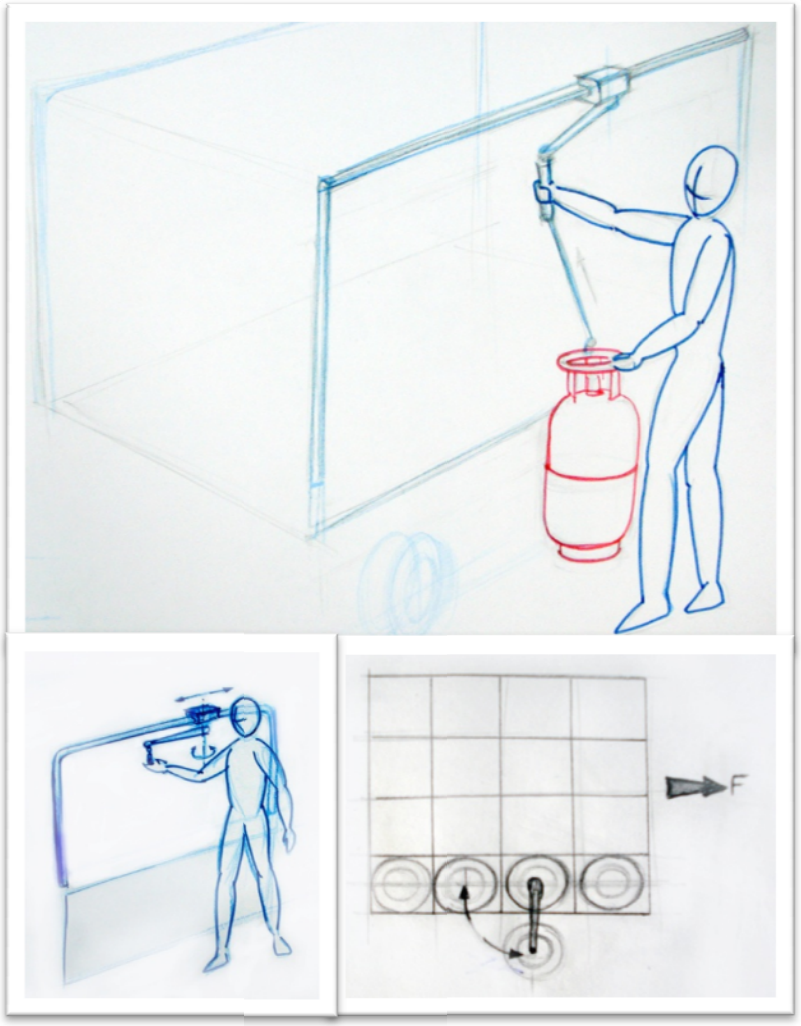
Idea no.	Idea	Description	Affordability	Effectiveness
11		A cart with a moving platform There is space constraint in godown area; since such aids which will require a free space to operate will be hard to fit in. The other factor is, it will be time consuming to load cylinders one by one with such aid; and handling a row of four cylinders at a time will not be possible because of the increased forces at the handle.	7	1
12		Chain pulley with a platform Structural and interaction issues must be solved before taking this idea ahead. Considering a safe force of 8kg which can be applied by a person; a reduction of 1:20 will be required. That does mean that a person has to pull a chain 20 times to increase the level of platform to 1m.	6	4

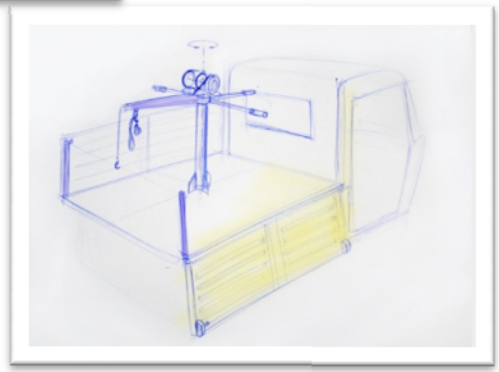
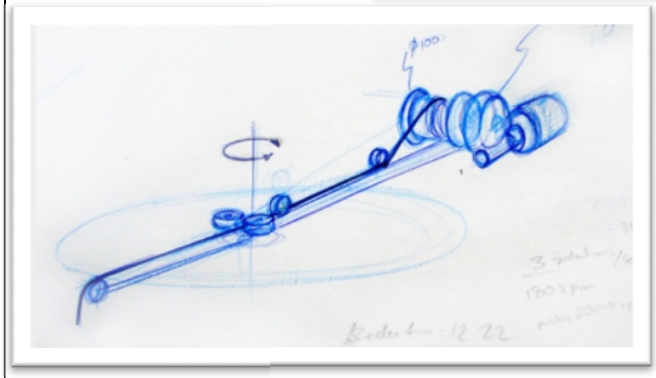
Idea no.	Idea	Description	Affordability	Effectiveness
13		Single Electric assisted platform for single cylinder It will be a time consuming activity to load cylinders one by one by putting them on platform. At the same time it will be uneconomical activity as it takes power from battery to operate. A fixed position platform will not be a good option, and making it movable means adding to the complexities of structure.	2	3
14		Inserting a rod through a row of cylinders so that they can be handled as one unit This option was not at all considered as safety of cylinder valves is a prime concern.	6	1

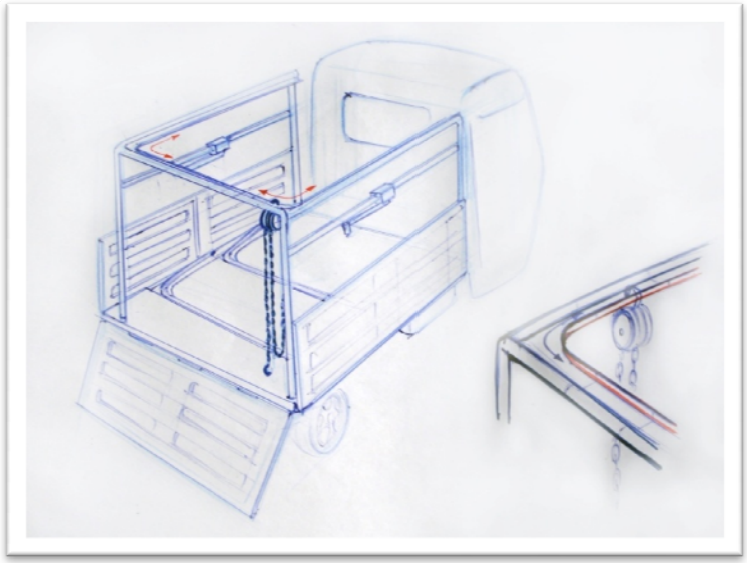
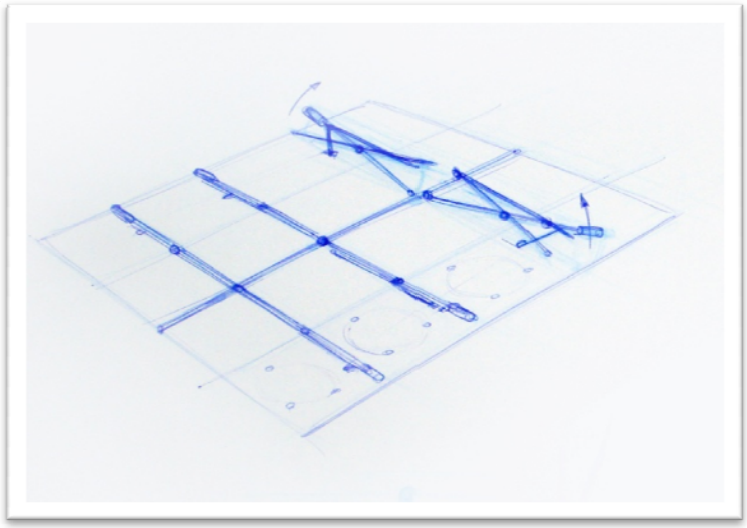
Idea no.	Idea	Description	Affordability	Effectiveness
15		Carriage with movable plates on rollers and guides The idea makes the complete structure complex, and as there are moving parts involved the problems like alignment, maintenance, etc will also play a part. The inclined ramp idea needs a validation that it reduces the efforts of loading and unloading cylinders.	2	3
16		Explorations of pattern by which cylinders can be accessed without unnecessary loading and unloading.		

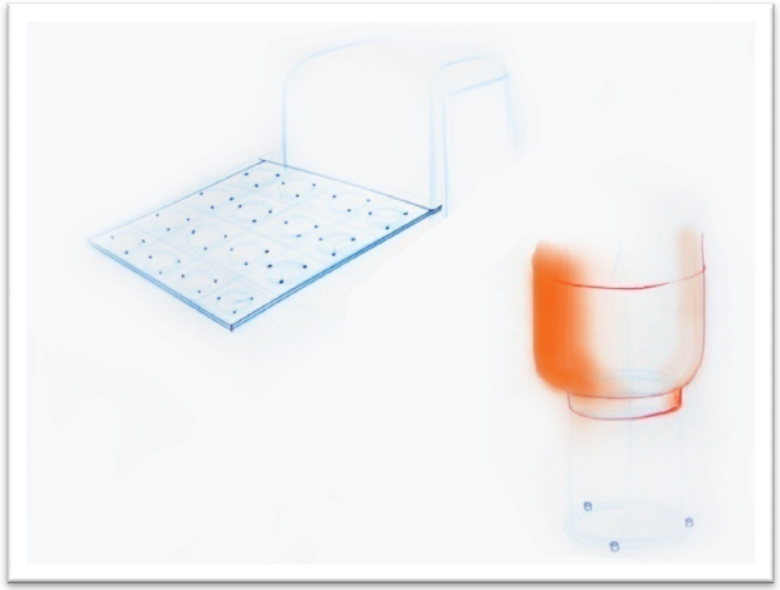
Idea no.	Idea	Description	Affordability	Effectiveness
17		A stand alone platform at godown place There are two major points against this idea 1) Space constraint at godown 2) Investment required by gas agency Apart from that there are other issues like, the platform will be only useful in godown but on site loading and unloading will be left unattained. And also there will be requirement of power source for platform. Such platform should also be movable; considering the godown scenario.	1	2
18		A leverage for handling one cylinder The leverage of 1:5 will be required to lift a 40 kg commercial cylinder with a safe applicable force of 8 kg. This means the aid will require a space to operate which is very scarce in godown scenario. And handling cylinders with such aid might take more time.	6	2

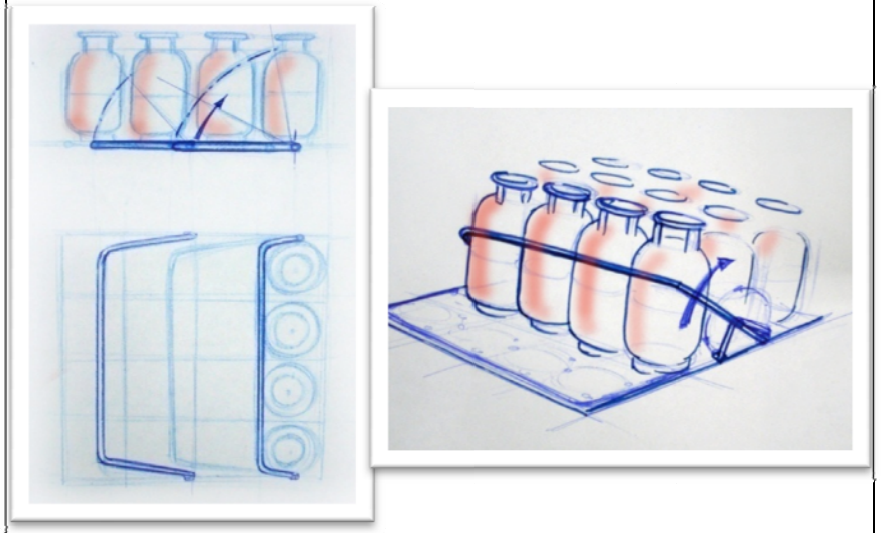
Idea no.	Idea	Description	Affordability	Effectiveness
19		Power take off (PTO) shaft from engine • Requires modification in standard engine ; Cost will increase It will involve additional gear box and linkages • High running cost	1	3
20	   	Aid for handling a cylinder. A handle which can be attached easily and removed with one's will; can help in handling a cylinder in better way. It may be also possible to swing the cylinder into the carriage without actually lifting it in air, reducing the physiological stress.	7	6

Idea no.	Idea	Description	Affordability	Effectiveness
21		A swinging arm with an elastic material and adjustable positions A swinging arm mounted on the frame of the carriage with an elastic material inside to assist the unloading of the cylinders which are at the periphery of the carriage.	5	4

Idea no.	Idea	Description	Affordability	Effectiveness
22	  	Electrical assistance – An overhead crane A jib crane mounted at the center of the carriage. Unit will consist of an electric motor running on vehicle battery and a reduction gears coupled with pulleys. The system does not fit into the scenario on affordability maintenance issues.	2	6

Idea no.	Idea	Description	Affordability	Effectiveness
23		Chain pulley system Coupled with swinging arm	6	6
24		Pantograph mechanism in vehicle carriage for holding cylinders in their position in transport. Drawback – complex linkages	4	2

Idea no.	Idea	Description	Affordability	Effectiveness
25		Dowel pins to keep the cylinders in their position Drawback – according to Gas cylinder Rules 2004, there should not be any projections inside the vehicle.	7	1
26		Instead of dowel pins spherical projections Drawback – may not be effective	7	1

Idea no.	Idea	Description	Affordability	Effectiveness
27		Pivoted bars which rests on the carriage floor and can be locked in position.	4	5
28		Trolley to carry one cylinder – 1	7	4

Idea no.	Idea	Description	Affordability	Effectiveness
29		Trolley to carry one cylinder – 2	7	5
30		Trolley to carry one cylinder – 3	7	6

In ideation it was becoming clear that trolley will require a same attention as that of the carriage. The trolley was left out from the scope of the project keeping in mind the formulated design brief and the time constraint.

Concepts

Concepts

Concept no.1 – A ramp and rollers

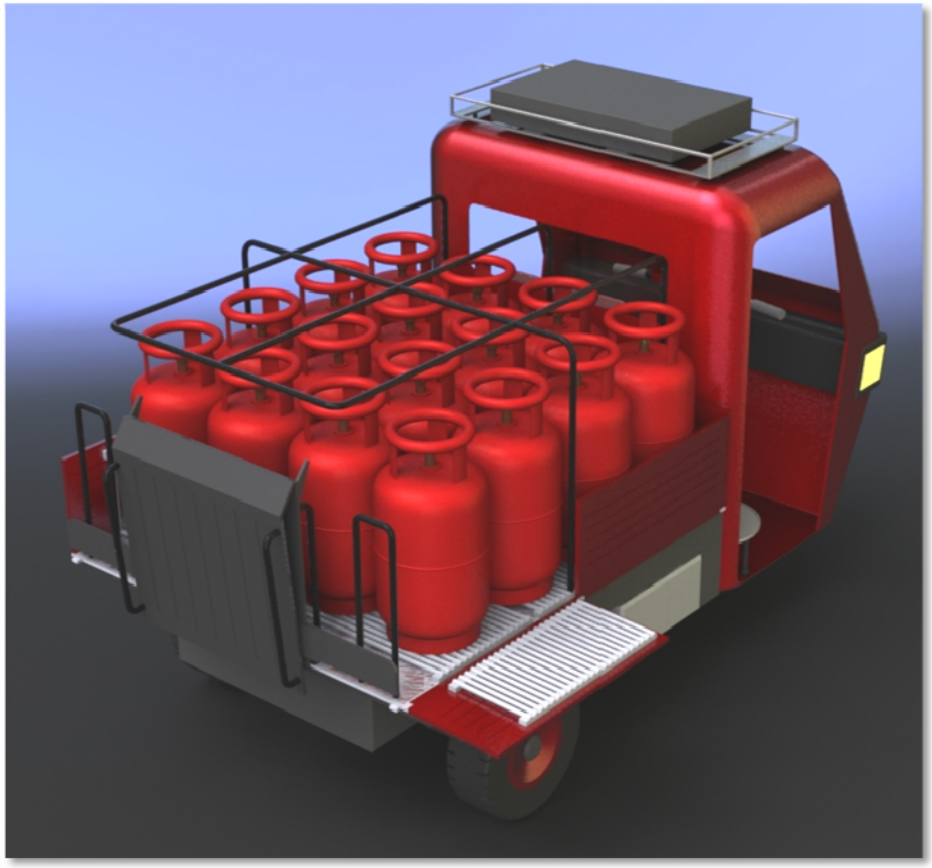


Fig no. 2 (a) Concept 1

It was found that by the rated capacity of the vehicle only 16 domestic cylinders can be loaded at a time. This meant that the stacking of cylinders in carriage is not required to carry more cylinders.

Fig no. 2(b) Concept 1

Fig no. 2(c) Concept 1

Image no. 11; Testing of ramp

Unique features of concept:

- Rollers on carriage floor to slide the cylinders when they are put on carriage of a vehicle.
- A foldable ramp with landing space; for loading and unloading of cylinders
- Side flaps broken into half, with hinges permitting half open (90 degree) or full open condition.

The whole concept relied on the assumption that the ramp will reduce the efforts of loading and unloading a cylinder. This assumption needed a validation which was done with a 1:1 model of a ramp as shown in image no.5

Observations/experience:

- Efforts required increases as cylinder needs to be stopped and held in that position while repositioning arms.
- Time required to load one cylinder (upto height 0.75 m) is around 14 sec

Short comings of concept:

Loading cylinder with ramp is a stressful activity as time taken to handle the load in considerable as compared to the existing free swinging method.

Concept no.2 – Electrical assistance – Jib crane

Features

- Electric assistance
- Jib crane mounted centrally to access it from three open sides
- A quick clamping and unclamping hook and a hand control unit

Short comings:

- The jib crane; mounted at the center of the carriage to facilitate loading and unloading of cylinder from three sides, will require a strong structural integrity. Also the operation will directly affect vehicles battery life.
- The system turns out to be costly as the cost of the motor, found after initial search , was about Rs. 8000/-

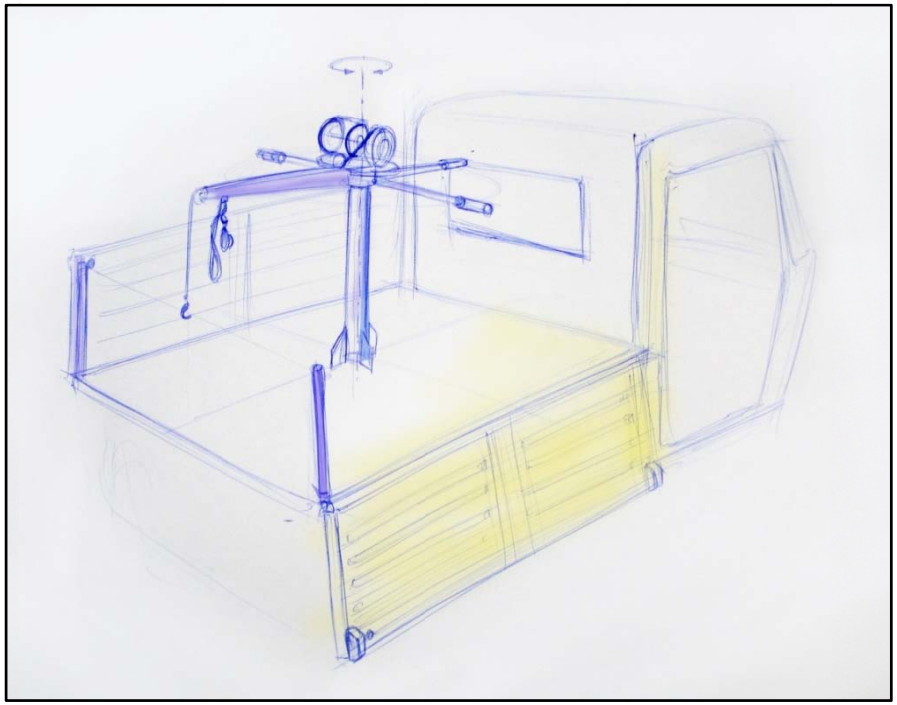


Fig no. 3, Concept 2

Concept no.3 – Combination of ramp, chain pulley, swinging arm and pivoted arms on carriage floor for securing cylinders

Features:

- Loading and unloading activities can be assisted with chain pulley which can be pulled to all three sides, and in combination with swinging arm.
- The pivoted arms on carriage floor will be easy solution for securing cylinders in position while in transit.
- With a reduction of 1:5 in chain pulley a weight of 40 kg of commercial cylinder can be lifted to height of 0.6 m (carriage height of LCV from ground) by pulling just 3 m of chain.

Short comings:

- Time required for handling one cylinder will be more as compared with the current practices followed for the same activities.
- Controlled and guided lifting of cylinders is required

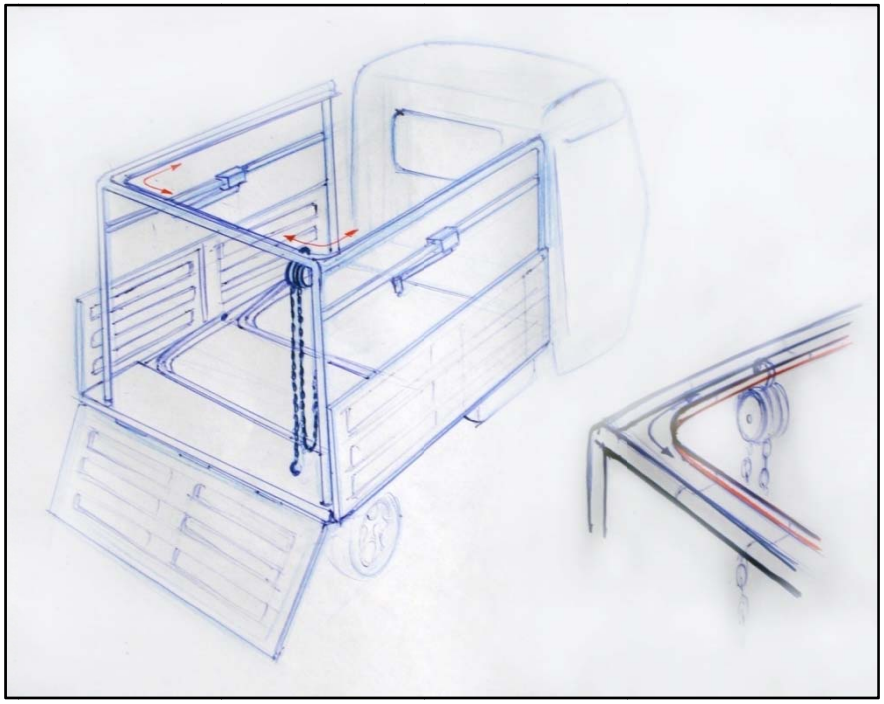


Fig no. 4, Concept 3

Concept no.4 – The spider

Features

- Provides a handle to the cylinder
- It is easy to latch and its removal has to be intentional
- Rubber gaskets on bottom end of spider for avoiding damage to the valve
- The action of loading is same as that of current practice of swinging, only difference being the cylinder is not required to be thrown in air.

Short comings:

- Positive gripping is required to avoid any slippage and possible accidents
- The insertion should be quick

Fig no. 5, Concept 4 – the spider

Selected concept

Final concept:

The solution is combination of the above mentioned ideas and concepts. The final concept as shown below will be an integration of Concept 3 and Concept 4.

Further directions:

- The interaction of user while using chain pulley for loading and unloading a cylinder needs to be tested.
- The proposed improvement in handling a cylinder with the spider also needs to be validated.

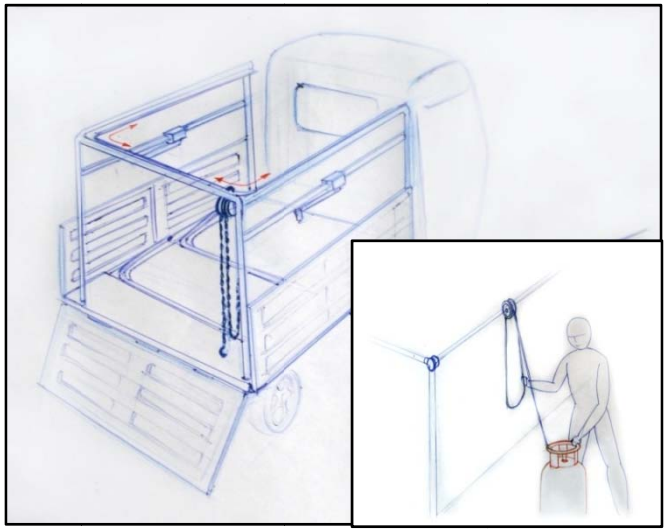


Fig no. 6, Handling cylinder with chain pulley

Fig no. 7, The spider – study model

Concept development

Concept development

Chain pulley mounted on the framework of LCV carriage:

The concept of chain and pulley mounted on the LCV frame was rejected after talking with LPG gas cylinder delivery persons. The reasons given were

1) They need a fast solution – as the number of cylinders handled by one person per day amounts to about 80 to 90
2) The dangling chains were a point of concern
3) The LCV framework needs to be strengthened – additional cost

Though the chain pulley and the lifting attachment was made available to the LPG gas cylinder delivery persons, their reluctance to change the mind-set made it impossible to try out the concept in actual scenario.

The Spider / RISTER

Spider was renamed as ‘RISTER’ before taking it to the inteded users. A working mechanism of Rister was developed. The mechanism *(image no. 6)* was taken to the LPG gas cylinder delivery persons and their opinion and feedback was used for further refinement of the RISTER concept.

The working of the Spider/RISTER mechanism is shown in the illustraion of *fig. no. 8.* And the construction details of Rister are revealed in *fig. no. 9* on next page.

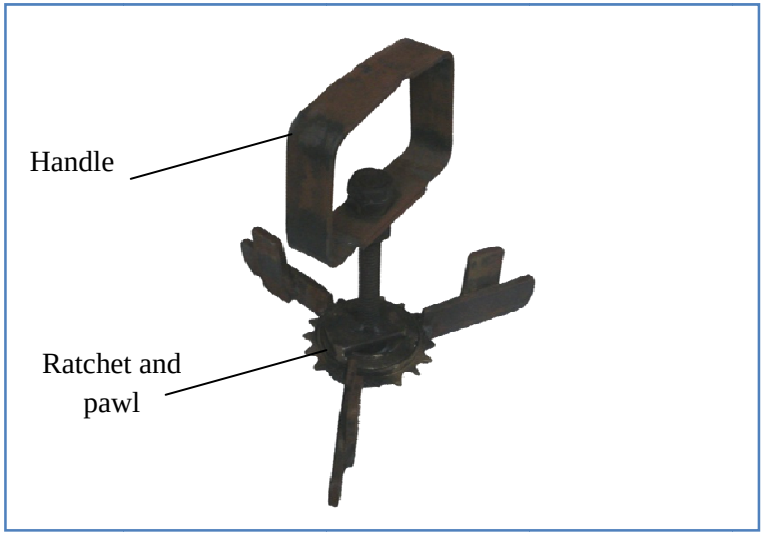


Image no. 12 – The RISTER mechanism

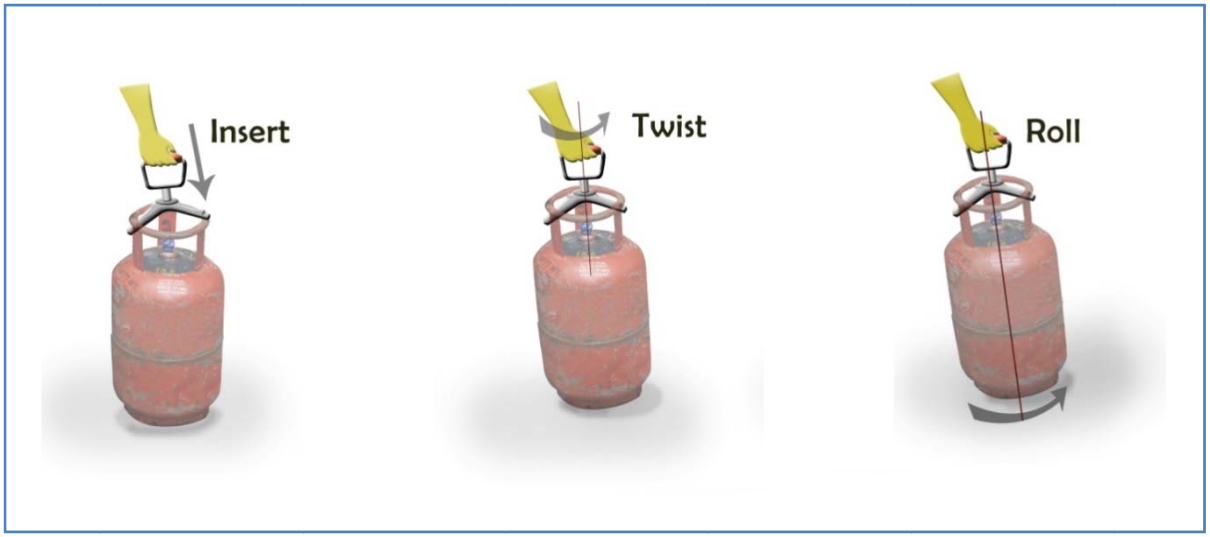


Fig no. 8, The spider/ Rister working

Fig no. 9 Details of RISTER

The feedbak from the trial of the RISTER mechanism:

1) The insertion and removal of the RISTER should be quick – as the current practices of lifting, draging, twisting, kicking cylinder are much quick than RISTER
2) They do not want to use the RISTER as the number of cylinders which they handle is around 80 to 90 cylinders per person. Spending time on such gadget is a “waste of time” for them.

Though the RISTER was tried and acknoledged by the LPG gas cylinder persons as a “fancy” gadget, they showed a little interest in using such product in their daily activity. The idea of reducing the fatigue with the use of such gadgets was totally new to them..

On the other hand RISTER showed:

1) It can perform the promised activity of transfering cylinder on ground
2) It can reduce the fatigue in long run as one may not bend to insert RISTER on to the cylinder ring and also one may not lift or drag the cylinder. The roll initiated by simple twist of the wrist works better than the existing methods.
3) The ratchet and pawl mechanism inside the RISTER performs its intended fuction of controlling the roll of the cylinder.

Conclusion

Conclusion

The project is just a small step towards solving everyday problems of persons involved in gas cylinder delivery. The gas cylinder delivery system which has evolved over time is truly remarkable which serves 1047 lakh customers and lives with a physiological stress per gas cylinder delivery.

As per the projection , the demand for LPG cylinders will grow for next six years. While more than 53% of population already using LPG gas cylinder, the aids for gas cylinder delivery person will be very much helpful for serving the customers efficiently and for a longer time.

The concept tried out in this project – Rister, will need further study for prooving the usefullness of such gadget in reducing the fatigue. But more than that the reluctance of the minds to change, will be the hardest challenge which will be faced by such new products. The problem delt here is a system level problem. The awairness of correct practicess and training as well as alocation of budget for buying appropriate gadgets for such activities will be the helping hand in this direction.

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