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Automated Vehicle Mounted Industrial Vacuum Cleaner with Suction Pump and Forklift

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Abstract:- This project has been made with an objective of creating a dual facility for manufacturing units by providing "Industrial Forklift" & "Industrial Vacuum Cleaner with Suction pump" on a singular vehicle. The industrial forklift would be operated from the front facet of the vehicle while the industrial vacuum cleaner would be mounted at the rear facet of the same vehicle. The vehicle shall be Li-ion battery driven with driver cabinet & control panels. This sleek vehicle mounted facility is being designed & devised to attain the purpose of easy maneuvering and reaching at the site of manufacturing plant where there has been oil spillage due to plant breakdown and heavy equipment requires to be shifted before cleaning the spillage, so as to avoid industrial mishap/accident. This vehicle mounted dual facility shall also prove a worth for big industrial manufacturing units as it shall heavily curtail cost of buying two different facilities i.e., forklift & industrial vacuum cleaner separately. This has been a "never before" endeavor and innovation. Hence the project work.

Keywords:- *Designed and Devised, Industrial Vacuum Cleaner, Suction Pump, Forklift, Dual Facility.*

I. INTRODUCTION

This project endeavors to devise a "never before twin utility" for small, medium and heavy manufacturing units where there is shop floor plant activity. It has been discovered that manufacturing units "struggle" to optimize the available floor area and designate a specific minimal circulation area for access and movement. However, during the plant breakdowns, there also exist eventualities of oil/fluid spillage. The oil and fluid spillage requires not only to be cleaned and cleared before imitating the maintenance work but it also requires shifting of the heavy equipment or bulk near the plant at the same time. The conventional, bulkier, big giant size of forklift and Industrial vacuum cleaners, suction pumps available as singular utilities and manufactured by big brands like Hyundai, Bosch and Tesla etc. are not easily maneuverable in such like eventualities. A sleeker, cost effective easily maneuverable option becomes need of the hour which may reach the site of breakdown in minimal time loss and shall address both the requirements—shifting of bulkier and heavy equipment as well as clear cleaning the spillage. Hence our project study.

II. SURVEY AND RESEARCH OF TECHNOLOGIES

A sustained survey of past research papers has been carried out to understand the very genesis of both the utilities of Industrial significance separately. As forklifts emerged as a separate innovation, the industrial vacuum cleaners also attained their hallmark as separate entities. The survey was carried out through various research papers for both the utilities separately.

III. REQUIREMENTS AND ANALYSIS

A. Problem Definition

In manufacturing units, at shop floor levels, the incidence of oil spillage and mechanical breakdown of heavy industrial machinery are frequent and it has been seen that such like incidences also lead to mishaps. The space constraint at the site of spillage is also a challenge. The heavy equipment requires to be removed and shifted before cleaning the spillage in order to undertake repairs & maintenance of plant. This is a task herculean in the absence of space and manoeuvring giant-sized heavy forklift vehicle along with a floor cleaning vehicle at the same time could pose a big challenge.

To address the above, a SLEEK and COMPACT "AUTOMATED VEHICLE" mounted industrial vacuum cleaner with suction pump and fork lift has been devised & designed. Both the utilities shall be mounted on a singular chassis (meaning 1.60m x 1.30m) with driver cabin and controls.

The automated vehicle shall address both the challenges at site of mishap in the industrial unit. It shall not only lift and shift the needed heavy materials but also shall clean the spillage with vacuumized suction and mops.

The innovation shall also render a big relief to the manufacturing units/ owners as both the utilities shall cost well within 40% of the huge capital outflow at 40-60 lacs for the giant vehicles manufactured by Hyundai, Tesla and Bosch.

To gross up, the innovation shall be user friendly, easily maneuverable in space constraints, shall be low on maintenance and running cost, as the concept is evolved on mechanical concept of pulley and powered by renewable LI battery, whereas the conventional giant prototypes are run on fossil fuel and are devised and designed on concept of hydraulics.

B. Components:

➢ *The Mainframe and Chassis*

- The chassis shall be sleek in structure and size.
- Shall be fabricated & manufactured by using heavy weight sustaining structural sections preferably ISMCs [Indian Standard Medium Weight Channels] or CRCW sections [Cold Rolled Continuous Structural Weld Structural Tubular Sections]
- These ISMCs [channels]/ CRCW sections shall be cut/notched/spliced and braze welded to create the cross members and load bearing base framework.
- The cross-sections of the structural steel shall be consistent with regard to the load being sustained by the trailer vehicle.
- The preferable section size of the tubular sections shall be 50mm x 50mm x 3.18mm
- The achievable size of trailer being 1600mm x 1300mm

➢ *Chassis Fitments & Parts*

- The chassis shall be provided with twin-leaf springs [size 35mm x 12mm] on either side of the cross section along with gas filled shocker pairs.
- Total number of leaf springs – 4 nos.
- Total number of shock absorbers – 4 nos.
- Driver seat, Steering and steering system, control panel, dashboard.
- Wheels Pneumatic 16'' -- 4 nos.
- Drum Braking System -- 4 nos.

➢ *Forklift*

- Fork arms
- Forklift Hoist—as per drawings and specifications
- Sheeves—pair, pulleys, pulley shaft, multi-strand steel wire rope
- DC motor for hoist – 3.5 H. P/2.5 Kw

➢ *Suction Pump*

- Suction pump 0.75 Kw, 1 H.P

➢ *Vacuum Floor Cleaner*

- Vacuum Floor Cleaner (Heavy Duty) – as per drawings and specifications

➢ *Drive Motor*

- Drive Motor – 40 Kw, 150 Nm, 4000rpm
- LI-ion battery (provisional) – 50 Kw, 240V
- Wiring/Harness and Electrical components/fitments

IV. DESIGN AND ANALYSIS

The chassis of the vehicle shall be manufactured and fabricated using heavy weight sustaining structural sections preferably ISMC (Indian Standards Medium Weight Channels) or CRCWs (Cold Rolled Continuous Weld Structural Tubular Sections). The preferable section size of tubular sections being considered for the chassis being 50mm x 50mm x 3.18 mm. The achievable size of the trailer being 1.30m wide x 1.60m long.

A. Vehicle Specification:

S. NO		
1.	Vehicle Length	1600mm
2.	Vehicle Width	1300mm
3.	Tubular Pipe Cross Section	50mm x 50mm x 3.18mm
4.	Roll Cage Length	20000mm (Criss Cross)
5.	Roll Cage Weight	22kg

The forklift shall be mounted on the front facet of the trailer. The fork load arms shall be attached to the carriage; the size of the arms being 750 mm paired together as per the load palate to be handled. The forklift load brackets shall be bolted as well as braze welded to the carriage in order to prevent the load from shifting backwards when the carriage is lifted to the full height. The top height of the load hoist being 2.90 m. The forklift shall be two stages lift one being an intermittent, the other being the top or the required stacking height. Power source: DC motor operated type, shall be powered with Li-ion battery. The weight handling tolerance aimed to be achieved is up to 600-650 Kgs.

The industrial vacuum cleaner shall be mounted at the rear facet of the trailer vehicle (1.30mtrs facet side). It shall have a side channel blower motor suitable for maintenance free heavy duty continuous works. Shall have various primary and 14 HEPA filters which ensure the exhaust air free from the dust particles. It shall have a suction pump enabling for bulk collection of oil and swarf containing cutting oil and emulsion along with metal scraps. It is aimed to achieve and evolve suction cum blow type industrial vacuum cleaner.

B. Numerical Analysis:

Fork has a side plate at its base. As there are two forks of volume = 2160 cm3. ----------(4.1)
So, total volume of base = 4320 cm3. ----------(4.2)
V= 2 (L×B×T) = 2 (90×10×1.2) = 2160 cm3 ----------(4.3)

The upper body of the forklift has total 4 plates welded together.
Front plate = (L×H×T) = (80×35×1.2) = 3360 cm3 ----------(4.4)
Upper plate = (50×25×1.2) = 1500 cm3 ----------(4.5)
2 side plates= 2 (35×25×1.2) = 2100 cm3 ----------(4.6)

Total volume of body above the fork = 3360＋1500＋2100 = 6960cm3.

The total volume of the forklift "Long Hollow Handle" = P/4 (do2 -di2) ×L =P/4(32-2.32) ×90 = 260 cm2
Gripping Handle =70cm3
Total Volume = 4320+6960+260 =11540cm3

Here, the power of the batteries is being determined. Assuming the system is 100% efficient, (i.e., resistive losses in cables are negligible, or there is no internal resistance from battery)

Power (Watts) = I (Amps) * V(Voltage) = 21A * 120V = 2520Watts. ----------(4.7)

So, Horse Power of DC Motor = 2520W/746 = 3.32 HP ----------(4.8)

Force Calculation = **mass (kg) x acceleration due to gravity (m/s2)**

= 600 kg x 9.8 m/s2
= 5880 N ----------(4.9)

Hence, **Pressure/Stress** on Fork Arms = Force per unit area = **Force(N)/Area(cm2)** = 5880 N/ 1800 cm2 = 3.26 Pa. ----------(4.10)

Now to find out the torque, the maximum torque being calculated
when forklift starts is T = 150 N-m.

In order to arrive a demand speed of 7 − 10 km/h, ----------(4.11)
the wheel speed is calculated as: n = 90-110 rev/min ----------(4.12)

The testing was done for evaluating the load that can be carried by the forklift. The resultant analysis shows that the vehicle can carry up to 600 kgs and it can run up to 9-10 hrs. with a fully charged Li-ion battery.

V. VIABILITY AND FEASABILITY

The trailer mounted dual facility so designed and conceptualized require a further scrutiny w.r.t it's adaptability & acceptance, in our local manufacturing sectors, logistics community, and modern warehouse management.

In the ever fast changing sophisticated world of today, there are multitude of challenges, which are emerging in the manufacturing, warehousing logistics industry which require to be addressed with an innovative aptitude evolving newer, more economical and suitable methodology.

The dual facility evolved being an outcome of the same inquisitiveness, has been analyzed from the following viability aspects: -

- Technical
- Financial
- User (Maneuverability, Accessibility & Ease of Operation)
- Social
- Regulatory

VI. RESULTS AND ANALYSIS

The conceptualized and designed dual facility, has reasonably countered the conventional heavy weight, big names like Hyundai, Bosch, Siemens, Voltas, Godrej, Clark etc. in manufacturing warehousing and logistics management w.r.t shifting and lifting of weights at shop floors as also cleaning of the fluids and spillage.

The various **parameters of viability** have been successfully addressed and desired objectives attained with remarkably a great future of the product being visioned in local, indigenous and international markets when the product (the dual facility) is thrust production.

The **Automated Vehicle Mounted Industrial Vacuum Cleaner with Suction Pump and Forklift as conceptualized designed and devised** are an outcome of a new technological innovation which has enabled in breaking the glass of many old adage and stereotypes that:

- The industrial forklifts are a hydraulic and pneumatic based concept.
- The industrial vacuum cleaners with suction pump and forklifts are two different vehicle mounted facilities.
- These two facilities can only be energized on fossil fuels for greater productivity.
- These separate facilities come with huge capital, maintenance and running costs.
- That these two separate facilities cannot be clubbed together on a smarter, sleeker, simpler mechanized, singular vehicle.
- These facilities would need a minimum track size of 3.5 to 4.0 m for their bulkier and voluminous size.
- Accidents and breakdowns are incremental due to technological bottlenecks and stereotypes.
- The carbon footprints, pollution and environmental regulatory may not be attainable in view of the conventional age-old technology of hydraulics and pneumatics.

➢ *Whereas, our concept and designed dual facility has negated all the above stereotypes by attaining the various viability objectives:*

- The dual facility has been designed and devised on 1.60 m x 1.30 m singular chassis accommodating forklift operations from the front and industrial vacuum cleaner with suction pump from the rear facet (1.30 m width).
- It is conceptualized on principles of mechanical pulley and DC motor.
- The dual facility being energized with Li-ion Battery, with backup capacity up to 10 working hours. This also renders an alternative source to the use of fossil fuel.
- It attracts only a fraction of the huge capital costs of owning a singular facility by the ownership (both facilities taken together) at less to INR 5 lacs as compared to big giants at INR 20 – 75 lacs (like Hyundai, Siemens, Bosch etc., refer 6.2 case study).
- The running cost of the dual facility being as low as INR 350/- per hour as compared to the huge running cost of INR 900/- to INR 1290/- per hour of each giant-sized facility.
- The annual maintenance cost is highly motivating as our dual facility attracts only an annual cost of INR 7000/- to 10000/- per annum as compared to the annual running cost of giant-sized facilities at INR 57000/- to 64000/- (each unit of both facilities taken together).

- Our devised and designed sleeker dual facility is a very smart solution w.r.t user perspective and maneuverability as it only requires a track size of 1.8m to 2.0m which is remarkably half the size required for maneuvering a conventional facility, requiring a track of 3.5 to 4.0m.
- The design within itself is suggestive of being user friendly with comparably no to negligible breakdowns, hence eliminating the chances of at site mishaps/ accidents.

➢ *To sum up the resultant extensive research has been an exhaustive analysis of our conceptualized, designed and devised dual facility which has substantiated and justified technological viability, financial viability, regulatory viability, user viability and social viability parameters.*

The "Running Cost Annexure" has been attached herewith:

➢ *Running Cost Annexure:*

The running cost of the dual facility has been worked out as under:

The energy of the battery (Watt hour) = Power (Watts) x Number of Hours

= 50,000 W x 10 hrs.

= 5,00,000 Wh

Therefore, In Ampere hrs. = 5,00,00 Wh / 240V = 2083 Ah -----(7.1)

Now energy (in Watt hr.) taken up by a 2083 Ah battery is 5,00,000 Wh or 500 KWh = 500 units of electricity

Also, as 1 Ah = 1000 mAh

Therefore, 2083 Ah = 2083 x 1000 mAh = 2083000 mAh battery ---------(7.2)

Now Cost of Charging @ INR 7.00/KWh = 500 KWh x INR 7.00/KWh= INR 3500/- ----------(7.4)

Operational Cost Per Hour is INR 3500 / 10 hrs.

This implies, **INR 350/- Per Hour (assuming 100% capacity utilization) ------- (7.5)**

VII. CONCLUSIONS

The research aimed at conceiving and further nurturing the concept and design of a (dual facility) namely "Automated Vehicle Mounted Industrial Vacuum Cleaner with Suction Pump and Forklift" and devising a **never before and must utility** for shop floor maintenance and operations at manufacturing units, warehousing and logistic hub's management.

The singular dual facility vehicle as designed and devised has turned out to be a new innovation which is smarter and sleeker, cost effective and space efficient, time saving, safe and eco-friendly mode of facility which has potential to replace the heavier and bulkier, uneconomical and unwieldy, huge giant size forklifts and industrial vacuum cleaners which attract huge capital costs, operational costs and are run on fossil fuels. These are presently being manufactured by big names like Hyundai, Bosch, Clarke, Siemens etc.

The dual facility vehicle has potential to attain the "scientific management" in the due course of plant breakdowns in due course of plant breakdowns and subsequent oil and fluid at shop floors at industrial and manufacturing units and/ or logistic hubs.

The dual facility single vehicle as devised and designed is a mechanical concept which comes as an adorable technology replacement to the conventional age old bulkier and costly mediums, breaking the stereotypes of pneumatic and hydraulic concept being applied so far.

The varied technological, financial, regulatory, user and social viability aspects have been scrutinized and explored exhaustively.

The various parameters and stakeholders, operators/drivers and even the owners and entrepreneurs have endorsed the dual facility vehicle with a rewarding note as "a game changer and a never before facility".

On a concluding note, the conceptualized, designed and devised dual facility namely "Automated Vehicle Mounted Industrial Vacuum Cleaner with Suction Pump and Forklift" visions a great future ahead in industry, and shall be **catalyst in attaining optimal outputs in terms of profits, productivity, time and space management and in turn saving huge capital costs while applying minimal inputs.**

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