

# Design and Fabrication of Automated Glass Facade Cleaning Machine

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**ABSTRACT:** There are vast number of tall structures with glass dividers in urban communities. Outside dividers of structures gives an alluring outer surface appearance, as well as builds their solidness. These dividers oblige consistent cleaning which constantly risky, costly and arduous work noticeable is all around. Cleaning is standard in our life. It includes numerous exercises in our everyday life. It is a diligent work occupation and a considerable measure of time is expended. Glass cleaning is additionally one part of support action. The clean glass will certainly give an agreeable domain to the workplace occupants. The two primary focuses that are focused in this undertaking are to conquer the risk of human inclusion in cleaning outer glass action and diminish high cost by the customary technique for cleaning outside glass. It gets to be important to conquer the confinement. The task plans to supplant or minimize human association in cleaning the glass window by supplanting it with a little cleaning robot for frameworks with a few abilities. The capacities are; compact, little size, lightweight, programmed operation and can clean all the corner of the outer glass windows.

**KEYWORDS :** Wall climbing robot, Façade cleaning, EVA foam Brush , Rolling outrigger.

## I. INTRODUCTION

Building facades, particularly tall urban buildings, are typically washed manually. A scaffolding structure is usually suspended from the top of the building to be washed. The scaffolding can be raised or lowered so that a person standing on the scaffolding can Wash the Windows and exterior surfaces of the building by hand. After a vertical section of the building is washed, the scaffolding is repositioned laterally so that the next adjacent vertical section of the building may be cleaned. This procedure may be repeated until the entire building has been washed. Cleaning Windows using scaffolding is extremely time-consuming. In an effort to reduce time and cost, therefore being more competitive in the industry, Window Washers tie a climbing rope to the roof anchors provided for the scaffolding and throw the rope over the side of the building. Then they attach a bosons chair to the rope and a climber's harness to themselves with repelling hardware. The man goes over the side of the building with his tools and Water/soap bucket and cleans 6-8 of horizontal glass Width per story. Then repels down to the next level and repeats until that drop is complete. Manual Washing of buildings has proven to be quite dangerous, especially With respect to tall skyscrapers. Typical Wind and air drafts surrounding a

Building can exert a significant aerodynamic force upon a scaffolding structure or Window cleaning labourer, causing them to swing out and away from the building, and placing persons standing on that scaffolding or suspended on a rope in peril. Injuries from manual Window Washing operations are common, and have caused insurance rates to soar. Typically, the cost of insuring a Window Washing operation can reach 40% of the labour costs. Furthermore, the

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manual washing of building exteriors is slow and labour-intensive. Effectively removing mineral deposits from building Windows has been a

Problem which has long plagued the industry. Normal Water supplies conventionally used for Wash Water contain some amount of dissolved solids, including calcium, magnesium, and sodium in the form of bicarbonates, carbon, chlorides, or sulphates. Regardless of the type or form of the dissolved solids, When a Water droplet is allowed to dry on a surface, the solids typically remain as deposits on the surface.

## II.SUMMERY

The present device addresses various of the above noted issues with conventional window washing methods and automated machinery for the same. It is an automated washing system for vertical surfaces of buildings comprising of frame assembly including a substantially planar base portion and a mast portion extending upwards from the base portion. A pair of rolling wheels are disposed on the opposing sides of the base portion and located adjacent the rear end thereof. A main brush is rotatably disposed between the opposing sides of the base portion. A shroud extends the length of the main brush and encloses a portion of the circumferential of the main brush opposite to the vertical surface of the building and an electric drive motor drives the main brush through a belt and pulley. Bumpers disposed on the shroud extend transversely toward the vertical surface of the building. The angle between the mast and the base is configured to hold the main brush against the vertical surface of the building when the mast is lifted vertically by a steel cable attached to the mast

The system and device are compact and lightweight. The size and weight make for quick and easy set-up, use and transport by two persons using a standard pick up truck.

## III.DETAILED DESCRIPTION OF THE CLEANING MODULE

The device generally comprises a metal, plastic, polymer or composite frame and a rotating brush. In this example, the frame is formed of a steel alloy. The metal frame comprises a plurality of tubular sections that are bolted, welded or fastened together via typical means to form the shape as shown.

Referring to the device more specifically, the automated window washing apparatus generally comprises a frame assembly, a main brush, an optional side brush and a shroud enclosing approximately half of the diameter of the main brush from end to end.

A plurality of rolling wheels are provided to the underside of the shroud or rear (brush end) of the frame. One or more castor wheels are provided to the underside of the frame adjacent to the front end thereof. These wheels allow the washing apparatus to be easily rolled along the ground by the user, for example, from the transport vehicle to the building to be washed, and back. The wheels allow the person to pull or push the device from the truck or trailer to the building to be cleaned, and reposition the device on the ground, if necessary. The wheels can remain attached during the cleaning operation, or they can be releasable with a quick pin if removability is desired. The wheels also act as landing gear for when the machine drops from the side of the building to the ground.

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Figure 2 cleaning unit during landing

A spray bar is disposed along an upper edge of the shroud and configured to supply cleaning solution to the main brush. The spray also includes an adjustable side nozzle for supplying cleaning solution to side brush.

A pair of bumper wheels are disposed one each adjacent to the longitudinal end of the shroud where they can contact the building surface during cleaning. Each bumper is longitudinally extendable away from shroud to create a widened track so that twisting of apparatus about a vertical axis is resisted. The longitudinal extension capability is provided by the bumper wheels being mounted to telescoping members. The bumper wheels can be formed of a foam material. The wheels can also be configured as foam balls to provide a soft contact surface so the building surface is not damaged. The telescoping bumper wheels or balls can be extended by the operator as needed in windy conditions. The wheels or balls can be maintained in the retracted position when it is not windy or during storage and transportation.

Frame assembly generally comprises a substantially planar base portion and a mast portion extending upwardly from the plane of the base. The angle formed between the mast and the plane of the base is approximately 60 degrees. Thus in side view, the base and the mast generally resemble the number 7 that has been tilted slightly clockwise. In a majority of configuration, this angle results in the brush being held against the vertical building surface with a counter force generated by the weight of the motor being laterally offset from the point where mast is connected to a cable. However other angles 20 degrees to 80 degrees can be provided accordingly. A vertical hinged support strut extends upward from the frame to reduce the flexures in the mast member and to further secure the mast to the frame base. The mast can be mounted to the frame via a hinge or welded.

The main brush is given rotationally about its axle via an electric motor disposed of the rear end of the frame, the motor used in the apparatus is a single HP single Phase AC motor which is couple to the brush through a belt and pulley arrangement which is selected to maintain the speed of the brush as required. The main brush is 1m long with 30inch nominal outside diameter, The brush preferably comprises a plurality of flexible individual finger elements secured at their base to a rotating roller of the shaft. One preferred material is EVA foam which will not scratch the glass, but is nonetheless a durable and flexible material.

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Figure 3 EVA foam brush before profile cutting

The drive motor can be electrically powered by an electrical cord connect to a power source or by an on-board battery. The device here shown has been powered by an electrical cord. The electrical cord is secured on top of the building and the wire is drawn adjacent the mast member. Such positioning of the motor causes a moment or torsional force to be generated to the cable attachment point, thereby counter balancing any force pushing the device away from the building.

The shroud is disposed behind the main brush opposite if the surface to be cleaned. The shroud enclosed approximately half of the longitudinal surface. The shroud functions to contain splashing and keeps any water running towards the building. The shroud is preferably made of light wait material such as aluminium, plastic, fiberglass or carbon fibre composite or other suitable material.

The cleaning apparatus includes a spray bar assembly to spray cleaning fluid, or water on the brushes. The spray bar assembly is disposed horizontally along the top edge of the shroud. The spray bar assembly comprises a tubular body, a quick connector and plurality of the spray nozzles.

The cleaning fluid can be supplied by a variety of sources. For example, a tank of solution and pump can be provided at ground or roof top levels can connected to apparatus by a hose or a reel. The tank can be filled either onsite or bought to the site. In a preferred alternative the cleaning fluid is deionised water. The water supply from the building, such an outer side water tap or spigot, is run through a deionizing and reverse osmosis water filter which takes most minerals out of the water.

Then a small supply hose is connected to the main connector of the cleaning apparatus. Water flow rates of less than 0.75gallon per minute are sufficient for the brush size and device operating speeds described as above.

## IV. DETAILED DESCRIPTION OF THE ROLLING OUTRIGGER

The outrigger comprises a main beam, a front wheel assembly and a rear wheel assembly. The main beam comprises hallow member. The rear or proximal end of the main beam includes a winch mounting bracket and tether loop.

A diagonal brace spanning at an angle between the front wheel assembly and the main beam can also be added to provide further stability and support to the outrigger. Additional braces can be provided, including braces connecting between the rear wheel assembly and the main beam, and between the two wheel assemblies.

The rear wheel assembly fastens to the beam adjacent to the proximal end and extends vertically downward to a wheel assembly. The rear wheel assembly comprises two or more wheels configured to roll the outrigger laterally parallel to the outer surface of the building that is being cleaned. The rear wheel assembly further includes one or more posts on which weight plates can be disposed. The weight plates counter the moment arm created by the cleaning apparatus suspended by the cable of the forward end of the beam. The user can adjust the amount of weight necessary to maintain the rear wheel assembly in contact with the roof the building.



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Figure 5 Rolling outrigger along with frame assembly

The wheels for the wheel assemblies can be any suitable design. Quick pins can be used to allow for quick assembly or disassembly or adjustment of the various rigging components. The winch used for outrigger is preferably an electrically powered winch with a suitable weigh rating given the weigh if the cleaning mechanism used.



Figure 6 Façade cleaning in progress

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## V. RESULTS

The contamination levels were divided into that upon the completion of construction and 5 and 10 years after the completion. The usage was divided differently for the wet, semi-dry, and dry methods. Further studies should be conducted on expanding the robot application technologies for building façade maintenance, including for defect monitoring and painting.

Division	Dry Method			Semi-dry Method			Wet Method		
	at completion	More than 5 years	More than 10 years	at completion	More than 5 years	More than 10 years	at completion	More than 5 years	More than 10 years
Water usage g/m <sup>2</sup>	-	-	-	5.3	5.3	5.3	142.5	213.7	356.1
Detergent Usage g/m <sup>2</sup>	0.2	0.2	0.2	-	1.8	3.6	-	1.8	3.6
Rubbing Count times/m <sup>2</sup>	63	76	95	13	16	20	8	9	12

Table 1. Quantitative analysis of glass surface cleaning

The usages were also divided based on cleaning surface such as stone, aluminium, and glass surfaces.

Division	Wet Method		
	at completion	More than 5 years	More than 10 years
Water usage g/m <sup>2</sup>	-	-	-
Detergent usage g/m <sup>2</sup>	-	3.6	7.1
Rubbing count times/m <sup>2</sup>	8	10	13

Table 2. Quantitative analysis of Stone surface cleaning

## VI. CONCLUSION

The automated glass curtain cleaning machine has been successfully designed and fabricated. The project work implements a simple glass cleaning machine that uses a portable rigging for the motion there by reducing the cost of climbing mechanism. This machine can work well for buildings having completely glass exterior. The machine construction is able to perform its intended function: the efficient cleaning of glass surfaces.

The overall weight of the machine is around 60 kg. The cleaning process takes about 5 minutes to finish a glass window pane. Uniform cleaning by using rubber brush and optimal in-line water pump deliver soap water for removing stubborn stains.

Together with the building façade maintenance robot, the new cleaning tool certainly reduces water usage compared to manual cleaning by human labour and conventional automated building cleaning machines.

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