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Design and Development of Plastic Carry Bag Crusher

Prof. M. A. Ahire[1], Shrinivas Jadhav[2], Krishana Choudhary[3], Om Dhote[4], Swapnil Lendve[5]
Assistant Professor, Department of Mechanical Engineering[1]
Engineering Graduates, Department of Mechanical Engineering[2,3,4,5]
JSPM Rajarshi Shahu College of Engineering, Pune, Maharashtra, India

Abstract: *The use of plastic carry bags is increasing in everyday life in the current scenario, causing a serious environmental problem. To do this, we need to make the environment greener by recycling possible waste from used bags. In order to solve this problem, there are already highly powered machines, but they are too expensive. Therefore, the main purpose of our study is to design and manufacture a low-cost plastic carry bag crusher machine by using a power supply and a single-shaft mechanism, which can be useful for micro, small and medium-sized enterprises. To implement this concept, a plastic carry bag crusher machine was implemented, which consists of some mechanical and electrical components such as frame, body, electric motor, drive system and cutter. This machine is used for cutting the plastic carry bags into small pieces which are in irregular shaped flakes which can be further processed. Recycle recovers the raw material that helps create new plastic products.*

Keywords: Plastic Pollution, Mechanical Recycling, Plastic carry bag, Waste Management

I. INTRODUCTION

The plastic carry bag industry is among the fastest growing markets due to its use in a variety of sectors such as automotive, construction, electronics, healthcare, textile, beverage, etc. As the world population continues to skyrocket, so does the amount of plastic waste people produce. In modern world plastic carry bag are used widely for shopping. Thanks to their desirable properties such as lightweight, waterproof, inexpensive, and practical. However, the overuse of plastic bags and the lack of a culture of reuse have a noticeable negative impact on the environment and pose serious challenges to modern waste management. Plastic bag waste has become a major cause of soil and water pollution, as well as a plague on the beauty of the countryside. Additionally, plastic bags are made of polyethylene and take around 200 years or more to naturally degrade. However, of the one trillion plastic bags used around the world each year, only a very small fraction is recycled. Recycling rates for bags are very low.

Recycling is a good option after the plastic carry bag has been reused as many times as possible and is ready to be disposed of. Recycling carry bags employments less vitality than making plastic from raw materials. In any case, with a small arranging, devotion, and exertion, it is simple to require steps to decrease your carbon impression. The greatest impact is achieved by avoiding smaller sized plastic carry bags in the first place and where that is not possible, reuse and recycling are the next best steps. Conscious efforts should be made to reduce the amount of plastic carry bags used by trying to replace them with something more sustainable where possible. Plastic that has already been purchased can be reused. Also, utilized plastic carry bags can be reused to keep them out of the squander stream as this serves to decrease the request for unused plastic carry bags. Reusing will help decrease plastic contamination and keep our planet clean and sound for future eras. The downside to this practice is waste collection problems, sorting problems, and high initial cost of machinery used to recycle the plastic carry bags.

To overcome this mechanical recycling, the most preferred type of recycling is mechanical recycling due to its non-contamination property, which further allows for a smaller number of operational units, resulting in an optimal amount of consumption of energy supply and resources, followed by mechanical recycling a physical process that converts plastic carry bag waste into secondary plastic materials. It is a multi- step process that typically involves collection, sorting, and heat treatment with reforming, decompounding with additives, and extrusion operations to produce recycled material that can replace new polymer. In mechanical recycling, each type of plastic is taken, sorted into

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different polymers and then crushed and then melted into pellets. After this stage it can then be used to craft all kinds of items such as plastic chairs and tables. Soft plastics such as polyethylene films and bags are also recycled. The project involves the construction of a plastic carry bag crusher that would help to crush the used plastic carry bags, thereby aiding in waste management and disposal.

A plastic carry bag crusher is a machine designed to crush large objects of solid material into smaller volume or smaller pieces. Crushers can be used to reduce the size or shape of materials to make them easier and more efficient to use for their intended purpose. Crushing is the method of transmitting a constrain, improved by a mechanical advantage, through a material composed of particles that tie together more emphatically and resist deformation than those within the material being crushed. Crushing gadgets hold material between two parallel (vertical) or digressive strong surfaces and apply sufficient drive to bring the surfaces together to form sufficient vitality inside the material to be crushed to cause its molecules to separate or change their orientation relative to one another. The equipment mainly includes the cutting machine and the crushing machine, the basic principle of which is to destroy the integrity of the material, depending on the shear strength and impact strength.

1.1 Objectives

- **To Reduce plastic waste:** One of the primary objectives of a plastic carry bag crushing machine is to reduce the amount of plastic waste generated from the disposal of plastic carry bags. By crushing the bags into smaller pieces, they take up less space and are easier to transport and dispose of.
- **To Promote recycling:** Another objective of a plastic carry bag crushing machine is to promote recycling. When plastic bags are crushed into smaller pieces, they can be used as a raw material for other products, such as plastic pellets or fibers.
- **To Increase efficiency:** A plastic carry bag crushing machine can increase the efficiency of waste management processes. By reducing the volume of plastic bags, the machine makes it easier to handle and transport the waste, which can save time and resources.
- **To Improve environmental sustainability:** By reducing plastic waste and promoting recycling, a plastic carry bag crushing machine can contribute to improving environmental sustainability. Plastic waste is a major environmental issue, and reducing it can have a significant impact on the environment.
- **To Provide an economical solution:** A plastic carry bag crushing machine can provide an economical solution for waste management. By reducing the volume of plastic bags, the machine can help to reduce the cost of waste disposal and promote more sustainable waste management practices.

1.2 Photographs of plastic waste at various places

Figure 1 plastic carry bag at dump yard

Figure 2 Plastic carry bag waste at beach

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II. LITERATURE REVIEW

Akmal Bin Uzir et.al(2017) outlines the design and fabrication of a plastic bag waste crusher machine using a rotary blade mechanism. The paper also discusses the performance of the machine in terms of crushing efficiency and capacity.

O. J. Oyedepo et al.(2017) describes the development of a plastic bag shredding machine that uses a double-shaft rotary cutting blade system. The paper includes details on the design, fabrication, and testing of the machine, as well as its potential for use in waste management and recycling.

Swapnil Raut and Rohit Patil discusses a plastic bag crusher machine designed by two engineering students in India. The machine uses a crank and slider mechanism to crush plastic bags and reduce their volume for easier storage and disposal.

John G. Hipple (2019) describes a plastic bag crusher that uses a rotary blade system to crush plastic bags. The patent includes details on the design and operation of the machine, as well as its potential applications in waste management and recycling.

Ravi Kanth et. al (2020) provides an overview of plastic waste management and recycling, including a discussion of plastic bag crushers and their potential role in reducing plastic waste. The article also discusses the challenges and opportunities associated with plastic waste management and suggests possible solutions.

Youcef Ghernouti et al.9(2015) presents aggregate in concreate by using plastic fine aggregate obtained from the crushing of waste plastic bags. Plastic waste was heated followed by cooling of liquid waste which was then cooled and crushed to obtained plastic sand having finess modules of 4.7.fine aggregate in the mix proportion of concreate was replaced with plastic bag waste sand.

A Ruban (2019) quantified the generation of plastic carry bag waste in a specific urban area and analyzed its environmental impacts. The research revealed that the consumption of plastic carry bags had detrimental effects on ecosystems, particularly through littering and marine pollution. The paper emphasized the need for sustainable alternatives and effective waste management strategies.

A Ahamed (2021) focused on conducting a lifecycle analysis of plastic carry bags, considering their production, usage, and disposal stages. The study found that the environmental impacts of plastic carry bags extended beyond their usage phase, with significant energy consumption and greenhouse gas emissions associated with their production. The economic analysis highlighted the hidden costs of plastic carry bags, including waste management expenses.

F GU (2023) explored the factors influencing public perception and behaviours regarding plastic carry bag waste. The research identified several key factors such as convenience, social norms, and awareness campaigns that influenced individual choices regarding plastic bag usage and disposal. The findings emphasized the importance of education and behaviour change interventions in reducing plastic bag waste.

Government Policies (2021) reviewed existing regulations and policy nterventions implemented to manage plastic carry bag waste. It assessed the effectiveness of different approaches, including bans, taxes, and extended producer responsibility (EPR) schemes. The study highlighted the importance of comprehensive policies that combine multiple strategies to achieve substantial reductions in plastic carry bag waste.

Jembeck et. al. (2021) examined various technological innovations aimed at reducing plastic carry bag waste. It discussed the development of biodegradable and compostable alternatives, as well as recycling technologies for plastic bags. The research highlighted the potential of innovative solutions to mitigate the environmental impacts of plastic carry bags while maintaining their functional benefits.

III. DESIGN CALCULATION

Design Calculation for hopper

Upper diameter = 340 mm
Lower diameter = 340 mm
Height= 175 mm
Angle of inclination = 90 degree
Base = 370mm x 370 mm x 585mm
Supports = 45 mm

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Radius of support= 45 mm
Volume of the hopper=πx^2h
x = Radius of hooper
where, x = diameter/2
h = Height of hooper
$\pi = 3.14$
$=\pi * 170 * 170 * 175$
=3.14*28900*175
=15880550 mm^3
i.e. **Volume of the hopper=15880550 mm^3**

Rotating velocity of blade shaft

$\frac{n1}{n2} = \frac{D_P}{d_p}$

Where,
n1=rotating velocity of the electric motor shaft
n2=rotating velocity of the blade shaft
Dp= Diameter of the driven pulley
dp=Diameter of the driving pulley

$\frac{230}{230} = \frac{1440}{n2}$

n_2 = **1440 rpm**

Linear and angular velocity of Rotor

V2 $= \frac{\pi \times d_p \times n_1}{60 \times 1000}$

$= \frac{\pi \times 230 \times 1440}{60 \times 1000}$

= 17.30 m/s.

= **V2 /x**

= 17.30/ 0.17

= **101.70 rad per sec**

Calculation of Belt length

The center-to-center distance between driving and driven pulley is given as:

$C = 2D1 + D2$

Where;
D1 = Diameter of the driver
D2 = Diameter of the driving
C= Centre to centre distance between driving pulley and driven pulley

C = $2\times 230 + 130$
= 590 mm

The belt length can be obtain as:

$L = 2C + \frac{\pi}{2}(D1 + D2) + \frac{D1+D2}{4C}$

Where; D1 = Diameter of the driver
D2 = Diameter of the driving
C= Centre to centre distance between driving pulley and driven pulley

$L = 2\times 590 + \frac{\pi}{2}(230 + 130) + \frac{230+130}{4\times 590}$

= **1745 mm**

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Design calculation for shaft

From PSG design data book(Page No 6.8)

Ultimate shear stress for MS = 345 – 525 MPa

Power from motor(P) = 5hp = 3730 W

RPM from motor given to shaft(N) = 1440 rpm

$$FOS = \frac{\text{Ultimate Shear Stress}}{\text{working Shear stress}}$$

$$\text{working Shear stress} = \frac{\text{Ultimate Shear Stress}}{FOS}$$

$$\text{working Shear stress} = \frac{348}{4} = 87\ N/mm^2$$

we know that,

P= T × ω,

Therefore,

T = P/ω

$$T = \frac{3730 \times 60}{2 \times \pi \times 1440} = 24.86 \times 10^3 \text{ N-mm.}$$

$$= \frac{T}{J} \frac{\tau}{r} \frac{G\theta}{L}$$

$$= \frac{24.8}{\pi \times d^4/32} \frac{6 \times 10^3}{d/2} \frac{8}{7}$$

Therefore,

d=**25.12mm**.

Design calculation for bearing

Outer diameter of shaft = 25 mm

Bore diameter of bearing = 25 mm

Outer diameter of bearing = 52 mm

Width = 15 mm

Thus, 6205 type bearing is selected (V.B. Bhandari, Page No 654)
is selected.
As the load capacities are less than the capacities of bearing that
We selected. So, our bearing is acceptable.

Design calculation for nut & bolt

We have selected M12 × 1.25 nut & bolt having standard size.

Dimension :-

Pitch diameter = 1.25 mm

Minor diameter for bolt = 10.466 mm

Minor diameter for nut = 10.647 mm

Design calculation for pully :

Diameter of the pulley:-

Let D = Diameter of the pulley,

σ = Centrifugal stress or tensile stress in the pulley rim(mild steel)
= 4 MPa = 4000000 N/m2

ρ = Density of the pulley material (i.e. mild steel) which may be taken as 7680 kg/m3.

We know that centrifugal stress (σ),

4000000 = ρ.v^2 = 7680 × v^2

∴v^2= 4000000/ 7680 = 520 or v = 22.8 m/s

and velocity of the pulley (v),

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v =πDN/60
22.8 =πD × 1900/60
or, D = 0.229 m =0.229 x 1000 =**229 mm**

Design calculation for cutter :
Design of cutter should contain two parts Blades and Rotor
Blades are fixed in frame at angle of 2 deg.
Diameter of the Rotor:-
Let D = Diameter of the Rotor,
σ = Centrifugal stress or tensile stress in the Rotor (mild steel)
= 4 MPa = 4000000 N/m2
ρ = Density of the rotor material (i.e. mild steel) which may be taken as 7680 kg/m3.
N = Revolutions per minute transmitted from shaft to rotor
= 2300
We know that centrifugal stress (σ),
4000000 = ρ.v^2 = 7680 × v^2
∴v^2= 4000000/ 7680 = 520 or v = 22.8 m/s
and velocity of the rotor (v),
v =πDN/60
22.8 =πD × 2300/60
or, D = 0.229 m =0.229 x 1000
=**189 mm**

Component Description

Hopper

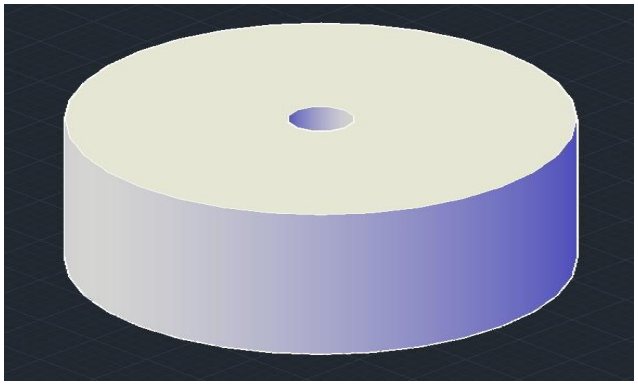

Figure 3

Dimensions :-

Diameter of base	:	34 cm
Length	:	17.5 cm
Thickness	:	0.3 cm
Angle of inclination	:	90 deg with horizontal axis
Height	:	17 cm
Material	:	Mild Steel

Purpose :-

The hopper provides a controlled feeding mechanism for the plastic carry bag crusher. It ensures a consistent flow of carry into the shredder, preventing overloading or jamming of the machine. The hopper design often includes features like an opening or chute that guides the carry bags into the crushing mechanism.

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Cutter box

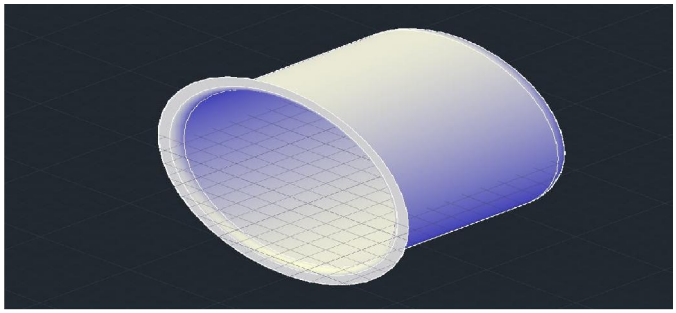

Figure 4

Dimensions :-

Length	:	30 cm
Breadth	:	29 cm
Heigth	:	cm
Thickness	:	0.3 cm
Material	:	Mild Steel

Purpose :-

The cutter box in a plastic carry bag machine serves the purpose of cutting the plastic carry bag into smaller pieces. This is an important component of the machine that aids in the recycling or disposal of plastic carry bag. When plastic carry bag are fed into the crushing machine, they need to be broken down into smaller fragments to facilitate further processing. The cutter box typically contains fixed blades or cutting mechanisms that cuts to the carry bag, reducing them into smaller pieces.

Frame

Dimensions

Length	:	37 cm
Breadth	:	37 cm
Height	:	58.5 cm
Thickness	:	0.3 cm
Material	:	Mild Steel

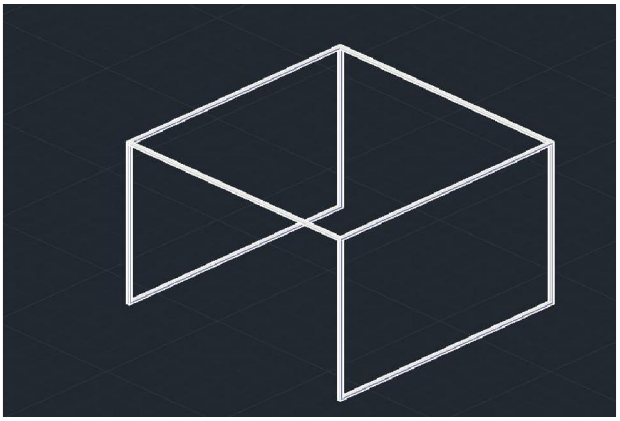

Figure 5

Purpose :-

The outer frame provides the necessary structural support to the hopper of machine. It helps maintain the rigidity and stability of the machine during operation, preventing any deformations or failures that could impact its efficiency and performance. The outer frame acts as a protective barrier, enclosing the internal components of the hopper of machine.

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It helps prevent any accidental contact with the moving parts or sharp edges, reducing the risk of injury to the operator or bystanders.

Pully

Dimensions

Inner Diameter	:	2.5 cm
Outer Diameter	:	10 cm
Thickness	:	2.5 cm
Material	:	Mild Steel

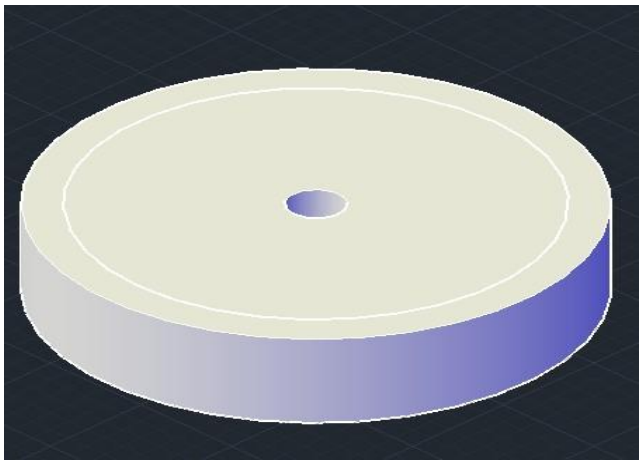

Figure 6

Purpose

Sr. No	Name of process	Charge per hour	Total time	Total charge
1	Wielding	85/-	10	850/-
2	Turning	150/-	5	750/-
3	Drilling	100/-	4	400/-
4	Boring	90/-	3	270/-
5	Finishing	40/-	5	120/-

A pulley can be used as a mechanical linkage to transfer rotational motion and power from a motor to the crushing mechanism. By connecting a belt or a chain to the pulley, the motor's rotational force can be efficiently transferred to drive the crusher rotor or crushing mechanism. Pulleys can be used to maintain proper tension in the belts or chains that transmit power to the rotor. Adequate tension is essential for efficient power transfer and to prevent slippage or excessive wear on the belts or chains. The pulley system can include tensioning mechanisms such as adjustable pulley positions or spring-loaded tensioners to ensure optimal performance.

Base:

Dimensions

Length	:	93 cm
Breadth	:	37 cm
Height	:	58.5 cm
Thickness	:	0.3 cm
Materia	:	Mild Steel

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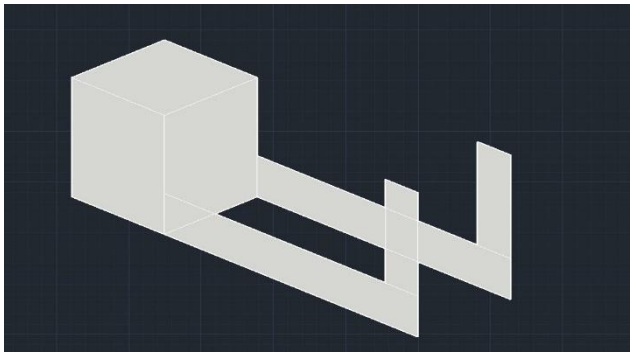

Figure 7

Purpose

The base of the machine is designed to provide stability and prevent any excessive movement or vibration during the shredding process. This stability ensures that the machine operates smoothly and reduces the risk of accidents or damage. The length of the stand is taken 930 mm (560 mm +370 mm) and breadth of 370 mm and height of 585 mm. These dimensions are taken as per the size of the hopper and pully.

Material : Mild steel

Cost Estimation of Component

IV. CONCLUSION

The developed model is simple, efficient, requires less time and is cost effective compared to the existing available model. Value is placed on user- friendly operation and, above all, on safety. The rotating elements such as the belt, pulley and gears are covered so that the operator is completely safe. The overall performance of the shredder was satisfactory. The plastic carrier bag crusher can be widely used in the plastic waste disposal industry. Using this plastic shredding machine will reduce the overall cost of the recycling process and labor. work becomes less.

Sr No	Name of Component	Cost Per Unit (in RS.)	Quantity	Total Cost (in RS)	Applications
1	Base	4000/-	1	4000/-	To support the model
2	Cutter Blade	500/-	6	3000/-	To crush the carry bag
3	Side Frame	5000/-	1	5000/-	To give structural support
4	Mild Steel	60/-	100 (kg)	6000/-	
5	Hopper	3000/-	1	3000/-	To insert Plastic carry bag
6	Cutter box	2000/-	1	2000/-	Provide cutting angle to blades
7	Rotor	2500/-	1	2500/-	Throughs the plastic carry bag with centrifugal force
8	Nut bolt	25/-	20	500/-	Tighten the material together
9	Miscellaneous cost	2500/-	-	2500/-	
10	belt	400/-	1	400/-	Transmit power
11	transport	-	-	5000/-	-
		Total cost (in RS)		**33,900/-**	

Overall, a plastic carry bag crusher machine is a useful tool for reducing plastic waste and improving waste management practices. The machine can crush plastic carry bags into smaller pieces, making them easier to handle and transport for disposal or recycling. Research studies and articles have explored various designs and mechanisms for plastic bag crushers, including rotary blades, double-shaft rotary cutting blades, and crank and slider mechanisms. These studies have evaluated the performance, efficiency, and capacity of these machines. Patents have also been granted for various designs of plastic bag crushers. Overall, plastic carry bag crusher machines can play an important role in reducing plastic waste and promoting sustainable waste management practices.

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V. FUTURE SCOPE

- Selection of new material which is light in weight and strength is equal to current material may be used to reduce weight of machine.
- If there is no carry bag in machine then machine must stop automatically.
- Once there is carry bag machine will start automatically.
- If motor gets heated and temperature of motor reaches upto 45 degrees then motor will automatically switch off.

Actual Photographs of model:

Figure 8 Side view of Model

Figure 9 Hopper

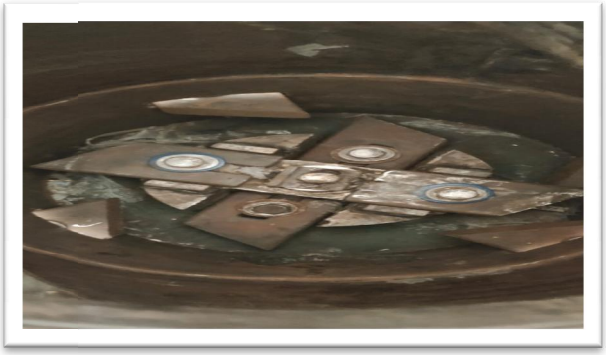

Figure 10 Rotor

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Figure 11 Front view

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