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Design of Lunar Lander for Soft Landing

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Abstract: *The design of a Lunar Lander capable of carrying a lightweight unspecified payload to the moon. Also introducing new technologies to improve the soft-landing, impact reduction during landing. We believes that such a system could make a large contribution towards the continued progress of the space program. The system could be utilized in further scientific study of the Moon by carrying payloads of scientific instruments custom-packaged for specific explorer missions. Additionally, it could help establish and/or support a manned lunar base, through the transfer of small amounts of building materials, communications equipment, a lunar rover vehicle, or other supplies. The ideas proposed as solution to soft-landing and impact problems. The work which will completed by the support of the design experts; justifications, validations, and verifications of decisions made during the project; and suggestions for future work to be done in support of the project.*

Keywords: Lunar Lander, Soft-landing, Impact problems, Lander Design

I. INTRODUCTION

A lunar lander or Moon lander is a spacecraft designed to land on the surface of the moon. The design requirements for these landers depend on factors imposed by the payload, flight rate, propulsive requirements and configuration constraints. Other important factors include overall energy requirements, mission duration, the type of mission operations on the lunar surface and life support systems if crewed. The relatively high gravity and lack of lunar atmosphere negates the use of aerobraking, so a lander must use propulsion to decelerate and achieve a soft-landing.

Several studies indicate the potential for both scientific and technological benefits from sustained lunar surface exploration that would culminate in the utilization of lunar resource, or in the development of necessary technology to land payloads on other planets in the solar systems.

Achieving a soft-landing is the overarching goal of any lunar lander, and distinguishes landers from impactor, which were the first type of spacecraft to reach the surface of the moon. All lunar landers require rocket engines for descent. Orbital speed around the moon can, depending on altitude exceeds 1500 m/s. Space craft on impact trajectories can have speeds well in excess of that. In the vacuum the only way to slow down from that speed is to use a rocket engine.

A landing by a spacecraft on the moon or a planet is at a sufficiently low velocity for the equipment or occupants to remain un harmed. Lunar landers are designed to conquer the unique conditions on the moon where a lack of atmosphere and intense temperature make touching down and staying operational a challenge.

Every time humans have sent spacecraft to land on a body in the solar system whether it was the moon, another planet or an asteroid. It has come with a new set of challenges. In the case of lunar landing, Aerospace engineers have to consider following factors like Moons high gravity, absence of atmosphere, long moon days. Idea of this project is proposed as a solution to soft landing and impact problems. The work which will completed by the design experts; justifications, validations and verifications of decisions made during the project; and suggestion for future work to be done in the support of the project.

1.1 Design of Moon Lander

Landing on moon and mars is tricky. A lander headed to the moon can go fast as 24,816 miles per hour. To land gently these space craft need to slow down before touch in the surface. And if there are astronauts on the board the lander needs to keep them safe.

In this challenge, we need to get to know about moon's gravity, motion, forces and target to design and build a lander that will protect astronauts when they touchdown. Just as engineers had to develop solutions for landing different types of vehicles on moon. We need to follow the engineering design process to design and build a moon lander.

1.2 Phases of Moon Landers Design

The complete design process has gone through three distinct phases that are carried out in sequence. They are

1. Conceptual design
2. Preliminary design
3. Detailed design

II. DETAILED ANALYSIS OF MOON SURFACE

The moon's surface is covered with dead volcanoes, impact craters, and lava flows, some visible to the unaided stargazer. Early scientists thought the dark stretches of the moon might be oceans, and so named such features mare, which is Latin for "seas" (maria when there are more than one

They are oceans of a sort, but rather than water, such bodies are made up of pools of hardened lava. Early in the moon's history, the interior was molten enough to produce volcanoes, though it quickly cooled and hardened.

Lava also burst from the crust when large enough asteroids broke through the surface.

The moon's surface shows plenty of evidence of asteroids, easily seen with a telescope during most moon phases.

Early in the solar system's history, all of the planets and moons suffered through a period of heavy bombardment, as the last of the large rocks were captured by their gravity and crashed into their surface.

On Earth, plate tectonics and erosion covered up much of the evidence from this period, while the atmosphere helped to burn up some of the smaller offenders before they hit the surface.

But the moon lacks all three of these cleanup elements, so the history of the solar system is preserved on its surface. The crust of the moon is made up of a rocky surface covered with regolith. As asteroids and meteorites collide with the surface, they blast it into fine pieces that capture imprints (such as Neil Armstrong's famous footprint) in exceptional detail.

The crust of the moon is about 38 to 63 miles (60 to 100 kilometers) thick. The regolith on the surface can be as shallow as 10 feet (3 meters) in the maria or as deep as 66 feet (20 meters) in the highlands.

Like the Earth, the moon boasts a crust, mantle and core. Deep inside of its interior, the moon may have a solid iron core surrounded by a softer, somewhat molten liquid iron outer core. The outer core may extend as far out as 310 miles (500 km). But the small inner core only makes up about 20 percent of the moon, compared to the 50 percent core of other rocky bodies.

	MOON	EARTH	RATIO
Mass	0.07346	5.9724	0.0123
Volume	2.1968	108.321	0.0203
Equatorial Radius	1738.0	6356.8	0.2731
Polar radius	1736.0	6378.1	0.2725
Volumetric mean radius	1737.4	6371.0	0.2727
Ellipticity	0.0012	0.00335	0.36
Mean desnsity	3344	5514	0.606

Table 2.1: Moon fact sheet

III. LANDER MISSIONS

Chandrayaan-2 mission is a highly complex mission, which represents a significant technological leap compared to the previous missions of ISRO. It comprised an Orbiter, Lander and Rover to explore the unexplored South Pole of the Moon. The mission is designed to expand the lunar scientific knowledge through detailed study of topography, seismography, mineral identification and distribution, surface chemical composition, thermo-physical characteristics of top soil and composition of the tenuous lunar atmosphere, leading to a new understanding of the origin and evolution of the Moon.

After the injection of Chandrayaan-2, a series of maneuvers were carried out to raise its orbit and on August 14, 2019, following Trans Lunar Insertion (TLI) maneuver, the spacecraft escaped from orbiting the earth and followed a path that took it to the vicinity of the Moon. On August 20, 2019, Chandrayaan-2 was successfully inserted into lunar orbit. While orbiting the moon in a 100 km lunar polar orbit, on September 02, 2019, Vikram Lander was separated from the Orbiter in preparation for landing. Subsequently, two de-orbit maneuvers were performed on Vikram Lander so as to change its orbit and begin circling the moon in a 100 km x 35 km orbit. Vikram Lander descent was as planned and normal

Figure 3.1 Vikram lander

IV. FIFTEEN MINUTES OF TERROR

A last-minute software glitch led to the failure of the Chandrayaan 2 mission. Vikram Lander crash-landed on the moon's surface after its guidance software went kaput, according to an internal report presented to the Space Commission.

The Indian Space Research Organisaiton (ISRO) designed Chandrayaan 2 to soft-land a probe on the moon, but the Vikram Lander lost control 500m short of the lunar surface and crashed. Efforts are on to locate the lander that was supposed to analyse the moon's terrain and send back data for 14 days. The glitch was unexpected since the software was functioning well throughout the trial period. The Vikram Lander successfully glided from a height of 30 kilometres to 5 kilometres. After this "rough braking," the lander experienced trouble during the "fine braking," the final stage in which the lander operated only one of its thrusters and slowed down to just 146m per second. The lander veered off its trajectory and crashed 750m away from the intended landing spot. The impact of the crash damaged the machinery on board and the lander went incommunicado.

Figure 3.2 Vikram Descent Trajectory

V. SPACEIL ISREAL AEROSPACE INDUSTRY – BERESHEET

Beresheet, a 1,300-pound robot built by Israeli Nonprofit SpaceIL, was sent into orbit by SpaceX in February 2021. However, when the dishwasher-sized robot collided with the lunar surface, the world's first private moon expedition ended in failure.

According to a press release from SpaceIL, the spacecraft's primary engine could have malfunctioned due to a technical problem in one of Beresheet's components.

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According to preliminary data obtained by SpaceIL and Israel Aerospace Industries (IAI), this technical error set off a cascade of events that temporarily disabled the spacecraft's primary engine. "It was impossible to stop Beresheet's velocity without the main engine working properly," the statement added.

VI. CONCEPTUAL DESIGN

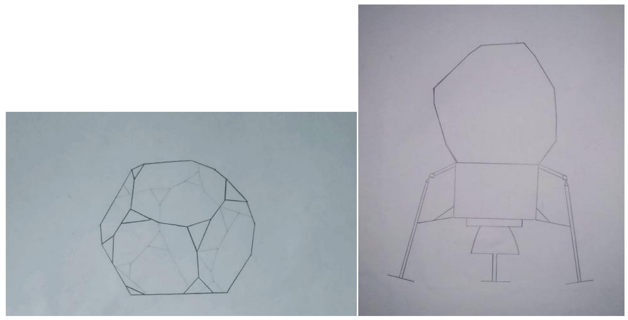

Figure 6.1 A Basic sketch of moon lander

The design process starts with a set of specification requirement for a new lander, or much less frequently as the response to the desire to implement some pioneering, innovative new ideas and technology. In entire case, there is rather concrete good towards which the designers are aiming. The first step towards achieving that goal constitutes the conceptual design phase. Here, within the certain somewhat fuzzy latitude, the overall shape, size, weight and performance of the new design are determined.

The product of the conceptual design phases is the layout on the paper or on the computer screen. But one has to visualize the drawing as one with flexible lines, capable of being slightly changed during the preliminary design phase. How-ever the conceptual design phase, determine the fundamental aspects of the lander structure and its performance. During the conceptual design phases the designer is influence by such qualitative as the increased structural loads, difficulties in landing, which are retracted etc.

VII. PRELIMINARY DESIGN

In the preliminary design phase, only minor changes are made to the configuration layout indeed, if major changes were demanded during this phase, the conceptual design process have been actually flowed to being with. It is in the preliminary design phase that serious structural and control system analysis and design take place.

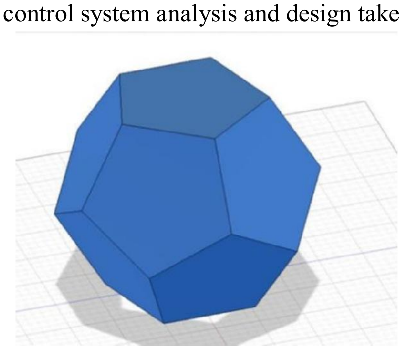

Figure 7.1 Accent part of lander

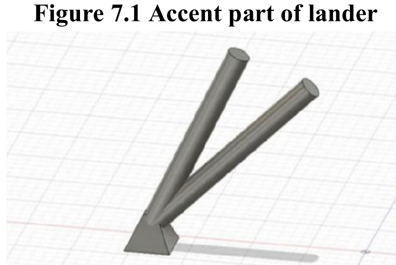

Figure 7.2 landing gear of lunar lander

VIII. LANDING SYSYTEM

Honeycomb Crushable Absorbers

For past landers, the honeycomb crushable absorbers had provided an effective and simple method of absorbing energy by crushing at a design load level. When the absorber is subjected to load over the design load level, the honeycomb structure deforms plastically and causes the absorber to stroke until the load becomes insufficient to continue crushing the elements. This design load level is determined by the axial buckling or yield strength of the honeycomb cells shows the honeycomb cartridges and operation of the honeycomb crushable absorbers.

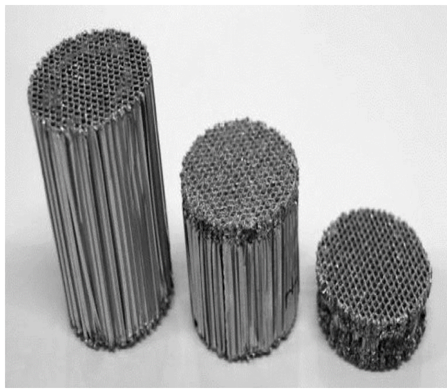

Figure 8.1 Honeycomb structure

Metal Bellows Shock Absorber

Metal bellow shock absorbers was proposed for application in space or harsh terrestrial conditions by University of Central Florida [11]. Stainless steel metal bellows are designed to operate from cryogenic to extreme temperatures of 400°C which are suitable for application in space environments [23]. This system consists of two gas chambers separated by an orifice and a piston connected to the metal bellow as shown in Fig. 2-7. The orifice between two pressurised gas chambers acts as the damper and the metal bellow with the gas chamber both act as the spring element of the shock absorber. Since the system is hermetically sealed, it eliminates the risks of leakage through seals.

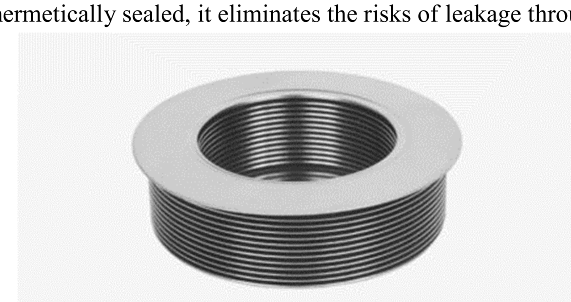

Figure 8.2 Metal bellow structure

IX. REQUIREMENTS

Touchdown Velocities

The touchdown velocities, both horizontal and vertical, are the velocities at which the footpad of the landing system comes into contact with the Moon surface. Depending on the time at which the engine thrust is cut-off and controls of the landing navigation system has ceased, these velocities can range from a pessimistic point of view for a heavy landing or a controlled landing even after touchdown for a near-zero velocity landing. conservative approach to assume the worst-case scenario in designing the landing system as it acts as a passive system to ensure the safety of the landing vehicle.

Landing Orientation

The landing orientation affects the stability and ground clearance of the landing. For legged landing system, there are two main critical orientations in which landing could occur. The 2-2 landing orientation touchdown on two leading legs before the two trailing legs

X. VISUALISATION

Detailed design of Lunar Lander for soft-landing is visualized below.

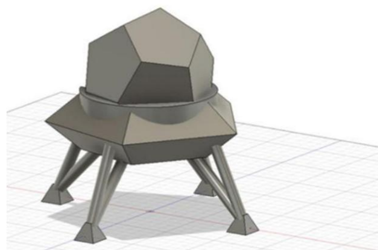

Figure 10. 1 Isometric view

XI. CONCLUTION

Therefore, this paper provided with a preliminary design of Lunar Lander for soft landing on the surface of the moon. Considering the impact problems and moon environmental conditions. Two type Selection of landing gear that is Honeycomb absorber and Metal bellow are studied. Lots of design parameters are consider for the soft-landing. Accent part are detached from decent part after a few minutes of touchdown, for the safety of payload.

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