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CONTRIBUTION OF MECHANICAL ENGINEERING IN ASTRONOMICAL RESEARCH

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Abstract - The ancient people used to look up at stars for the purpose of making an authentic calendar. People from antiquity were interested to know the actual juncture to sow seedlings and when to expect rains. Eventually the movement of stars were the foremost way to keep track of the passage of time. In July 1609, Galileo Galilei used an instrument to look at celestial objects. This instrument is known as 'Telescope'. Telescope is an instrument, which has been manufactured by utilising Engineering &Technology. The Working principle; as well as control system, is guided by Engineering. Telescope is an inevitable instrument for observational Sciences. To set up and control the Telescope efficiently; Civil Engineering, Mechanical Engineering, Electrical Engineering, Electronics& Telecommunication Engineering andComputer Engineering play vital role in construction,installation,testing and operation of Telescope with successful attributes. The current paper will emphasize exclusively on the role of Mechanical Engineering to facilitate the main motto of Astronomical Research, throughObservational Science.

Keywords - Telescope,Dome,CCD,Steel,Auto Cad,Optics,Delrin,Aluminum 6061 T6,Filter Disc,Mechanical Design,Inspection,Quality Control,Machine,Roll off Roof,Stress,Strain,Yield Point etc.

I.INTRODUCTION

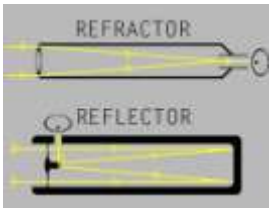
The Observational Science is based on telescope. In Greek language,'Tele' means 'Far' and 'Skopein' means 'To look or to see'.In Greek;'TELESKOPOS' means 'Far-Seeing'. Galileo made his own Telescope in June 1609.In addition to that, Astronomical Research demands some other segments, viz.Optics;Dome,Roll- off- roof, RollingShutter, ChargedCoupledDevice(CCD);Aluminising Chamber, OpticalFilter, Photometric& Spectroscopic back endinstrument; Mechanical Engineers play a vital role in designing,manufacturing,fabrication,inspection & quality control, installation, commissioning and servicing of Telescope & its accessories. The dome can be defined as the structure, which protects the telescopeagainst external factors. The Mirrors and Lenses are called the optics of a Telescope. Sometimes Roll-Off-Roof is used instead of Dome to house the Telescope, but aerodynamically, Dome is the better choice. Rolling Shutter is used in Roll – Off-Roof, to facilitate clear exposure of the Telescope; under the sky. Charged Coupled Device(CCD)is treated as a sensor, which is used as a camera for taking images of celestial objects; through photo-electric effect. It can also be defined as a light-sensitive integrated circuit; imprinted on a silicon surface; to form light-sensitive elements; called pixels, and each pixel is converted into an electrical charge. An optical filter is a device that selectively transmits light of different wavelengths. Aluminising Chamber is used to facilitate the re-aluminisation of Telescope Mirror; which passes through harsh environment; tomaintain its reflectivity.An astronomical Filter is a Telescope accessory; used by astronomers to simply enhance the details of celestial objects.Filter disc is having Mechanically manufactured Ring Gear,which is connected with the driving gear ;followed by a motor. The motion of the motor is controlled by electronic device(encoder etc.),according to the need of scientists; for observation for the astronomical objects. The Hubble Space Telescope has three types of instruments that analyze light from the universe: cameras, spectrographs and interferometers. 4K×4K Imager and the Faint Object Spectrograph and Camera (FOSC), have been used in 3.6 M Devasthal Optical Telescope (Asia's largest movable Telescope)All these back end instruments have been basically manufactured with the help of Mechanical Engineering.

II.CLASSIFICATION OF TELESCOPE

There are several divisions of Telescopes, according to their functions. An optical telescope is a telescope that gathers and focuses light, mainly from the visible part of the electromagnetic spectrum, to create a magnified image for direct view, or to make a photograph, or to collect data through electronic image sensors.Basically,Telescopes are divided in Two following categories,viz. Radio Telescope and Optical Telescope. A radio telescope is a specialized antenna and radio receiver used to receive radio waves from astronomical radio sources in the sky. An optical telescope is a telescope that gathers and focuses light, mainly from the visible part of the electromagnetic spectrum, to create a magnified image for direct view, or to make a photograph, or to collect data through electronic image sensors. Both the Telescopes & their accessories are mostly manufactured and assembled with the concept of Mechanical Engineering.In the current topic,

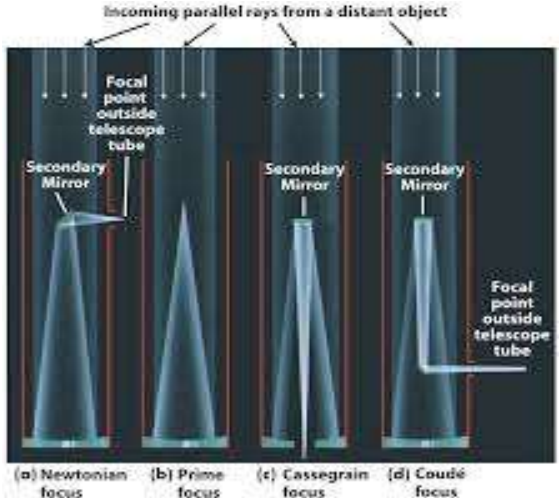
therelation between Optical Telescope and Mechanical Engineering will be emphasized.

Reflecting & Refracting Telescope:-



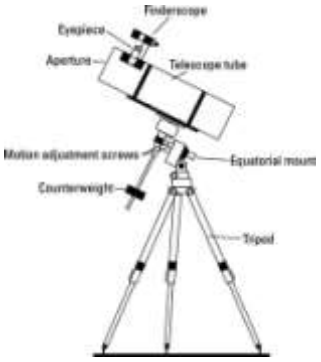
The distinction between the reflective and refractive Telescope; is; how they manipulate the incoming light in order to magnify the image. The main component in a reflecting telescope is a mirror where the light will bounce off and is then focused into a smaller area. In contrast, a refracting telescope uses lenses that focus the light as it travels towards the other end. The reflective Telescope is further divided into three categories,

(i)Newtonian Telescope ;(ii)Cassegrain Telescope and (iii)Gregorian Telescope.



In a Cassegrain Telescope, a convex mirror is used as secondary, which magnifies the image formed by the primary mirror. In Gregorian Telescope, the secondary mirror is concave in shape.Some popular observatories within India are as follows.(a) Indian Astronomical Observatory, Hanle;(b) Kodaikanal Solar Observatory, Kodaikanal;(c) Udaipur Solar Observatory, Udaipur;(d) VainuBappu Observatory, Kavalur,(e) ARIES Observatory, Nainital.Aryabhatta Research Institute of Observational Sciences(ARIES,Nainital);Indian Institute Of Astrophysics(IIA,Bengaluru); The Inter-University Centre for Astronomy and Astrophysics(IUCAA,Pune)and Physical Research Laboratory(PRL,Ahmedabad)are the leading Government of India funded research institutes withinthe country.

III.BASIC MECHANICAL DESIGN OF A TELESCOPE



A Telescope basically consists of (a)Metallic Tube;(b)Optics;(c)Radial Support;(d)Axial Support;(e)Counter Weight;(f)Mounting Equipment;(g)Eye Piece and (h)Finderscope;(i)Tripod etc.To manufacture the same within Mechanical Engineering Department,following steps have to be followed.

Prototype Design--→Prototype Manufacturing----→Prototype Inspection-----→Prototype Assembly----→Performance Study.

If Prototype samples shows a desired result, then the Mechanical Engineering section opt for the following steps.

Design For Manufacturing---→Preparing Part List(Bill Of Materials)----→Study of total financial Implication for procuring raw materials etc.---→Method Study---→Time & Motion Study---→-Manufacturing----→Inspection & Quality Control---→Assembly---→Installation & Commissioning---→Performance Observation---→Final endorsement for use in astronomical research work.

IV.MACHINES USED FOR MANUFACTURING OF TELESCOPE & ACCESSORIES

Lathe,Shaper,Milling,Power Saw,Surface Grinder,Cylindrical Grinder,Drill Machine(Both Conventional & CNC),Gas Cutter & Welding Machine(For fabrication Work).

Lathe

Shaper

Surface Grinder

CNC Milling

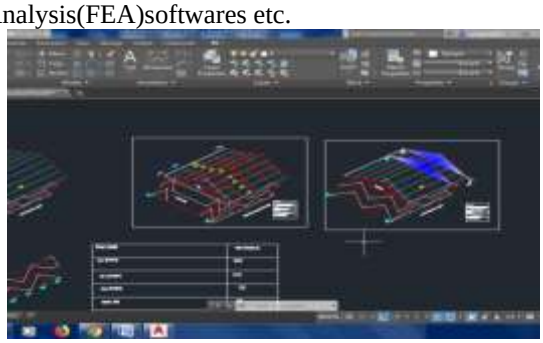
GAS Cutting/Welding Equipment

Arc Welding Machine

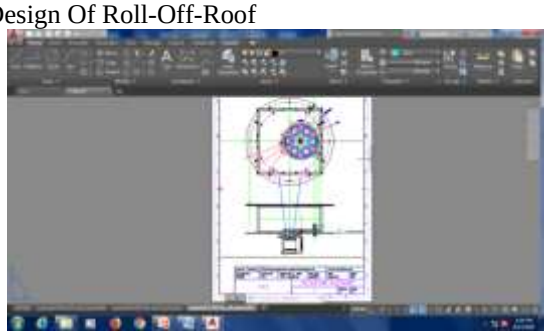
Granite Surface Plate for component inspection & Quality control

V.DESIGN SOFTWARES USED FOR PART DESIGN

Auto Cad,Solidworks,Catia,Finite Element Analysis(FEA)softwares etc.



Design Of Roll-Off-Roof



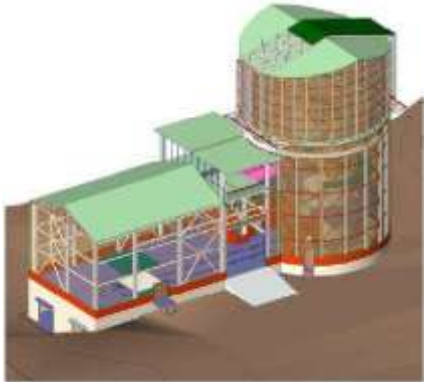
Design of CCD Filter

Testing of CCD Filter after manufacturing

Fitment of CCD Filter Housing within Telescope back end

Design of Anti flexure Unit for Telescope back end instrument

Fitment of Anti flexure unit on Telescope back end instrument



Design of Telescope Dome and Extension Building (3.6M Devasthal Optical Telescope,ARIES,Nainital)

Manufacturing of Lathe Radius Attachment to facilitate the grinding of Optics polishing tool

Mechanical Inspection of the contour of the Telescope Tube

VI.MATERIALS USED FOR TELESCOPE AND ACCESSORIES

Mild Steel,Aluminum(6061-T6),Delrin,Nylon 66 etc.

(a)Mild Steel:-Carbon(0.16%-0.18%), Silicon(0.40%max),Manganese(0.70%-0.90%),Sulphur(0.040% max),Phosphorus(0.040% max)&Iron(Rest). A small amount of carbon makes mild steel to change it properties. Different amount of carbon produces different types of steels. There are small spaces between the iron lattice. Carbon atoms get attached to this spaces and makes it stronger and harder. The harder the steel the lesser the ductility.

*The modulus of elasticity calculated for the industry grade mild steel is 210,000 Mpa. It has a average density of about 7860 kg/m3.

* Mild steel is a great conductor of electricity. So it can be used easily in the welding process.

*Because of its malleability, mild steel can be used for constructing pipelines and other construction materials. Even domestic cookwares are made of mild steel. It is ductile and not brittle but hard.

*Mild steel can be easily magnetized because of its ferromagnetic properties. So electrical devices can be made of mild steel.

*Mild steel is very much suitable as structural steel. Different automobile manufacturers also use mild steel for making the body and parts of the vehicle.

*Mild steel can be easily machined in the lathe, shaper, drilling or milling machine. Its hardness can be increased by the application of carbon.

*Mild steel is very much prone to rust because it has high amount of carbon. When rust free products are needed people prefer stainless steel over mild steel.

(b)Alumnum(6061-T6):-Cromium(0.04%-0.35%),Copper(0.15%-0.4%),Iron(0.7% max), Magnesium (0.8%-1.2%),Manganese(0.15% max),Silicon(0.40%-0.80%),Tin(0.15% max),Zinc(0.25% max) &Aluminum(Rest). This alloy features medium to high strength. It also has good corrosion resistance, weldability, workability, and machinability.

(c)Delrin:-Delrin acetal homopolymer (Polyoxymethylene POM) is the ideal material in parts designed to replace metal. It combines low-friction and high-wear resistance with the high strength and stiffness such applications require. It provides a wide operating temperature range (-40 °C to 120 °C) and good colourability. Delrin also mates well with metals and other polymers and offers excellent dimensional stability in high precision molding.

(d)Nylon 66:- Nylon 66 (nylon 6-6, nylon 6/6 or nylon 6,6) is a type of polyamide or nylon. It, and nylon 6, are the two most common for textile and plastic industries. Nylon 66 is made of two monomers each containing 6 carbon atoms, hexamethylenediamine and adipic acid, which give nylon 66 its name. Nylon 66 is frequently used when high mechanical strength, rigidity, good stability under heat and/or chemical resistance are required.

Mild Steel Sheets, components are corrosion prone. To overcome this problem, sandblasting,galvanising, paint coating etc. are followed. Recent study shows that, corrosion on Mild Steel/Low Carbon Steel could be controlled by using inhibitor of banana peel extract in diluted acid solutions.

VII. TENSION/COMPRESSION TESTS ON TESTING MACHINE TO OBTAIN THE STRESS-STRAIN RELATIONSHIP FOR THE MATERIAL MAXIMUM USED AND EVALUATION OF ITS YIELD STRESS,ULTIMATE STRESS AND FRACTURE STRESS

Observation Table:-
Material for the test specimen:-Mild Steel (MS).
Gripping diameter of the test specimen:-20.50 mm.
Working diameter of the test specimen:-10 mm.
Gauge length of the specimen=50 mm.
Breaking load=47.52 KN.
Yield point load=31.68 KN.
Upper Yield point load=38.016 KN.
Lower Yield point load=36.0052 KN.

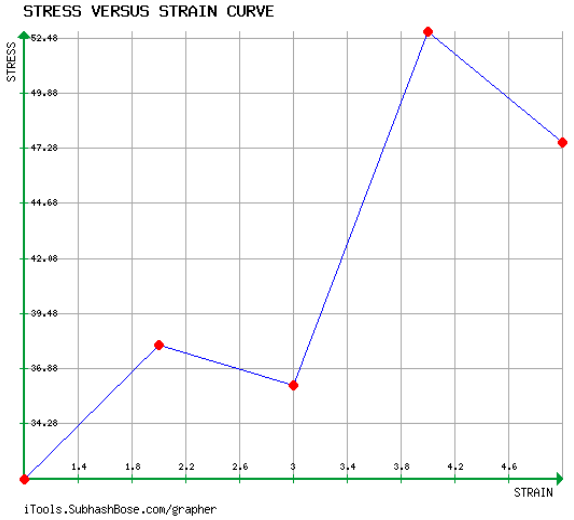
Observation Number	Initial gauge length	Ultimate load	Breaking load	Elongation after fracture	Reduced diameter through gauge length	Diameter of fracture point	Type of fracture observed
01	50 mm	52.8 KN	47.52 KN	(55.3-50)=5.3 mm	9.6 mm 9.2 mm 9.3 mm Mean=9.3 mm	8 mm	Cup & Cone shape(Ductile fracture)

Modulus ofElasticity:-E=P/A x L/Δl
=52.8÷π/4 x (9.36)^2 X 50÷(55.3-50)=7.23621915 KN/mm^2=7.24 GPa .

% of elongation= (55.3-50)/50 X 100=10.6 %.

% of reduction in area=π/4(10)^2-π/4(9.36)^2÷π/4(10)^2 X 100=19.36 x0.64=12.4%.

X	Y
1	31.68
2	38.01
3	36.11
4	52.8
5	47.52



VIII.FUTURE SCOPE

This paper is confined to the basic contribution of Mechanical Engineering on Observational Sciences. To avoid the current paper from getting lengthier, the detailed calculations regarding CCD filter Disc design, Dome designand Machining time calculations have been avoided.Definitely,these aspects will be depicted within the next paper, which is the due part; with respect to the current one.

IX. CONCLUSION

Mechanical Engineering plays a crucial role in Observational Sciences. Beyond the Designing, Machining, Assembly, Fabrication, Construction, Inspection, QualityControl,----- Mechanical Engineering takes an active part in Maintenance Work, which is an inevitable criteria for Telescope and its accessories. Rigorous preventive maintenance averts breakdown maintenance, subsequentlyreduces downtime. Mechanical Engineering department is also associated with Aluminising of optics.Planning,organising,direction and controlling are the modern work strategy of Mechanical Engineering section, which yields a positive output. A Total Quality Management can enhance the performance of Telescope, simultaneously facilitating the observational sciences, in a nutshell.

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6. The Institution of Engineers (INDIA).
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