



IJEAST

INTERNATIONAL JOURNAL
OF ENGINEERING APPLIED SCIENCE
AND TECHNOLOGY



VOLUME : 7 ISSUE : 11 Print / Issue Publication Date: 14-May-2023



ISSN : 2455-2143



DOI : 10.33564/IJEAST.2023.v07i11.007

Indexed In



WWW.IJEAST.COM

editor@ijeast.com



CENTRIFUGAL COMPRESSORS CONTROL CRITICALITY

Ravi Kiran Dasari
Process Engineering Manager
Audubon Engineering

Abstract- This article focused mainly on the importance of anti-surge control of compressor and how to design the recirculation line for turndown of compressors that's referred as surge. Also some recommendations will be made for better design and safety.

Keywords: Anti-surge, Surge, Seals, Lube oil, centrifugal

I. INTRODUCTION

A compressor is a mechanical device that increases the pressure of a gas by reducing its volume. It is a machine used to supply air or other gas at increased pressure, e.g. to power a gas turbine. Compressors are used in many

applications, most of which involve increasing the pressure inside a gas storage container, such as:

- Compression of gases in petroleum refineries and chemical plants
- Storage of gas in high-pressure cylinders
- Cabin pressurization in airplanes
- Air storage for underwater activities
- Filling tires

Other applications include, but are not limited to:

- Refrigeration and air conditioners
- Rail vehicle operation
- Gas turbines
- Powering pneumatic tools
- Pipeline transport of natural gas

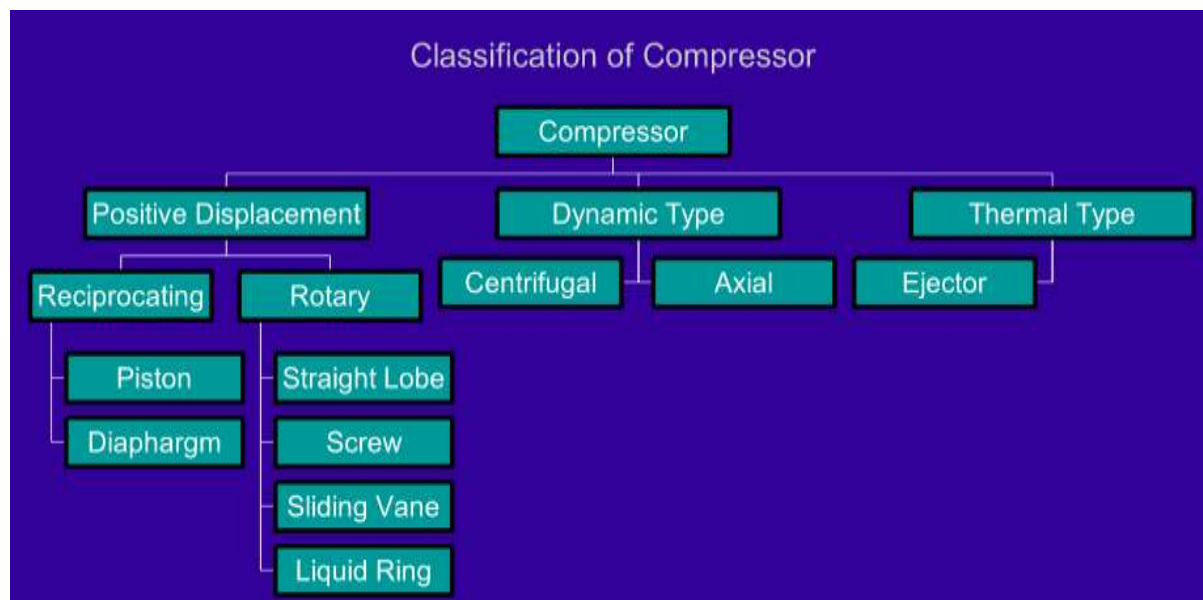


Fig 1: Types of compressors classification

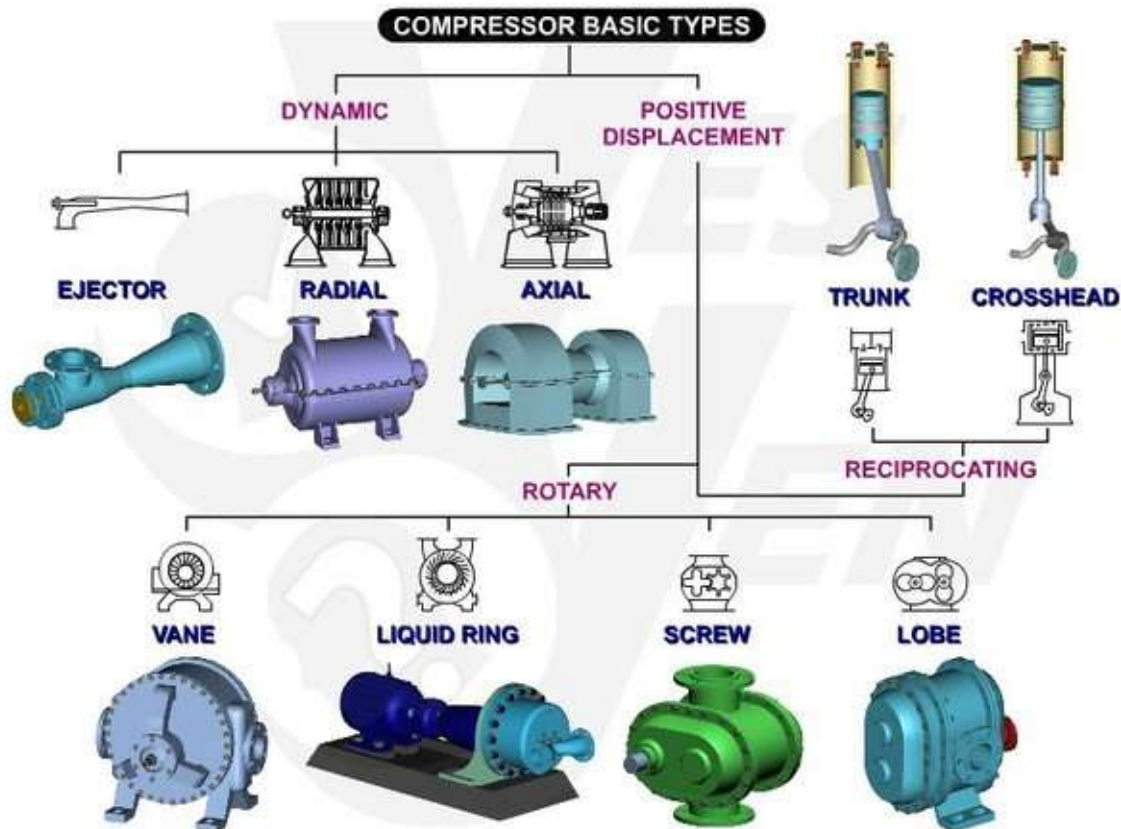


Fig 2: Schematic classification of compressors

II. SURGE AND ITS CONTROL

A. Surge:

The Capacity below which centrifugal compressor performance become unstable.

Factor Responsible for Surging:

- Reduction in suction gas density.
- Reduction in impeller speed.
- Reduction in Compressor Flow.
- More discharge pressure required than possible from the available kinetic energy.

Effect of Surging:

- Excessive vibration in compressor
- High deviation in discharge pressure.
- Drastic over heating of the machine.
- Ingress of liquid from suction KOD.

B. Anti Surge Control System

Anti-surge Control system (ASC):

Operating Principle: To provide a minimum flow through the compressor suction at all speeds which is higher than the surge.

This is achieved by the following ways:

- Recirculating back the quantity form the discharge to the suction (intercooler is required).

- Venting the quantity.(air)
- Reducing the compressor speed in case of variable speed drive.

III. SEALS & SEALING SYSTEMS

Sealing system is mainly used to prevent the leakage of the gas from the compressor between rotating and stationary parts of the compressor.

- Selection of Sealing system depends on following factors:
- Nature of gas. i.e corrosive, hazardous, flammable
- Permissible leakage quantity.
- Cost of the gas.
- Different types of Sealing systems:

– Labyrinth seal

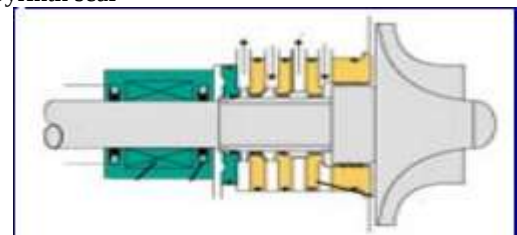


Fig 3: Labyrinth seal

when leakage in atmosphere is tolerated.

Sealing System

– Carbon ring Seal or Mechanical Seal

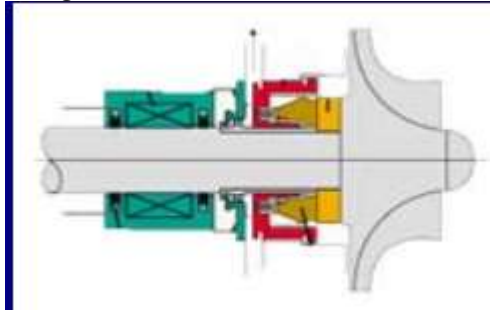


Fig 4: Carbon Ring seal

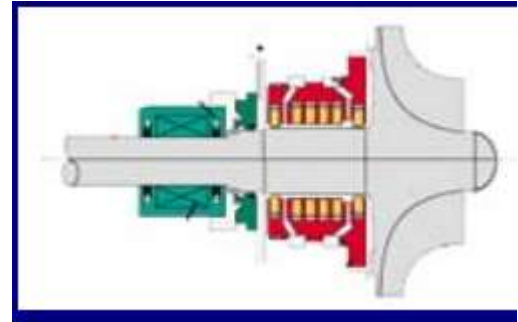


Fig 5: Dry gas seal

- For moderate pressure application.
- Permits less leakage than labyrinth seals.

– Liquid Film shaft seals:

For Poisonous and inflammable gases

– Dry gas Seals:

- for higher pressure application.
- For costly and hazardous gas
- nearly zero leakage.

IV. LUBE OIL SYSTEM

• Lube Oil System:

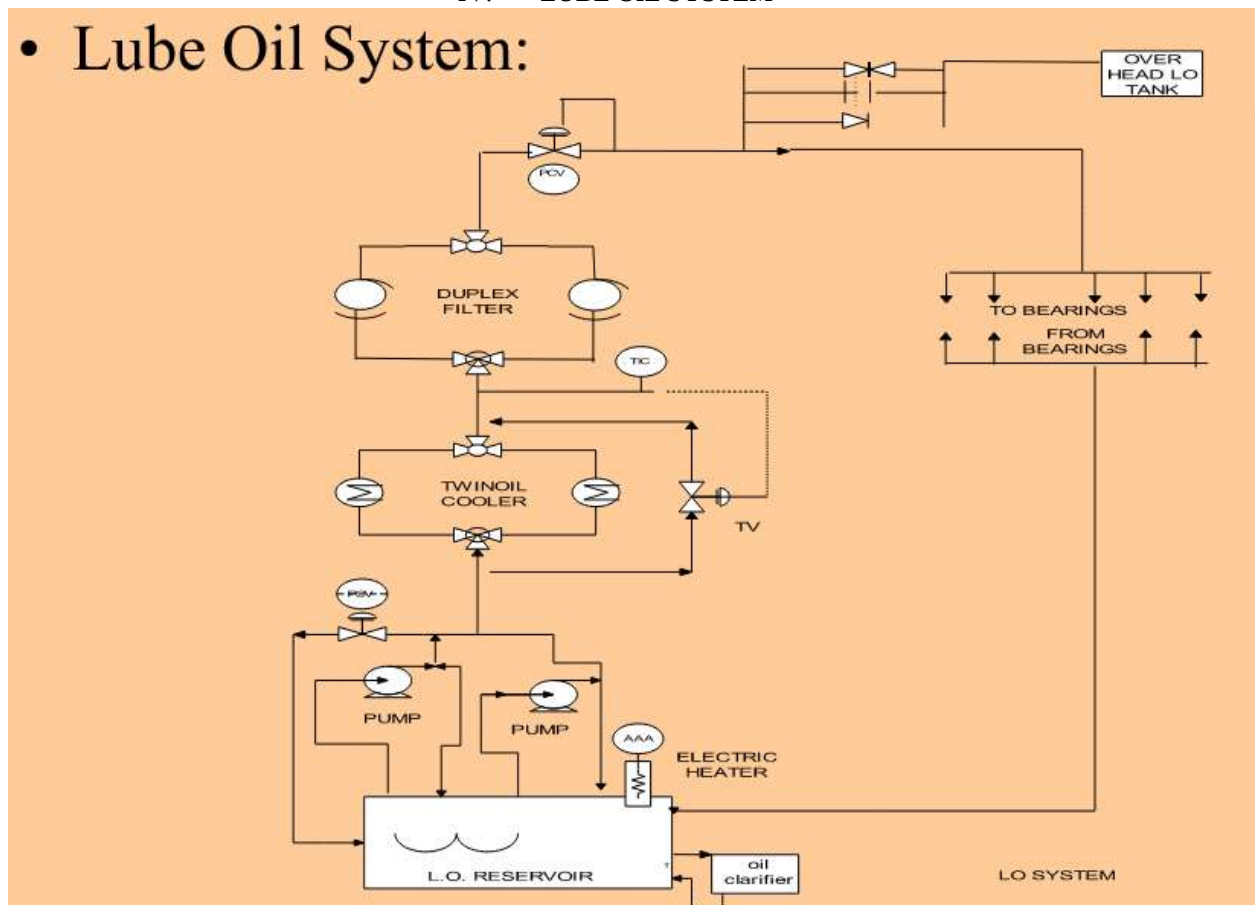


Fig 6 : Lube oil schematic

- Lube oil is used for the lubrication of bearings at the drive end and the non drive end. The Lube oil creates a hydrodynamic film between shaft and bearing which creates a lift of a shaft. The inefficiencies (losses) in the compressor appear as heat loads at the bearings.

Oil acts as a carrier medium of the heat load in addition to lubrication.

- The major components used in lube oil system are:

- Reservoir Tank
- pumps (main & Auxiliary)
- Cooler
- Filters
- Pressure Control Valves.

Interaction of compressor with downstream loop equipment

- Consider the following typical arrangement of the compressor with downstream equipment.

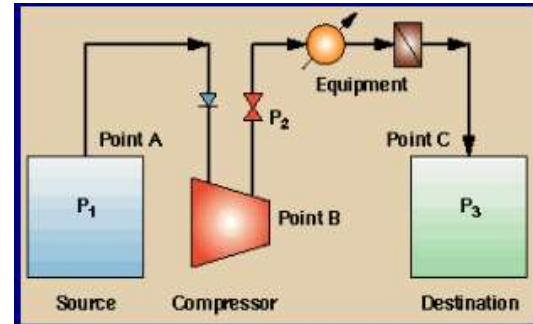


Fig 7: Typical arrangement of compressor

- For different changes in the system, operating point of the compressor can be changed
- Discharge control valve/recycle Valve
- Changing the speed of the driver
- Combination of both.

Single speed drive with Suction/Discharge control valve

Incoming flow decreases

Incoming flow decreases below surge

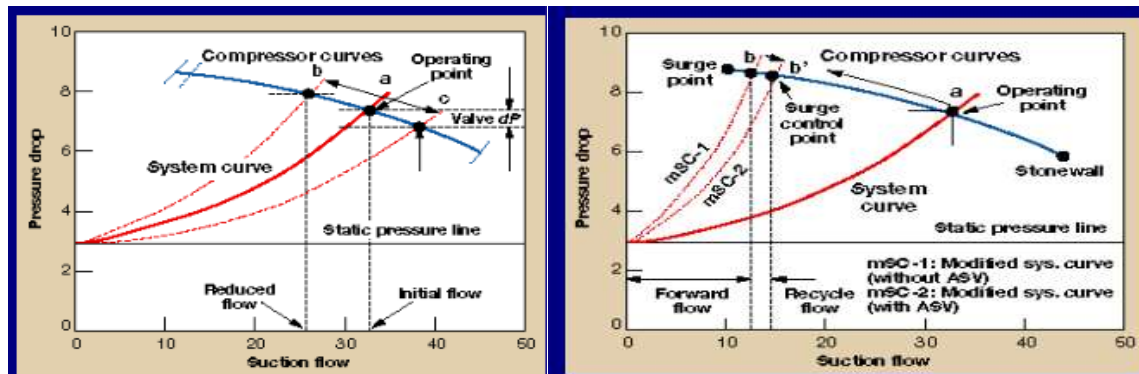


Fig 8: compressor curves for incoming flow decreases

Control valve closes, operating curve moves left ASV opens and control valve closes
 Variable speed compressor drive

Cases:

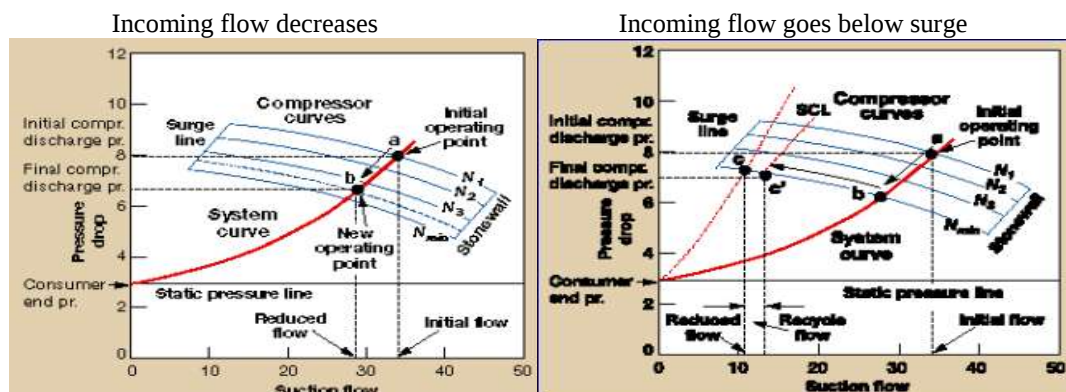


Fig 9: compressor curves for variable speed compressor drive

Driver slows down

Operating point changes by the action of Combination of speed control ,control valve and ASV.

Molecular Weight changes

• As the molecular weight decreases it leads to the lower discharge pressure and curve shifts right downward and vice versa for the increase in the molecular weight.

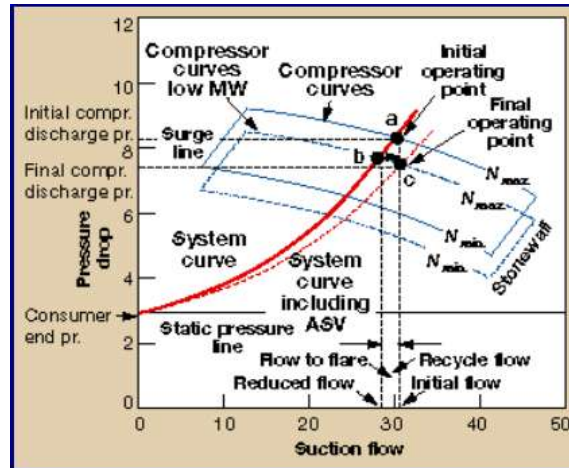


Fig 9: compressor curves for molecular weight increase

V. CONCLUSION

It is recommended to have anti-surge line sized full compressor to avoid start-up issues. Seal system is very critical for safe and reliable operations, also lube oil system is the critical part for operation to be efficient.

VI. REFERENCES

- [1]. Wen L, Gao L, Dai Y, 21–23 June 2011, June 2011 Research on system modeling and control of turbine-driven centrifugal compressor. In: 2011 6th IEEE conference on industrial electronics and applications, Beijing, China: IEEE.pp.2090–2095
- [2]. Wang C, Shao C, Han Y, 8–10 June 2010, Centrifugal compressor surge control using nonlinear model predictive control based on LS-SVM. In: 2010 3rd international symposium on systems and control in aeronautics and astronautics, Harbin, China: IEEE.pp.466–471
- [3]. Nored MG, Brun K, Kurz R, 9–13 June 2008. Development of a guideline for the design of surge control systems. In: Volume 7: education; Industrial and cogeneration, Marine; Oil and gas applications, Berlin, Germany, USA: ASMEDC.pp.565–573
- [4]. Dunn WC. , 2005, Process control. In: McGraw-Hill (Ed.) Fundamentals of industrial instrumentation and process control. McGraw Hill Professional,. New York, pp.241–258
- [5]. White RC, Kurz R, 2006, Surge avoidance for compressor systems. In: Proceedings of the Thirty Fifth turbo machinery symposium, Texas A&M University, USA. USA: Texas A&M University. p. 12
- [6]. Yoon SY, Lin Z, Goyné C, 15–17 December 2010, et al. Control of compressor surge with active magnetic bearings. In: 49th IEEE conference on decision and control (CDC), Atlanta, GA,. Atlanta: IEEE.pp.4323–4328
- [7]. Suciu GL, Merry BD, Dye CM, 2014 ,et al. Gas turbine engine compressor arrangement.,pp. 8,807,477
- [8]. Johnsen JR. 2017 Turbocompressorantisurge control by vibration monitoring, pp. 9,624,936,.
- [9]. Cortinovis A, Pareschi D, Mercangoez M, et al. Model predictive anti-surge control of centrifugal compressors with variable-speed drives. IFAC Proc Vol 2012; 45: 251–256. Crossref.
- [10]. Bentaleb T, Cacitti A, De Franciscis S, 15–17 July 2015, et al. Model predictive control for pressure regulation and surge prevention in centrifugal compressors. In: 2015 European control conference (ECC), Linz, Austria, pp.3346–3351. Linz: IEEE.
- [11]. Uddin N, Gravidahl, 26–29 December 2011, JT. Piston-actuated active surge control of centrifugal compressor including integral action. In: 2011 11th international conference on control, automation and systems. Gyeonggi-do, South Korea, , pp.991–996. IEEE.
- [12]. Torrisi G, 2017, Grammatico S, Cortinovis A, et al. Model predictive approaches for active surge control in centrifugal compressors. IEEE Trans ContrSystTechnol ; 25: 1947–1960. Crossref.



- [13]. Hafaifa A, Laaouad F, Laroussi K. 2010, Fuzzy logic approach applied to the surge detection and isolation in centrifugal compressor. *AutConrol Comp Sci* ; 44: 53–59. Crossref.
- [14]. mei He H, Sun X. 1–3 May 2020, Application of anti surge technology of compressor based on fuzzy control. In: 2020 3rd international conference on electron device and mechanical engineering (ICEDME), pp.330–333. Suzhou: IEEE.
- [15]. Dominic S, Lohr Y, Schwung A, 2017, et al. PLC-based real-time realization of flatness-based feedforward control for industrial compression systems. *IEEE Trans IndElectron* ; 64: 1323–1331. Crossref.
- [16]. Sheng H, Chen Q, Li J, 2020, et al. Robust adaptive backstepping active control of compressor surge based on wavelet neural network. *AerospSciTechnol* ; 106: 106139. Crossref.
- [17]. Zhang N, Malekgoudarzi M. 2020, Compressor surge control using a new robust adaptive method in the presence of uncertainty and unmatched disturbance. *SystSci Control Eng* ; 8: 405–412. Crossref.
- [18]. Amin AA, Mahmood-Ul-Hasan K. 2015, Advanced anti-surge control algorithm for turbine driven centrifugal compressors. *SciInt (Lahore)* ; 28: 10.
- [19]. Mirsky S, Jacobson W, Tiscornia D, 2015, et al. Development and design of antisurge and performance control system for centrifugal compressor. In: Middle East turbomachinery symposia. Proceedings, 2015. Turbomachinery Laboratory, Texas A&M Engineering Experiment Station.
- [20]. Compressor Control Corporations. Series 3 plus anti-surge controller for axial and centrifugal compressors. Compressor Control Corporations (CCC); Product Version: 756-005.
- [21]. 2011, Aspen HYSYS. Dynamic modeling guide, Version 7.3, Burlington, Massachusetts,
- [22]. E. Balje, *Trans ASME J, Eng. for Power Parts B* at Jan. 1962, "A Study On Design Criteria and Matching Of Turbomachines"
- [23]. R. F. Neerken, *Chern Eng. Jan. 20, 1975*, "Compressor Selection For The Chemical Process Industries"
- [24]. M. O. Khan, Brown & Root BP-00-01 May 1984, "Basic Practice in Compressors Selection"
- [25]. Compressor Handbook for the Hydrocarbon Processing Industries Gulf Publishing Company, Houston 1979
- [26]. Gulf South Compression Conference Aug. 1983, Louisiana State University Group Discussions.
- [27]. Ferguson T. B., 1963, The centrifugal compressor stage (Butterworth, London).
- [28]. Scheel L. F., 1961, Gas and air compressor machinery (McGraw-Hill, New York and London).
- [29]. Richings W. V., 1964, 'Acoustic noise measurement and analysis', *Wireless world* .
- [30]. S. I. R. Report ,The investigation of atmospheric pollution, (H. M. S. O., London).
- [31]. Guignard J. C. ,1967–68 182 (Pt 1), 55 , 'Human response to intense low-frequency noise and vibration', *Proc. Instn mech. Engrs* .
- [32]. Brightwell M. A., 1964 , 'Rotary compressor cylinder design', *Engineer, Lond.* (October).

IJEAST

INTERNATIONAL JOURNAL
OF ENGINEERING APPLIED SCIENCE
AND TECHNOLOGY

ABOUT IJEAST

International Journal of Engineering Applied Science and Technology (IJEAST) is a peer-reviewed, open access journal that publishes high-quality research papers in the field of Engineering, Applied Science and Technology.

IJEAST aims to provide a platform for researchers, academicians, and professionals to share their innovative ideas, research findings, and practical experiences with the global scientific community.

FOCUS AREAS

- Engineering
- Applied Science
- Technology
- Innovation & Development
- Interdisciplinary Studies



PEER REVIEWED

All submissions are rigorously peer reviewed to ensure quality.



OPEN ACCESS

Free and unrestricted access to research for all.



GLOBAL REACH

Connecting researchers and professionals worldwide.



TIMELY PUBLICATION

We ensure a swift and efficient publication process.



For more information, visit our website
www.ijeast.com



INTERNATIONAL JOURNAL
OF ENGINEERING APPLIED SCIENCE
AND TECHNOLOGY

✉ editor@ijeast.com

🌐 www.ijeast.com

📍 India



2455-2143