Lecture 17

3^{rd} Semester M Tech. Mechanical Systems Design

Mechanical Engineering Department

Subject: Advanced Engine Design

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Lecture 17 – Engine Design
Topic: Bore to Stroke Optimization In Internal Combustion Engines

Once the number and configuration of cylinders has been determined, the final remaining basic layout question is that of bore-to-stroke ratio.
For any given cylinder displacement volume a theoretically infinite range of bore-to-stroke ratio could be chosen.

The following factors govern the selection of bore-to-stroke ratio for a cylinder:

Surface to Volume Ratio:

Earlier in our discussions, **surface to volume** was identified as impacting the amount of **fuel energy transferred to the cooling system.**
The number of cylinders over which the total engine displacement is divided directly impacts this ratio.

Once the number of cylinders has been determined, the surface to volume ratio is further determined by the bore-to-stroke ratio.

While the surface-to-volume ratio is nearly independent of bore-to-stroke ratio when considering the BDC volume, it is strongly dependent at and near the TDC cylinder volume.

For the same cylinder displacement, **a large bore, shorter stroke** engine has a **higher surface-to-volume ratio** and thus **greater heat rejection to the cooling system.**

Piston Speed and Mean Piston Speed:

The next parameter to consider is piston speed.
For a **given** desired **engine speed**, as the **stroke is made longer**, the **piston** must travel further during each stroke and thus **must move faster**.
This increases friction, wear, and inertia forces.
A **maximum mean piston speed** is one of the **structural limits** imposed on any **engine design**. --- Range (8-15m/sec)

Volumetric Efficiency and Thermal Efficiency:
(pressure drop across intake valve)

As **bore diameter is increased**, the **intake and exhaust valves** can be made **larger** and **less restrictive**.
Engine breathing improves, providing a **power output and thermal efficiency advantage**.

Combustion Chamber Aspect Ratio:

Another consideration is that of combustion chamber aspect ratio.
For different reasons, the **combustion chambers** of both diesel and spark-ignition engines become more **difficult to optimize** as **bore diameter increases.**

In the **spark-ignition engine**, the challenge is one of **flame travel length** – the distance the flame must travel as it traverses from the spark plug across the cylinder **increases with increasing bore diameter.**
Should initially **effect the combustion efficiency** and subsequently engine **Performance Parameters** and **emissions characteristics**.

In the **diesel engine**, the **larger bore** results in a **shallower combustion chamber** and a greater propensity for **fuel injection spray impingement** on either the **cylinder head** or the **piston surface**.
Should initially **effect the combustion efficiency** and subsequently engine **Performance Parameters** and **emissions characteristics.**

Emissions Formation and Control:

A **larger bore** also results in a **greater crevice volume** above the top ring of the **piston**. The effect of increased crevice volume on **hydrocarbon emissions** is **especially** important in **spark-ignition engines**, but must be considered in **diesel engines as well.**
For effect of bore-to-stroke ratio other emissions, refer to my research paper in the journal of Energy and Power, October 2020 of Scientific and Academic Publishing USA.

Optimized and Combined Use of Above Three Parameters:

It is important to consider the combined effect of the three parameters considered above. The bore must be made sufficiently large to keep the mean piston speed below its design target and to minimize pressure drop across the valves (since the pressure drop increases sharply as the valve area is reduced).

As a general rule, the bore is made no longer than is necessary to fulfill these two requirements - this minimizes the heat rejection to the coolant.

6.8 Recommendation for further reading

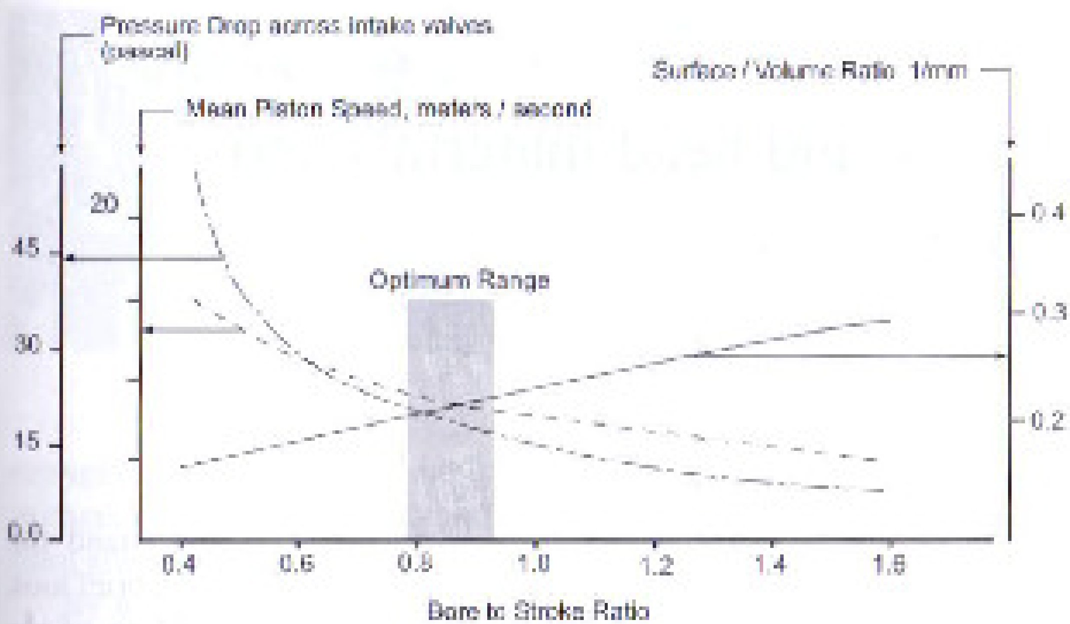

Fig. 6.12. Effects of variables determining the optimum bore-to-stroke ratio

The resulting bore-to-stroke ratio will differ depending on the design criteria for the specific application of engine.

1. **In high performance application:**

The bore-to-stroke ratio tends to be larger in order to **maximize breathing** and provide acceptable piston speeds at **high engine speeds**.
Bore-to-stroke ratio of 1.1 to 1.2 are common with ratio of **1.4** or more **sometimes seen**.

2. **Production automobiles:**

In production automobile engines where **fuel economy** is an **important consideration** and the desired engine speeds are lower,
Bore-to-stroke of 0.9 to 1.1 are typical.

3. **Heavy duty engines: lower speed engine**

In lower speed, heavy-duty engines -- **Bore-to-stroke ratios of 0.8 to 0.9** are typical.

4. **Marine Ships and Stationary Power Generation: Very low speed engine**

The very large, very low speed engines used in **ships and stationary power generation** engines use, --- **Bore-to-strokes is as low as 0.5**

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Text Book:
Vehicular Engine Design
By Kevin L. Hoag
Published By: SAE International USA