CHAPTER 6

INFORMATION FROM OTHER SOURCES

6.1. INTRODUCTION

In this chapter we will describe the information we got from other sources. These sources however are limited to the popular handbook "THE ROCKET MANUAL FOR AMATEURS" and the Brasilian rocket group "SOCIEDADE DE ESTUDOS DE FOQUETES". It will be shown that the data from this last group are different from our results mainly because they used an other propellant composition.

6.2. DATA FROM THE ROCKET MANUAL FOR AMATEURS

Burning rate at 700 psi (49 bar): 0,8 in/s (2,03 cm/s)

Composition: sugar 40% (granulated)

potassiumnitrate 60%

Ignition temperature: ± 600 °F (315°C)

Melting temperature: 350°F (177 °C)

Note: the propellant is very hygroscopic

6.3. DATA FROM THE SOCIEDADE DE ESTUDOS DE FOQUETES

6.3.1. ballistic performances

burning rate equation	: $r = 0{,}116\ p^{0{,}65}$
specific impulse	: Isp= 80 - 130 s
combustion temperature	: Tc = 2760°K*
molecular weight gas	: M = 36,9
heat of reaction	: H_R= 689 cal/g
specific heat ratio	: γ = 1,19
characteristic velocity	: C^*= 956 m/s
density	: ρ_b= 2,1 g/cm^3

*This temperature is certainly too high! It is however possible that they mean °R , which brings the temperature in our range.

6.3.2. manufacture of the propellant

6.3.2.1. formulation:

48% KNO_3 (coarse: 50 mesh)
20% KNO_3 (fine: 100 mesh)
27% sugar (fine: 100 mesh)
5% bariumsulphate (fine : 100 mesh)

6.3.2.2. oxidizer preparation:

The potassiumnitrate must previously be dissicated in an oven for 5 hours at 100°C. Than it must be milled with a hammermill or ball mill to get fine crystals. These crystals are than sifted at 100 mesh. Any particle larger than 100 mesh is broken in a mortar or pestle. The objective is to collect two different oxidizer fractions (50 and 100 mesh) in order to achieve highest density and to control the burning rate.

6.3.2.3. fuel preparation:

The sugar used in this formulation is powdered cane sugar. It is treated like the potassiumnitrate.

6.3.2.4. burning rate additive:

Bariumsulphate is added to the propellant in order to decrease the burning rate. Technical grade of bariumsulphate is sifted at 100 mesh in order to prevent any lumps in the propellant.

6.3.2.5. Mixing the ingredients:

The solid ingredients must first be mixed in a large rectangular container of aluminum, with the help of a large wooden spatula, which is continuously revolved in the mixture. In order to check the homogenety a small percentage of a red dye "Rhodamine" is added. When the mixing of the proepllant has ended (after about 20-30 minutes) the propellant is sifted in a 50 mesh sifter in order to increase the homogenety and to reject any lump of nitrate,sugar or bariumsulphate

6.3.2.6. propellant manufacturing and grain casting:

After a sufficient homogenety of the propellant is reached the propellant is melted before it is cast directly in the rocket. Heating is done on a hot plate or in an oil bath, with thermostatic temperature control. Normally the oil bath is used because of uniform temperature distribution.

Before adding the propellant to the rocket motor, the motor itself is preheated to 190°C in an oven. This procedure is needed to prevent cooling during the casting, which will crack the grain. The mandrel (star, tubular, etc...) is coated with a release agent like "Dow Corning RC-20" or teflon. Also anyscrew section in the rocket is coated with this material to prevent adherence.

Before heating the propellant about 300 cm^3 of water is added for each 1000 g of propellant. When boiling occurs sugar and nitrate dissolve and are well mixed. Continued boiling untill 195-200°C evaporates all the water and leaves the propellant, ready to be compacked into the rocket motor. When the mixture is still hot (about 200°C) it is scooped out and compacted into the chamber using a wooden ram which fits inside the chamber. Care should be taken to do this smoothly and a effort should be made to prevent cracks. Packing should be done under moderate pressure. To cast 1000 g of a grain with this propellant, the operation must be performed with amounts of 200 grams each time.

After all the propellant has been casted inside the motor, it is cooled to the ambient temperature during 1 hour. Than the mandrel is removed. A small bag with some grams of silicagel is than inserted. This bag is replaced every 3 to 5 days till the day of the firing of the rocket. However the rocket should not be stored longer than 1 week.

6.3.3. Ignition of the propellant

The ignition is performed with about 5 grams of black powder which itself is ignited by an electric igniter or a squib. A diaphragm is nct necessary since a minimum combustion pressure of 5 kg/cm^2 is sufficient. So one can insert a rubber stoper or a cork in the throat.

6.3.4. some safety aspects

The mixture can be heated on a hot plate or in an oil bath until about 300°C without any danger of explosion. It can also be machined on a lathe without problems.

6.4. REMARKS

The data given by other sources differ from the results from our experiments.

In the first place the burning rate in both cases is much higher than what we found. In the case of S.E.F. this is probably due to the other propellant composition.

More striking is the fact that S.E.F. gives a density which is higher than what theoretically can be achieved!

It is not clear why S.E.F. dissolves the mixture in water when it was first dehydrated and sifted. When the water evaporates the nitrates and sugar will crystallise again such that there is no linck between the original crystals and the crystals after all the water is evaporated. This is even more true for sugar that becomes liquid!

It is also strange that S.E.F. heats the mixture till 200°C, since at that temperature the sugar decomposes very rapid.

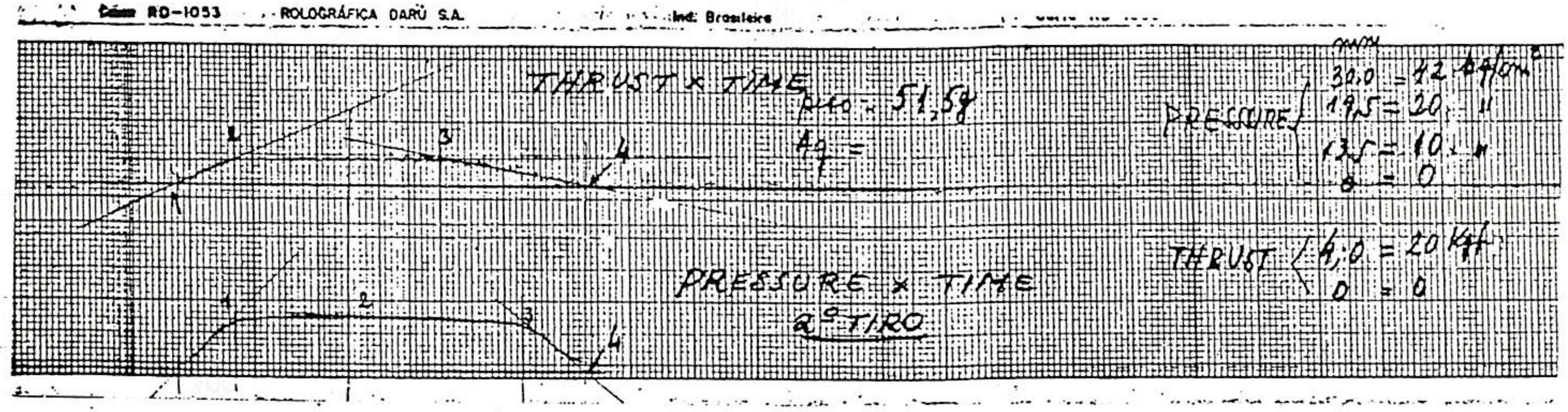

Fig.6.1. Thrust and pressure diagrams by S.E.F.

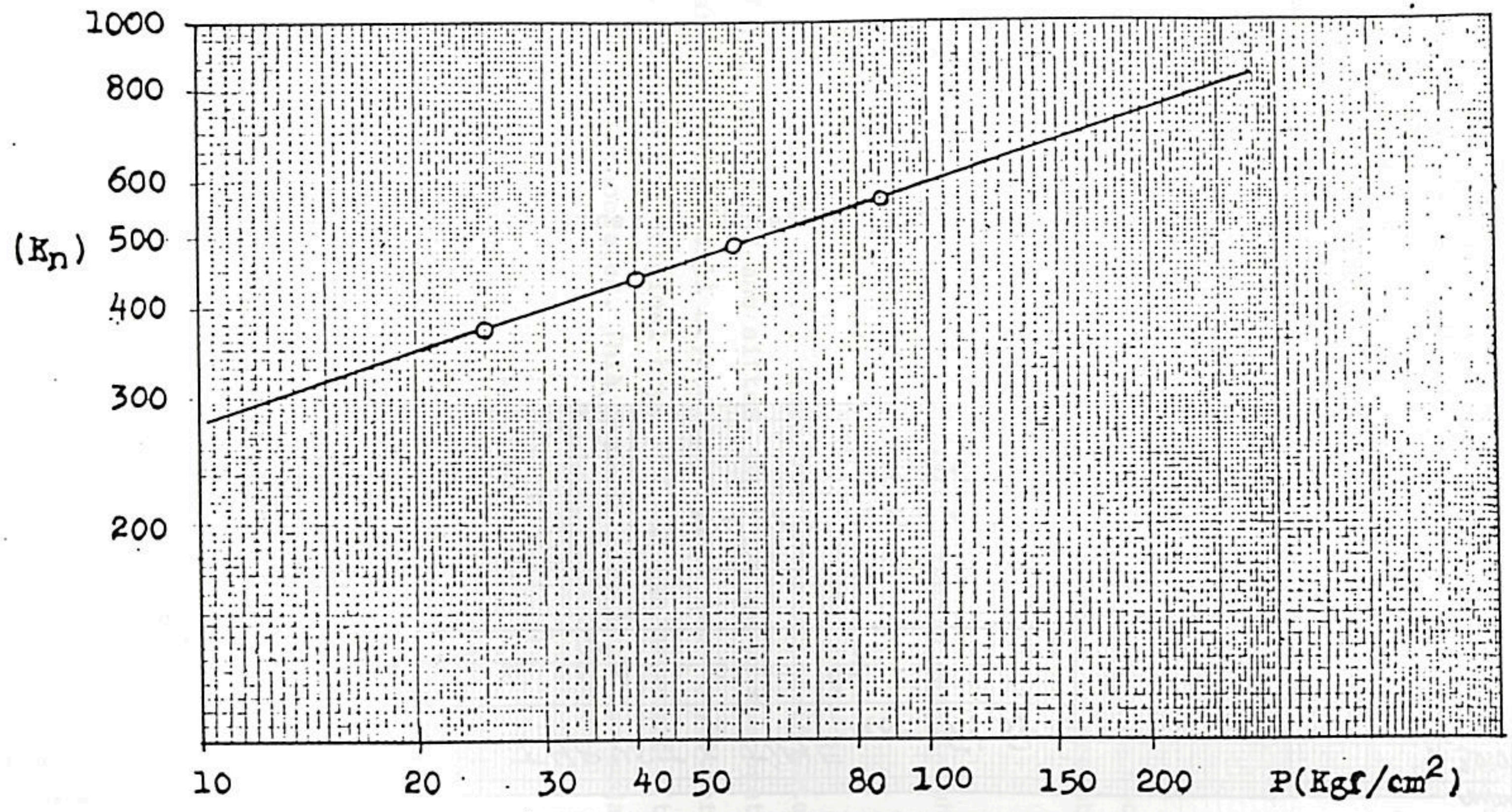

Fig.6.2. Burning area to throat area versus combustion pressure (S.E.F)

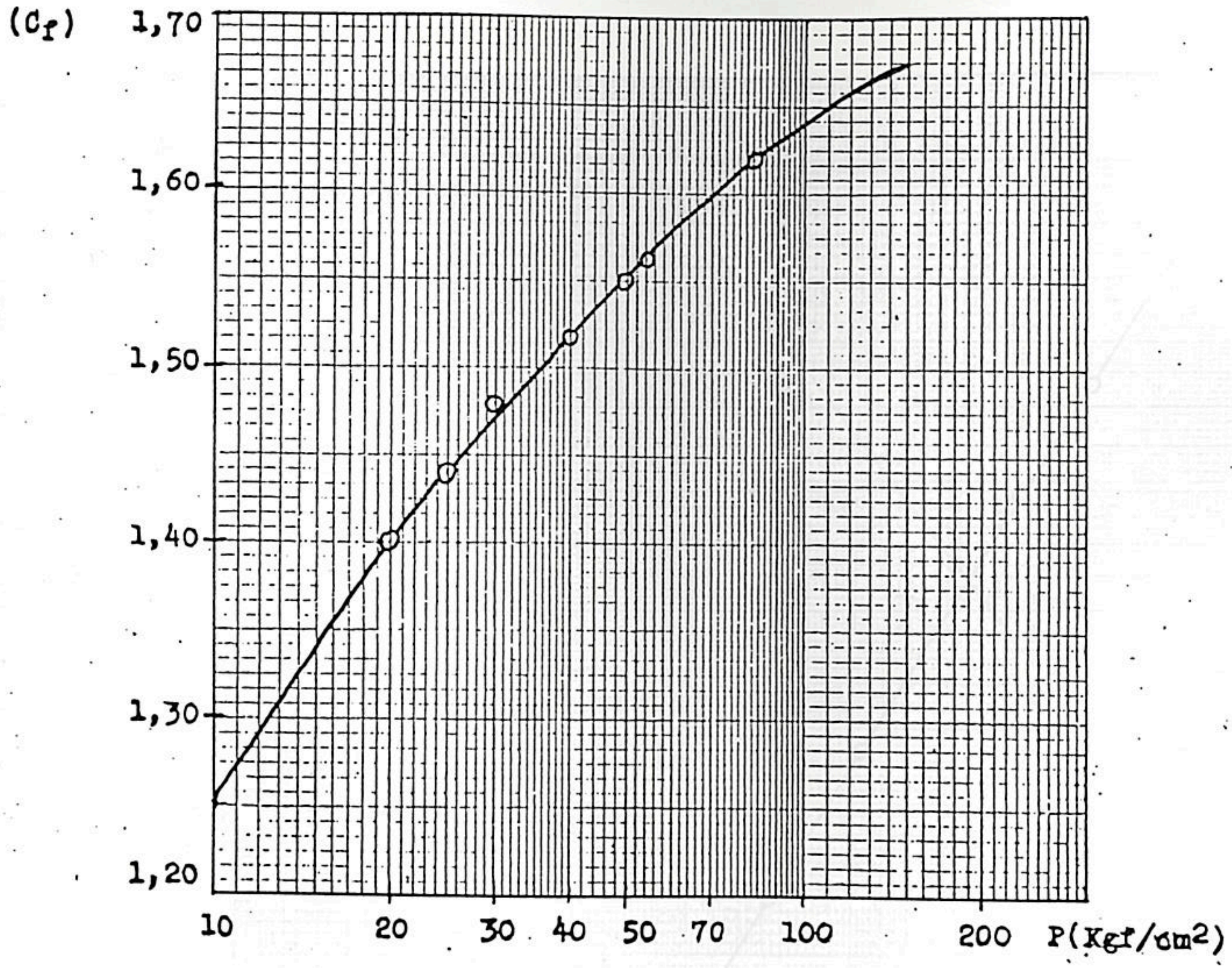

Fig.6.3. Thrust coefficient versus combustion pressure (S.E.F.)

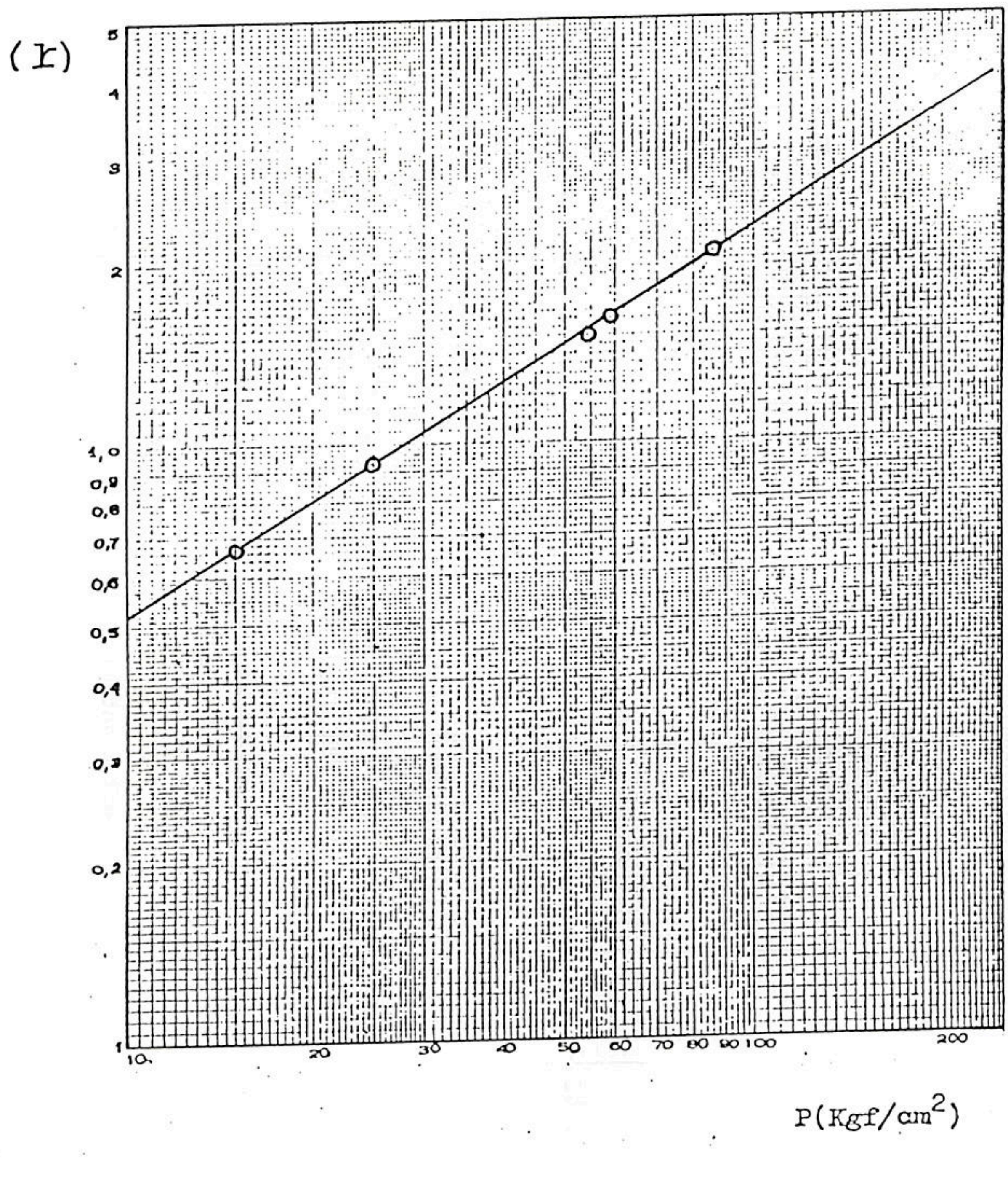

Fig.6.4. Burning rate (cm/s) versus combustion pressure (S.E.F.)

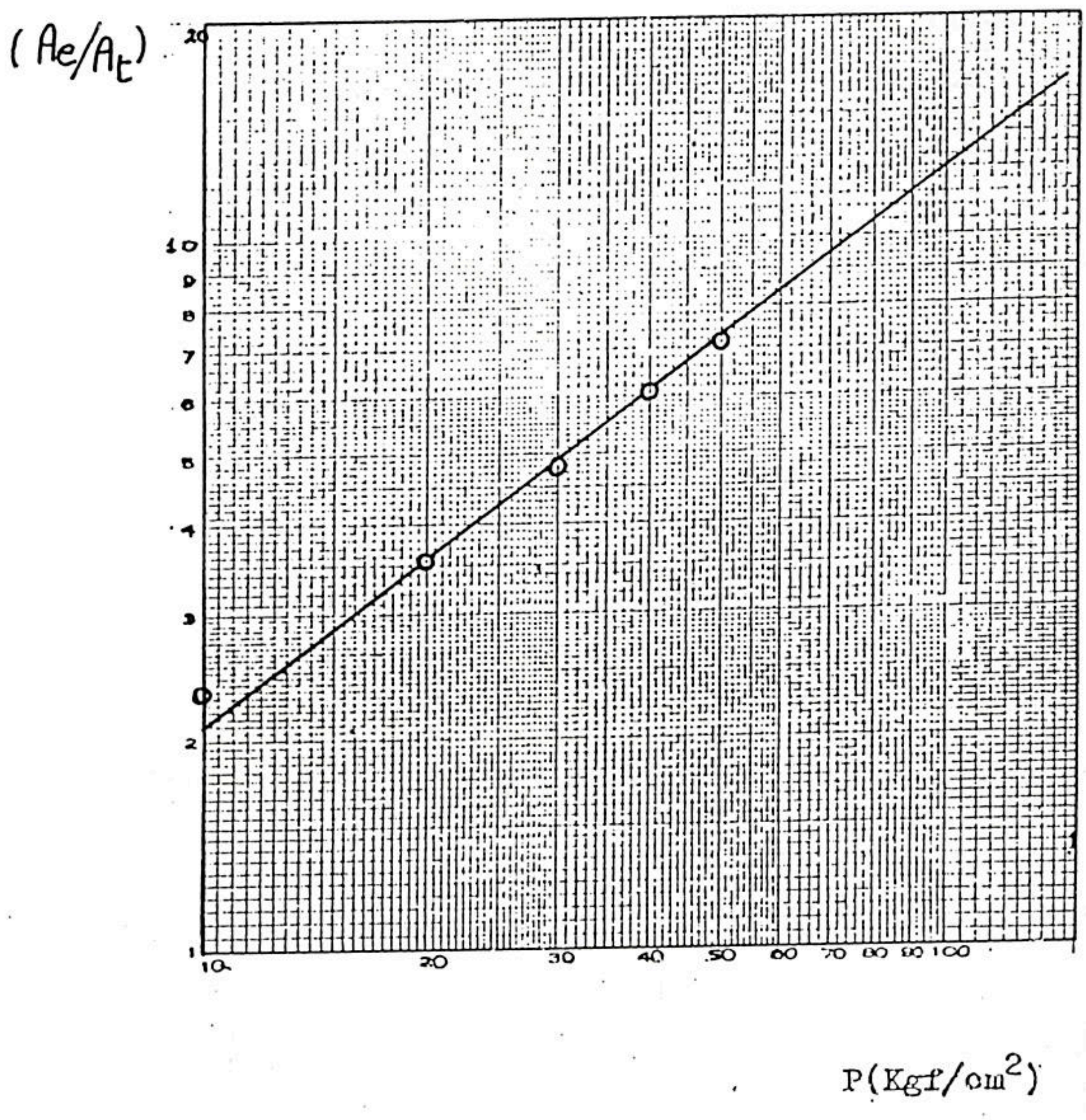

Fig.6.5. Ratio of the exit to throat area versus combustion presure (S.E.F.)