PROPULSORES

Impeller = Fuel (Down) + Oxidizing (Oxidizing)

"Propelente" **comes from a poor translation of the English term** ***"propellant"*** **and is not accepted by the Royal Spanish Academy. The word** ***"propellant"*** **nor is there, being more suited to this concept;** ***propellant.***

The word of French origin ***"propergol"*** **was recently adopted by the HKSAR and fits perfectly with the concept that we seek.**

CONCEPT:

The impeller or propergol is responsible for providing the impetus to rocket through the various transformations of chemical energy.

During combustion, propulsion mixture decomposes into gases mainly occupy a much greater volume and thus leave expelled abroad at high speed, producing reaction force that propels the rocket.

At first, amateur beginner seeks greater power possible entusiasmándose with high values of ISPs and with the intention of obtaining the greatest benefits possible. It's hard not to be seduced by such exciting idea.

It is not uncommon to find someone who wants to propel the rocket with the most powerful oxidizers and fuel mixtures because they found information military rockets or space and aims to equip their exemplary professional thrusters.

They soon realize that there is little point in a propellant that melts everything they reach their several thousand degrees in temperature. The jets, metal pipes and other parts of the reactor require sophisticated heat treatments which prevent the carrying out its amateur draft successfully.

In practice it is much better access to a safe propellant, predictable and which has been previously experienced by other fans. This avoids potential accidents and make things easier. We will always be time to introduce small variations or additives in their formulation if we add value to our research project.

Since security is the main point of the rocket pilot, our group resignation from this moment on the use of high-end oxidants such as ammonium nitrate and ammonium perchlorate to understand that their greatest power oxidant may compromise security.

Classification

Propulsores that have been experienced, as their fuel: Sorbitol, RESIN EPOXÍDICA, ERITRITOL.

Preparation of propellant based sorbitol

It chooses the sorbitol (C6H14O6), it provides advantages over common sugar or sucrose. Mainly avoids caramelisation excess temperature or time cast and the consequences of their degradation.

The melting temperature of sorbitol is only 117 ° C, leaving us far from its ignition temperature during the cast.

The sorbitol brings increased handling time that the common sugar and provides you with the cast and shuttering more careful and quiet.

The propellant based on sorbitol brings some stability because of its relative difficulty of ignition, resulting in safety, but requires a reliable ignition system.

In preparing the propellant has an electric cooker plate with a thermostat and stainless steel saucepan with quarry at the base. The indirect heating is by immersion bath oil or refined paraffin and the merger is accomplished without propeller points high heat. The temperature is thermostatically controlled and checked with a thermometer immersion. It recommends the involvement of two operators on this critical point and a constant control of temperature.

The protective elements are used to the hands, face and the rest of the body being respectively, leather gloves, transparent screen facial and long sleeved clothing. It also will use a mask to prevent inhalation of dust.

Elements such as a fire extinguisher and several buckets of water are on hand during the process. See SECURITY.

There are chemicals of high purity (99.9%), purchased from a vendor that specializes in chemical supplies.

An estimated 15-20% of excess weight and the percentages are 65% and 35% respectively of KNO3 and sorbitol. It performs with the heavy weight of precision (+ / - 0.1 deg.) Controlled automatically deduct for tare weight of the container.

The KNO3 was finely grinds in a coffee grinder to be used only for this product because they are the same particles in the interior of the motor shaft and blades can be combined with other fuels.

After grinding, it tamiza with a strainer to detect lumps, returning later to join a new milling. Both processes are carried out thoroughly and at the last moment, lest the KNO3 again apelmazarse. The KNO3 already been previously milled, it is this process of refinement.

The sorbitol or fuel is chosen, it grinds in the same way in another coffee grinder or with mortar and different hub, for the reason stated above, according to a similar process. Never must be re-grind the mixture once.
If sorbitol has a fine particle size, it is not necessary ground.

It pours dust collected in a container. First KNO3 and then sorbitol and after making contact with potential mass downloading static loads, the two components are mixed in a plastic airtight container with a lid.

From this moment will be observed on security protocol described in terms of passive protection and handling. Particular attention will be paid to the possibility and prevention of static discharge, making frequent contacts with mass touching, such as a faucet or pipe by hand.

The dust of both products is mixed by shaking and rolling through manual or mechanical means discarding those that may cause sparks near as electric motors or metal parts in friction or percussion. It should avoid breathing dust, which will use a mask ad hoc.

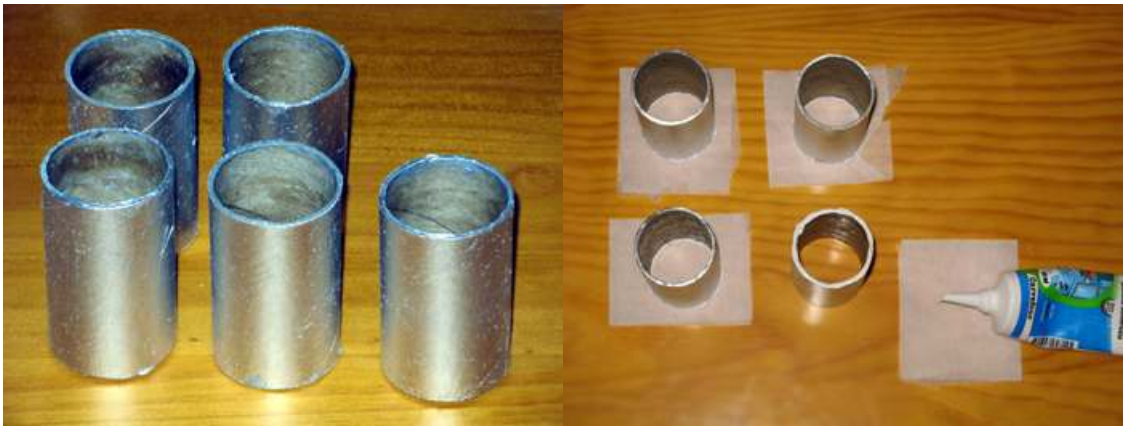
It makes the molten bath propeller thermostatically controlled and stabilized.
It comes with the shuttering of the grain, which will be ready for the mould and waxed paper (or vegetable) covering the interior and base of the mold.

It gets the lowest viscosity (in the case of sorbitol) during casting, if mixture leads to 117 º C in the bathroom thermostatically. For other fuels such as dextrose or sucrose, the minimum viscosity normally achieved at temperatures higher, up to approximately 140 ° C. In practice this process becomes intuitive.

There will be a system centered and subject to the nucleus and insert it before, this will be coated nonstick nature of a product to facilitate their removal because of the characteristic sticky propeller.

It recommends a helical coating of the surface of the nucleus with Teflon tape used in plumbing. It should also obturarse the end of the core so as to avoid entering inside the impeller and the resulting waste product.

Will be released both kernel and propellant grain when it has cooled slightly, later to evolve the role that covers before it accedes too, but not before it can sustain itself without cracking form.



When the joint has cooled off, stored for a while in an upright position until they complete hardening and then a small box with a lid or a hermetic sealing plastic higroscopicidad due to the product obtained.

The propellant grain is protected from moisture accommodated in the same container a desiccant-based calcium chloride salts or silica gel (Silica Gel).

The propellant grain should be accommodated with sufficient clearance and impregnated with black powder to facilitate the ignition of those areas where no show inhibited. The priming applies amassing gunpowder with isopropyl alcohol or methyl high purity in which previously has diluted some scales rubber-lacquer.

When purchasing practice, you can melt the impeller directly in a saucepan with a large thick at the base. The viscosity is also monitored, with the practice without the need to measure temperature, the mixture based sorbitol allows heat and cool as many times as necessary without risk of caramelisation.

Some versions of this propellant, as used in the engine A-50 / A, including a 0.3% Fe2O3 to stabilize combustion, accelerating slightly the same and avoid an irregularity that forms on the curve exponent of pressure that has the propellant based on sorbitol.

For ease of ignition of the faces circular side is conifican both ends by a cutting tool or rather directly to mold with this form using molds appropriate.

It also must permeate these surfaces with gunpowder fireworks, since the inertia of combustion and that distorts the delay curve burned neutral system BATES. This is accomplished by dissolving the powder in isopropyl alcohol with shellac.

The shellac is acquired in the form of flakes and gold is dissolved in isopropyl alcohol for priming.

The preparation of the priming powder of grain, is the last part of the preparation of propulsion system and explained below.

From the moment the cast, the grain needed for a day or more before they complete hardening and therefore its use.


Preparation of thrusters based epoxy

EPOKSAL

The proponents of basic epoxy have many advantages and also some disadvantages compared with thrusters based on poly sugars or alcohol.

In their preparation is not required to merge the base, with the advantage of ease of the process and the security it represents, but the qualitative improvement lies in the superior mechanical characteristics of the grain output.


The resistant characteristic of the epoxy resin is highly advisable to form this propellant body with the pipe which carries. It is also more resistant to shocks, accelerations, fragmentation, and so on.

Many propellants have been developed with this base fuel and several names have been attributed to differentiate.

The formulation recently developed for the EPOKSAL is tentative and could later include other components such as charcoal and sulfur.

56.00% KNO3

14.00% KCLO4

28.50% Resin Epoxídica **(Health and Safety)**

0.50% Fe2O3

At 1.00%

Previously provides an estimate of the mass proportional to all components through a volumetric calculation considering a density of 1.7 over an excess of the 15% that it is always wasted.

On the one hand mixing KNO3 and KCLO4 next to Fe2O3. On the other side is added to the Al powder resin, which can be diluted slightly, if desired, with isopropyl alcohol, in order to reduce viscosity.

It is important to conduct preliminary tests gradually decreasing the proportion of agent hardener to make the resin cure more slowly. You can achieve a proportion nearly half of that recommended by the manufacturer.

The KNO3 must drying in an oven at 100 ° C for a couple of hours. This will remove any residual moisture that could react with the resin and create gas bubbles. The bubbles produced in the combustion irregularities and should be eliminated or minimized this problem.

It is recommended to vibrate or beat the propellant grain when just encofrar and the mixture is smooth. This eliminates part of the bubbles inside. If possible, also lead to the "vacuum" with a machine planned for this.

The propellant based epoxy is stable but from that moment will be observed on security protocol in terms of passive protection and handling.

It pours resin which incorporates dust on Al dust resulting from the first mixture consisting of KNO3, KCLO4 and Fe2O3.

Initially, the mixture of all components, it seems impossible that it apelmazada and dry, but gradually, the resin is "dipping" all the dust and resulting in a mass of plastic consistency similar to clay.

The proportion of firming agent of the mixture has to be less than that recommended in order to extend the time for handling, which also decreases as the amount of propellant that process is greater because of the thermo catalytic reaction curative resin.

The kneading should be extended long enough to make plastic and the homogeneous mixture. It is recommended to use a wooden spatula and a container or tray polyethylene.

The remains of propellant easily cured withdrew from polyethylene whether this is not scratched. The paddlefish can be cleaned, if desired, with specific solvent for epoxy resin. You can also cleaned on an old rag and lijarse if necessary.

The main drawback of this type of propellant is usually a slightly higher cost because of the cost of the components used in the formula.

The quantitative ratio of the formula described is not consistent and can be adjusted to taste and necessity, because the granulometrías of solid components influencing the exponent of pressure and the speed of combustion.

The exponent of pressure is the result empirical route in the form of curve. The speed of combustion are growing in terms of progressive pressurization of the combustion chamber. There is a feedback that can lead to structural failure over pressurization.

This also brings greater propellant energy propulsion (ISP). The design of the reactor has also to take into account its highest temperature combustion by the presence of aluminum and potassium perchlorate.

It can be considered a grain geometry regressive to offset heavy pressure exponent. This type of impeller is very appropriate for a delay pyrotechnic device, like those used for the ejection parachutes or rockets several phases.

It should not be used until they are cured and hardening total which could last several days.

Evidence combustion EPOKSAL

Advantages:

-- We must not melt or heat in their preparation.
-- No retraction experienced during the cooling.
-- Improved working time with the mixture before solidifying.
-- It adheres to the inhibitor with great force.
-- Mechanical features unbeatable.
-- Increased Isp by the presence of aluminum powder and KCLO4.
-- It is not brittle or sensitive to shock or strong accelerations.
-- The speed of combustion is even slower erythritol.
-- The dense smoke grey facilitates the tracking of the rocket.
-- Easy to machine without fracture or break.
-- Increased relative density of the grain output.
-- It is not hygroscopic.

NEPOX (RNX-42)

MEMBERSHIP:

KNO3 66%
Epoxy 25%
Fe2O3 7%
At 2%

Epoxy Resin

Aluminum powder

Encofrado of propellant grains of NEPOX

Richard Nakka developed the range of propellants RNX based on epoxy resin and KNO3.

Both compounds are readily available in specialized stores or through the Internet.

After several years of experimentation, R. Nakka tested in the summer of 2002, a propellant for rockets with very interesting features which it named RNX-42. (Based on the epoxy resin East Systems).

The problem is getting the United States brand with epoxy resin which experienced and characterized the RNX-42.

Improving specific RNX-42 with respect to the family and other contemporary RNX precedent lies in the ability to operate at relatively low pressure of the combustion chamber. The RNX-42 works well from 400 PSI with Kn 800.

Not always has the potential technical or economical to build reactors that support 1000 PSI (7 MPa or 70 Bars), and we may run the risk of exploitation if the employee works propellant high pressure or tends to presurizarse feedback.

Propellants based epoxy incorporating potassium perchlorate work well at low pressures, but they tend to increase the speed of combustion because of the feedback should be designed and grains combustion regressive thrusters to compensate.

With regard to the pressure exponent of "No", there is empirical equation for the speed of combustion, the law of Saint Robert:

Bp = V ^ n, where "p" is the pressure, "No" constant (pressure exponent) and "b", a coefficient is a function of the initial temperature of the propellant grain. Values of n> 0.7 mean that the impeller is unwieldy.

The propellant RNX-42 incorporates a 7% Fe2O3, although a catalyst at high doses "slows down" the increasing speed of combustion. This was discovered when tested with different percentages of Fe2O3 in pressurized chambers.

Moreover, the addition of 2% of aluminium powder, acts as a stabilizer to raise the combustion flame temperature and provides little more specific impulse (Isp) to the set.

With regard to Kn, we can define it as the mathematical relationship between the area of the propellant burned instantly and the surface of the throat of the nozzle. A mayor Kn, increased pressure in the reactor and vice versa.

Coating aluminizado drug

RECOMMENDATIONS:

-- The proportion of mixed epoxy resin / hardener has to be less than that recommended by the manufacturer, it being necessary to use the minimum amount of hardener allowing the resin to cure.

To determine the ratio is necessary to conduct small tests cured with varying proportions of these two components. A

9:1 relationship seems to be enough but it takes more than a week to heal completely.

-- The Fe2O3 is to be like "red" discarding other types as the "yellow" or "brown".

-- The aluminum powder is not required to be at grade fireworks (for security is discouraged). You can use the "burden" metal epoxy resins.

-- The potassium nitrate tends to absorb moisture hygroscopic in nature so it is necessary desecarlo in an oven for one hour at 90-100 ° C. This procedure prevents the formation of bubbles of gaseous ammonia during the subsequent mixture.

-- The mix of KNO3 and Fe2O3 is not explosive and can be handled safely.

-- The aluminum powder is added separately diluted in the epoxy resin.

-- It should not be used until they are cured and hardening total, which which can last several days.

CONCLUSION:

-- Due to the difficulty of obtaining epoxy resin manufactured in the United States, uses a national mark (Feroca) with a good price and performance.

-- At vary one of the main components of the fómula was again should characterize the impeller through successive static testing and rename the impeller (RNX-42 to NEPOX) to avoid confusion and to have their own characteristics.

-- The outcome of the formulation described is a propellant combustion eventually controlled with few requirements for structural strength of the tube that contains it.

Grain of propellant ended NEPOX

Preparation of propellant based erythritol

	Eritritol	Xylitol	Mannitol	Sorbitol	Maltitol	Isomalt	Lactitol	Sucrose
No. Carbonos	4	5	6	6	12	12	12	12
Molecular Weight	122	152	182	182	344	344	344	342
Q. Fusion (° C)	121	94	165	97	150	147	122	190

-42	-22	-39	-5	47	34	33	52
-43	-36.5	-28.5	-26	-18.9	-9.4	-13.9	-4.3
> 160	> 160	> 160	> 160	> 160	> 160	> 160	<150
2-10	2-10	2-10	2-10	2-10	2-10	> 3	Hydrolyzed
36	66	18	72	60	28	58	67
MuyBaja	Low	MuyBaja	High	Low	Low	Media	Media

Upon hearing some details of this polyol that would improve both the development of the grain as the general characteristics of the reactor, it was decided to develop a propellant based on erythritol.

Erythritol has a number of sweetener E968 and number of CAS 149-32-6. Being a product of recent approval in the European Union, there was some difficulty in purchasing on Spain. (Written at June 25, 2007).

The C4H10O4 has used the trade name C * Eridex 16954, comes from Italy, has a purity of 99.5% and is food grade.

It presents an appearance of odorless white crystalline powder particle size of less than 200 microns. Decomposes combustion carbon dioxide, carbon monoxide and water.

Erythritol mixed with KNO3 consistency with slightly melted smooth unlike the previous mixtures propulsion higher viscosity. This feature translates into greater density and ease of encofrar grain, avoiding hidden bubbles and cracks that could cause disastrous consequences during combustion. To pour the molten propellant can be used with a cacito handle.

The impeller is made based on erythritol in the same way that the impeller based on sorbitol. The difference is in the shuttering, because here, thanks to the lower viscosity above, the propellant is poured molten and hardly use the spatula.

The temperature at which we must bring the mixture is 125-135 ° C and should be monitored by a thermometer immersion.

From the standpoint of the benefits, we must increase the relationship "area combustion / throat of the nozzle (Kn). The combustion is slower and the curve push practice conforms much to the theory, avoiding peaks and lack of horizontality.

There is more difficult than others to get started burning propellant, which must permeate with a black powder coating exposed areas of the grains.

The combustion test is fairly slow to an atmosphere, but there is always the option of adding a catalyst such as Fe2O3.

The rate increases burned, obviously, after the pressurization of the reactor. It requires a kn = 400 or more, so as not to compromise the stability of combustion. Adding a catalyst such as Fe2O3, must consequently lowered the value of Kn.

Evidence combustion KNER

Preparation of gunpowder of priming

Upon completion of the preparation of the impeller and after solidify totally grain should be given a priming powder commercial or manufactured.

The reason for this step is to facilitate combustion in a synchronized manner so that the behavior of combustion that comes closest to the theoretical. Gunpowder helps initiate combustion in those points away from the front of the flame that produces inflamador.

It is a mixture of 75% potassium perchlorate, a 15% charcoal powder and 10% sulphur (non-crystalline). They sprayed the components separately and mixed with distilled or demineralized water.

NOTE: Under no circumstances will be used potassium chlorate due to their high volatility and risk of an accident.

It will form a smooth paste and continue stirring until the porridge completely homogeneous in sight. Using a wooden spoon or plastic covers on a cardboard and allowed to dry in the sun.

NOTE: A colilla cigarette evil can be thrown off by a careless and cause a fire to contact with gunpowder. In any event the area drying must be controlled and be completely safe.

After a few days of sun exposure, will be formed a crust that has to be removed with a spatula. These lumps of crust must be ground by hand with wooden mallet and mortar, without drums or extreme pressures.

The preparation of the powder should be used with extreme caution, following safety guidelines in preparing the propellant because it is very easy inflammation.

Never should prepare, store or transport large quantities, whilst a maximum limit to 100 g each time.

The gunpowder was stored the shortest time possible, in airtight plastic pots, thin-walled and properly labeled.

Types of grain

BATES (BAllistic TESt)

The document NASA/SP-8076 the year 1972 called "Solid propellant grain design and internal ballistics" was declassified by NASA in the last decades of the last century and provides invaluable information on combustion geometries and designs for rocket propellant grains solid propulsion.

Part of this paper explains the operation of the system called BATES. It then expose the foundation and practice of this system to our projects in a concrete way.

Such systems are currently used in both military and design projects for amateurs.

What form a number of segments with optimized measures.

The acronym BATES comprises BAllistic TESt and constitutes one of the most important designs to control the combustion within a jet solid rocket propulsion.

In practice, we call BATES each of the cylindrical segments of propellant grains. Each grain is formed by moulding, is inhibited by the combustion in your hand and has an external cylindrical core axial cylindrical hollow too.

The inhibitor is the same external mold and shape it is finally acceded to the point surrounding and protecting its external diameter of combustion as part of the design BATE. It recommends the cardboard tube laminated aluminium as a material inhibitor.

The inhibitor may be cardboard tube with a thick enough to resist combustion.

Should also be coated with Teflon plumbing nuclei that form the heart and soul of each segment or BATE. This is necessary in order to remove them later with ease.

The system is inhibited BATES externally and produces a thrust theoretical curve shaped gentle convex arc.

The relationship between optimized geometric diameters and lengths of the grains inhibited, produces an amount of surfaces burned relatively constant over combustion.

For ease of ignition is impregnated with the priming powder surfaces side and occasionally the central conduit. It should be noted some separation between the grains interspersing segments separators or conificando grains conveniently.

The advance of the combustion progresses layers from the inside outward in concentric and from the ends inward along the axial axis of the grain.

The progressive cylindrical surface burn progresses outward grain corrects acortándose extremes of this to advance their faces burned from circular side toward the center of its length.

Varying the length of the grains get different geometries combustion, and grain shorter burn regressive and progressive burned longer.

During the operation of the reactor, combustion reaches the nucleus and lateral sides of each grain (or BATE), falling outside the scope of this external cylindrical surface to be covered with material support for it we call inhibitor. This inhibitor formed by moulding the propellant grain or may accede to it later.

The cylindrical core is increasing its area burned during combustion. Moreover, the lateral surfaces diminishing your area becoming increasingly these rings closer.

Under a given geometric relationship between the diameter of the grain internally, externally and length, there is a compensation and as a result is a curve in the shape of an arc relatively "stable", which produces a thrust propulsion "constant," if combustion also it is.

If you shorten the BATES get a boost declining or regressive. If on the contrary the alargamos BATES, we get a push increasing or progressive. All this without changing the rest of the parameters.

This interesting device allows us to decide and dosing geometrically and easily thrust of the rocket propellant.

You may want to further push in the takeoff to stabilize the flight or we agree combustion regressive to offset a high exponent of pressure in a given propellant or under certain conditions.

There is a relationship between the diameter and length of the grain it produces a balanced situation provided that the speed of combustion is uniform.

What / Do = 1.7 (approximately); being Lo = grain length and Do = width of the grain.

Grain unrestricted

This grain of propellant burns layered concentric cylindrical outside to inside and vice versa. It is also often burn their extremes.

Produces when inhibit extremes, a burned neutral by offsetting an area that grows and another decreases.

The rate of burning when not inhibit the edges, is slightly decreasing. This is further accused the shorter length of the grains. When working with exponents of high pressure may be desirable to use grains with geometries retrogressive to offset the increased speed of combustion.

It is necessary to bear in mind that the expensive side show some delay in starting to burn and therefore is printed with gunpowder.

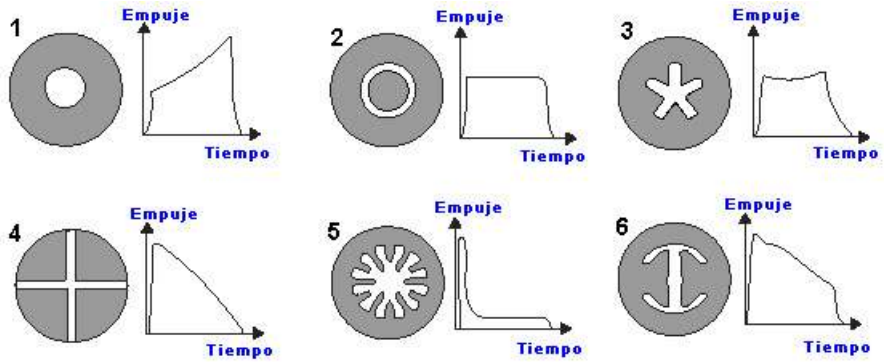
This is a type of grain very reliable and rapid combustion. It apantallarse well inside the tube that contains it because the outer surface enters burning generating high temperatures and could weaken the mechanical strength of the tube that contains it.

This setup is simple grain processing and produces a push very violent but short-lived.

Other types of grain

Depending on the geometry of the grain kernel that runs lengthwise, we found different curves surfaces burned with a value of thrust over time combustion.

Admitting the theoretical concept of a burning layers, it must choose the appropriate form of grain to each design, depending on the other parameters involved. The following charts represent different geometries propellant grain and are the thrust of the reactor as a function of time.



The images have described the external surface inhibited, being in contact with the same tube reactor or the heat shield that protects.

Ignition propeller

The ignition of propellant in any of its configurations of grain, is entrusted to inflamador. See INFLAMADORES.

The propeller chemical energy is converted into kinetic energy by the nozzle. See TOBERAS.

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Photo Gallery

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