Israel Military Industries Ltd. (IMI)

Heavy Ammunition Division

Extrusion of a New LOVA Gun Propellant by TSE

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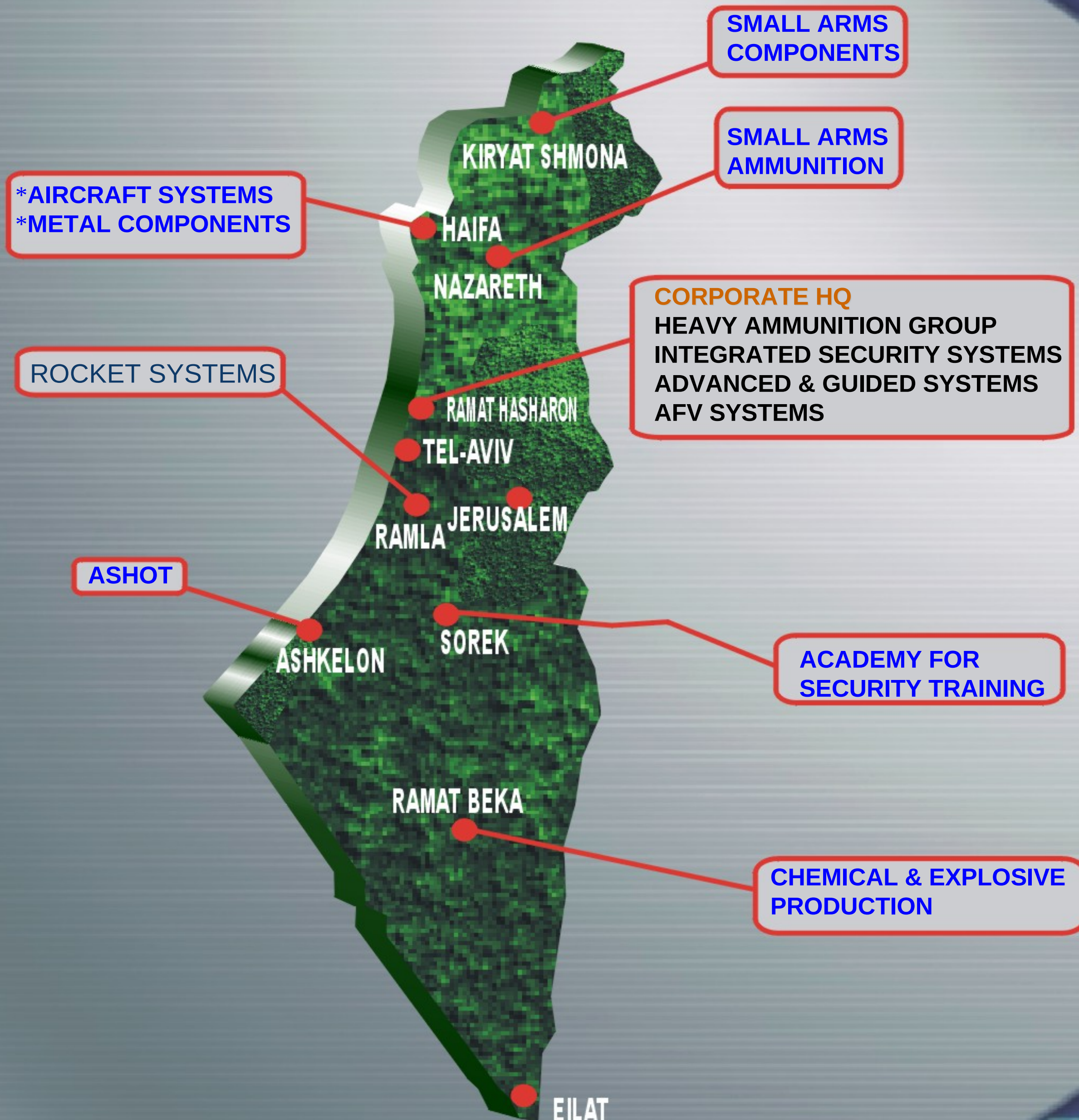
Insensitive Munitions & Energetic Materials 2007

IMI – ISRAEL MILITARY INDUSTRIES

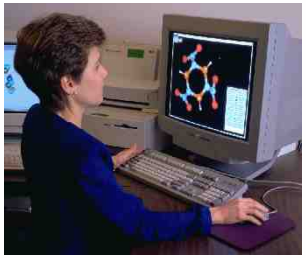


Outline :

- Introduction to high performance LOVA propellant.
- Extrusion Facility & Benefits.
- Design of experiments & processing parameters.
- Safety and performance features.
- Conclusions.

Methodology of New Propellant Development

Synthesis R&D – Lab scale



- Potential energetic materials
- Thermochemical evaluation

Synthesis R&D – Pilot scale

Production

Formulation & testing

Qual. & Ammunition

IMI has introduced a novel LOVA gun propellant

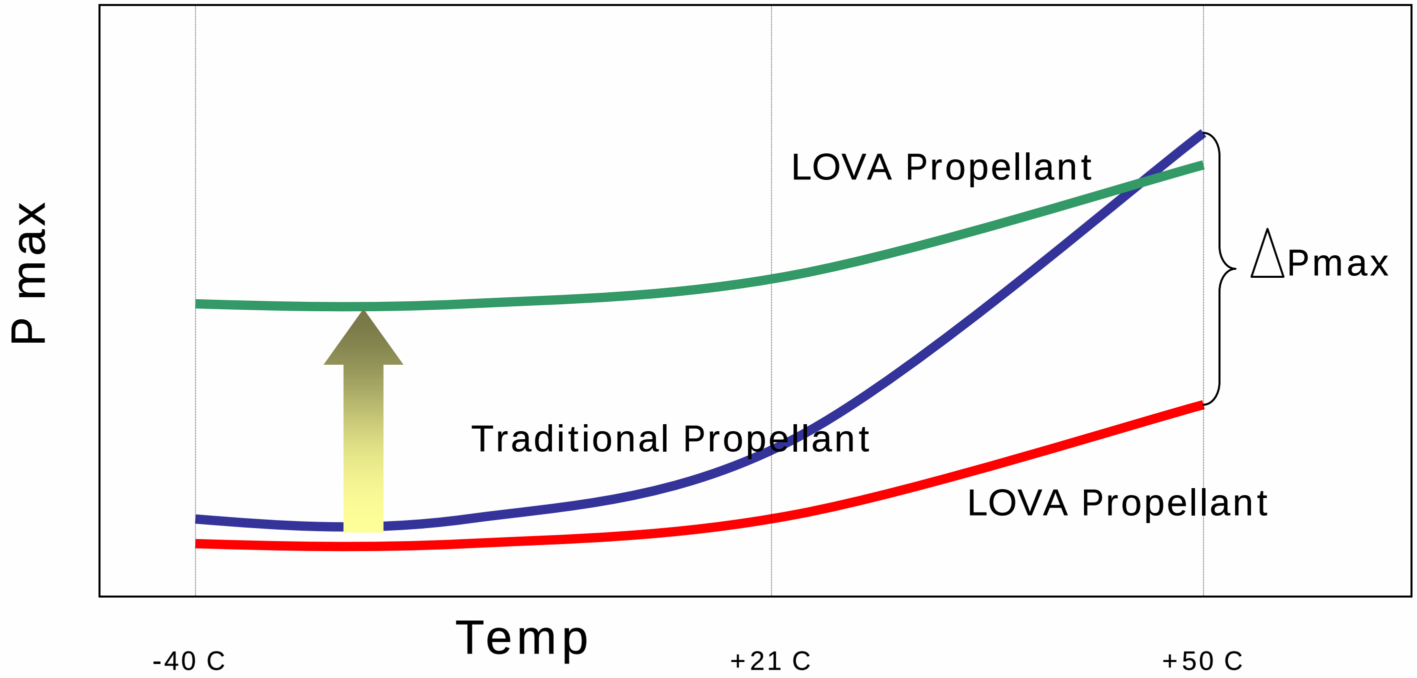
Improved Ballistic performances
- -Higher muzzle velocity
- -Low flame temperature (< 3500K)
- -High Impetus (>1200 j/g)

- Stable formulation
- - Low weight loss during aging
- - Low stabilizer degradation

-Enhanced safety properties
- - low vulnerability in IM test
- - Nitroglycerin free

Low Vulnerability Ammunition
(LOVA) Propellant

Typical behavior of gun propellants



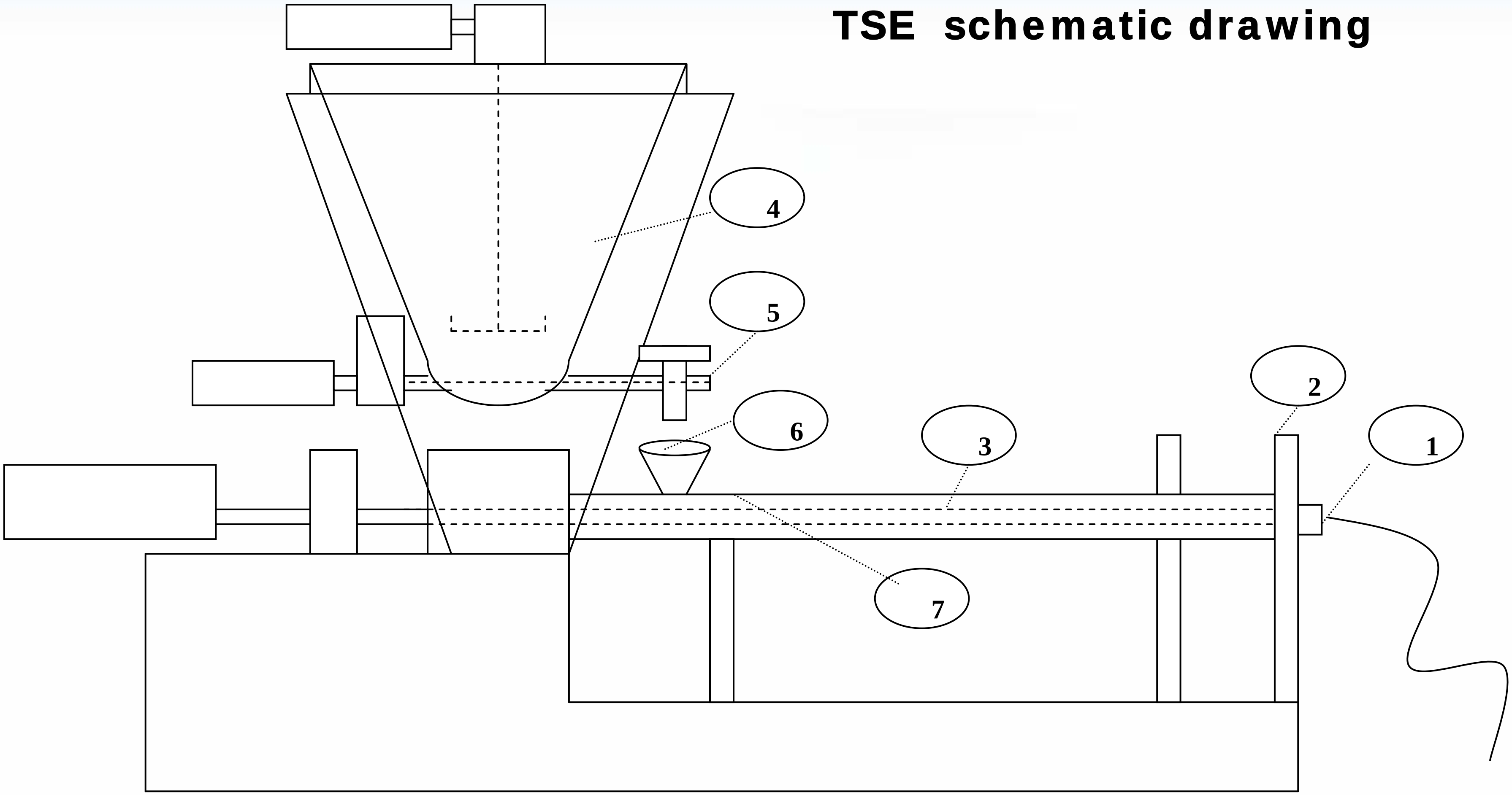
The objectives of this task were:

- **To enhance the safety of the processing of the extruded propellant.**

- **Define TSE Lower & Upper processing parameters to be used for LOVA extruded Powder .**

To enhance the homogeneity of the propellant matrices for a high quality product.

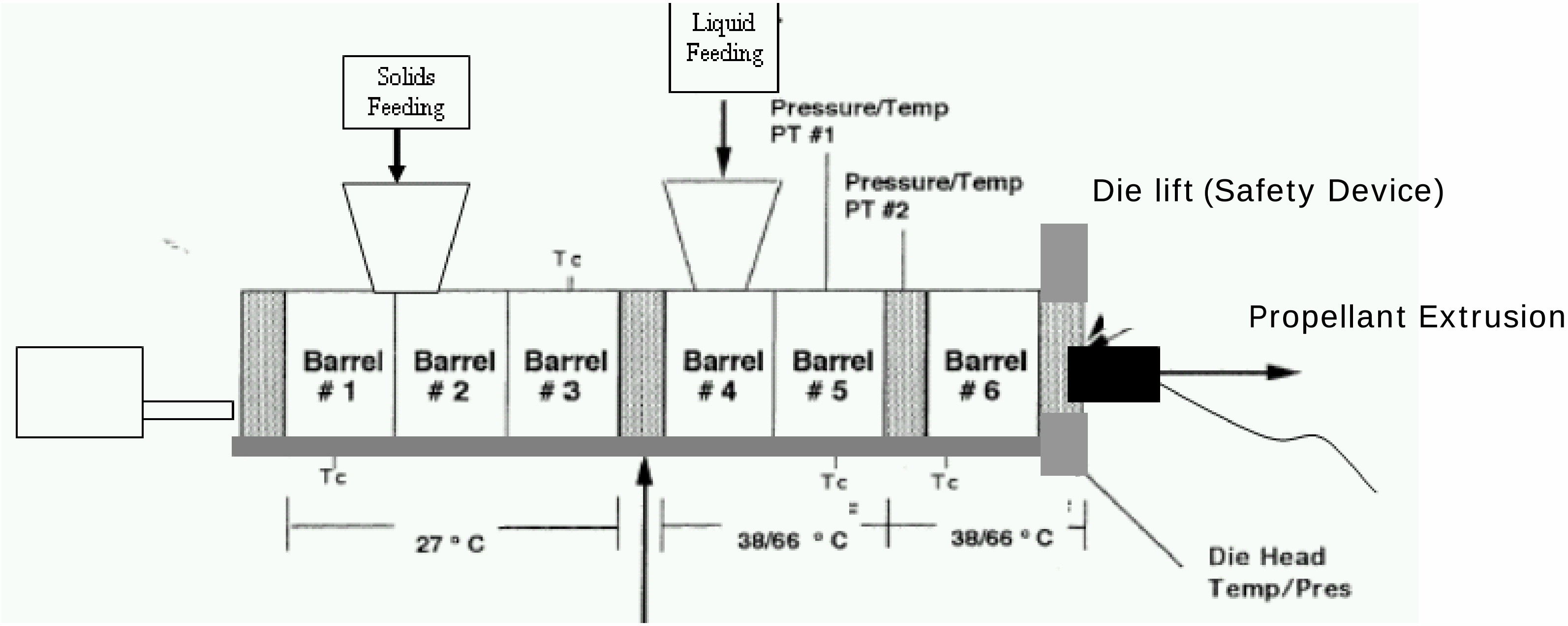
TSE schematic drawing



(1) Strand & Die (2) lift Die – Press relief (3)TSE Compartment (4)Solid feeder (5)Screw Feeder (6) Solids Loading (7) Liquids TSE feeding

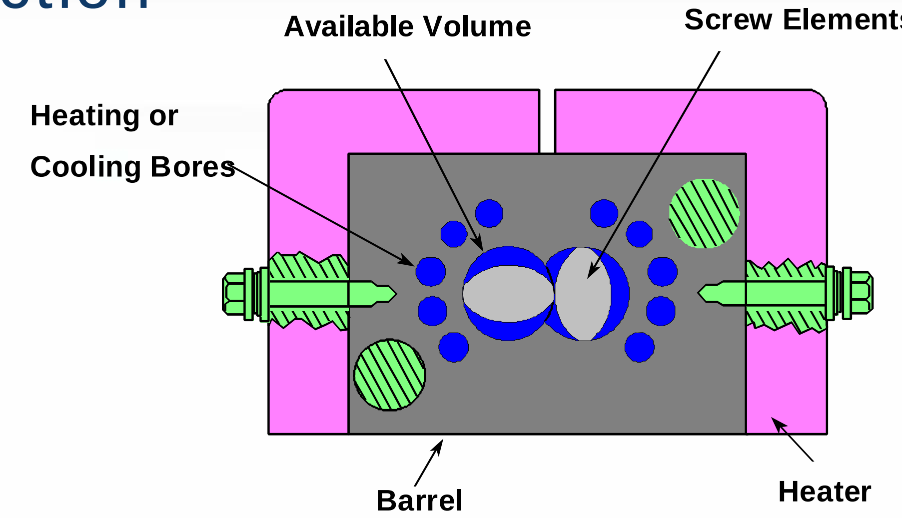
TSE Configuration

Power at 300 RPM	:	5-6 KW
Power Increase Up to	:	370 %
Max. Screw speed	:	600 RPM

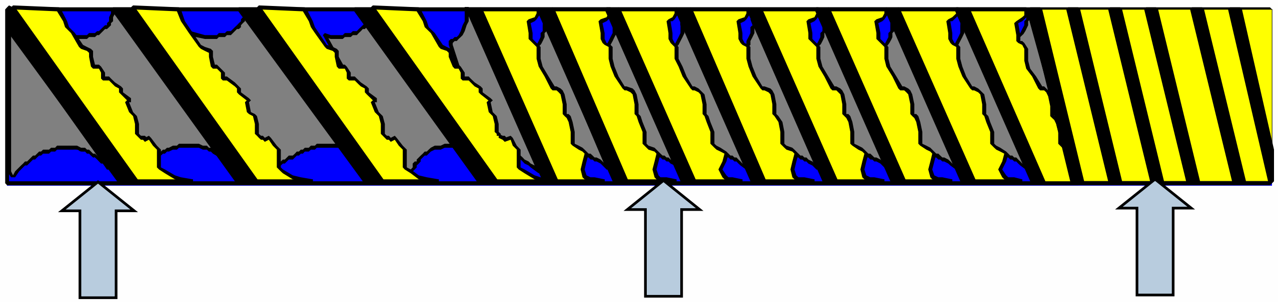


IMI TSE 30 For LOVA Extrusion

Barrel cross section



Working Principle



Large Pitch
(Feeding/ Venting)

Medium Pitch
(Conveyance)

Narrow Pitch
(Pressurization
Heat Transfer)

Advantages of TSE compared to CEP

CEP – Conventional Extrusion Press.
TSE – Twin Screw Extruder.

Parameter	CEP	TSE
Potential Hazard	40 Kgs. Under pressure.	Less than 0.5 Kgs along the barrel.
Area Facility	Huge (High cost..) Mixing blocking, straining, and extruding processes big sites.	Mixing blocking, straining, and extruding processes with one continuous process. Low maintenance cost.
Process Waste Propellant	From Every Block	Negligible – Waste from Start Up & Shut down only !
Environmental Pollution Volatile Organic Compound	Very High !!	Very Low – **Green Process**

Experimental Tests

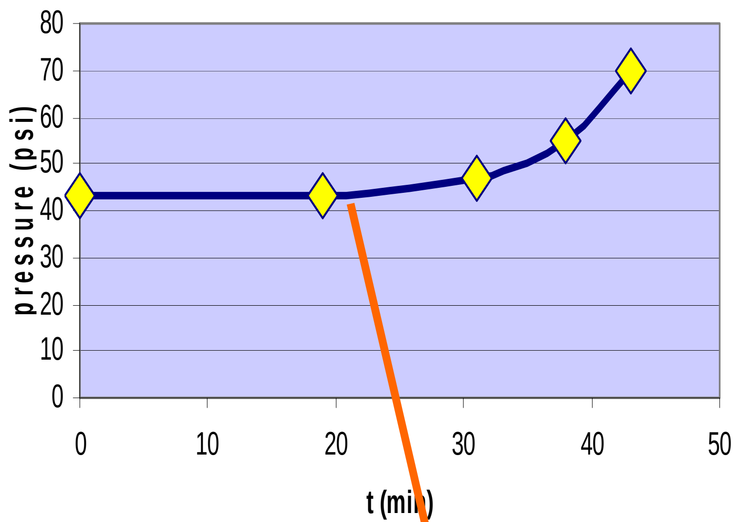
A LOVA propellant composition (NC, Nitramine, Plastisizer) was manufactured & investigated using different extrusion technologies :

- CEP – Conventional Extrusion Press.
- TSE – Twin Screw Extruder.

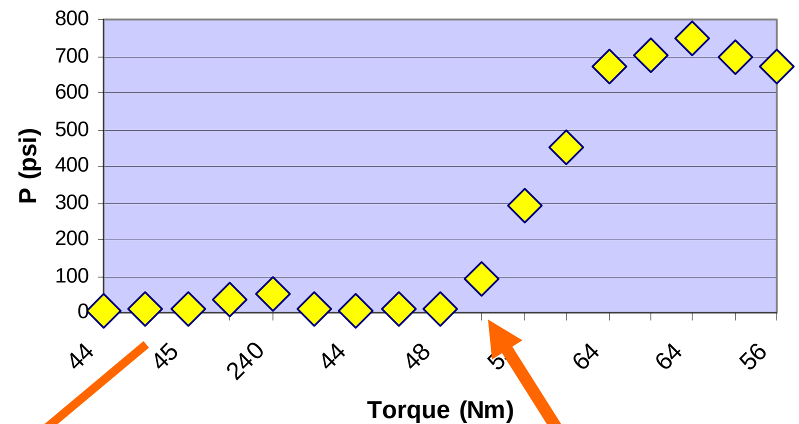
	CEP	TSE
Method	Solvent	Solventless
Throughout Pressure	50-80 Bars	40 Bars
Flow rate	100-150 Lb/hr (Batch)	40-50 lb/hr (Continuous)
Loaded Material	Batch Paste	Premix

Screw Extrusion parameters

Pressure vs Time



Torque vs Pressure



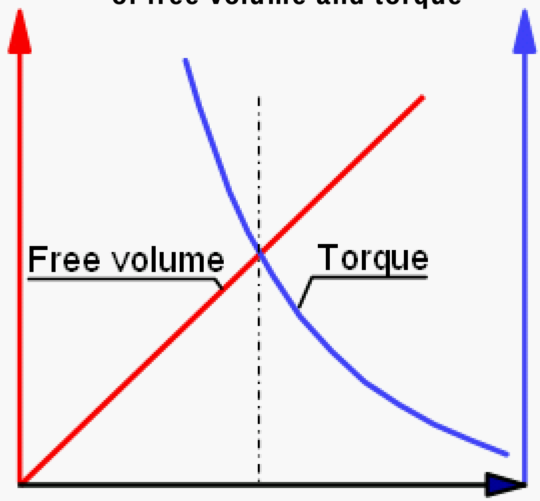
Extrusion start of propellant

Pressure	40 PSI
Torque	40 Nm
Time	23 min
Temperature	40 C

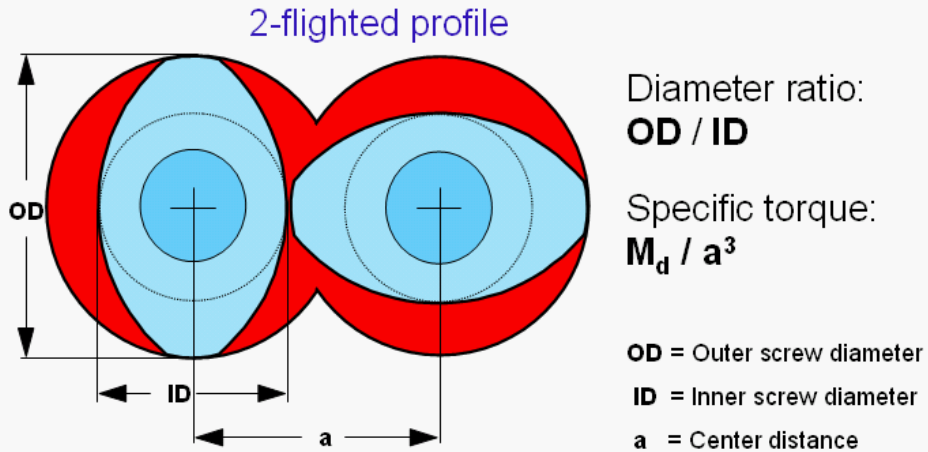
Flow rate augmentation

TSE optimization / working point

Balanced ratio
of free volume and torque



OD/ID
Free volume and permissible torque as a function OD/ID



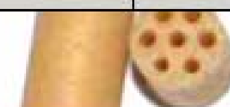
Adjusting the torque to the ratio of the OD to ID of the pitches can optimize the process and enhance safety.

Safety Test results of the final product

Test	Conventional Extrusion	TSE
Friction, Impact Sensitivity & ESD	No Change No Change	
Density	D	D + 0.03
Gap Test (50 cards)	2 Detonations + 3 Deflagrations	5 Deflagrations
Interruption Bomb	No Change	
Pressure Bomb	High Temp. Dependency	Low Temp Dependency

Dimensional Test results of the final product (mm)

Average of 10 indicative grains

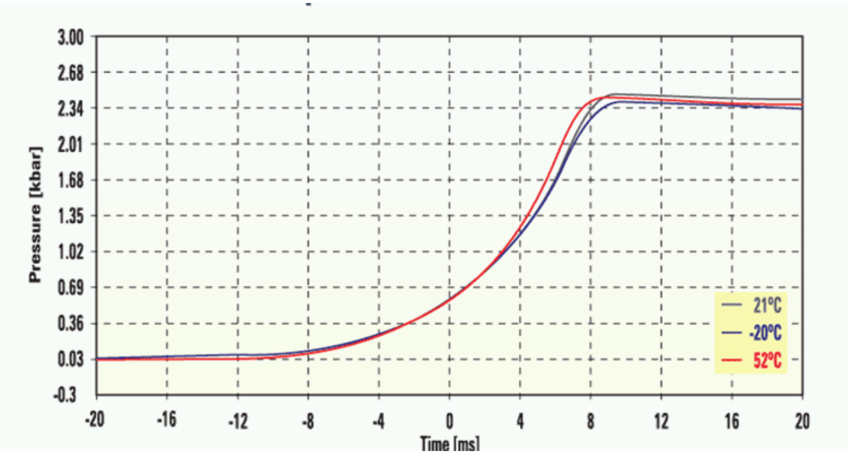
	WO1	d1	W11	d2	W12	D	L
	 **Conventional Extrusion**						
Average	1.69	0.36	1.66	0.36	1.62	7.74	13.62
S.D	0.15	0.06	0.18	0.05	0.11	0.07	0.41
	TSE 						
Average	1.69	0.34	1.67	0.34	1.63	7.75	13.65
S.D.	0.08	0.04	0.05	0.03	0.09	0.08	0.29

The single grain propellant geometry was found more accurate (lower s.d.) for TSE compared to conventional extrusion.

This can lead to better ballistic performance.

Barometric Closed Bomb of an Extruded LOVA propellant

Conventional Extrusion



TSE

TSE improves homogeneity and therefore enhances performance

Conclusions & Summary

- IMI has introduced a novel LOVA gun propellant. Safety and reliable manufacturing process, were concerns.
- An extrusion process was found safe and appropriate by using a working condition, which is an optimized combination between torque and free volume .
- Safety tests has shown a less sensitive product.
- High quality product enhances safety and ballistic performance.

Acknowledgments

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