QuickField[™] applications : DC Electromagnetic plunger

Part 1 : DC Magnetic plungers and specs | Part 2 : Designing a plunger | Part 3 : Virtual tests for design and production

Note 1 : **Bleu** : information will appear on hovering. **Vert** : to an internal link . **Orange** : to an external link. Note 2 : **F11** turn your browser in presentation mode (Opera browser only).

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Part 1 : DC Magnetic plungers and specs

Part 2 : Designing a plunger

Part 3 : Virtual tests for design and production

Magnetic DC plungers and specs

- <u>Different types</u>
- <u>Force/stroke characteristics</u>
- <u>Timing characteristics</u>
- Environment conditions
- <u>A simple design</u>





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(Photo from MSA products catalog)

Magnetic DC plungers and specs

- Different types
- <u>Force/stroke characteristics</u>
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- <u>A simple design</u>



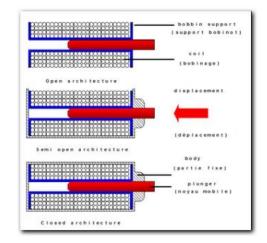


Different types

- C frame plunger solenoid (semi open architecture)
- D frame plunger solenoid (closed architecture)
- Tubular plunger solenoid (closed type)



(photos from MSA Products catalog)



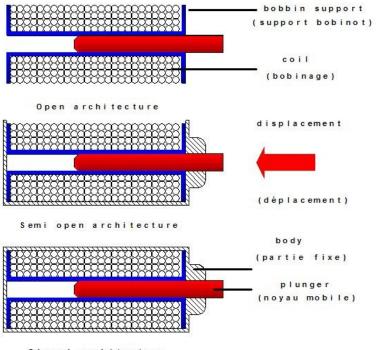
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Different types (page 1/2)

- Open architecture
- Semi open architecture
- Closed type



Closed architecture

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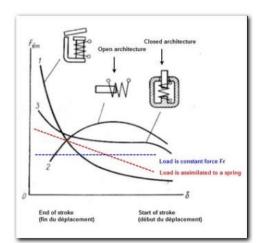


Different types (page 2/2)

- C frame plunger solenoid
- D frame plunger solenoid
- Tubular plunger solenoid



Force vs stroke



Force/stroke characteristics

The Force/stroke characteristics gives the static force according the displacement of the core. The shortest is the flux path, the strongest is force.

Main points

- The maximum force is very different for each type
- The plunger force must superior to the load force, and the higher is the difference, the faster is the plunger.
- The length of the stroke is dependent of the plunger type

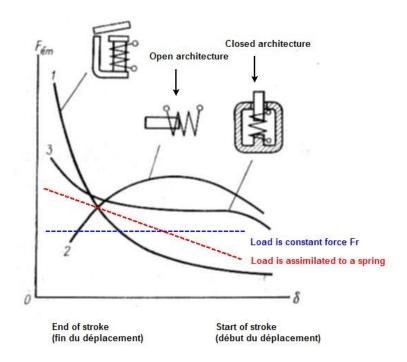
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Force/stroke characteristics

- Maximum force
- $F_{plunger} > F_{load}$
- Length of the stroke



Timing characteristics

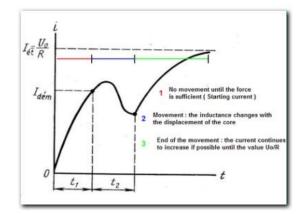
Inrush current

The timing characteristics is important for the applications that require a low response time. The higher is the current to obtain a large force, the longer it will take more time, but the higher the force and the faster is the movement.

Points principaux

- R and L values of the coil
 m × (d²x/d²t) = F_{plunger} F_{load}
- Three steps

Note : The use and calculations of these characteristics will be presented in a next webinar.



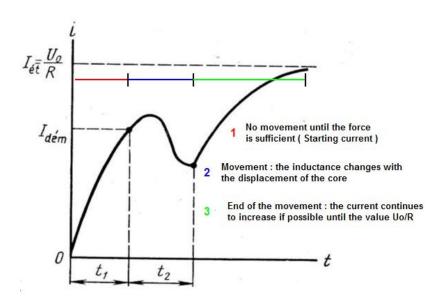
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Timing characteristics

- R and L values of the coil •
- $\mathbf{m} \times (\mathbf{d}^2 \mathbf{x} / \mathbf{d}^2 \mathbf{t}) = \mathbf{F}_{\mathbf{p}} \mathbf{F}_{\mathbf{l}}$ •
- Three steps •



Note : The use and calculations of these characteristics will be presented in a next webinar.

Environment conditions

The modules of Quickfield allow to check the behaviour of the appliance under different thermal, electrical or mechanical conditions. the available modules are : DC magnetics, AC magnetics, Transient magnetics, DC Conduction + Electrostatics, AC Conduction + Electrostatics, Transient Electric, Static and Transient Heat Transfer and Linear Stress.

Possible conditions to be tested

- Thermal use of coil
- Insulation test
- Mounting test

<u>Note</u> : The use and calculations of these characteristics will be presented in a next webinar.

QuickField modules



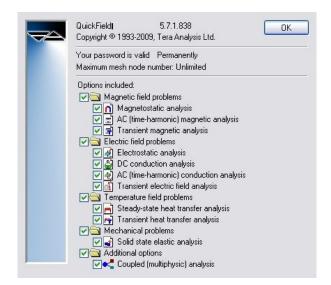
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Environment conditions

- Thermal use of coil
- Insulation test
- Mounting test



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A simple design

Quickfield is pleasant as it's a software that allow you to check simple things very quickkly. Here is an example where you want to ckeck if a linear model can replace a non-linear model (note that as there is no closed magnetical path, the linear choice will always be reasonnable, but the example wants also how to prepare the geometry for use with LabelMover or other modules) Static and Transient Heat Transfer and Linear Stress

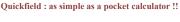
Main steps

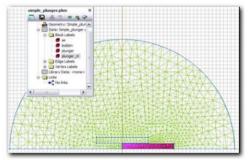
- The main objects
- The bondary conditions
- Problem parametersLabelMover tips
- Thermal tips

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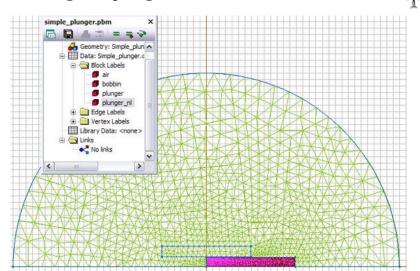
A simple design

- The main objects
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Tubular solenoid from MSA catalog

Designing a plunger

- Datasheet
- <u>Main formulae and calculations</u>
- <u>Designing</u>
- Parameter sweeping with LabelMover
- Improving sweeping with Tcl scripts
- Use of computer algebra systems



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(Photo from MSA products catalog)

Designing a plunger

- <u>Datasheet</u>
- Main formulae and calculations
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<u>Note</u> : The use and calculations of these characteristics will be presented in a next webinar.

Datasheet

- Dimensions
- Profile
- Force
- EnergyTemperature ?
- Response time ?

 \underline{Note} : The use and calculations of these characteristics will be presented in a next webinar.

Size	SMALLEST TUBUL	AR
length-diameter	1 x .5 in.	
	25.4 x 12.8mm	*
Performance (conti	nuous duty coil)	-
Maximum Stroke:)
Force—		
Holding:	27 oz (7.5 N)	<
At Max Stroke:	.39 oz (.11 N)	<
Coil Power:	2.5 watts	

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IBULAR	stics of 14 different Tu	ıbular solenoids withir	CUSTOMIZABL
Size length-diameter	SMALLEST TUBULAR 1 x .5 in. 25.4 x 12.8mm	LARGEST TUBULAR 3.2 x 1.5 in. 81.3 x 38.1mm	Direction of Actuation Available: Push or Pull
Performance (conti Maximum Stroke: Force—	nuous duty coil) .25 in. (6.35mm)	1 in. (25.4mm)	Frequently Customized Features Include:
Holding: At Max Stroke:	27 oz (7.5 N) .39 oz (.11 N)	250 oz (69.5 N) 18 oz (5 N)	Plunger interface, spring return, mounting threads/brackets, coil
Coil Power: Higher forces can be ad power to the coil.	2.5 watts shieved by changing the di	15 watts uty cycle and input	voltage/wattage, force/stroke.

Datasheet • Dimensions • Profile • Force • Energy • Temperature ? • Response time ?

<u>Note</u> : The use and calculations of these characteristics will be presented in a next webinar.

Main formulae

Algèbre 1 first_calculations.dfw Algèbre 2 formulae.dfv • Force at the end of the stroke Current density in conductor = $6~\text{A/mm}^2$ U = 1.2 V P = 2.5 W Bmax = 1.8 T Holding stroke = 5~NMechanical • Electrical power Bmax = maximum magnetic field Score = section of the core µ0 magnetical constant Calculations 2 Bmax ·Score 2 Bmax +Score #1: Fem = $\frac{bmax}{2 \cdot \mu 0}$ Core section SOLVE Fem = #1: Score 2·µ0 • Wire section -6 Score = 1.318693212.10 Electrical #2: P = power U = DC voltage I = current #3: Rcore = 0.0011 $I = \frac{P}{U}$ #4: #2: P = U.I I := 2.083333333 #5: <u>Hypothesis</u> : The numbers proposed allow to design acoil with a small number of turns for the webinar but usually the number of turns is much higher a plunger Swire $=\frac{2}{6}$ #6 -3 Dwire := 0.6.10 #3: #7:

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🖭 Alg	èbre 2 formulae.dfw	Algèbre 1 first_calculations.dfw	
	Mechanical Bmax = maximum magnetic field Score = section of the core µ0 magnetical constant	Current density in conductor = 6 A/mm ² U = 1.2 V P = 2.5 W Bmax = 1.8 T Holding stroke = 5 N	
#1:	$Fem = \frac{\frac{2}{Bmax} \cdot Score}{2 \cdot \mu 0}$	#1: SOLVE $Fem = \frac{Bmax \cdot Score}{2 \cdot \mu 0}$, Score	
	Electrical P = power U = DC voltage I = current	#2: Score = 1.318693212.10 #3: Rcore = 0.0011 P	
#2:	P = U.I <u>Hypothesis</u> : The numbers proposed allow to design acoil with a small number of turns for the webinar but usually the number of turns is much higher a plunger	#4: I := #5: I := 2.083333333 #6: Swire := $\frac{2}{6}$	
#3:	x	#7: Dwire = 0.6.10 ⁻³	

Main formulae • Maximum force at the end of the stroke • Electrical power

Calculations • Core section • Wire section

Designing and some tips

• Thermal coefficient for coils

Open architecture if h = coil height, D = Dext

$$\begin{split} &K = 25 \ W/m^2 \times deg \ if \ h/D < 1 \\ &K = 20 \ W/m^2 \times deg \ if \ h/D = 1 \\ &K = 16 \ W/m^2 \times deg \ if \ h/D > 1 \end{split}$$

For other surfaces take

$$\begin{split} K &= 5 \ W/m^2 \times deg \ (natural \ convection) \\ K &= 80 \ W/m^2 \times deg \ (forced \ convection) \end{split}$$

(For final design these data must be checked)

• Filling coefficient of windings

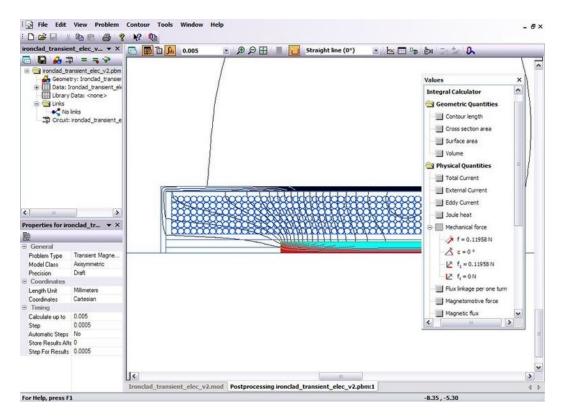
Under a wire diameter of 0.8 mm, this coefficient can be under 0.5 and depends of the type of wire

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Coordinates Length Unit	Draft Milmeters Catesian	f = 0 N Fiux Inkage per one turn Magnetonotive force
Timing Calculate up to Step Automatic Steps Store Results Afre	0.0005 No	All Hagnetic flux

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Designing

Example from MSA catalog

Virtual tests for design and production

- General issues
- <u>Thermal model</u>
- Insulation model
- Mounting model
- <u>Tolerance analysis</u>

 \underline{Note} : The use and calculations of these characteristics will be presented in a next webinar.



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Virtual tests for design and production

- General issues
- Thermal model
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(Photo from MSA products catalog)

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General issues

- Think about a global geometry
- Linearize as much as possibleTransient simulations are longer
- Use circuit (for accuracy and understanding)



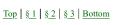
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