EDM – RC type generator formula

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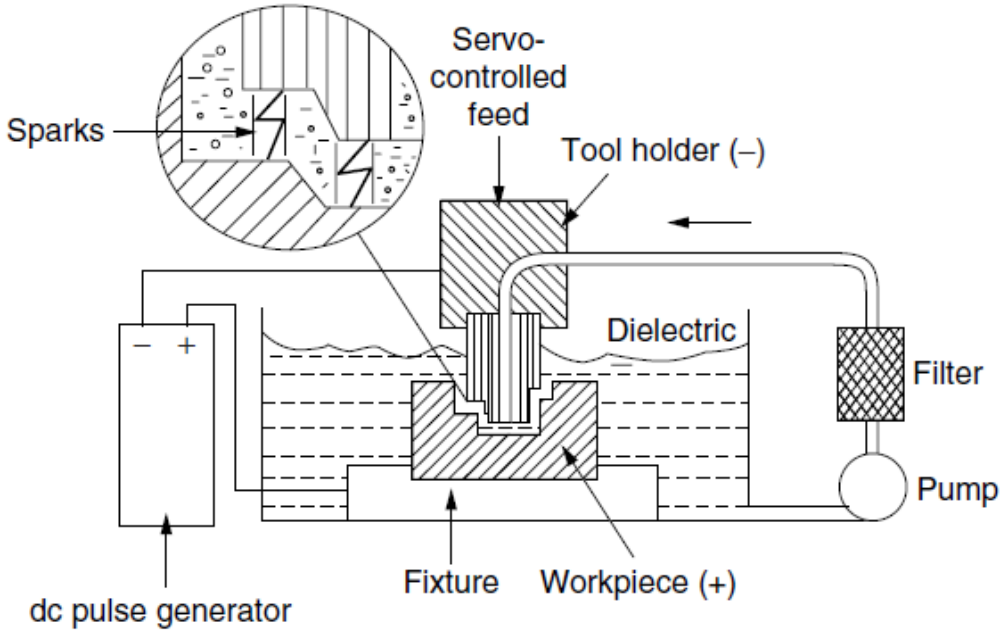
Machine Structure



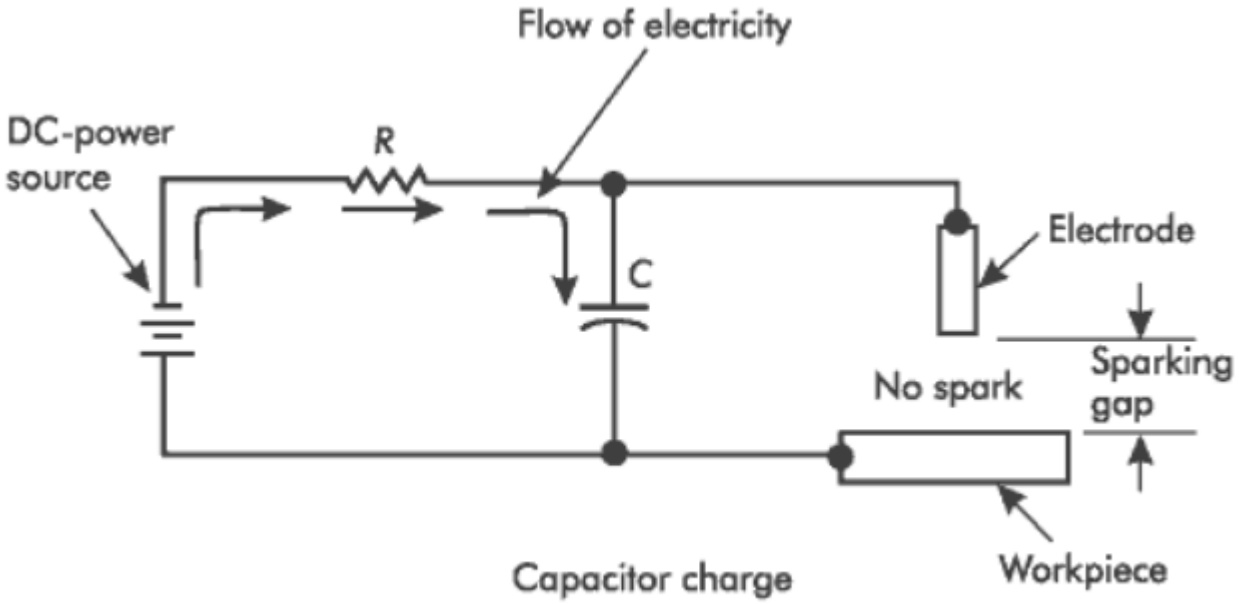
Machine consists of four main elements:

1- Power supply system
2- Tool feed system (Gap control system)
3- Dielectric system
4- Machine mechanical components

There are 3 mains power supply systems as:

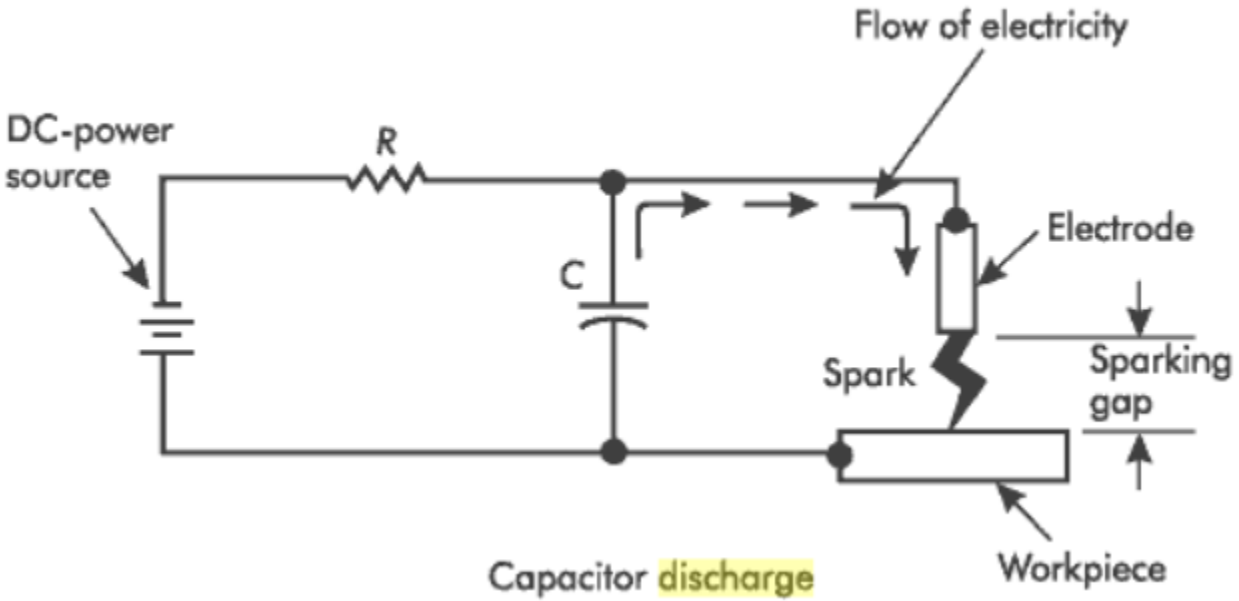
1- RC type generator
2- Iso frequency generator
3- Iso pulse generator

Capacitor charging



In this Figure, electricity flows from the DC-power source through the resistor and stored in the capacitor. Capacitor is charged to its electrical capacity, then it discharges through the electrode to the workpiece, and lastly through the sparking gap in the form of a spark. Spark-off time is the time when the capacitor is being electrically charged. Spark-on time is when the capacitor is fully discharged.

Capacitor discharging



In this Figure, when the capacitor is discharge, electrode will produce a spark through the sparking gap. For RC circuit, on time is when the capacitor discharge time and off time becomes charge time. This flow will make the generator on and off automatically.

RC generator system-Charging

During charge, at any instant, from circuit theory we have:

$$V_c = \frac{1}{c}\int i(t)dt \quad \Rightarrow \quad i(t) = c\frac{dV_C}{dt} \quad (1)$$

$$\begin{cases} V_R = Ri(t) \\ V_0 = V_R + V_c \end{cases} \quad \Rightarrow \quad V_0 - V_C = R\, i(t) \quad \Rightarrow \quad i(t) = \frac{V_0 - V_C}{R} \quad (2)$$

$$(1),(2) \Rightarrow \frac{V_0 - V_C}{R} = c\frac{dV_C}{dt} \quad \Rightarrow \quad \begin{cases} \frac{V_0 - V_C}{R} = c\frac{dV_C}{dt} \\ t = 0 \Rightarrow V_c = 0 \\ t = t_c \Rightarrow V_c = V_C^* \end{cases} \quad \Rightarrow \quad \begin{cases} \boldsymbol{V_C^* = V_0(1 - e^{-\frac{t_C}{RC}})} \\ \boldsymbol{i_c = \frac{V_0}{R}e^{-\frac{t}{RC}}} \end{cases}$$

So , in general the charging Voltage and Current are:

$$\begin{cases} \boldsymbol{V_C = V_0(1 - e^{-\frac{t}{RC}})} \\ \boldsymbol{i_c = \frac{V_0}{R}e^{-\frac{t}{RC}}} \end{cases}$$

where,

I_c = charging current
V_o= open circuit voltage
R_c= charging resistance
C = capacitance
V_c= instantaneous capacitor voltage during charging

RC generator system-Discharging

During Discharge, the electrical load coming from the EDM may be assumed a totally resistive and is characterized by a machine resistance of R_m Then the current passing through the EDM machine is given by:

$$\begin{cases} i_d = \dfrac{V_c}{R_m} \\ i_d = -c\dfrac{dV_c}{dt} \end{cases}$$

The negative sign in front of the derivative of the voltage represents that the Vc is gradually decreasing during discharging. Now at t=0 (i.e. at the start of sparking, i.e. initiation of spark) Vc=Vc* and t=td, Vc=Vd*

$$\begin{cases} \dfrac{dV_c}{V_c} = -\dfrac{dt}{\boldsymbol{R_m C}} \\ t = 0 V_c = V_c^* \\ t = t_d V_c = V_d \end{cases} \qquad \begin{cases} \boldsymbol{V_d = V_c^* e^{-\frac{t_d}{R_m C}}} \\ \boldsymbol{i_d = \dfrac{V_c^*}{R_m} e^{-\frac{t_d}{R_m C}}} \end{cases}$$

RC generator system-Discharging

The charging time or idle time or off time, tc, can be expressed as:

$$T_c = RCLn\left(\frac{V_0}{V_0 - V_c^*}\right)$$

The discharging time or machining time or on time, td, can be expressed as:

$$T_d = R_m CLn\frac{V_c^*}{V_d}$$

Frequency of operation, f is:

$$F = \frac{1}{T_c + T_d} = \frac{1}{RCLn\left(\frac{V_0}{V_0 - V_c^*}\right) + R_m CLn\frac{V_c^*}{V_d}}$$

انرژی جرقه به صورت نمایی تخلیه شده و در لحظه شروع مقدار ماکزیمم را دارد. علت آن صفر بودن مقاومت Rm در لحظه شروع تخلیه است.

Total energy discharged through spark gap

$$= \int_0^{t_d} i_d^2 R_m dt = \int_0^{t_d} \frac{V_c^{*2}}{R_m^2} R_m e^{-\frac{2t}{R_m C}} dt$$

$$= \frac{V_c^{*2}}{R_m} \int_o^{t_d} e^{-\frac{2t}{R_m C}} dt$$

$$= \frac{V_c^{*2}}{R_m} \cdot \frac{R_m C}{2} \left| -e^{\frac{-2t}{R_m C}} \right|_0^{t_d}$$

$$= \frac{1}{2} C V_c^{*2} \left\{ 1 - e^{\frac{-2t_d}{R_m C}} \right\}$$

$$\cong \frac{1}{2} C V_c^{*2}$$

انرژی ذخیره شده در خازن

انرژی ذخیره شده =w

$$\int_0^{t_d} R_m i^2(t)dt = \int_0^{t_d} \frac{V_c^{*2}}{R_m} e^{-\frac{2t}{R_m c}} dt = \frac{1}{2c} V_c^{*2}\left(1 - e^{-\frac{2t}{R_m c}}\right) \quad t=\infty \Longrightarrow$$

$$W = \frac{1}{2} C V_c^{*2}$$

Questions???