Guideline to choose the right type and number of EGM-M for handling of brake disks

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Abstract

In the following application note we will explain how to choose the right type of EGM–M to handle brake disks. We will explain how to take care of material, surface, movements of the robot and how to check if the selected EGM is suitable with the cycle time of the handling application.
Then we will explain how is possible to control the EGMs with the PLC of your automated cell.
At the end you can find an example of a real application.

Introduction

Handling of brake disks is a common application in robotics.
Car or trucks brake disks are usually made of cast iron or carbon steel while motorbikes ones can be also of stainless steel.
Often a carbide or paint layer is on the brake surface to increase friction or protect against corrosion.
EGM-M are ideal for their possibility to build a modular gripping system (like in Image 1) with the option to change their position in order to handle workpieces of different type and dimensions.

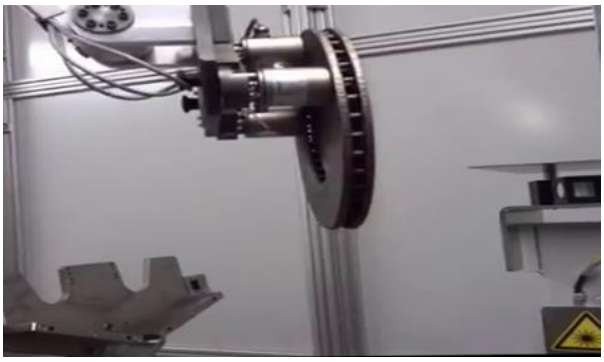

Image 1 - Gripping of brake disks with 3 X EGM-M 30Q

This application note in based on the following hypothesis:

- The disks are in a defined position or, if in a bulk, robot has a vision system able to identify a single disk.
- The disks are at room temperature.

If these hypothesis are not satisfied a special EGM solution is needed.

Gripper design

Our first suggestion is to consider to use a minimum number of 3 EGM-M for each disk, to have a balanced gripper (image 2)

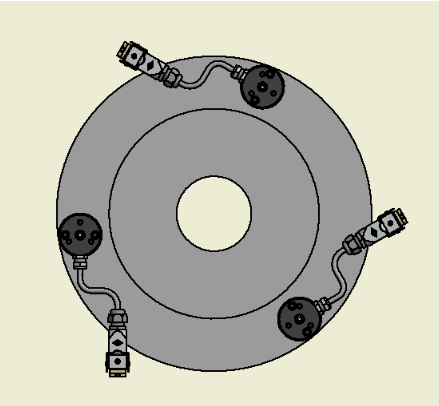

Image 2 - 3 X EGM-M 30Q grip a brake disk

Second step is to choose the type of EGM-M to use.

In a first hypothesis we can consider to grip all the range of workpieces we have to handle using the same model of EGM-M, so the rule we suggest to follow is to choose the EGM-M enough small to lean all its magnetic area against the workpiece.

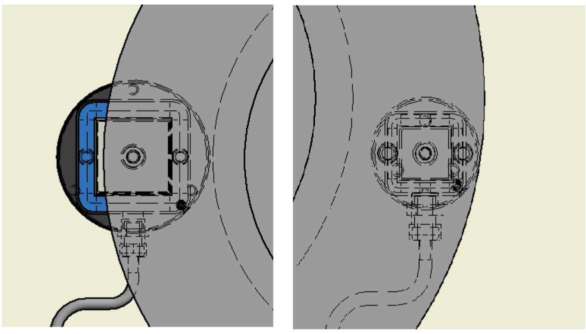

Image 3 - Taking as an example the same case study of image 2 EGM-M 50Q does not lean all its magnetic area against the workpiece, while EGM-M 30Q does.

After doing this we can start to calculate the performance (magnetic force in daN) the selected EGM have on the brake disks we are considering.

Magnetic force of the EGMs depends basically on three factors:

A. Thickness of the workpiece
B. Airgap between the magnetic area and the steel / cast iron surface of the workpiece
C. Material of the workpiece.

Usually in this application the thickness of gripping surface is relatively high (from 10 to 35 mm usually) and near to the thickness at which these EGM reach their maximum force. This mean that in the importance of factors B and C is usually much more important that A . We will focus then on factors B and C.

The force of a generic EGM with a certain airgap can be evaluated from the EGM datasheet (image 4).

The value of the Air Gap, expressed in [mm] can be estimated from the table that follows.

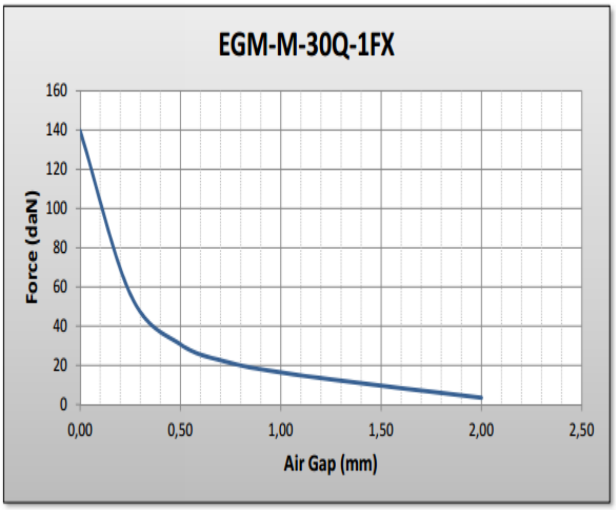

Image 4 Airgap-Force graph of EGM-M 30Q

Material conditions	Estimated airgap [mm]
Machining process leaves no traces or traces you can barely feel with finger nails (examples: Grinding, polishing, finish or good condition milling and turning).	0
Machining process leaves clearly visible traces you can clearly feel with your fingers (examples: Casting, sawing, hot plastic deformation, very rough milling and turning, sandblasting, normal scratches)	0.2
Gripping surface shows signs of light damage. Process leaves clearly visible traces and uneven surfaces (ex. poor casting)	0.5
Painted / coated surfaces	Paint/layer thickness

We have then obtained our first value of the force, that we call $\boldsymbol{F'}$.

Now we must consider factor C.
Considering the most common material already mentioned in introduction we can consider this reduction factors $\boldsymbol{r}$.

Material	Reduction factor $\boldsymbol{r}$
Carbon Steel	1
Cast Iron	0,5
Stainless steel	Generally are non magnetic but some can be. Ask SPD for more infos.

We can then obtain the value of the force of the selected EGM on our workpiece.

$$\boldsymbol{F = F'r}\ [\mathbf{daN}] \qquad \mathbf{(1)}$$

$\boldsymbol{F}$ is not the force value we have to use to calculate the number of EGM we need to handle the workpieces.
In fact we need to introduce an overload factor **S**.
In the hypotesis that we are in an application with normal accelerations (2-5 m/s^2) overload factor depends fundamentally from the position the workpiece assume during the handling

We can identify two possibilities:

1. Brake disk remain always with the axis perpendicular to ground (image 5).
2. Brake disk can assume a position with its axis parallel to ground (image 6)

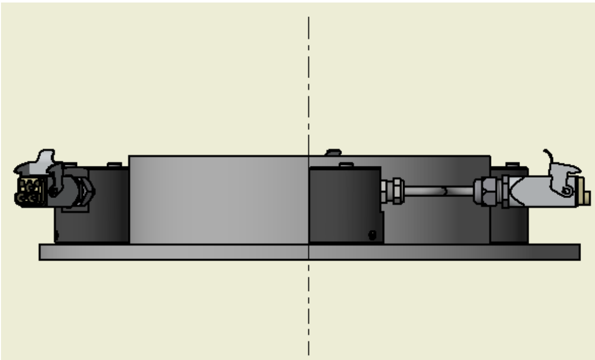

Image 5 Workpiece with axis perpendicular to ground

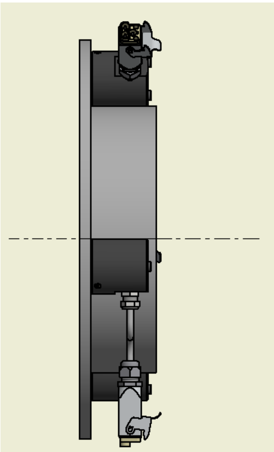

Image 6 Workpiece with axis parallel to ground

SPD suggests to consider overload factor **S=6** if we are in the first situation and **S=15** if we are in the second.

After this we can then calculate $\boldsymbol{F_S}$, that is the force value we will use to calculate the number of EGMs we need.

$$\boldsymbol{F_S = \frac{F}{S}} \ \textbf{[daN]} \qquad \textbf{(2)}$$

We have now to check if , for each of our workpiece if the following inequality is satisfied:

$$\boldsymbol{nF_S > P} \qquad \textbf{(3)}$$

Where:

- $\boldsymbol{n}$ is the number of EGM-M we want to use
- **P** is the weight of the workpiece in daN

If (3) is not satisfied we can make one of the following changes

- Increase the number of EGM $\boldsymbol{n}$
- Change EGM to one with a bigger value of $\boldsymbol{F_S}$.

When we have defined the type and number of EGMs we have to do another important check. EGMs increase their temperature during the operations, until they reach a steady state.
First of all it's important to define the mean number of activation in a minute $\boldsymbol{f}$ [1/min].

It's important to remark that activation mean every change of the EGM status so magnetization but also demagnetization.
After this we can check with a graph the increase in temperature ΔT **[C°]** with a graph that can be finded in the datasheet of each EGM model (image 7).

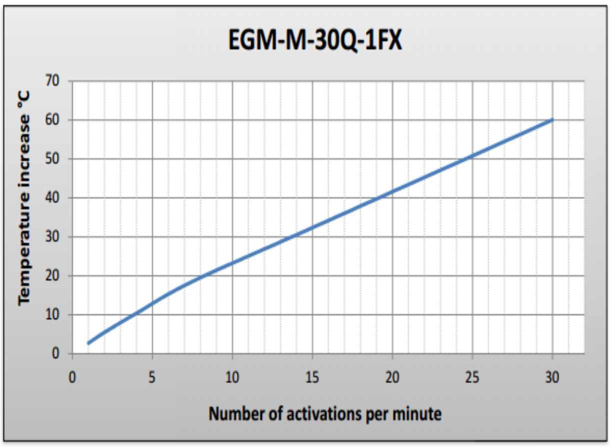

Image 7 – Number of activations/temperature increase graph for EGM-M 30Q-1FX.

Finally we can calculate the temperature that the EGM reach during the operations as

$$\boldsymbol{T = T_r + \Delta T} \qquad \textbf{(4)}$$

Where $\boldsymbol{T_r}$ **[C°]** is the room temperature.

Then we can have two possibility

1. $T < 70°$
2. $T > 70°$

If **1** is true then there are no problems.

If **2** is true then we can have problem of EGM overheating.

In this case you can contact SPD that can help you to find a special solution.

How to control the magnetization of EGMs

To activate the EGMs with the PLC of your automated cell you will need an EGM control device, that we call **ECG**.
The standard supply of the ECG controllers is **400 VAC 50 Hz**, but ECG with different supply are available on request.
A very important thing to take care is also to choose the ECG with the correct setting to control the EGMs selected: different EGM need different setting of the control device ECG. The standard ECGs are available with two different settings that we call **01** and **02**.
On the EGM catalogue or datasheet you can find which setting of the ECG the EGMs you choose for your application need.
Every ECG has three possible input connections from PLC:

- Enable
  (enable the other two inputs)
- Magnetization (from now briefly mag)
  (start a magnetization cycle)
- Demagnetization (from now briefly demag)
  (start a demagnetization cycle)

It’s important to say that the control unit read the mag or demag input only as a rise of the signal level, and not as the value of the level itself, you can easy this in the graph of image 9 that is related to mag (but it’s the same for demag). The duration of the mag or demag cycle depends from the EGM magnet but is usually around 500 ms and generally less than 1 s.

The value of the current that flows through the EGM is function of the number and model of EGM, you can find the value for a single EGM on the datasheet of each EGM model. The maximum number of EGM you can connect on a single ECG is also function of EGM model, and on the datasheet you can find this information too.

From graph of image 9 you can easy see also that the current flows though the EGM only for the short time of the mag or demag cycle: we remember that we are talking about an electropermanent magnets, this means that after the very short mag cycle **the gripper remain magnetized absorbing no current.**

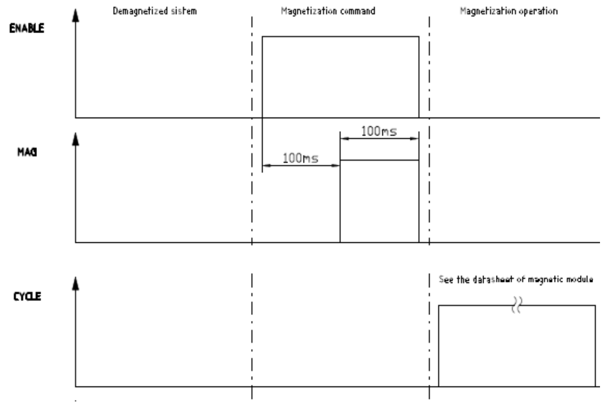

Image 8 – Graph that explain what a ECG controller does when a mag is commanded.

The possible output are two: magnetized or demagnetized. It’s important to note that this does not mean that the workpiece gripped or not, and does not mean also if the EGMs are magnetized or not. It means only that the control unit did correctly the last magnetization or demagnetization cycle.

In some cases (a typical case is when you need to pick up a single workpiece from a bulk avoiding to grip other ones) is necessary to have the possibility to regulate the power of the magnet: is possible to do this with the controller type ECG-R (while letter C identify the version with no power regulation). With this controller you can select 8 possible power level. Very important is that you can magnetize at a low level to grip the workpiece and then you can re-magnetize (without need of a demag before!) the EGM at its full power to handle the workpiece at the maximum acceleration planned for the specific application.

It's possible to connect multiple EGMs to the same ECG: to do this you must connect each EGM in parallel to the others.
In our catalogue you can find standard connection box (**J-BOX**) already prepared to connect togheter 2, 4 or 8 EGMs but if you need we can make also special ones.
For example you can find in image 8 a simple layout with 4 EGM connected to a single ECG using a J-BOX 1-4.

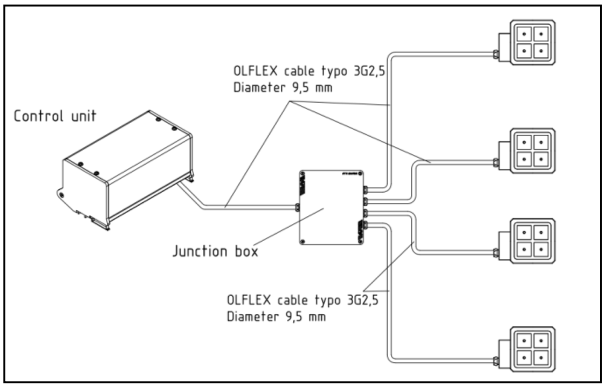

Image 9 - Connection of 4 EGM to a single ECG using a J-BOX 1-4

It's important to remark that because you must connect each EGM in parallel to each other if your PLC would give a magnetization (or demagnetization) command every EGM will be magnetized (or demagnetized). If you need to control independently ***n*** different groups of EGM you must have ***n*** ECG controller (one for each group).

Example

We have to handle carbon steel brake disk.
They have to be gripped from a conveyor and then they have to be placed on a machine. After this they have to be gripped from the machine and placed on another conveyor.
Width of the strip available for gripping 70 mm (image 10).

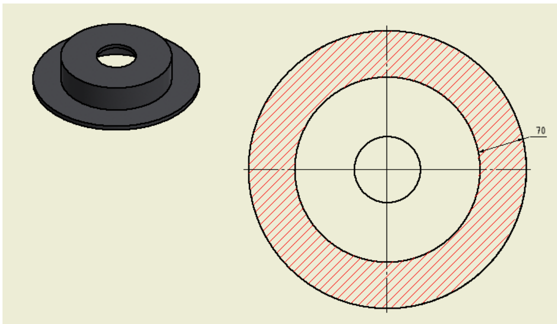

Image 10 Workpiece example

P= 25 daN

We can choose to use **3 x EGM-M 30Q** (magnetic area Ø58 mm).
On the workpiece there is a layer of carbide thickness 0,1 mm.
This mean that we can estimate from image 4:

F'= 100 kg

Reduction factor of carbon steel ***r*** is 1, so

F=F'.

During handling workpiece axis will be parallel to ground so we consider ***S=15***.

$$\boldsymbol{F_S = \frac{100}{15} \cong 6,6[daN]}$$

We now check inequality (3).

$$nF_S = 3 \cdot 6.6 = 19.8 < 25$$

Inequality is not satisfied.
We can think to increase to 4 the number of EGM-M 30Q and re-check inequality.

$$nF_S = 4 \cdot 6.6 = 26.4 > 25$$

Our first hypothesis of solution is then to use **4 EGM-M 30Q-1.**
We can proceed then to check cycle time.
Workpiece are at room temperature that is fixed and is ***T_r=25°.***
The number of activation in a minute $\boldsymbol{f}$ is 4, so with image 7 we can calculate the increase in temperature $\Delta \boldsymbol{T}$ =10°

$$T = 25 + 10 = 35\ [C°]$$

T<70 so it's ok.

We can confirm as a solution
4 x EGM-M 30Q-1.

Workpieces are not in a bulk so we can choose a controller type **ECG-C**. From the datasheet this magnet need the setting **01** and we can connect a max. number of 28 of this EGM to the same control unit.
So we will choose control unit **ECG-C 01**.

We can connect the 4 EGM togheter using a J-BOX 1-4 (image 11).

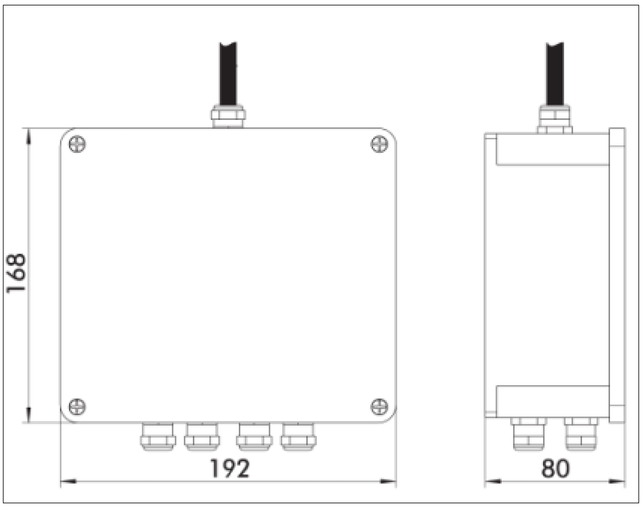

Image 11 – J-BOX 1-4