DECEMBER 28, 2023

# PROJECT EXERCISE 03 REPORT

Selection of electromagnet for the actuator

HARSHIT VERMA
WARSAW UNIVERSITY OF TECHNOLOGY
Faculty of Mechatronics

# 1. Introduction

The voltage source $U_z$ [V] is used to activate the electromagnet after it receives a signal from the microcontroller. The armature and linked valve are then drawn to the electromagnet. The part is then picked up by the feeding mechanism, which is a belt conveyor. For the duration $t_z$ [s], the electromagnet is kept in energized state. The return spring returns the armature to its starting position when the power supply is cut off, and it stays there until the microcontroller sends out another signal. The feeding mechanism has a maximum capacity of $E$ [pcs/h].

# 2. Aim

We Select an electromagnet from the indicated catalogue, which will be used to drive the mechanism that releases individual parts fed to the assembly system for the finished product.

# 3. My data

| No. of data set | $F_t$ | $F_{min}$ | $F_{max}$ | $L$ | $E$ | $t_z$ | $T_{ot}$ |
|---|---|---|---|---|---|---|---|
| 14 | 2 | 3 | 4 | 6 | 900 | 1 | 40 |

$F_t$ – Force of resistance to motion

$F_{min}$ – $Min.$ Force of the spring at the beginning and at the end of the working stroke L

$F_{max}$ – $Max.$ Force of the spring at the beginning and at the end of the working stroke L

$L$ – Working stroke length

$E$ – Maximum capacity of the feeding mechanism

$t_z$ – Time for which the electromagnet is powered

$T_{ot}$ – Ambient temperature

# 4. Electromagnet selection algorithm

In order to choose our solenoid, we first need to perform the calculation mentioned in the manual. We already have data that is going to help us further find out the duty cycle, but we need the data plotted so that the data can be compared with the KUHNKE catalogues.

Since our $F_{min}$ = 3 and $F_{max}$ = 4 and $F_t$ = 2

We can plot a graph to help us:

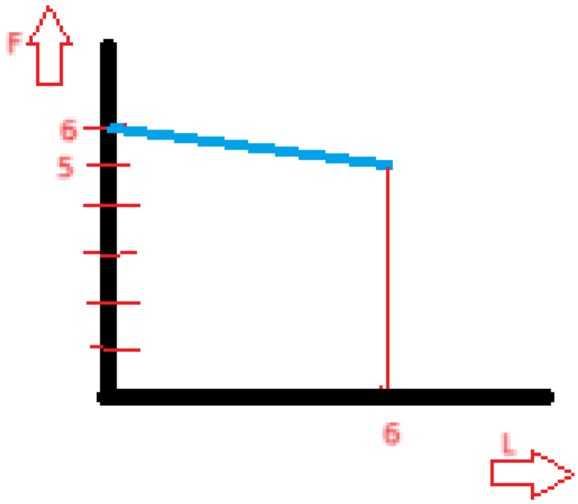



*Figure 4-1 Force vs Stroke diagram of given data*

## 4.1. Calculation of the required duty cycle ED

$$T = 1 \cdot 3600/E = 1 \cdot 3600/900 = 4\ s \qquad \ldots 1$$

$$ED = t_z \cdot 100\%/T = 1 \cdot 100\%/4 = 25\% \qquad \ldots 2$$

**T – length of a single machine cycle [s]**

**ED – Required Duty cycle [%]**

## 4.2. Calculation of the duty cycle ED of the solenoid at 35°C

$$K(\tau) = (\tau\text{-}383)/75 = (313\text{-}383)/75 = 0.93 \qquad \ldots 3$$

$$E_{308} = ED(\tau)/K(\tau) = 25\%/0.93 = 27\% \qquad \ldots 4$$

$\tau$-Ambient Temperature[K]

**K - temperature coefficient [1]**

$E_{308}$ - duty cycle at an ambient temperature of 35°C [%]

## 4.3. Documentation of the selection (characteristics)

Now, since we have $E_{308}$, F and L values calculated for our required solenoid, we can start looking for a solenoid that matches our required solenoid.

After looking at Force vs Stroke diagrams for multiple solenoids, we have selected H 62 Solenoid from the KUHNKE catalogue, since it matches our attributes most precisely.

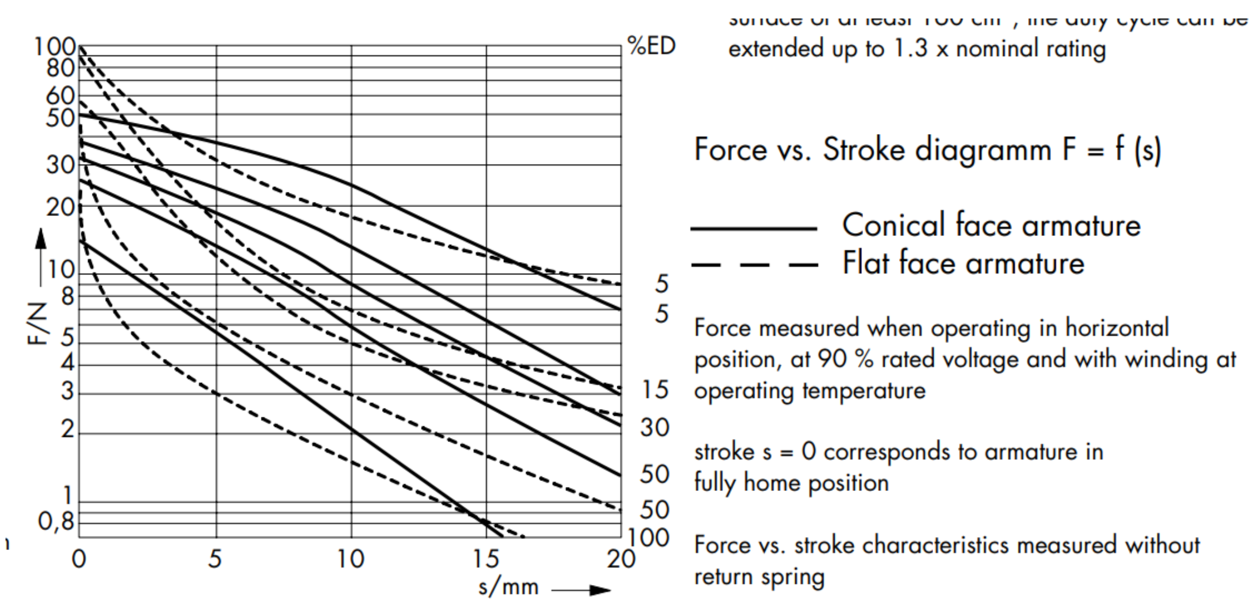



*Figure 4.3-1 Force vs Stroke diagram of selected solenoid*

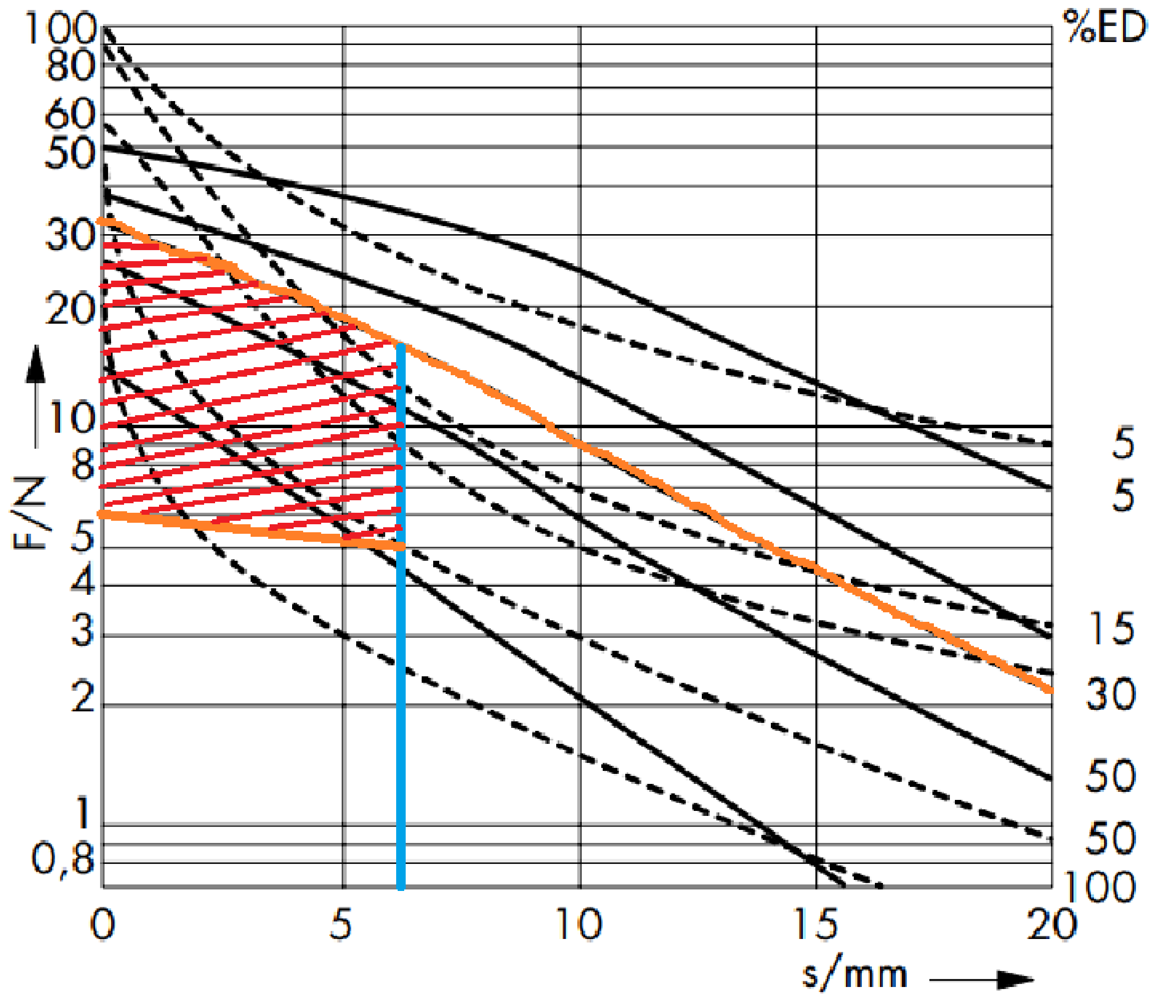



*Figure 4.3-2 Given data inscribed in Figure 4.3-3 to find kinetic energy $E_k$*

We observe in the Figure 4.3-4, the region in red is the required region to find kinetic energy $E_k$.

The specification for the selected electromagnet should be as follows,

**HD6206-F-24 V DC 30% ED**

Each of the attributes are explained as follows:

H-Linear Solenoid

D-Plain Bearing

62-Size

06-Pull Type Solenoid

F-Flying leads

24-Nominal Voltage

30%-ED% selected

## 4.4 Finding Kinetic Energy $E_k$

Using the shaded region in Figure 0-1, we can roughly calculate the kinetic energy of the armature $E_k$. By roughly estimating the sides in Figure 4.4-2, I presume my shape of the shaded region to be a Trapezium. We found the area using formula no.5.

$$A = (a + b) \cdot h/2 = (24 + 18) \cdot 6/2 \approx 126 \text{ mJ} \quad \ldots 5$$

A – Area of trapezium [mJ]

a – One parallel side of the trapezium [1]

b – Other parallel side of the trapezium [1]

h - Distance between the parallel sides of the trapezium [1]

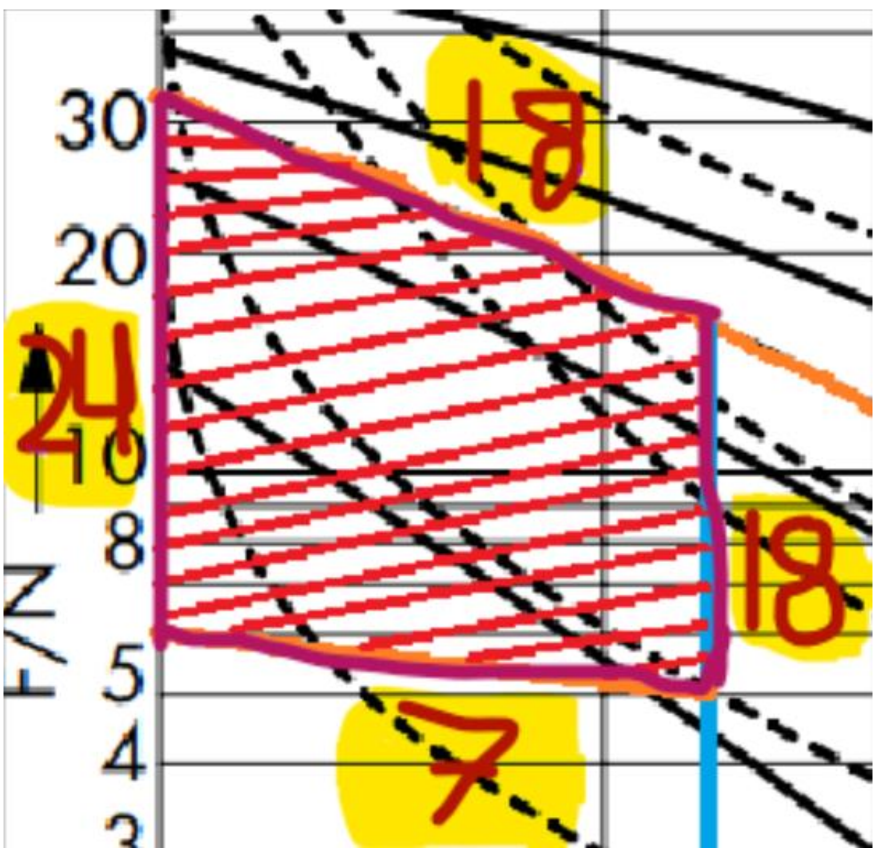



*Figure 4.4-3 Roughly estimated sides give the trapezium shape of the region.*

# 5. Armature speed at end of travel

Now, since we have kinetic energy of the armature at the end of travel, we can find the velocity of armature. Before that we find the value of armature mass from the catalogue.

m = 45 g

$$v = \sqrt{2 \cdot E_k/\mathrm{m}} = \sqrt{2 \cdot 126/45} \approx 2.36\ \mathrm{m/s} \qquad \ldots 6$$

$E_k$ – kinetic energy of armature at the end of travel **[mJ]**

$m$ – armature mass **[g]**

$v$ – velocity of armature **[m/s]**

# 6.Conclusions:

- The method used to select the solenoid that meets specific requirements.
- The selected solenoid meets the specific requirements.
- We do not get high accuracy with this method.

# 7.Literature:


a. MDR_2022 - Proj_Ex_3 – Instruction by J. Wierciak.
b. MDR_2022 - Proj_Ex_3 – Kuhnke catalogue


# 8.Attachments:

Catalogue card of the selected solenoid – Hubmagnet H 62.

## Declaration of Work

I, Harshit Verma, confirm that the work for the following term paper with the title: "PROJECT EXERCISE 03 Report - Selection of electromagnet for the actuator" was solely undertaken by myself and that no help was provided from other sources as those allowed. All sections of the paper that use quotes or describe an argument or concept developed by another author have been referenced, including all secondary literature used, to show that this material has been adopted to support my thesis.

Harshit Verma — Warsaw,
Poland
302601 — 28/12/23

# Hubmagnet
# H 62

Stoßende und/oder ziehende Ausführung

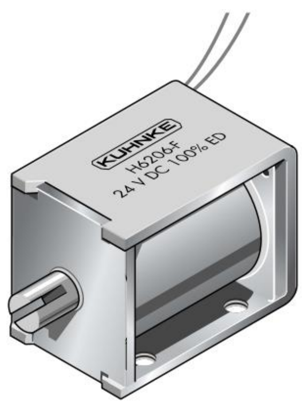
# Linear Solenoid
# H 62

Thrust and/or pull type

| **Bestellformel** | **H** | **D*** | **62** | **06** | **– F –** | **24 V DC** | **100 % ED** | **Order specifications** |
|---|---|---|---|---|---|---|---|---|
| Hubmagnet | H | | | | | | | Linear solenoid |
| Gleitlager | | D* | | | | | | Plain bearing |
| Größe | | | 62 | | | | | Sizes |
| Bauart | | | | | | | | Design type |
| Zugmagnet mit Flachanker | | | | 03 | | | | Pull type solenoid with flat face armature |
| Zugmagnet mit Konusanker[1] | | | | 06 | | | | Pull type solenoid with conical face armature[1] |
| Stoßmagnet mit Flachanker | | | | 43 | | | | Thrust type solenoid with flat face armature |
| Stoßmagnet mit Konusanker[1] | | | | 46 | | | | Thrust type solenoid with conical face armature[1] |
| Kombimagnet mit Konusanker und Rückholfeder[2] | | | | 86-R | | | | Combi type solenoid with return spring[2] |
| Anschlussart | | | | | | | | Coil terminals |
| Litze (Standardlänge 10 cm) | | | | | F | | | Flying leads (10 cm standard length) |
| Flachstecker (optional) | | | | | A | | | Push-on connector (optional) |
| Nennspannung (Standardspannung)[3] | | | | | | 24 | | Nominal voltage (standard voltage)[3] |
| Zulässige relative Einschaltdauer bei Luftkühlung (LK) | | | | | | | 100 % ED | Perm. duty cycle under air cooled conditions (LK) |

1) Nur bei Gleichstrom
2) Die Magnete mit der Bezeichnung H 6286-R-... sind mit einer Rückholfeder F (0 mm) = 2,5 N und F (15 mm) = 0,75 N ausgeführt
3) Die Magnete sind auf Anfrage bis 230 V DC lieferbar

1) Only available for DC
2) Series H 6286-R-... solenoids are available with return spring F (0 mm) = 2.5 N and F (15 mm) = 0.75 N
3) Other voltages are available on request up to 230 V DC




Gewicht:
Magnet: ca. 320 g
Anker: ca. 45 g
Standard:
Spannung: 24 V DC
Litze: 10 cm
Thermische Klasse: B ($T_{grenz}$ = 130 °C)

Isolationsgruppe nach: VDE 0110 C 150
Prüfspannung: 2500 V (eff)
Hohe Lebensdauer durch Ankerlagerung im Kunststoffspulenkörper.
* Auf Anfrage ist dieser Magnet auch mit wartungsfreier Ankerlagerung (Gleitlager) für höchste Lebensdauer lieferbar.

Weight:
Complete solenoid: appr. 320 g
Armature: appr. 45 g
Standard:
Voltage: 24 V DC
Flying leads: 10 cm
Thermal stability: B (max. permissible temperature = 130 °C)
Insulation group according to: VDE 0110 C 150
Test voltage: 2500 V (eff)
Long life expectancy due to armature bearing in plastic bobbin.
* On request, the solenoid can also be supplied with service-free armature bearing (plain bearing) for maximum durability.

| **Zul. rel. Einschaltdauer (ED)[4]** | **%** | **100** | **50** | **30** | **15** | **5** | **%** | **Perm. duty cycle (ED)[4]** |
|---|---|---|---|---|---|---|---|---|
| Nennaufnahme Pn | W | 11 | 20 | 33 | 63 | 156 | W | Nominal coil power Pn |
| Anzugszeit (ED) | ms | 45 | | | | 16 | ms | Actuation time (ED) |

4) Bei Montage auf eine Kühlfläche von mindestens 160 cm² ist die 1,3fache ED zulässig

4) If solenoid is mounted directly onto a flat metal surface of at least 160 cm², the duty cycle can be extended up to 1.3 x nominal rating

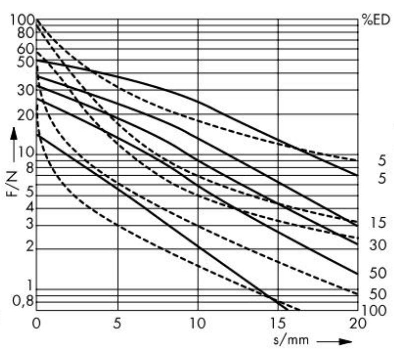
Kraft-Weg-Diagramm F = f (s)

Konusanker
Flachanker

Kraft bei waagerechter Bewegungsrichtung und bei 90 % Nennspannung und betriebswarmer Wicklung

Hub s = 0 entspricht dem angezogenen, bestromten Zustand

Kraft-Wege-Kennlinien sind ohne Feder gemessen




Force vs. Stroke diagramm F = f (s)

Conical face armature
Flat face armature

Force measured when operating in horizontal position, at 90 % rated voltage and with winding at operating temperature

stroke s = 0 corresponds to armature in fully home position

Force vs. stroke characteristics measured without return spring