Multibit Screwdriver

GROUP ME A4

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E/19/203

E/19/204

E/19/211

E/19/218

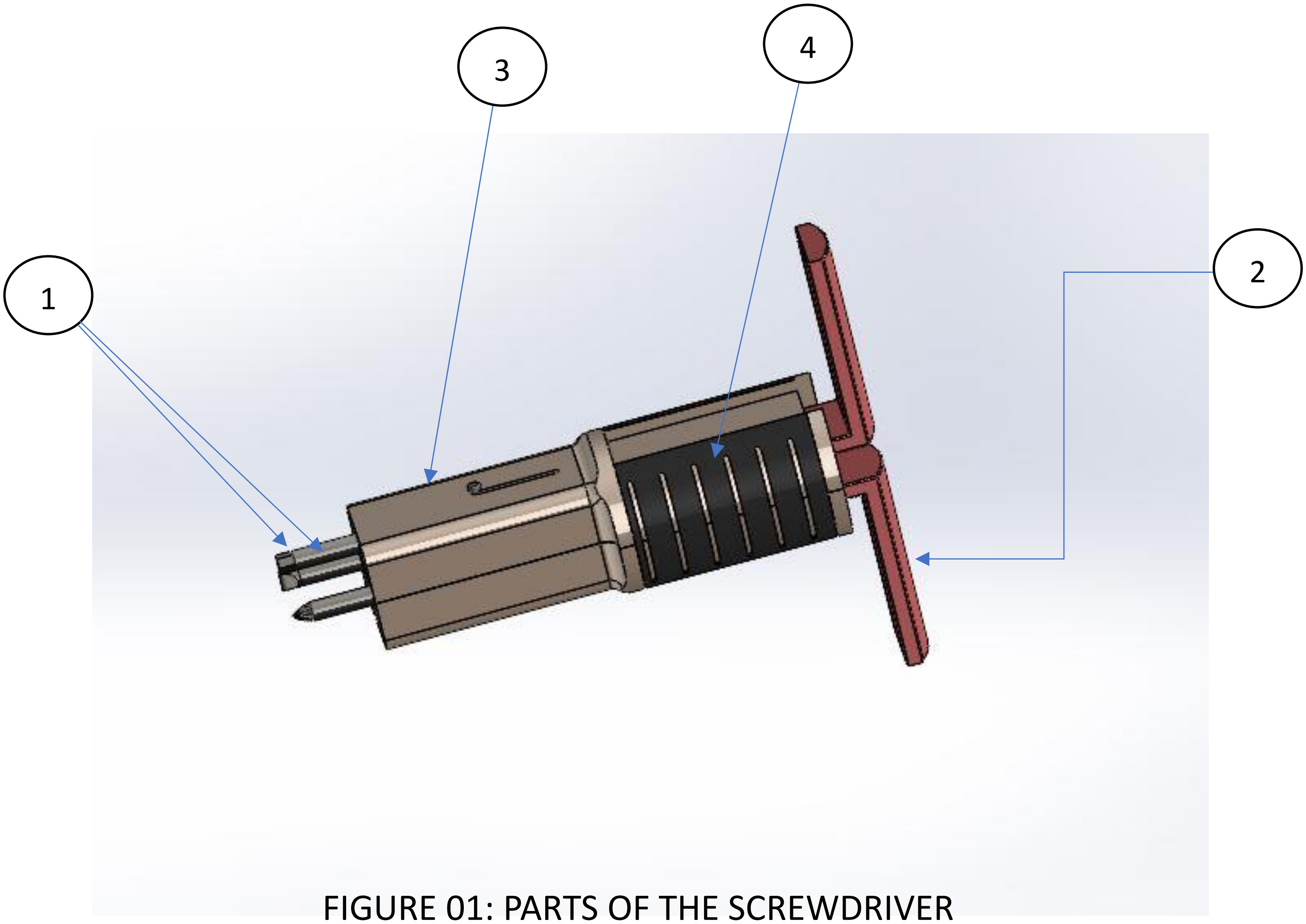


FIGURE 01: PARTS OF THE SCREWDRIVER

1 – SCREW BIT

2 – FOLDABLE HANDLE

3 – HANDLE

4 - GRIP

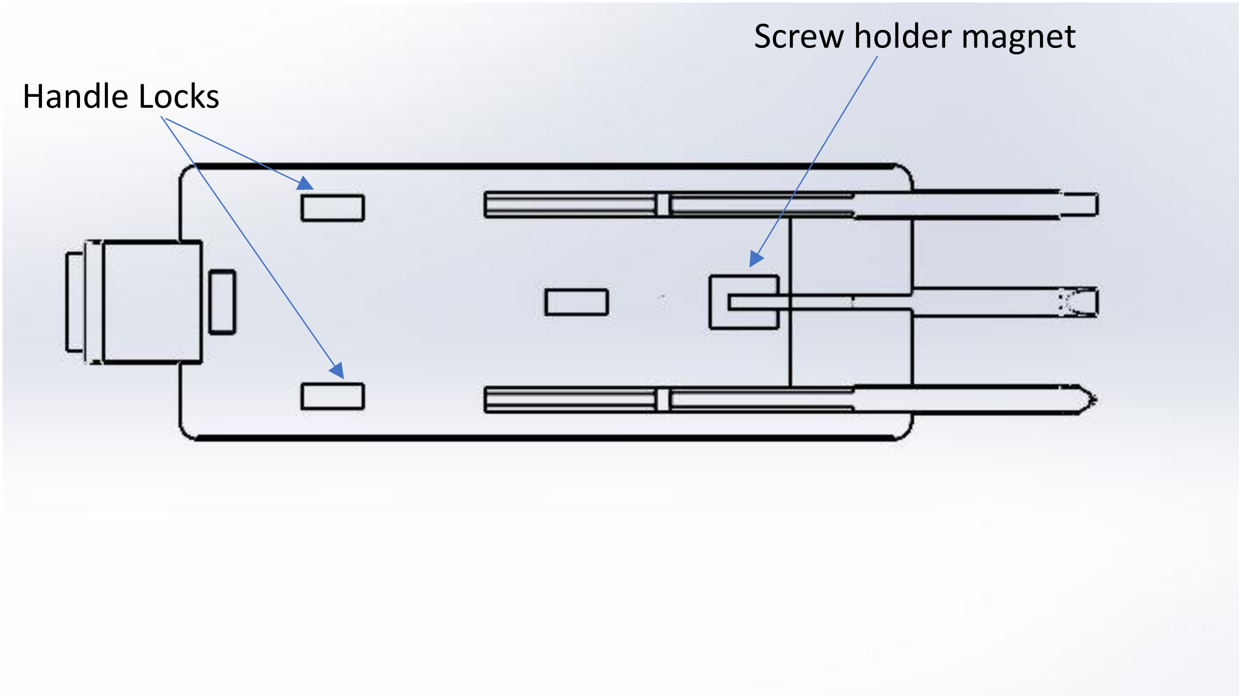


FIGURE 02: SECTIONAL VIEW OF THE DESIGN

TABLE 01: Modes of Failures

Component		Type of Loading	Modes of failure
Shaft	Screw head	Compression Force	Compression Failure
		Shear force	Shear failure
	Shaft	Compression	Compression failure
		Torsion	Torsional failure
		Buckling	Buckling Failure
Foldable handle		Bending Force	Bending Failue
		Shear force	Shear failure
		Bending moment	Bending failure
Body		Torsion Force	Torsional Failure
Shaft holder		Compression	Compressive failure
		Compression Force	Crushing Failure

Data

Maximum load applied by an operator on the Body (F) = 80N

Length of the foldable handle (L_1) = 6 cm

Assumption

- Body is assumed cylindrical.
- Frictional forces of the shaft are negligible.
- Cross section of the shaft is uniform.
- Weight of the screw driver is neglegibly small.

TABLE 02: Components, Selected materials, FOS

No	Component	Material	FOS
1	Body	acrylonitrile butadiene styrene	3
2	Screw	HIGH CARBON STEEL (AISI 1095)	3
3	Foldable Handle	acrylonitrile butadiene styrene	2
4	Magnet	Alnico	2
5	Pin(screw exiter)	AISI 1020 Plain carbon Steel	2
6	Grip	Thermo plastic Rubber	2
7	Screw exiter	AISI 1020 Plain carbon Steel	2

TABLE 03: Material Properties

Material	Yield/Compressive/ Bending strength (MPa)	Bearing strength (MPa)	Modulus of Elasticity (GPa)	Shear strength (MPa)
HIGH CARBON STEEL (AISI 1095)	1300	2600	200	750
Acrylonitrile butadiene styrene	50	100	2.3	28.85
Themo plastic Rubber	10	20	0.12	5.77
AISI 1020 Plain carbon Steel	400	800	190	230.8
Alnico	100	200	120	57.77

Reference	Calculations	Result

Design of Body

Maximum Torque applied on the body.

$$T = F \times L$$
$$= 80 \times 6 \times 10^{-2}$$
$$= \underline{4.8\ Nm}$$

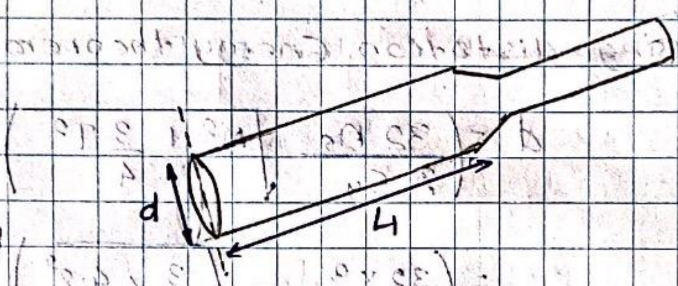


Figure 03: Circular body section

Assumption: Cross section Area of the body is a circle,

Using simple torshional formula,

$$\frac{T}{J} = \frac{\tau}{\rho} = G\left(\frac{\phi}{L}\right), \quad J = \frac{\pi d^4}{32} \quad \rho = d \quad T = 4.8\ Nm$$

for the allowable Shear stress

$$\tau_{allowable} = \frac{\tau_{material}}{F.O.S}$$
$$= \frac{28.85}{3}$$
$$= \underline{9.62\ MPa}$$

using torshional formula,

$$\frac{T}{J} = \frac{\tau}{\rho}$$
$$\frac{4.8 \times 32}{\pi d^4} = \frac{\tau}{d}.$$
$$\tau = \frac{4.8 \times 32}{\pi d^3}$$

Reference	Calculations	Result

We know that,

$$\tau_{allowable} > \tau_{material}$$

$$9.62 \times 10^6 > \frac{32 \times 4.8}{\pi d^3}$$

$$d > 17.19\,mm$$

lets get $\underline{d = 50mm}$

To find dmin using distortion Energy theorem

$$d = \left(\frac{32\, n_s}{\pi\, S_y} \sqrt{M^2 + \frac{3}{4} T^2} \right)^{1/3}$$

$$= \left(\frac{32 \times 3}{\pi \times 28.55 \times 10^6} \sqrt{\frac{3}{4} \times 4.8^2} \right)^{1/3}$$

$$= 12.61\,mm$$

So, $d = 50mm$ is acceptable,

Length of circular cross section,

$L_1 > L$ (Length of foldable handle)

So, $L_1 = \underline{70mm}$

Design of the screw shaft

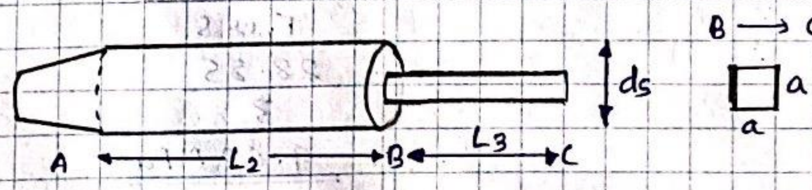


Figure 04 : Screw shaft

Assumption cross section of the screw shaf is a circular,

Reference	Calculations	Result
	Considering the compression failure,	
	$\sigma_{allowable} = \frac{\sigma_{material}}{F.O.S} = \frac{1300\,MPa}{3} = \underline{\underline{433.4\,MPa}}$	
	For the compression failure,	
	$\sigma_{allowable} > \sigma_{\cancel{material}}$	
	$433.4 \times 10^6 > \frac{80N \times 4}{\pi \times d_s^2}$	
	$d_s^2 > \frac{80 \times 4}{433.4 \times 10^6 \times \pi}$	
	$d_s > 0.5\,mm$	
	Considering the torshional failure of the screw shaft.	
	Using maximum shear stress theory	
	$d_{s\,min} = \left(\frac{32\,n_s}{\pi\,S_y}\,(T_{max}\right)^{1/3} = 4.8\,mm$	
	$\therefore d_s = 6\,mm$	$d_s = 6\,mm$
	Considering the AB section, for buckling failure.	
	$P_{cr} > P$ (critical force)	
	$\frac{\pi^2 EI}{L_2^2} > P$	
	$\frac{0.006^2 \times \pi^2 \times 200 \times 10^9 \times \pi}{80 \times 64} > L_2^2$	
	$L_2 < 1.5\,m$	
	$L_2 = 30\,mm$	$L_2 = 30\,mm$

Reference	Calculations	Result
	For BC Section, for allowable shear stress.	
	$\tau_{allowable} = \dfrac{\tau_{material}}{F.O.S}$	
	$= \dfrac{750\ MPa}{3}$	
	$= 250\ MPa$	
	Using simple Torshional formula.	
	$\dfrac{T}{J} = \dfrac{\tau}{\rho}, J = \left(\dfrac{a^4}{6}\right) \quad \rho = \left(\dfrac{a}{2}\right)$	
	$\therefore \dfrac{48 \times \left(\dfrac{a}{2}\right)}{\left(\dfrac{a^4}{6}\right)} = \tau$	
	$\dfrac{2.4 \times 3}{a^3} = \tau$	
	we know that $\tau_{allowable} > \tau$	
	$250\ Mpa > \dfrac{2.4 \times 3}{a^3}$	
	$a > 3mm$	
	lets get $\underline{\underline{a = 4mm}}$	$a = 4mm$
	for L_3 value,	
	considering buckling failure of screw,	
	$P_{cr} > P \quad , I = \dfrac{1}{12} a^4$	
	$\dfrac{\pi EI}{L_3^2} > 80\ N$	
	$\dfrac{\pi^2 \times 200 \times 10^9 \times 0.004^4}{12 \times 80} > L_3^2$	
	$L_3 < 0.725 m$	
	lets get $\underline{L_3 = 26\ mm}$	$L_3 = 26mm$

Reference	Calculations	Result.

Design of screw bit.

i) slotted screw bit

Thickness of the screw = 2mm
diameter of the screw bit = 6mm
height of the screw bit = 5mm

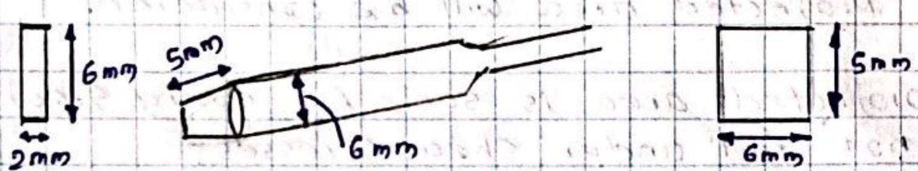


Figure 05 : screw bit

Considering shear failure of the screw bit

$$\sigma_{allowable} = \frac{\sigma_{material}}{F.O.S} = \frac{750\ MPa}{3} = 250\ MPa$$

Considering the shear failure,

$$\tau = (F/A) = \frac{80}{0.005 \times 0.006} = 2.6.6\ MPa$$

Since $\sigma_{allow} > \sigma$ screw is in safe region

For compressive failure,

$$\sigma_{allowable} = \frac{\sigma_{material}}{F.O.S} = \frac{1300}{3} = 433.4\ MPa$$

Reference	Calculations	Results

$$\tau = (F/A) = \frac{80N}{2\times 6\ mm^2} = 6.66\ MPa$$

So screw will not fail under compression.

For other screws shear failure does not need to be calculated. Since when considering the shear failure projected area will be considered.

Since projected area is same for every srew it will not fail under shear stresses.

When considering the screw bits used srew bits are

- → Slotted
- → Cross slot
- → Pozzidriv
- → Torx

for failure under compression cross slott has the minimum cross section area.

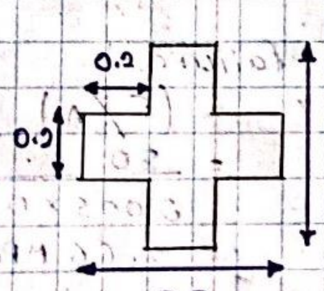


Figure 06: Screw head

$$\text{Area} = 0.7^2 - 4\times 0.2^2 = 0.33\ mm^2$$

For compression force;

$$\sigma = \frac{80N}{0.33\ mm^2} = 242.42\ MPa$$

Since, $\sigma < \sigma_{allowable}$

All the screw bits are in safe region.

Reference	Calculations	Result.

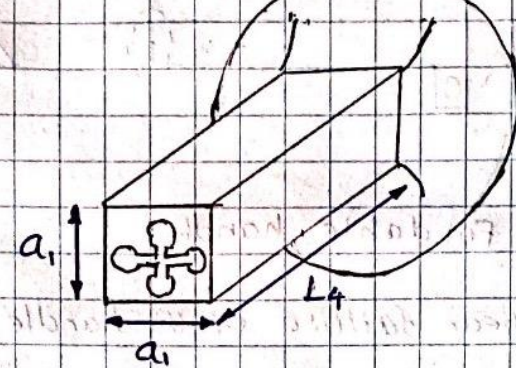


Figure 07: Screw body

$$T = 4.8\,Nm \quad ; \quad J = \left(\frac{a^4}{6}\right)$$

To determine the square section of the body, From simple torsion formula.

$$\tau = \left(\frac{T\rho}{J}\right)$$

$$\sigma_{allow} > \tau$$

Therefore,

$$9.62\,MPa > \frac{4.8 \times (a_1/2)}{(a_1^4/6)}$$

$$a_1^3 > \frac{4.8 \times 6}{2 \times 9.62 \times 10^6}$$

$$a_1 > 11.43\,mm$$

lets get $a_1 = 36\,mm$

Considering the length of the hande

$$L_4 > \text{Screw length.}$$

$$L_4 > 70\,mm$$

$$\underline{\underline{L_4 = 75\,mm}}$$

Reference	Calculations	Results

Design of foldable handle

Figure 08: Foldable handle

Considering the shear failure of the handle.

$$\tau_{allowable} = \frac{\tau_{material}}{F.O.S}$$

$$= \frac{28.85\ MPa}{3}$$

$$= 9.62\ MPa$$

Considering the shear failure

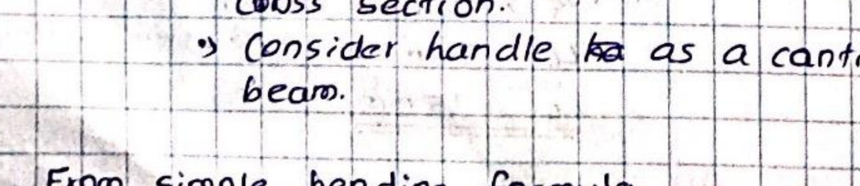
$$\tau < \tau_{allowable}$$

$$\frac{80\ N \times 4}{\pi d_n^2} < 9.62\ MPa$$

$$d_n > 3.25\ mm$$

$$d_n = 4mm$$

to Find the thickness of foldable handle.



Assumption :- Foldable handle has a rectangular cross section.
- Consider handle as a cantilever beam.

From simple bending formula.

$$\frac{M}{I} = \frac{\sigma}{y}$$

$$\sigma = \left(\frac{M}{I}\right) y$$

Reference	Calculations	Result

$$I = \frac{1}{12} \times \frac{\pi}{3} \times 40 \times t^3 \quad mm^4$$

$$\sigma = \frac{4.8\,Nm}{40\pi t^3} \times \frac{t}{2} \times 36$$

$$\sigma_{allow} = \frac{\sigma_{material}}{F.O.S}$$

$$= \frac{50}{3}$$

$$= 16.6\,MPa$$

For not fail

$$\sigma_{allow} > \sigma$$

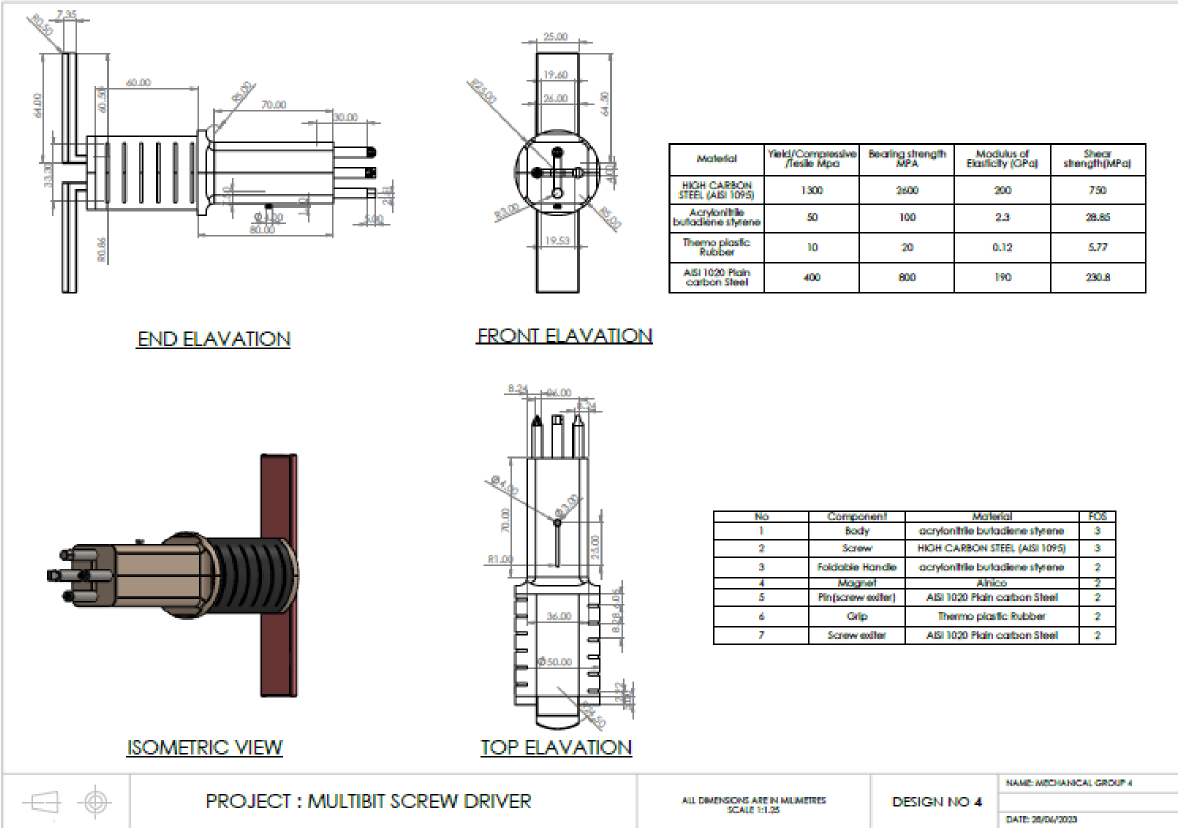
$$16.6 \times 10^6 > \frac{4.8 \times 36}{40\pi \times 2 \times t^2}$$

$$t > 0.20\,mm$$

$$\underline{\underline{t = 5\,mm}}$$

TABLE 04: Component Dimensions

Component	Dimension	Sign	Value (mm)
Body	Circular section Diameter	d	50
	square section length	a	40
	Circular section length	L_1	70
	Square section length	L_4	75
Foldable Handle	Length of foldable handle	L	60
	thickness of foldable handle	t	5
	Foldable handle pin diameter	D_n	4
	Foldable handle pin thickness	T_n	5
Grip	Grip thickness	t_g	1
	Outer Diameter	$D_{g,out}$	50
	Inner Diameter	$D_{g,inner}$	48
	Grip length	$L_{g,\ length}$	60
Pin	Pin Diameter	D_{pin}	4
	Pin shaft diameter	$D_{pin,shaft}$	2
	Pin head thicknes	$P_{thickness}$	2
	pin shaft length	$P_{shaft\ length}$	8
	fillet darius	F	0.5
Screw exiter	square sectionn length	a_{exiter}	4
	thickness	t_{exiter}	4
	length between columns	l_{col}	28.09
Screw	Screw circular diameter	d_s	6
	square section length	a_s	4
	length of circular section	$l_{Circular}$	30
	length square section	l_{square}	26
	thickness of screw head	t_{head}	5
Magnet	Thickness of magnet	T_{magnet}	2
	Square section	a_{magnet}	2
	length of magnet	l_{magnet}	12



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5	Pin(screw exiter)	AISI 1020 Plain carbon Steel	2
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FIGURE 9 DRAWING OF THE SCREWBIT

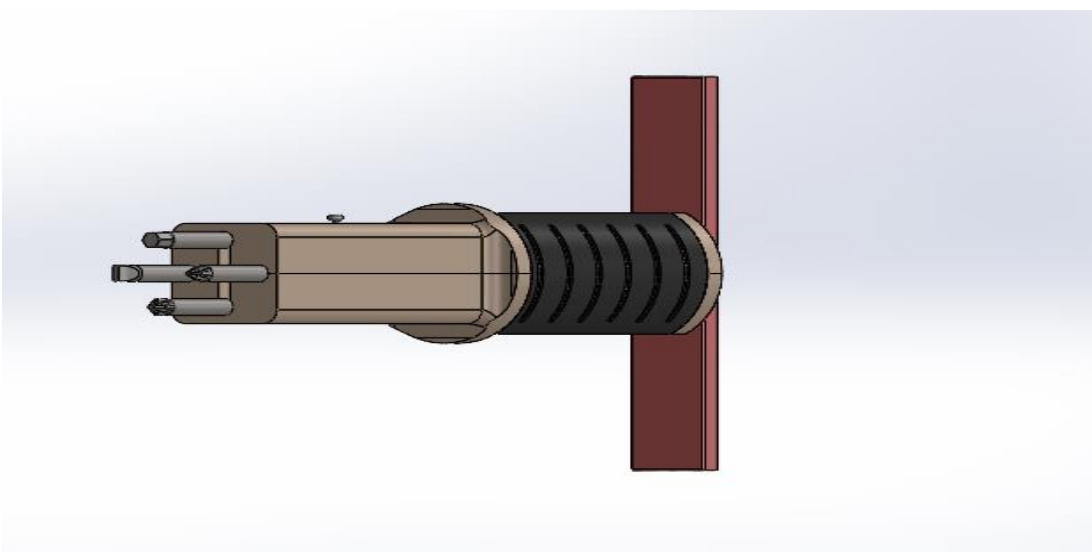

FIGURE 10 ISOMETRIC VIEW OF MULTIBIT SCREW DRIVER

REFRENCE

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- Budynas, R.G., J Keith Nisbett and Joseph Edward Shigley (2011). Shigley's mechanical engineering design. New York: Mcgraw-Hill.
- Beer, F.P. (2020). Mechanics of materials. New York, Ny: Mcgraw-Hill Education.