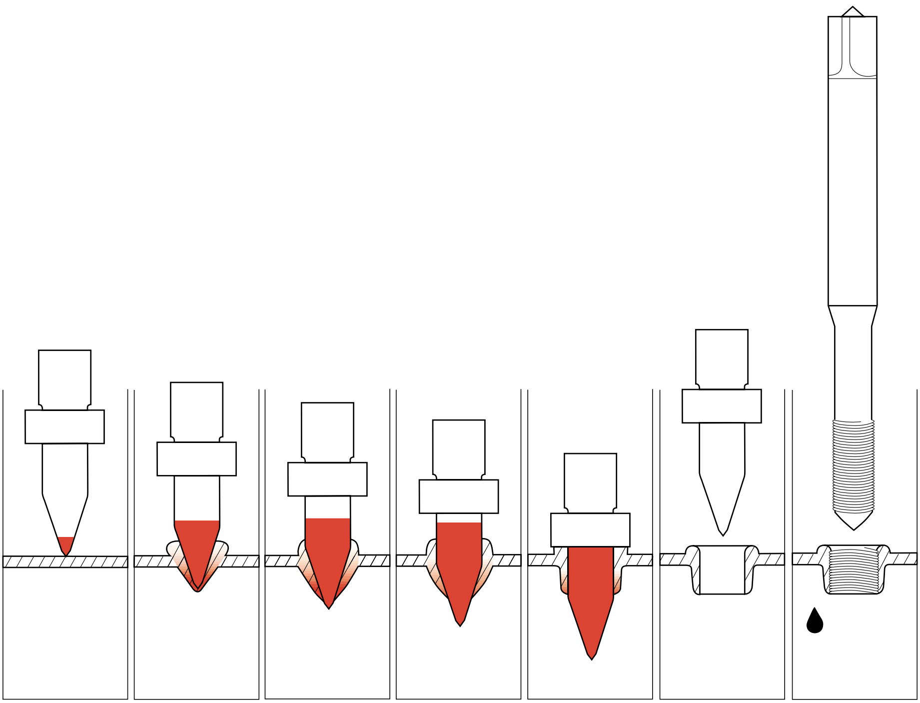
User guide

Flowdrill®



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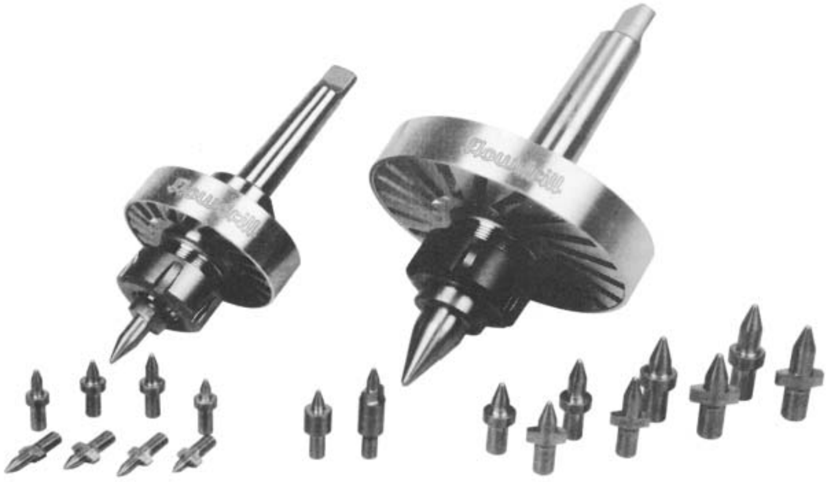
The Flowdrill ® System



Toolholder with Nut, Spanner and "C" Spanner
-FDMC2
-FDMC3

Collets
-Fd 430e 6 up till 14
-Fd 470e 12 up till 20
-Rubber flex collets

Flowdrills and Flowtaps
-Standard (see cover at the back)
-Specials

Lubricants and Miscellaneous

1.0 History

In 1923, in a little barn in the south of France, Jan Claude de Valliere attempted to develop a tool for producing holes in thin steel sheet using the principle of frictional heat instead of cutting. After many experiments, he was technically successful.

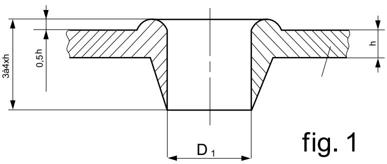


fig. 1

However, practical industrial applications were not possible, because:

- Very hard material such as tungsten carbide was not available.
- Correct geometry of the tools was not known.
- Diamond grinding wheels for hard materials did not exist.
- Machinery to generate the required complicated profile were not available.

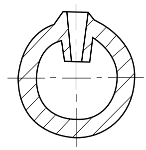


fig. 2a

It would take almost 60 years before these problems could be solved and the Flowdrill could find its way to successful commercial use.

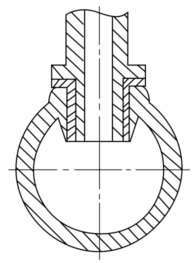


fig. 2b

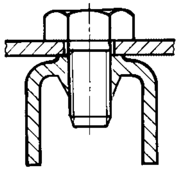


fig. 2c

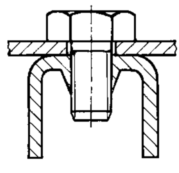


fig. 2d

2.0 Introduction

A Flowdrill(fig.3) is a lobed, conical tungsten carbide tool. When rotated at high speed and pressed with high axial force into sheet metal or thin walled tube, generated heat softens the metal and allows the drill to feed forward, produce a hole and simultaneously form a bushing from the displaced material (fig. 1).

There are numerous possible applications for Flowdrill; it increases effective wall thickness for threaded connections or soldered joints etc. (fig. 2a-f).

2a Chipless drilled hole for spraying appliances. No chips, no broken drills.

2b Gas tight connection

2c Threaded connection with rim around the hole

2d Threaded connection (Flat face)

2e Bearing or shaft support

2f Water tight + soldering high pressure

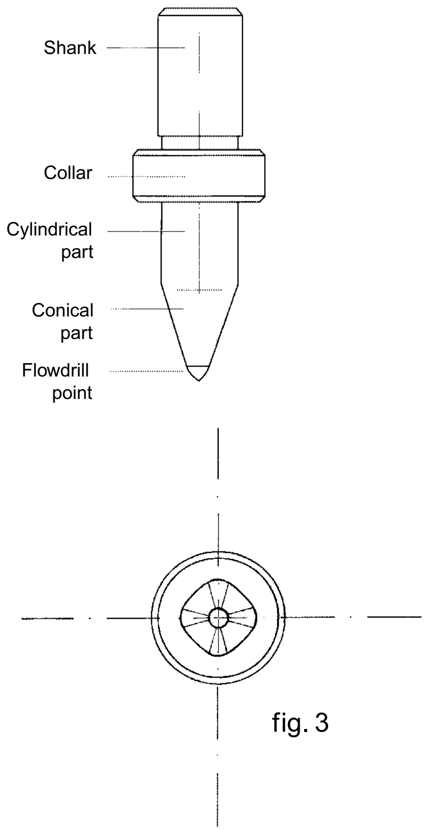


fig. 3

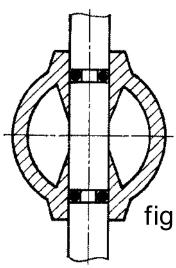


fig. 2e

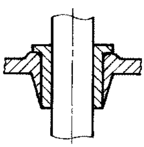


fig. 2e

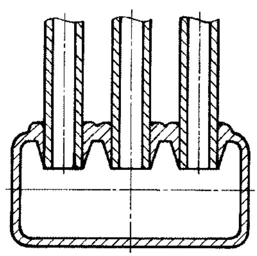


fig. 2f

3.0 Flowdrill® - Ideal for Automation

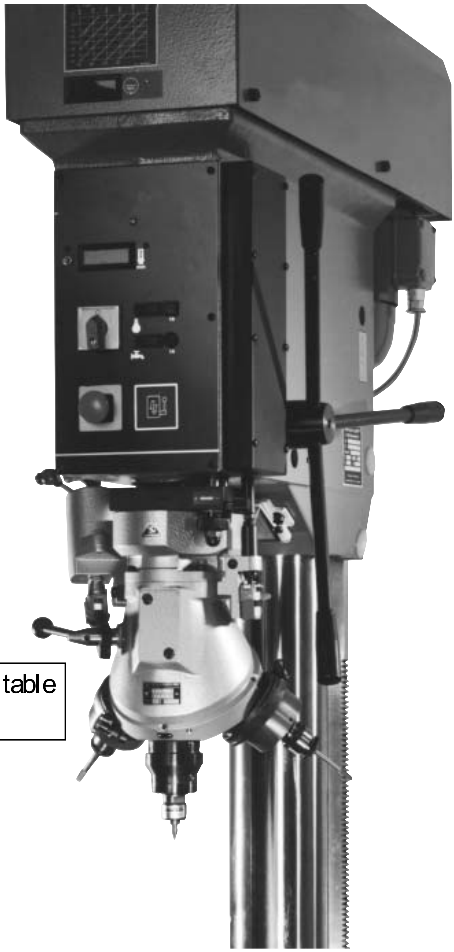
(a) No swarf

(b) Long tool life

(c) Accurate hole form

Much experience has been gained in the automobile, gas-heating, metal furniture, lighting and household appliance industries, etc.

Although the process itself has been applied for some time, it is necessary for the user to understand the nature of the Flowdrill process, the various types of Flowdrills and the physical requirements of the drilling machine for best results.



Automatic Turret drilling Head suitable for any column drilling machine

4.0 How the Flowdrill® works

The standard Flowdrill design is shown in figure 3. Its working portion consists of a pointed end, a cone and a parallel body. Both the cone and the body are polygon shaped. This specially designed shape plays an essential part in the Flowdrill process. The Flowdrill also has a collar and a straight shank. Flowdrills are made of a carbide grade developed to satisfy the unique characteristics of the Flowdrill operation.

4.1 The phases of Flowdrill

4.1.1 Initial Contact

Relatively high axial pressure (F. ax), combined with high rotational speed is needed to generate heat between Flowdrill and workpiece (fig. 4 a,b,c).
The Flowdrill temperature rises rapidly to about 650 - 750 º C. and the workpiece 600 º C.
High axial force is needed until the Flowdrill point penetrates the material.

4.1.2 Material Flow

Displaced material initially flows up towards the Flowdrill; when the point penetrates, material flows in the direction of the drill feed.
As the material softens, axial force is reduced and feed rate increased (fig. 4 d,e,f,g,h).

Final size and shape of the Flowdrilled hole and bushing are determined by the diameter and cone shape of the Flowdrill.
Material that flows back towards the Flowdrill can be formed into a collar (fig. 4 i) or cut off flush to the surface with a 'flat' type Flowdrill (fig. 4 k).

4.1.3 High axial force:

- Develops heat rapidly in Flowdrill creating thermal stress.
- Increases feed rate - reduces drilling time.
- May alter the physical properties of workpiece material.

4.1.4 Low axial force:

- Provides gradual warming, reducing stress in Flowdrill.
- Increases drilling time which can result in excessively high temperatures.
- Reduces torque on Flowdrill.
- Requires less power input.

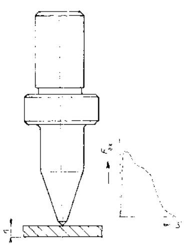


fig. 4a

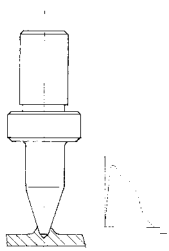


fig. 4b

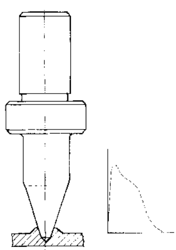


fig. 4c

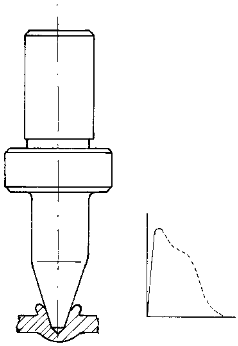


fig. 4d

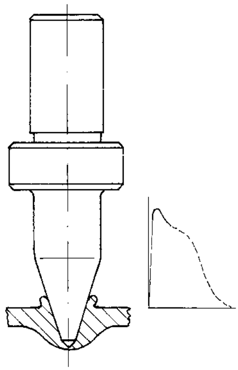


fig. 4e

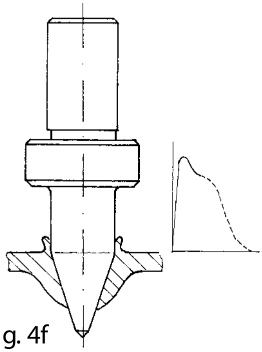


fig. 4f

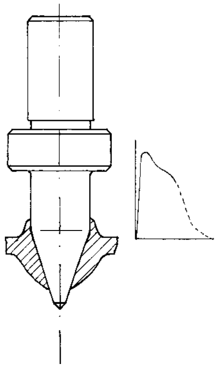


fig. 4g

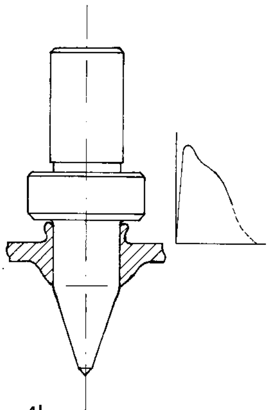


fig. 4h

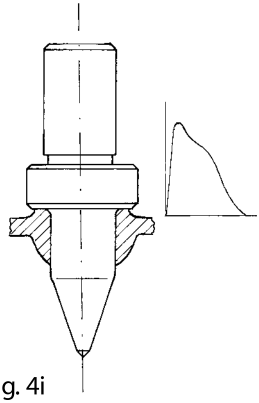


fig. 4i

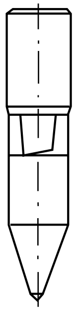


fig. 4j

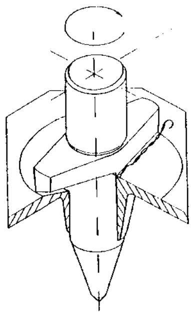


fig. 4k

5.0 Flowdrill® parameters

The Flowdrill diameter determines values for:

Axial forces	F ax (N)	See fig. 5a
Speed Rpm	n(min-1)	5b
Power	P(kW)	5c
Material thickness	(max.) h(mm)	6

5.1 Axial force (F. ax)

Maximum axial force is proportional to the Flowdrill diameter.
As temperature increases, axial force required reduces, feed rate increases.

5.2 Speed (n)

Keep speed as low as possible to obtain longer Flowdrill life.
Speed selection is influenced by material thickness as well as material type.
Thicker stainless- and high carbon steel require lower speed and will usually result in shorter Flowdrill life.
As a general rule, soft non-ferrous materials require more speed: the softer the material, the higher the speed.

Graphics 5a, b, c, are based on Fe.360 h=2mm.

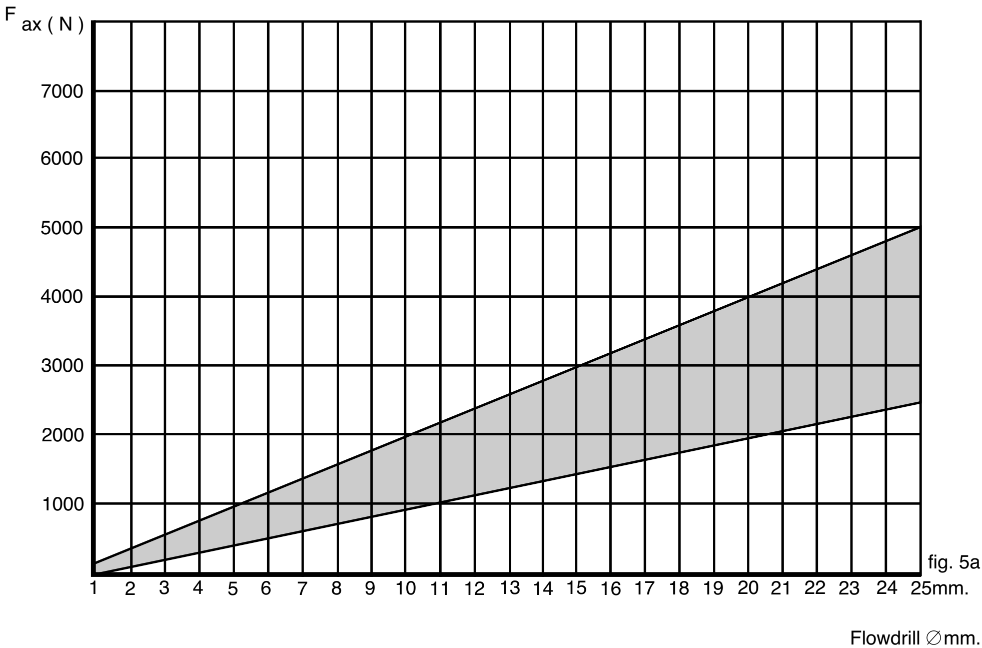


fig. 5a

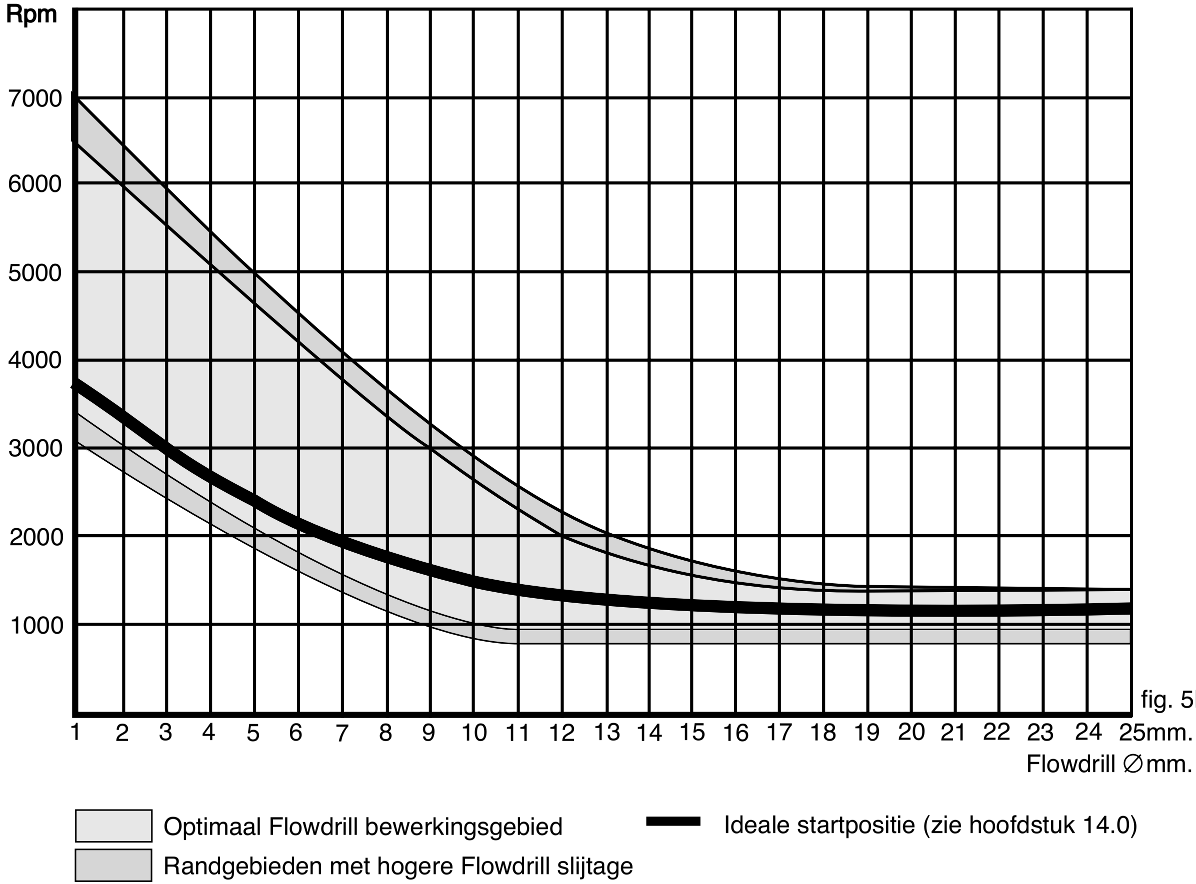

Rpm
7000
6000
5000
4000
3000
2000
1000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25mm.
Flowdrill ∅mm.
Optimaal Flowdrill bewerkingsgebied
Randgebieden met hogere Flowdrill slijtage
Ideale startpositie (zie hoofdstuk 14.0)

fig. 5b


Flowdrill

5.3 The effects of different speed are shown in this example:

Material thickness (h)	2.0 mm	2.0 mm
Flowdrill dia.	7.3mm	7.3mm
Speed (n)	3 000 min- 1	1750 min-1
Drilling time	1. 5 sec.	2.0 sec.
Flowdrill Temperature	700 ° C	600 ° C

5.4 Power (kW)

Most good quality drilling machines are suitable for Flowdrill, provided they meet the power and speed requirements. The required power of the drilling machine is shown on chart (fig. 5c).

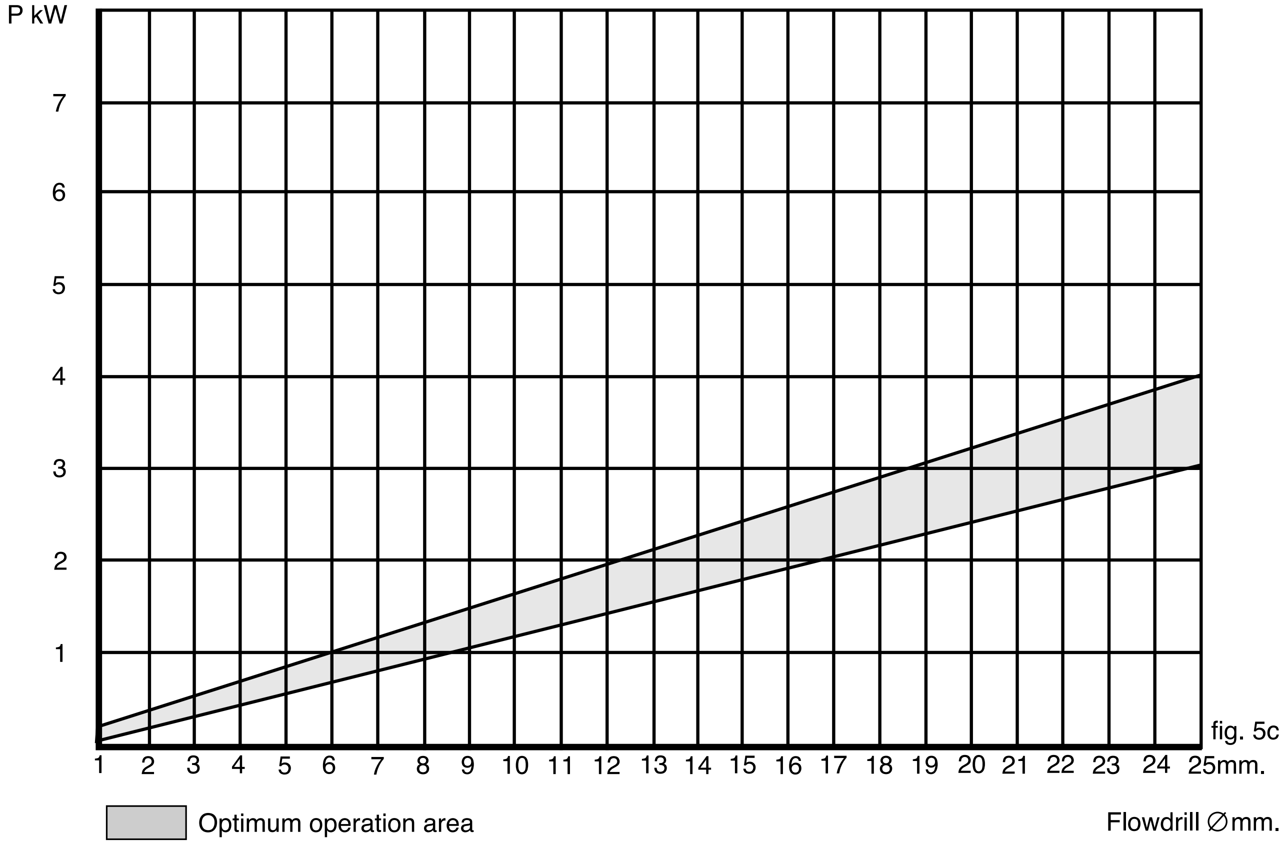

P kW
7
6
5
4
3
2
1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25mm.
Optimum operation area
Flowdrill ∅mm.

fig. 5c

5.5 Material Thickness (h)

Maximum material thickness (h.Max) is proportional to the Flowdrill diameter. Minimum thickness follows the general rule: h Min = approx. 0.2 x D 1 up to 2mm, which rule is suitable for most of the bigger sizes. D1 is the Flowdrill diameter.

Flowdrill life is reduced if used on heavier gauge material or materials with high tensile strength.

Fig. 6 indicates maximum material thickness that can be Flowdrilled with standard long or short Flowdrills. See also table in chapter 16.0
Special Flowdrills can be supplied to meet unusual needs.
For greater thickness an extra long L 5 may be necessary.
(Ask for advise)

Notes:

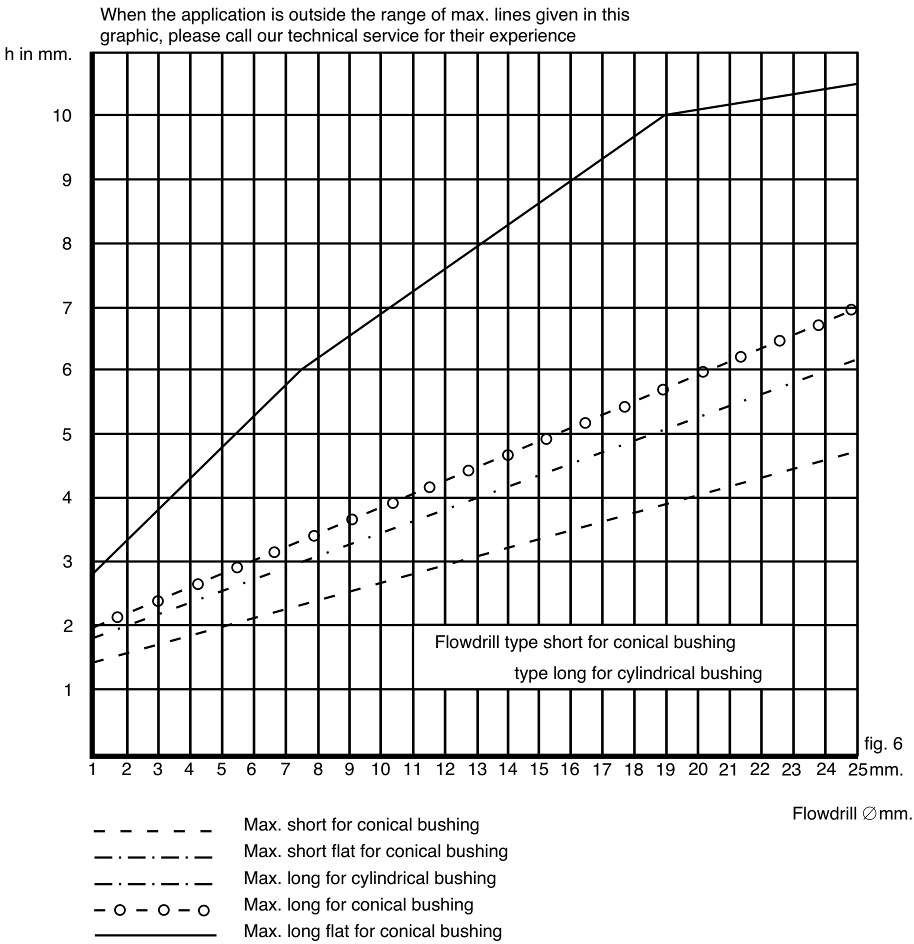

When the application is outside the range of max. lines given in this graphic, please call our technical service for their experience
h in mm.
10
9
8
7
6
5
4
3
2
1
Flowdrill type short for conical bushing
type long for cylindrical bushing
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25mm.
Flowdrill ∅mm.
Max. short for conical bushing
Max. short flat for conical bushing
Max. long for cylindrical bushing
Max. long for conical bushing
Max. long flat for conical bushing

fig. 6

6.0 Flowdrill® types

6.1 Long Flowdrill (fig. 7a)

The long Flowdrill has a long parallel body (L5)(fig.7) designed to produce a hole that is cylindrical for the entire bush length. Material that is backward extruded is rolled into a rim by the Flowdrill collar (fig. 8e).

6.2 Short Flowdrill (fig. 7b)

Short Flowdrills have a shorter parallel body. This design produces a bush that is conical and provides great strength when formed into a thread (fig. 8a).

6.3 Short Special Flowdrill (fig. 7c)

Special L 4 & L 5 dimensions are available for use when Flowdrill penetration length is restricted for example in small diameter tube.

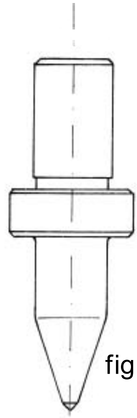


fig. 7a

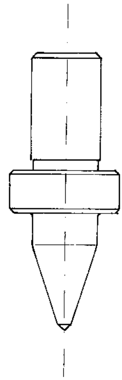


fig. 7b

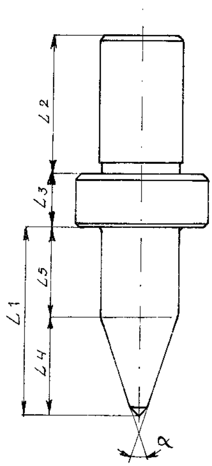


fig. 7

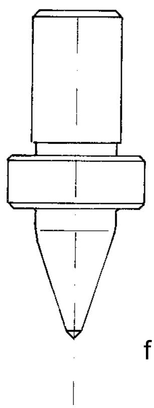


fig. 7c

6.4 Optional Features

The following optional features can be supplied on any Flowdrill:

6.4.1 Milling cutters "Flat Flowdrill" (fig. 7d)

The Flowdrill collar is ground into a cutter (fig. 8c,g).
This removes the rim formed around the top surface of a Flowdrilled hole, leaving the surface flat.

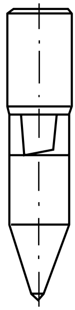


fig . 7d

6.4.2 Fluted point "Rem Flowdrill" (fig.7e)

Fluted point: all Flowdrills can be supplied with two small cutting flutes at the tip (fig. 8b,f). This style is useful for coated materials such as paint, anodised and some galvanised steel, depending on thickness of layer. The axial force is also reduced, permitting use in portable hand drills, or when a work-piece has insufficient support in the area to be Flowdrilled and tends to dent , due to insufficient rigidity.

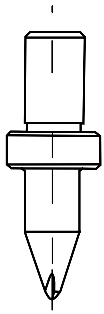


fig. 7e

6.4.3 Flat Rem (fig.7f)

All Flowdrills can be supplied with combination of cutting flutes and milling cutters (fig. 8d,h).

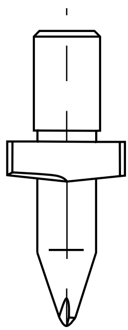
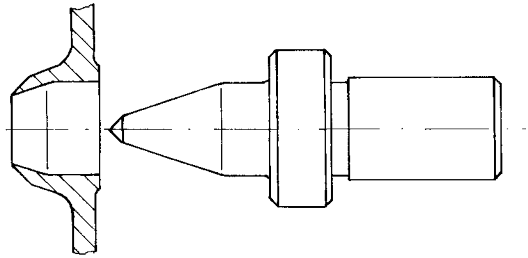
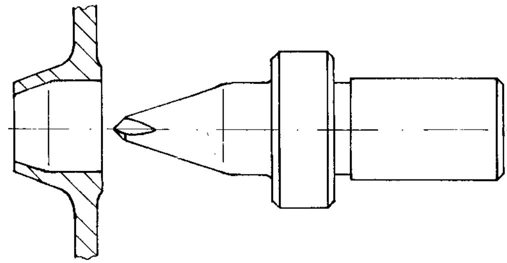


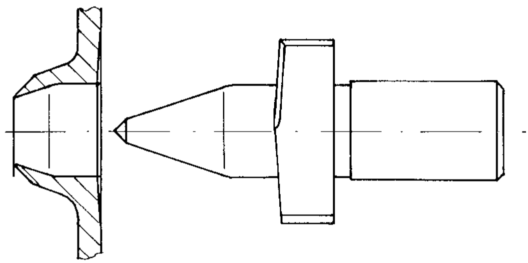
fig. 7f



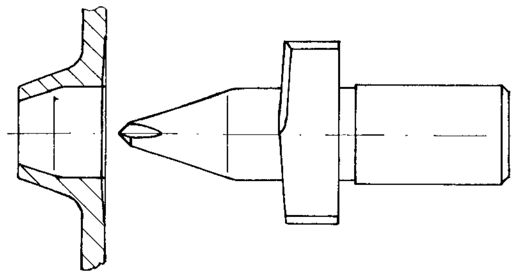
8a. short



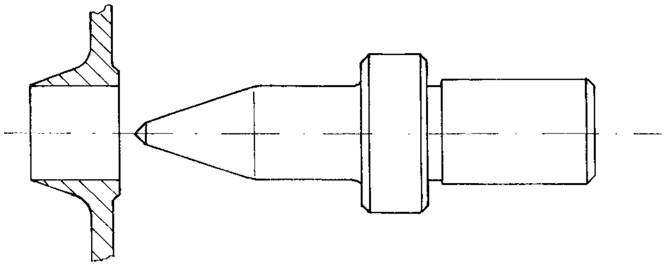
8b. short rem



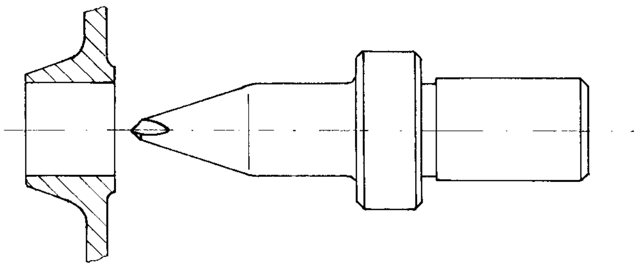
8c. short flat



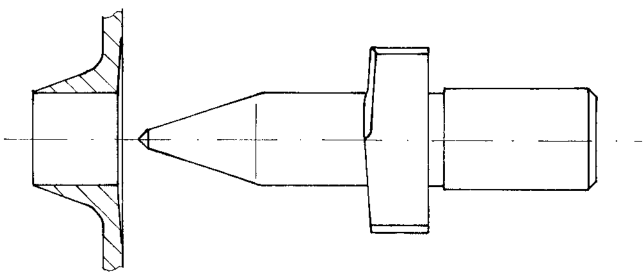
8d. short flat rem



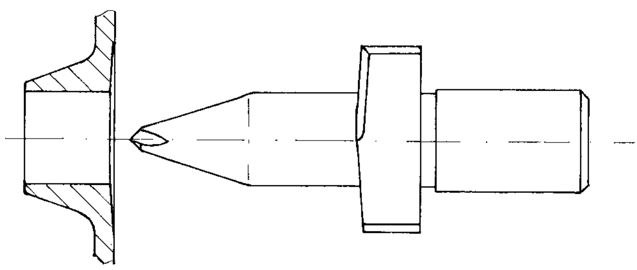
8e. long



8f. long rem



8g. long flat



8h. long flat rem

7.0 Applications of Flowdrills

7.1 Flowtapping

The most common use of Flowdrills is to provide a high strength threaded fastener in thin sheet metal or tube. A Flowdrilled hole may be tapped with conventional cutting taps or preferably, with cold form Flowtaps. Flowtapping resembles Flowdrill except the operating temperature is much lower; instead of cutting, Flowtaps cold-form the thread(no swarf). The diameter of the Flowdrill determines the final thread form,-depth and -strength. Tables in chapter 18.0 (back cover) show the recommended Flowdrill diameters for various thread sizes.

7.1.1 Advantages of Flowtaps compared with thread cutting taps

- No weakening of the threaded wall due to metal removal.
- Higher production speed.
- Better thread strength through cold forming of the material.
- Less chance of pitch errors that can be incurred when cutting threads.
- No swarf, no pollution or chip removal problems.
- Less tap breakage.
- Good tap life.

7.1.2 Example

M6 in 2 mm Fe 360

Use Flowdrill:	FD - 5.3 short
Use Flowtap	FT - M6
Thread strength	17 kN.

7.2 OtherApplications

Bearing support (fig. 2e)
Soldered connection (fig. 2f)

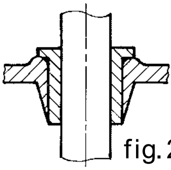


fig. 2e

Bearing support

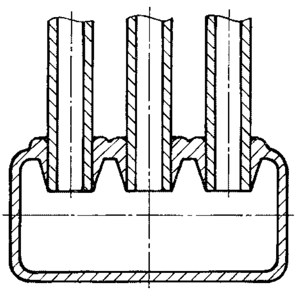
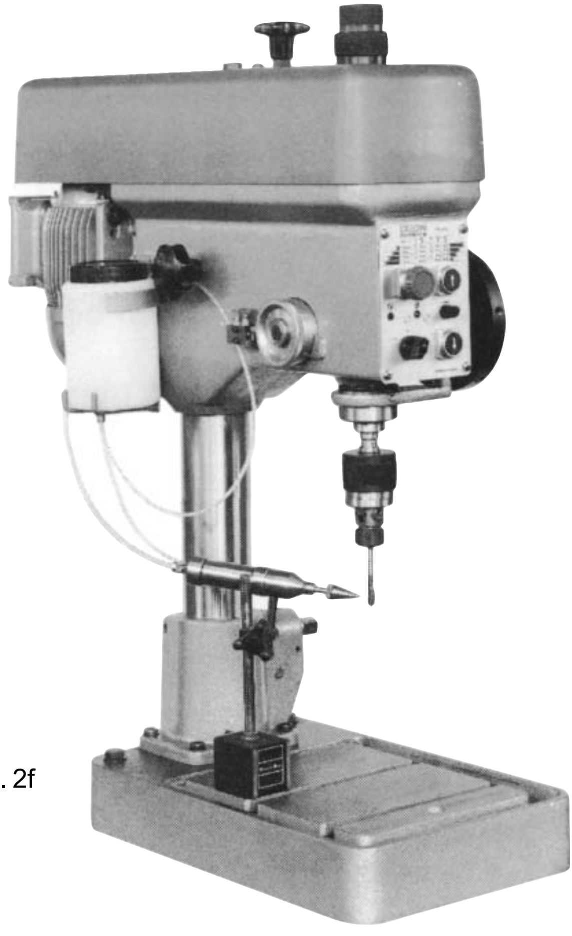


fig. 2f

Soldered connection



8.0 Suitable materials

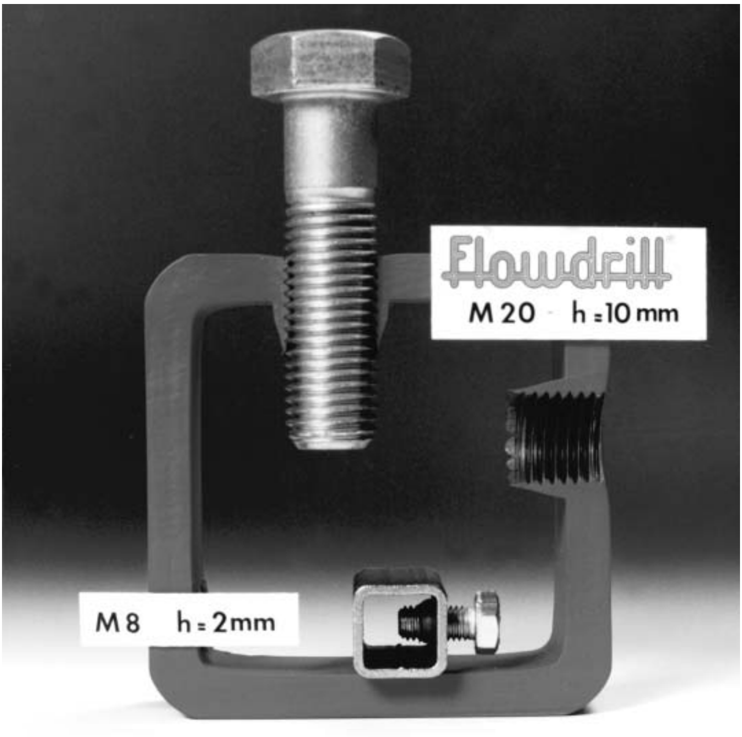
8.1 Steel (up to 700 N/mm² tensile strength).

8.2 Non-ferrous metals (with the exception of brittle material, like CuZn40Pb2).

8.3 Aluminium with less than 5% Si.

8.4 Stainless steel, acid resistant steel.

In some cases it is desirable to test the suitability of the Flowdrill system. In particular in case of zinc coated materials.



9.0 Working Life - Influential factors

9.1 Flowdrills are made of specially developed carbide. This will maintain its strength at high temperatures but is sensitive to thermal stress. Local cooling should be avoided.

9.2 Flowdrills cannot withstand high mechanical shock. They should not be dropped and hard impact onto the surface of the workpiece, as well as welded spots should be avoided.

9.3 Avoid radial forces on the Flowdrill

9.4 Torsional stability of the Flowdrill is important. Too rapid release of torsional load caused by fast break through (very high feed rate) can cause fatigue.

9.5 A similar condition can occur due to wind up if start pressure is too great.

9.6 DO NOT DRILL an unfinished hole, risking taper lock due to shrinkage.

9.7 Instability due to wear in machine spindle or collet can allow the Flowdrill to wander. Stress caused by misalignment can break the Flowdrill.

9.8 Finish -quality- in the Flowdrilled hole will deteriorate when the Flowdrill becomes worn.

9.9 Regular lubrication will increase life of Flowdrill. Use Fdks for lubrication of the FD every 1-5 holes on the hot rotating FD.

9.10 Flowdrill temperature should not exceed dark red colour.

9.11 Speed and axial force should be adjusted optimally under observation of the temperature of the FD (indicated by dark red colour).

9.12 Hole quality will be affected by build up of work-piece metal on the tool, also from film caused by anodised aluminium or zinc from galvanising.

9.13 Timely removal of built up material with diamond file

9.14 Cleaning with a diamond file will extend tool life.

9.15 Don't dwell at depth when using Flowdrills - especially flat Flowdrills - dwelling reduces cutter life.

9.16 Protect the Flowdrill and drilling machine spindle for overheating by using the special Flowdrill toolholder with cooling fan.

10.0 Work-piece material and lubrication

Flowdrill lubrication

Flowdrill results depend on the material's physical properties, such as tensile strength, hardness, chemical content and conductivity. Generally all malleable materials can be Flowdrilled.
Lubrication of the Flowdrill can work against the need to generate heat but is required in small amounts to prevent pick-up or adhesion on the carbide surface, particularly when Flowdrilling aluminium. Flowdrill lubricants are specially developed to meet this criterion.

10.1 Remark

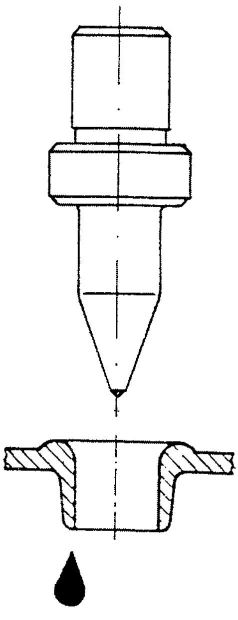
Lubricate while Flowdrill is still running, directly after Flowdrill operation.

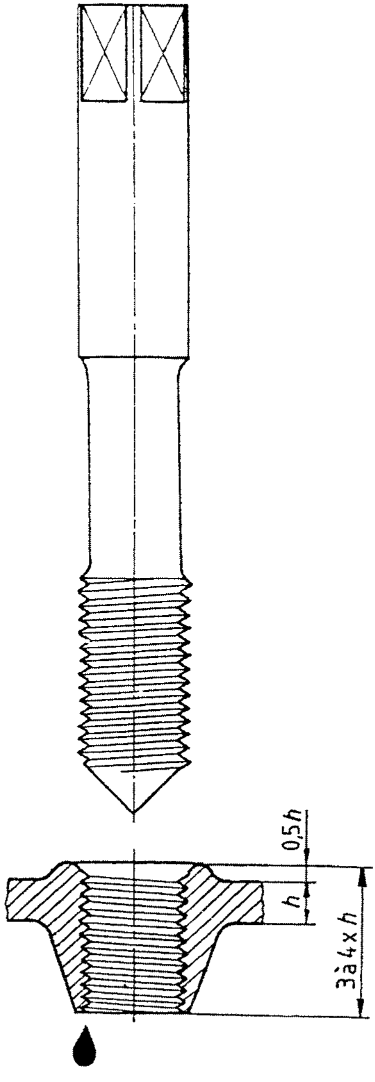
10.2 Flowdrill lubricants

FDKS paste and FDKS fluid to use for drilling in steel, stainless steel, copper and brass. FDUN paste to use for drilling in aluminium.

10.3 Tapping lubrication

High material deformation during tapping places strong demands on the lubricant used. To obtain optimum speed and quality we recommend use of Flowdrill FTMZ high pressure lubricant.
It should be applied for each hole tapped.
Dispensers are available for automatic production.
Avoid overheating the lubricant.




0,5h
h
3 à 4 x h

11.0 Tapping information

11.1 Tapping Torque

The torque required for tapping (cold forming) threads depends on the Flowdrill diameter, Rpm, work-piece material and lubrication.
Cold forming threads generally use about 20 % more torque than cutting. However, the conical hole shape generated to give maximum thread strength in a Flowdrilled bushing can double the torque required (fig. 11b).

11.2 Flowtap speed (fig. 11c)

See also chapter 14.0.

11.3 Recommended Flowdrill diameters for tapping (backcover)

Recommended Flowdrill diameters produce 65% thread depth.
Because the cold forming process toughens the material, thread strength is greater than when a cutting tap is used (fig. 11a).
Larger Flowdrill diameters have a favourable effect on Flowtap life.
They may also be advantageous in some very tough materials or materials that tend to recover or shrink after forming (for example M 6 thread can be formed using 5.3 - 5.4 - 5.5 Flowdrill, depending on conditions)

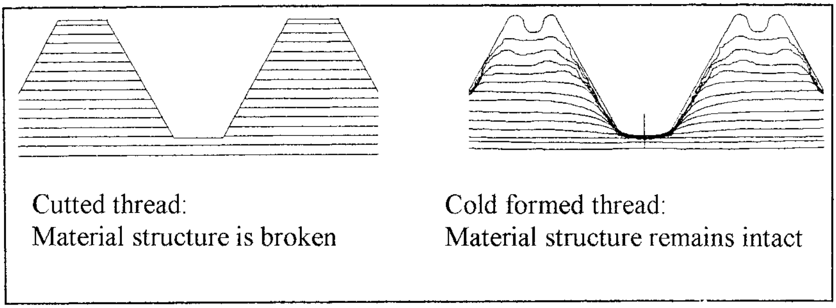


fig. 11a

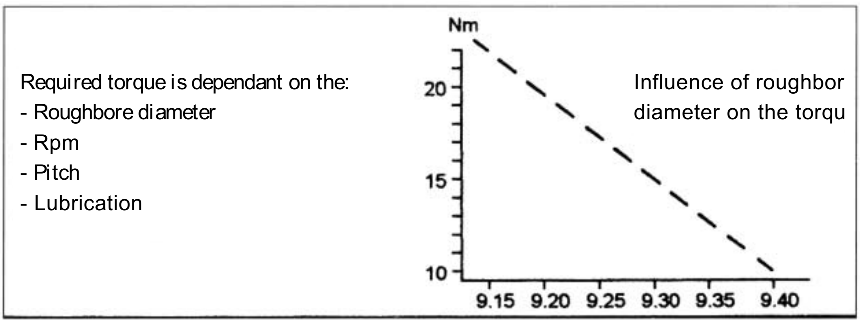


fig. 11b

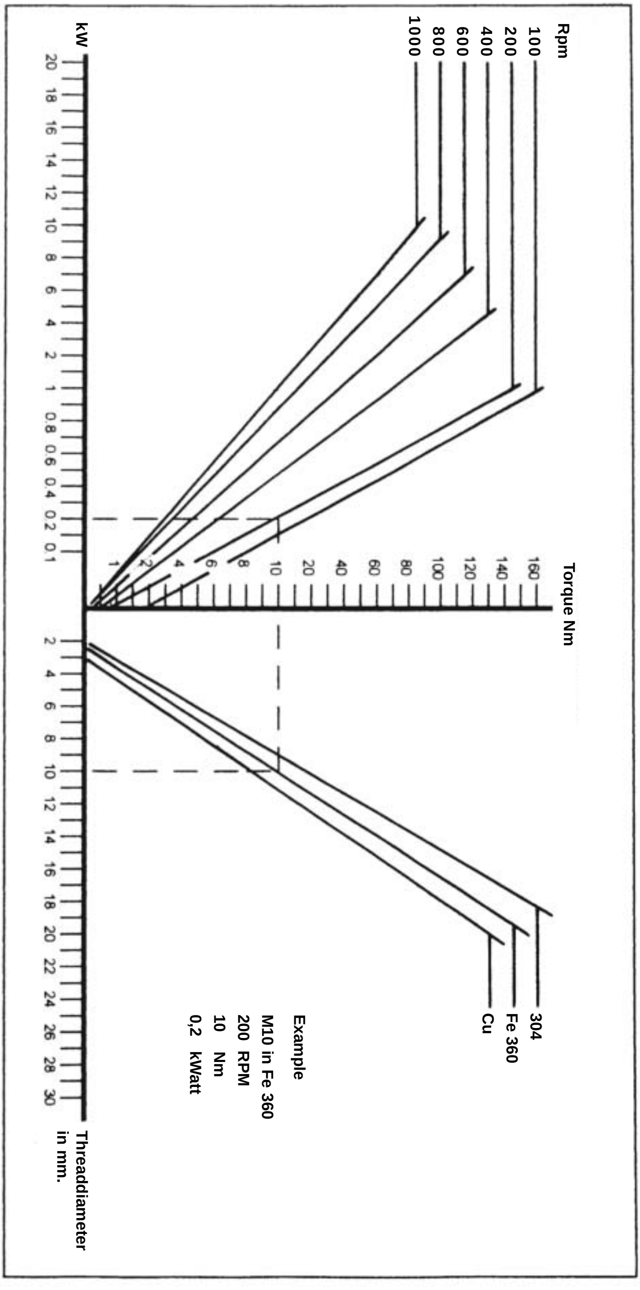
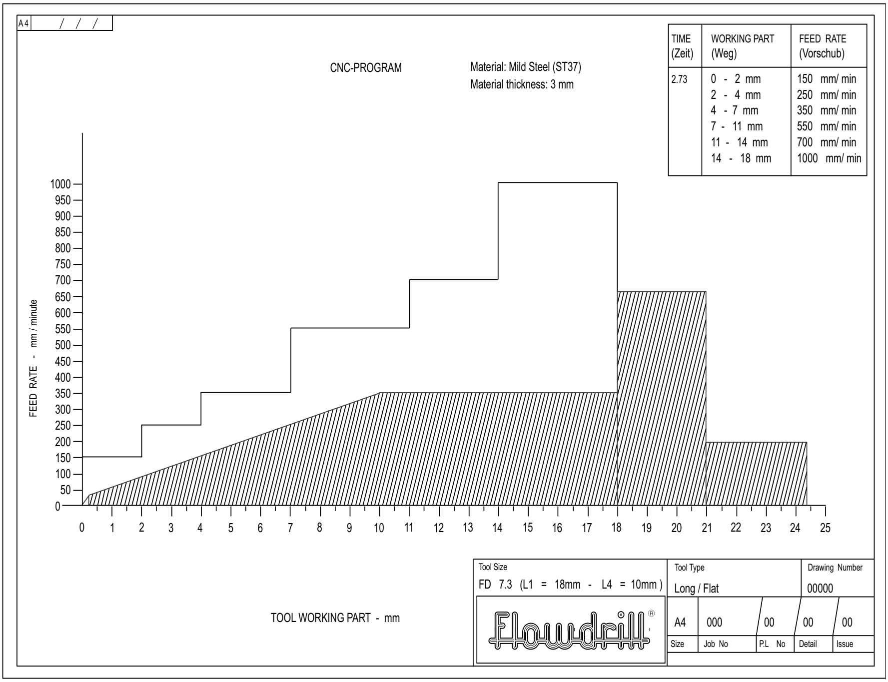

Rpm
100
200
400
600
800
1000
kW
Torque Nm
304
Fe 360
Cu
Example
M10 in Fe 360
200 RPM
10 Nm
0,2 kWatt
Threaddiameter
in mm.

fig.11c

12.0 Flowdrill® process with CNC



A Flowdrill's feed rate is determined by pressure - initial pressure is quite high, to create frictional heating. As the work piece softens, it allows the drill to advance, the rate of advance increases with heating and also as the drill point penetrates through the material.

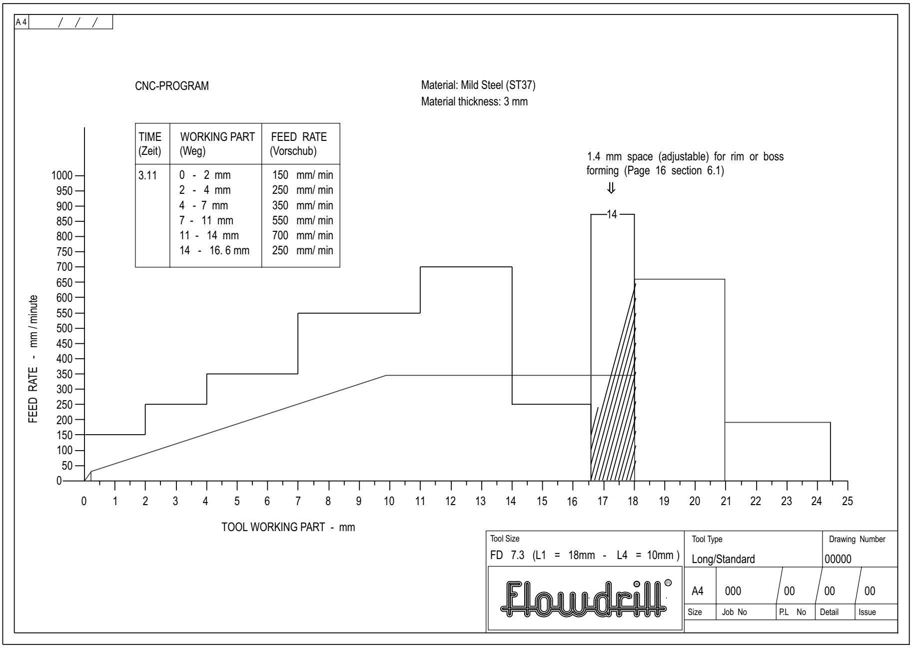
The required accelerating feed rate can be achieved by hand or with pneumatic feed devices.

If CNC is to be used, this effect has to be simulated with a slow initial feed rate accelerating to a high final feed rate.

Feed and rates of acceleration will vary according to Flowdrill size, Flowdrill speed, material type and thickness, but correct feed can be established fairly easily by trial and observation. The aim is to achieve and maintain a constant dull red glow while the tool is drilling.

Example of feed for 7.3 (M8) long/flat Flowdrill through 3.0mm thick mild steel. (As a guideline, depending on machine and material)

13.0 Starter Set



Example M8, Fe 360 3mm:

13.1 Flowdrill 7.3 long (average life approx. 10,000 holes)

13.2 Flowdrill lubricant Fd ks paste

13.3 Toolholder FD MC2 (locking spanners included)

13.4 Collet Fd 430E-8

13.5 Flowtap M8 (average life approx 10,000 holes)

13.6 Flowtap lubricant Ft mz

13.7 FD-Case (keeps kit together)

13.8 Tapping attachment (optional extra)

13.9 Reduction cone 3-2 (optional extra)

13.10 Diamond file (optional extra)

13.11 Ejecting drift key (optional extra)

14.0 Parameters for metric thread tools

Mild steel FE 360 2mm. Indication to start with

Thread size	Flowdrill Diameter mm	Flowdrill Rpm	Motor capacity kW.	Production time sec.	Flowtap Rpm
M 2	1.8	3200	0.5	2	1600
M 3	2.7	3000	0.6	2	1350
M 4	3.7	2600	0.7	2	1000
M 5	4.5	2500	0.8	2	800
M 6	5.3	2400	1.0	2	650
M 8	7.3	2200	1.3	2	500
M 10	9.2	2000	1.5	3	400
M 12	10.9	1800	1.7	3	330
M 16	14.8	1400	2.2	4	250
M 20	18.7	1200	2.7	5	200

15.0 Tables of torque and pull strength

Pull out strength in [kN] 1kN=100Kg.
Material: Fe 360 Thickness: 1.0 - 5.0 mm

s=Short Flowdrill
l=Long Flowdrill

Material Thickness h=mm	Thread M4	M5	M6	M8	M10	M12	M16	M20
1.0	6 s	10 s						
1.5		13 s	16 s					
2.0	9 s	15 s	17 s	27 s				
3.0			24 s	37 l	52 l	67 l	97 s	142 s
4.0				45 l	68 l	86 l	115 l	162 s
5.0						106 l	141 l	>200 s

Torque in [Nm]
Material: Fe 360 Thickness: 1.0 - 5.0 mm

Material Thickness h=mm	Thread Size	M4	M5	M6	M8	M10	M12	M16
1.0		5	8					
1.5			11	17				
2.0		9	13	20	28			
3.0				27	50	66	136	197
4.0					67	98	163	
5.0							269	

16.0 Maximum material thickness for thread holes

Thread	Flowdrill diameter for Flow-tapping	Max. material thickness				Shaft Ø	Total length working part	
		Short	Short/Flat	Long	Long/Flat		Short	Long
M2	1.8	1.6	1.8	2.2	3.2	6	5.8	7.8
M2.5	2.3	1.6	1.9	2.3	3.5	6	6.1	8.1
M3	2.7	1.7	2.0	2.4	3.7	6	6.7	8.7
M4	3.7	1.8	2.2	2.6	4.2	6	8.1	10.3
M4 x 0.5	3.8	1.8	2.2	2.6	4.2	6	8.2	10.5
M5	4.5	1.9	2.4	2.7	4.6	6	9.2	11.8
M5 x 0.5	4.8	1.9	2.4	2.7	4.7	6	9.6	12.4
M6	5.3	2.0	2.5	2.9	5.0	6	10.3	13.5
M6 x 0.75	5.6	2.0	2.5	2.9	5.0	6	10.8	14.2
M6 x 0.5	5.8	2.0	2.6	3.0	5.2	6	11.2	14.7
M8	7.3	2.2	2.9	3.3	5.9	8	13.5	18.1
M8x 1	7.5	2.3	2.9	3.4	6.0	8	14.0	18.7
M8 x 0.75	7.6	2.3	2.9	3.4	6.0	8	14.1	18.8
M10	9.2	2.6	3.2	3.7	6.6	10	16.8	22.5
M10 x 1.25	9.3	2.6	3.3	3.7	6.7	10	17.0	22.8
M10 x 1	9.5	2.6	3.3	3.8	6.7	10	17.3	23.2
M12	10.9	2.8	3.5	4.0	7.2	12	19.8	26.4
M12 x 1.5	11.2	2.8	3.6	4.1	7.3	12	20.3	27.1
M12 x 1	11.5	2.9	3.6	4.2	7.3	12	20.8	27.8
M14	13.0	3.0	3.9	4.5	7.9	14	23.5	31.3
M14 x 1.5	13.2	3.1	4.0	4.6	8.0	14	23.8	31.6
M16	14.8	3.3	4.2	4.8	8.5	16	26.9	35.4
M16 x 1.5	15.2	3.4	4.3	4.9	8.7	16	27.6	36.3
M18	16.7	3.5	4.6	5.2	9.2	18	30.4	39.7
M18 x 1	17.5	3.7	4.8	5.6	9.5	18	31.9	41.5
M 20	18.7	3.8	5.0	5.7	9.9	18	34.1	44.3
M 20 x 1.5	19.2	3.9	5.1	5.8	10.0	18	35.1	45.5
M 20 x 1	19.5	3.9	5.2	5.8	10.0	18	35.6	46.2
G1/16	7.3	2.3	2.9	3.3	5.9	8	13.5	18.1
G1/8	9.2	2.6	3.2	3.7	6.6	10	16.8	22.5
G1/4	12.4	2.9	3.8	4.3	7.8	12	22.4	29.8
G3/8	15.9	3.4	4.5	5.0	8.9	16	28.9	37.9
G1/2	19.9	4.0	5.2	5.9	10.0	18	36.3	47.0
G3/4	25.4	4.8	6.2	7.0	10.4	20	46.4	59.6

Data based on Fe 360

17.0 Hints & Tips

17.1

Observation in process	Possible Causes
Flowdrill point wanders (can break Flowdrill)	Worn Machine Spindle, Bearings Worn collet Excessive start pressure Spindle speed too low
Flowdrill overheating	Spindle speed too high
Colour bright red Flowdrill sparkles	Feed rate too slow

17.2

Observation on Work-piece	
Split collar (daisy petals)	Start pressure/feed too high or spindle speed too slow or final feed to slow. Pilot hole or Rem FD may help
Flash or burr on edge of collar	Drill point wanders
Excessive discoloration around hole	Feed too slow or spindle speed too high

17.3 Cycle Time

A guide to process speed for 2 mm Fe 360 is:

1 second + 1 second for each millimetre of material thickness i.e. Flowdrill time is 3 sec. approx.
This guide can be used up to about diam. 12mm. Larger Flowdrills take longer but cycle time should not exceed 15 seconds.

17.3.1

Operation examples		
	M6	M8
Rpm	2400	2200
F. ax	800 N	1000 N
Motor capacity	0.75 kW	1 kW
Operation time	1.5 - 2 sec.	2 - 3 sec.
Material Thickness	1.0 mm	2.0 mm

17.4 Flowtaps
Consult the cover of this technical guide for the right diameter.

17.5 Check the table chapter 14.0 for the right speed.

17.6 Lubricate before every action, the Flowtap as well as the bush

18.0 Thread tables

Metric thread		
Thread	Pitch/mm	Flowdrill diameter
M 2	0.4	1.8
M 2.5	0.45	2.3
M 3	0.5	2.7
M 4	0.7	3.7
M 5	0.8	4.5
M 6	1.0	5.3(5.4)
M 8	1.25	7.3(7.4)
M 10	1.5	9.2
M 12	1.75	10.9
M 16	2.0	14.8
M 20	2.5	18.7

US thread UNC		
Thread	Thread per inch	Flowdrill diameter
No. 4	40	2.5
No. 5	40	2.9
No. 6	32	3.1
No. 8	32	3.8
No. 10	24	4.3
No. 12	24	4.9
1/4	20	5.7
5/16	18	7.2
3/8	16	8.7
7/16	14	10.2
1/2	13	11.7
9/16	12	13.2
5/8	11	14.7
3/4	10	17.8

Metric thread fine		
Thread	Pitch/mm	Flowdrill diameter
M 4	0.5	3.8
M 5	0.5	4.8
M 6	0.75	5.6
M 6	0.5	5.8
M 8	1.0	7.5
M 8	0.75	7.6
M 10	1.25	9.3
M 10	1.0	9.5
M 12	1.5	11.2
M 12	1.0	11.5
M 16	1.5	15.2
M 16	1.0	15.5
M 20	1.5	19.2
M 20	1.0	19.5

US thread UNF		
Thread	Thread per inch	Flowdrill diameter
No. 4	48	2.6
No. 5	44	2.9
No. 6	40	3.2
No. 8	36	3.9
No. 10	32	4.4
No. 12	28	5.0
1/4	28	5.9
5/16	24	7.4
3/8	24	9.0
7/16	20	10.4
1/2	20	12.1
9/16	18	13.6
5/8	18	15.2
3/4	16	18.3

BSP thread		
Thread	Thread per inch	Flowdrill diameter
G 1/16"	28	7.3
G 1/8"	28	9.2
G 1/4"	19	12.4
G 3/8"	19	15.9
G 1/2"	14	19.9
G 3/4"	14	25.4
G 1"	11	31.9

US thread NPT		
Thread	Thread per inch	Flowdrill diameter
1/16"	27	7.0
1/8"	27	9.4
1/4"	18	12.4
3/8"	18	15.8
1/2"	14	19.6
3/4"	14	24.9
1"	11.5	31.4

Sizes based on Fe 360 2mm
Thicker material or material with greater tensile strength (stainless) Flowdrill diameter 0.1 mm bigger