What is

Wire EDM ?

Introduction
to
Wire EDM

**This document was designed to help
educate all interested people
in the operation and application
of traveling wire EDM machines.**

Composed by

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**Ann Arbor, Michigan, USA
October 1992**

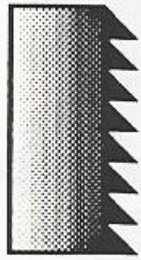**Special thanks to
Brother Industries and Charmilles Technologies**

WIRE EDM CUTS LIKE A BAND SAW

A band saw uses a motor to drive a blade, the blade has sharp teeth that cut chips of metal using force and friction.

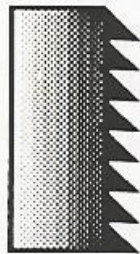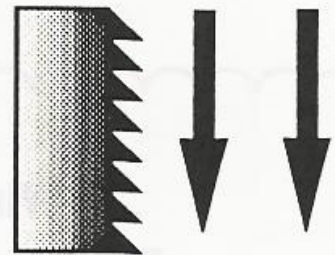There are three major variables in using a band saw:
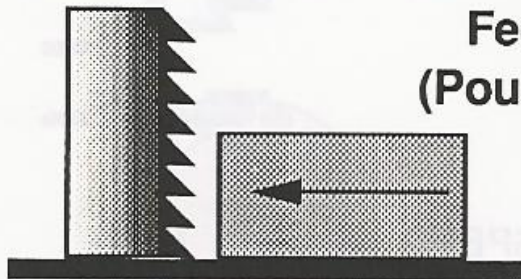
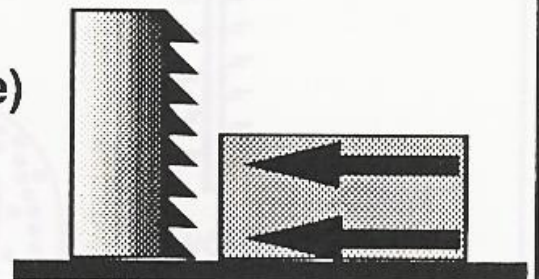**1**   **Size of teeth**

(Teeth per inch)

2   **Speed of blade**

(Feet per minute)

3   **Feed of work**

(Pounds of force)

A WIRE EDM IS LIKE A BAND SAW.....

Band saw blade has Teeth
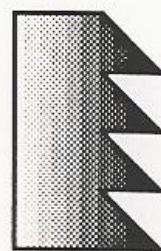
Slow	CUTTING SPEED	Fast
Smoother	SURFACE FINISH	Rough
Small	CHIP SIZE	Large
24 teeth/inch	CUTTER INTENSITY	2 teeth/inch
>.020 inch	WIDTH OF CUT	>.080 inch

Wire EDM "Teeth" are Sparks:
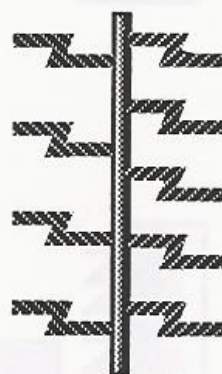
Slow	CUTTING SPEED	Fast
Micron	SURFACE FINISH	"Rough"
Small	"CHIP" SIZE	Large
5 amps	SPARK INTENSITY	600 amps
.0002"	LENGTH OF SPARK	.003"

SPARK ENERGY
The spark energy determines the size of "chip"

Spark Energy Settings:

18 - 16	Highest setting, for .012 " / .30 mm wire only.
15 - 10	First or rough cut setting for most wires.
9 - 5	Second or skim cut for improving tolerance.
4 - 1	Third cut for best finish.

Higher settings give you:

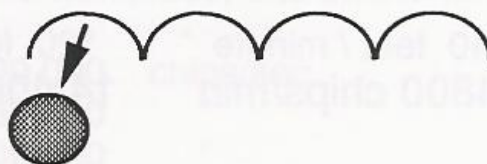   Faster cutting speed
           Rougher surface finish
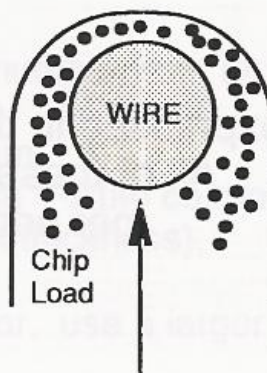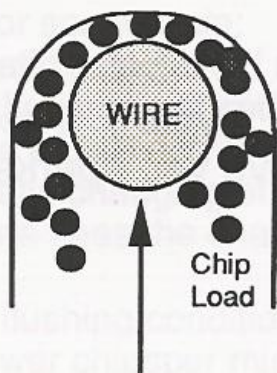   Larger chips

Lower settings give you:

           Slower cutting speeds
           Smoother surface finish
           Smaller chips

For best results:

You may find that using lower spark energy settings with higher spark cycle settings will reduce the chip size and give you better flushing of the cutting chips. This could let you cut faster.

WIRE

Chip Load

WIRE

Chip Load

A WIRE EDM IS LIKE A BAND SAW.....

Band saw blade speed is variable

40 feet / minute	120 feet/ minute	200 feet / minute
4800 chips/min	14,400 chips/min	24,000 chips/min

Wire EDM spark cycle is variable

40 micro second	15 micro second	4 micro second
25,000 sparks/sec	66,000 sparks/sec	250,000 sparks/sec
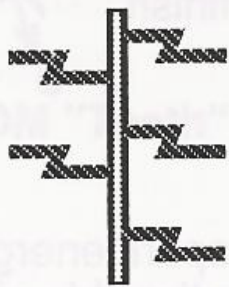
Sparking rates are expressed in the terms "Cycle", "Frequency", and "On-Off Time". All of these terms give you sparks (chips) per second.

SPARK CYCLE
The spark cycle determines how many chips per second

Spark Cycle is Microseconds between sparks. (On time + Off time).
Ranges:

4 - 999	Available settings
10 - 35	Normal user range of microseconds between sparks
4 - 10	Special for lowest spark energy Setting #1

Actual translation of Microsecond cycle settings:
(note, one spark makes two chips, one in the workpiece, one on the wire)

4	250,000	sparks/sec	500,000	chips/sec
8	125,000	"	250,000	"
10	100,000	"	200,000	"
15	66,666	"	133,333	"
20	50,000	"	100,000	"
25	40,000	"	80,000	"
30	33,000	"	66,000	"
35	28,500	"	57,000	"
40	25,000	"	50,000	"

Selecting a spark microsecond cycle time:
1) Thicker parts, smaller cycle number (lots of room to fit in a lot of sparks)
2) Thinner parts, larger cycle number (no room to fit in a lot of sparks)
3) Poor flushing conditions, larger number (less chips to flush away)

Controls for spark cycle:
1) Automatic selection of standard number from technology tables
2) Manual override of settings
3) Change of settings in part program
4) Automatic changing of cycle using T-Auto control (changes cycle as
    machine sees the change of part thickness).

NOTE: If flushing conditions are poor, use a larger spark cycle, which makes
        fewer chipsper minute.

A WIRE EDM IS LIKE A BAND SAW.....

Band saw blade speed is variable
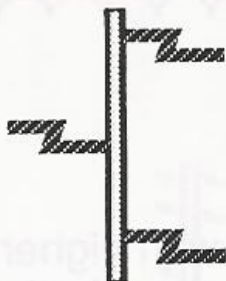
40 feet / minute	120 feet/ minute	200 feet / minute
4800 chips/min	14,400 chips/min	24,000 chips/min

Wire EDM spark cycle is variable

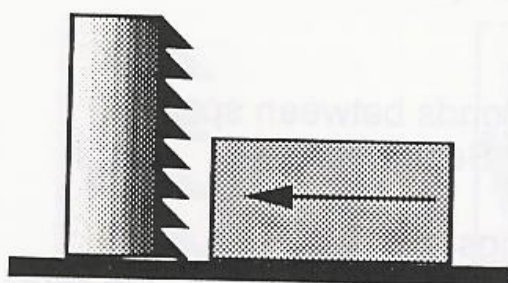| 40 micro second	15 micro second	4 micro second
25,000 sparks/sec	66,000 sparks/sec	250,000 sparks/sec

Sparking rates are expressed in the terms "Cycle", "Frequency", and "On-Off Time". All of these terms give you sparks (chips) per second.
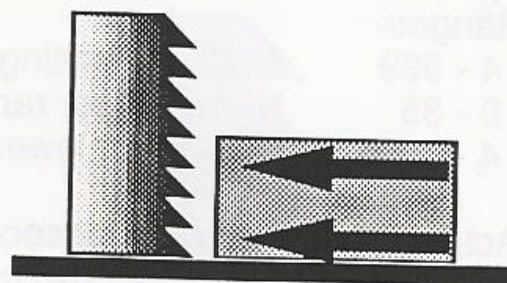
A WIRE EDM IS LIKE A BAND SAW.....

Band saw uses feed of workpiece
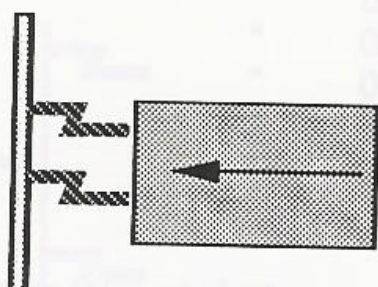
10 pounds feed

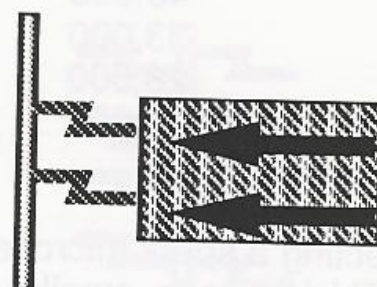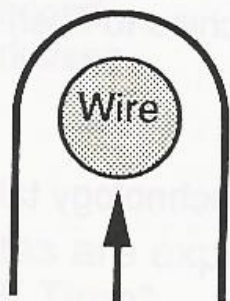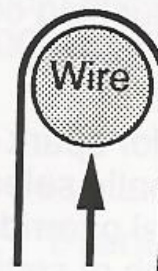50 pounds feed

Wire EDM uses feed of workpiece

80 volt Gap

30 volt Gap

Gap is defined as the electrical voltage between the cutting wire and the workpiece which can be defined as a physical distance.

Wire EDM machines allow you to set traveling speed in terms of inches/min, inches/hour, square inches/hour, or with adaptive controls, in terms of gap voltage.

FEED RATE CONTROLS
The feed rate determines how fast you cut your workpiece

Feed Rate Settings:
Manual input, from .002"/minute to 12.000"/minute
Automatic input from technology tables
Automatic settings based on target gap voltage.

S-Auto Control:
Automatic speed changes based on gap voltage.
Machine reads actual current voltage, and speeds up or slows down the feed rate to maintain constant gap voltage.

Gap Voltage:
The smaller the gap voltage:
>The faster you cut
>The smaller the distance between wire and workpiece for the chips to flush out of the wire/workpiece gap
>The more likely you are to break the cutting wire.

Normal Gap Voltage:
35 volts   Watch it, you are pushing it. Only with best flushing.
44 volts   Normal high speed cutting.
55 volts   Safer cutting with larger spark gap.

Speed Limit Control:
Prevents the machine from traveling too fast in a skim cut setting when you are using higher spark energy after a stress relieving rough cut. (when skim cutting with S-Auto control on, and, high energy because your stock removal varies from .010" to .0002", the machine could cut too fast when it reaches the .0002" area). Speed limit control allows the machine to slow down as necessary, but prevents the machine from cutting so fast as to get into trouble when you come to a corner.

REMOVING THE CHIPS WE MAKE

Bandsaw blade pulls the
chips we make through the
cut. They are disposed under
the work table.
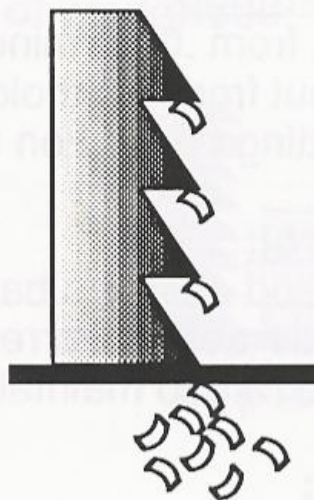
Wire EDM does not have a
blade to pull the chips through
the cut. Wire EDM uses high
pressure flushing with dielectric
water to wash away the chips.
You must be careful to place
the high pressure flushing
nozzle close to the work to be
successful in cutting your work.

Upper Nozzle

Dielectric water at up to 300 PSI
comes out of the nozzles
to surround the cutting wire
and flush away the chips.

Lower Nozzle
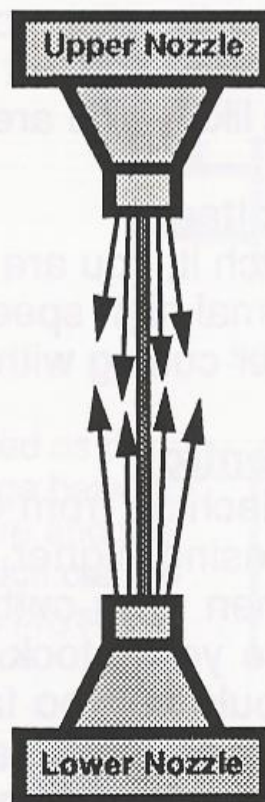
FLUSHING AWAY THE CHIPS
The single most important factor in Wire EDM
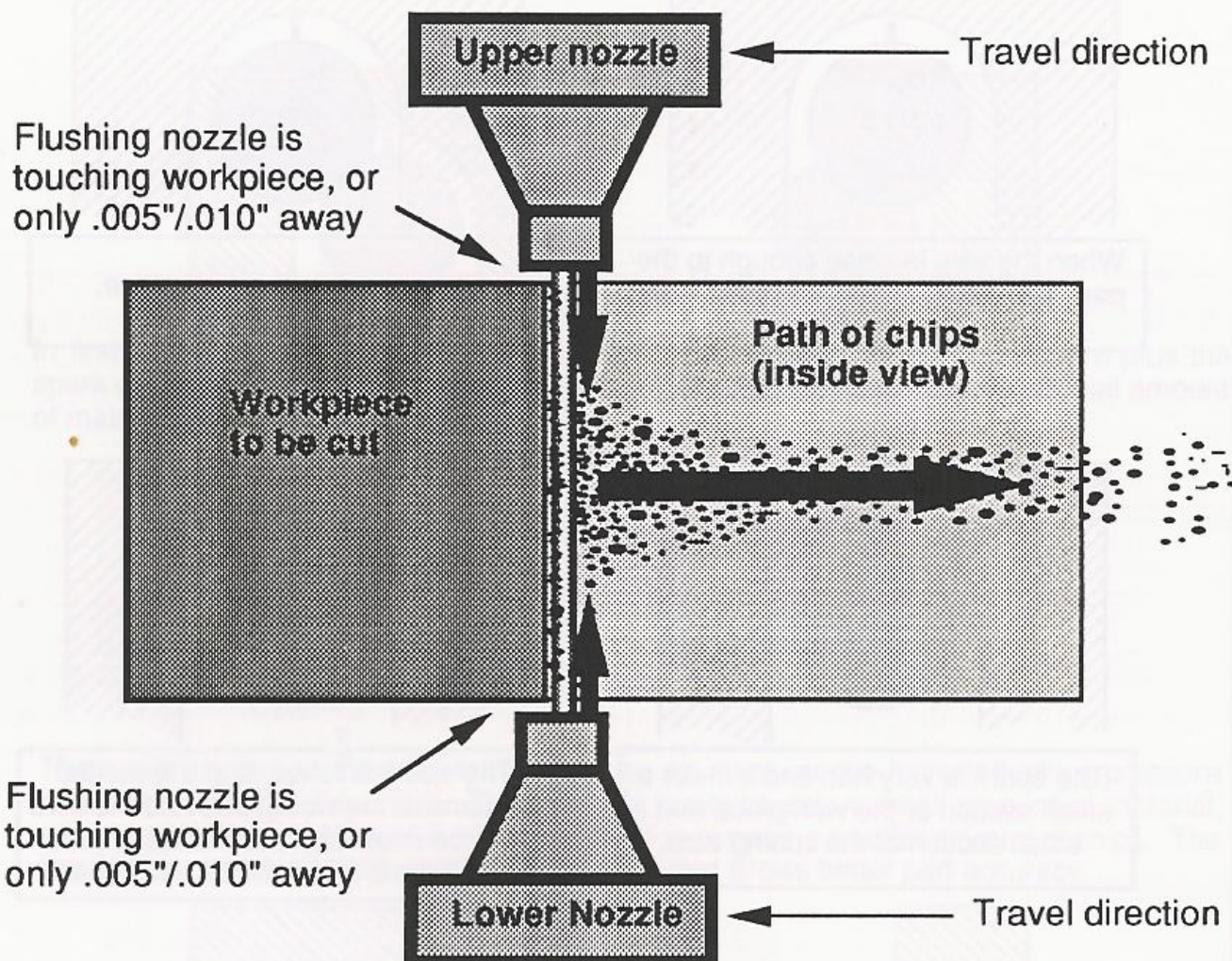
Upper nozzle ← Travel direction

Flushing nozzle is touching workpiece, or only .005"/.010" away

Path of chips (inside view)

Workpiece to be cut

Flushing nozzle is touching workpiece, or only .005"/.010" away

Lower Nozzle ← Travel direction

Flushing nozzles push the chips away from the cutting zone.

The top and bottom nozzles use up to 300 psi of flushing pressure to quickly move the chips out of the cutting area. The dielectric water and chips meet in the middle of the cut where the chips move around the wire, and out the path that was already cut. This gives you a darkened area in the middle of your part. If the dark area is above or below the centerline, it means the top and bottom nozzles are not balanced.
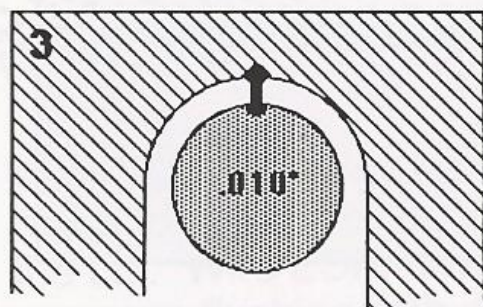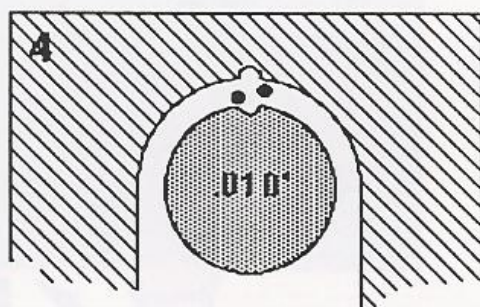
SPARK DYNAMICS IN THE ROUGH CUT

1

.010"
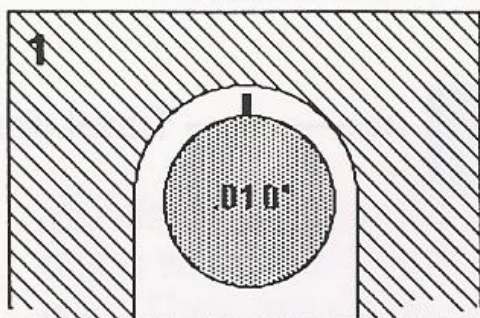
When the wire is close enough to the part, a spark can form and jump from the wire.

2

.010"
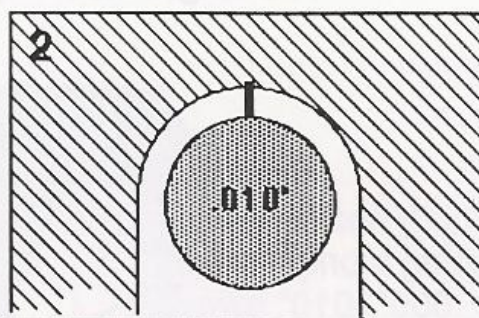
The spark hits the workpiece.

3

.010"

The spark is very hot, and it melts a small section of the workpiece and a small section of the cutting wire.

4

.010"

The spark finishes, and the melted sections of the workpiece and the wire become cooled by the dielectric water. Two chips are formed by each spark.

5

.010"
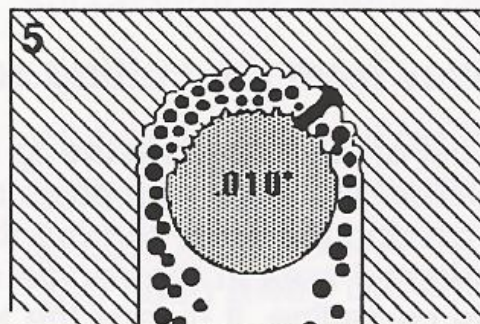
This process is repeated based on the spark cycle, up to 250,000 times a second, one spark at a time.

6

.010"

Weak   Strong
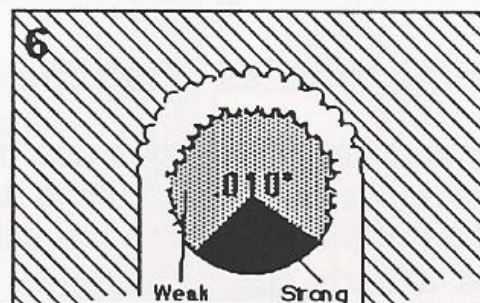
As a result, the cutting wire is damaged so much we can not put high tension on the wire, or it will break. Low wire tension causes wire drag, and lower accuracy.

ROUGH AND SKIM CUTS (FIRST CUT AND SECOND CUT)
By cutting the part twice, you improve workpiece accuracy

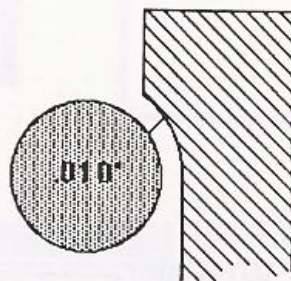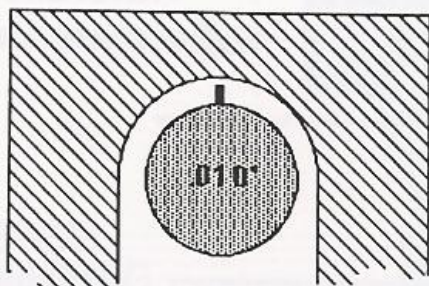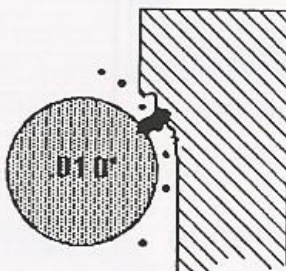In first cut called a rough cut, removes the entire diameter of the cutting wire plus the spark gap. The second cut is called a skim cut, because we only remove a small amount of material, typically from .0002" to .002".
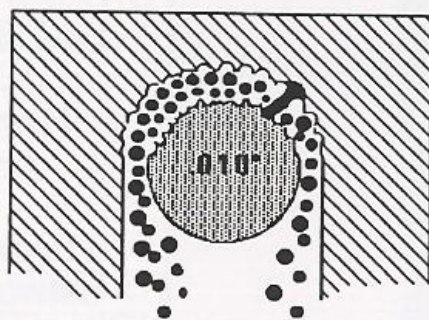
The rough cut has to remove a lot of metal, so we must use the highest flushing pressure possible to remove the chips. The skim cut removes only a small amount of material, and we can now use a lower flushing pressure to remove a smaller amount of chips. The low flushing pressure does not deflect the wire, and allows better part accuracy.
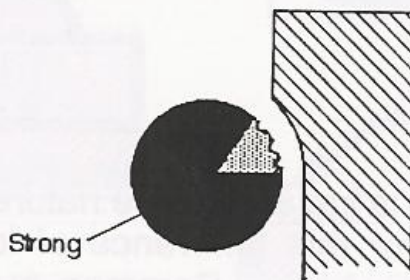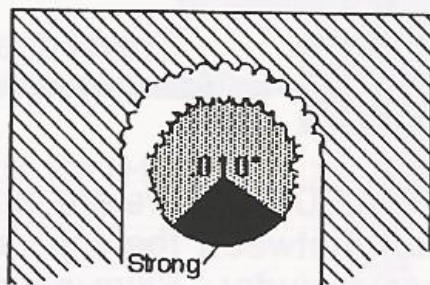
The large sparks used in the rough cut along with the large cutting area gives us a weak cutting wire. Rough cuts require low wire tensions. The smaller sparks used in the skim cut along with a small cutting area gives us a strong cutting wire. Skim cuts can use highest wire tensions for better tolerance.

THE WIRE CENTER DRAGS BEHIND THE TOP & BOTTOM

It is like pulling a rope from two ends
Caused by physics, low rough cut wire tension, and high flushing pressure

Travel direction

WIRE STAYS STRAIGHT WHEN:

Smaller sparks

High wire tension

Low flushing pressure

Shorter distance between nozzles

Larger gap voltage

WIRE DRAGS BEHIND WHEN:

Larger sparks
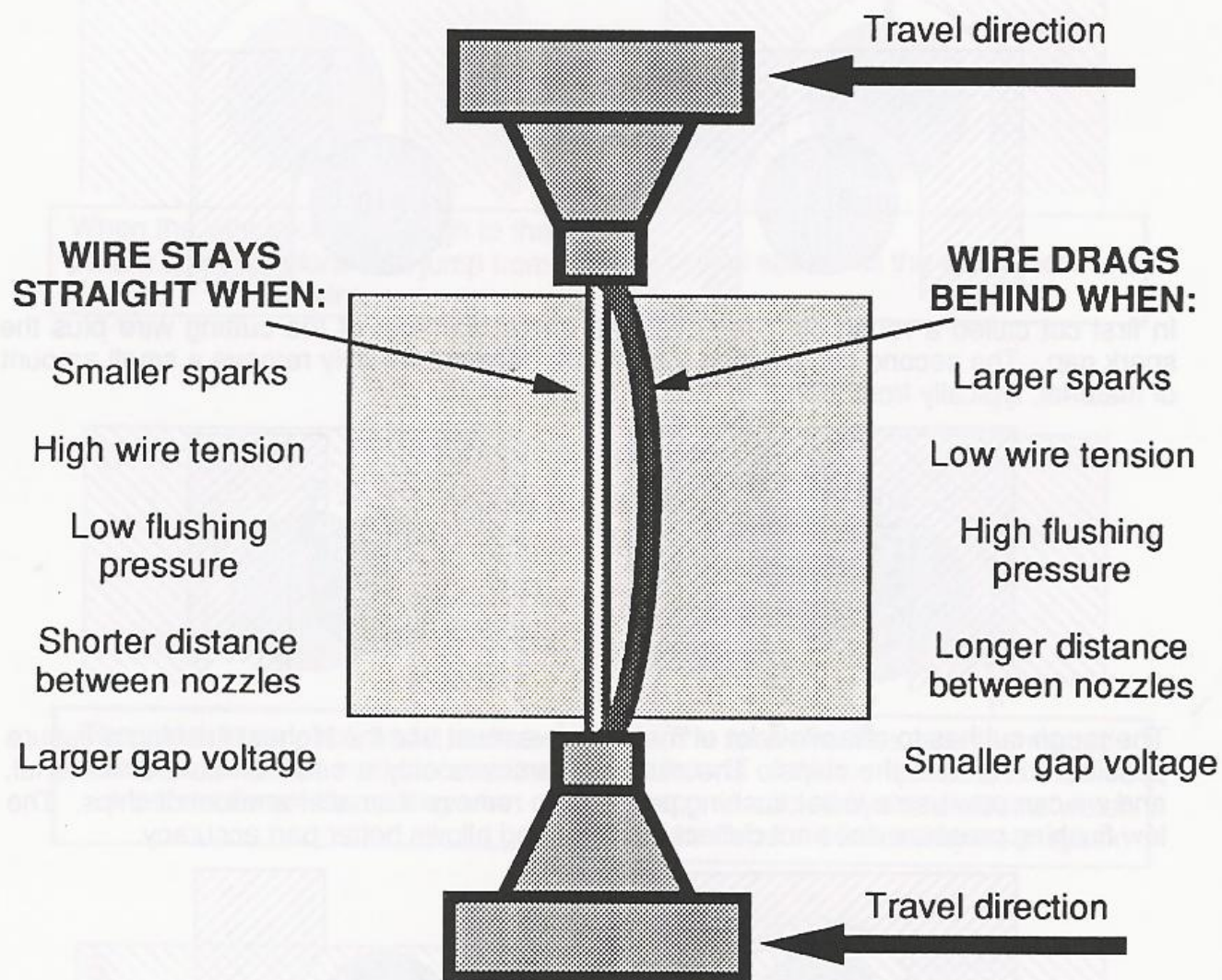
Low wire tension

High flushing pressure

Longer distance between nozzles

Smaller gap voltage

Travel direction

This wire drag is just part of the nature of wire EDM. There are many ways to compensate for this difference of location between the top, middle, and bottom of the wire. Common methods include: Skim pass with high tension, slowing down the feed rate at circles and the ends of straight line cuts, program dwell at each line end to allow the middle to catch up, automatic corner control to automatically slow down, and overshooting sharp corner to make "Mickey Mouse" ears that over burn the blank but leave the corners of the actual part square.
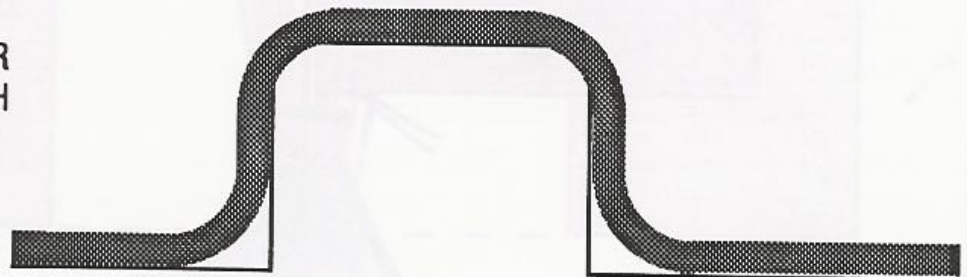
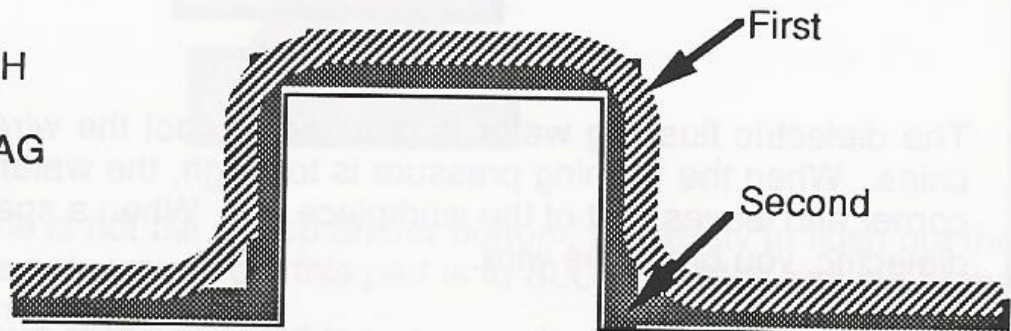# WHAT HAPPENS TO THE PART BECAUSE OF WIRE DRAG

DESIRED
PART SHAPE

IDEAL PATH:
NO WIRE DRAG
USING SLOW
CUTTING SPEEDS
OR AUTOMATIC
CORNER
CONTROLS.

ACTUAL CUTTER
PATH WITH HIGH
WIRE DRAG(UP
TO .008" IN A
CORNER).

TWO CUT PATH
FIRST ROUGH
HAS WIRE DRAG
SECOND CUT
HAS HIGH
TENSION.

First

Second

FLUSHING IS POOR NEAR THE PART EDGE
Flushing water bounces off the part edge
instead of injecting into the spark cutting zone

Upper nozzle

Workpiece

If flushing pressure is too high, this area will be dry. When a spark discharges in this dry area, the wire will weld and break

Lower Nozzle
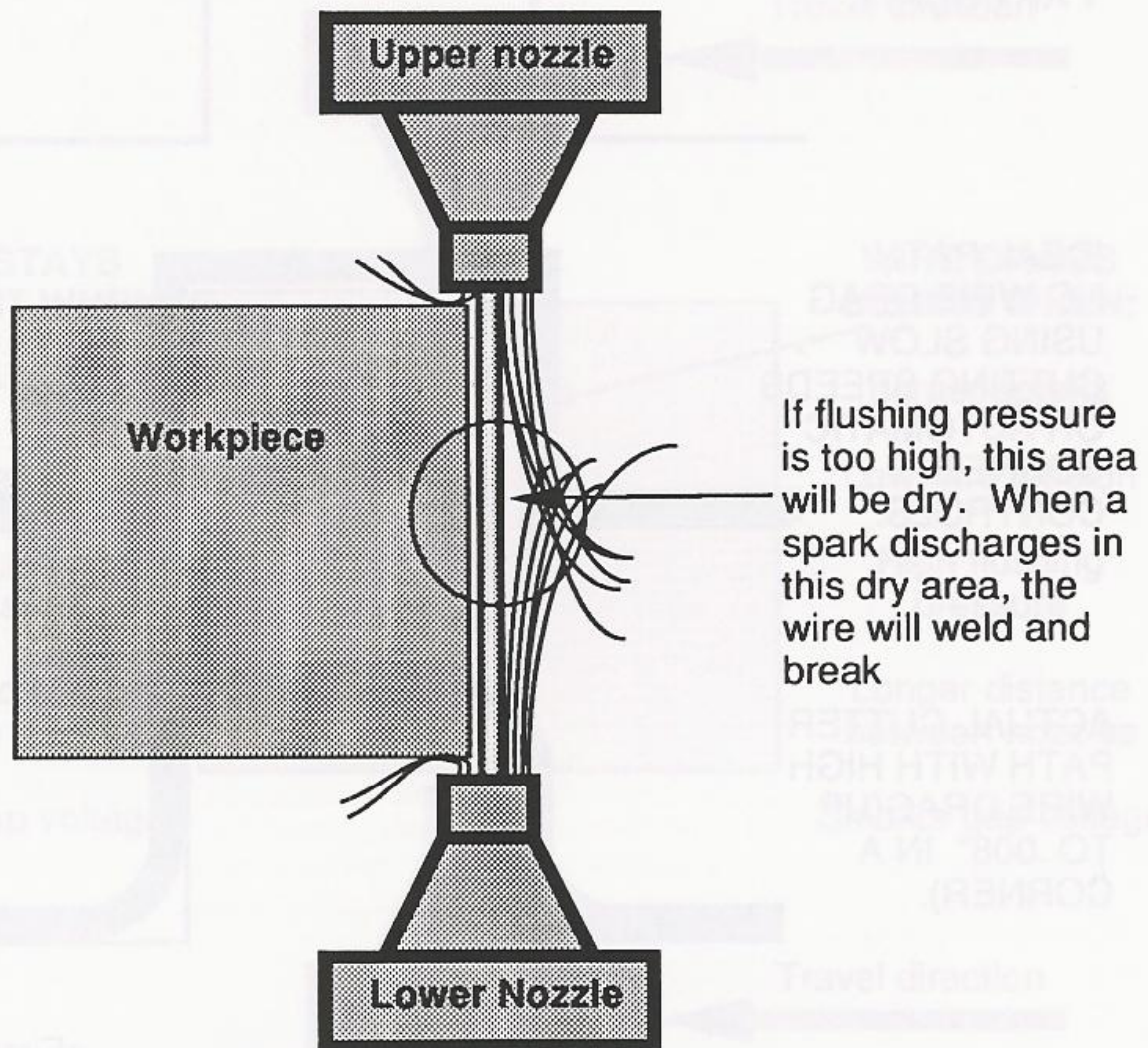
The dielectric flushing water is required to cool the wire and flush away the chips. When the flushing pressure is too high, the water bounces off the part corner and leaves part of the workpiece dry. When a spark occurs without the dielectric, you break the wire.

In a submerged worktank, you do not break the wire due to lack of dielectric, but can break the wire due to poor pressure to remove the chips.

WIRE EDM PREFERS A FLAT SURFACE
A flat surface gives you tight nozzle contact for the best chip flushing

Water needed here ➤   **Water not needed here**
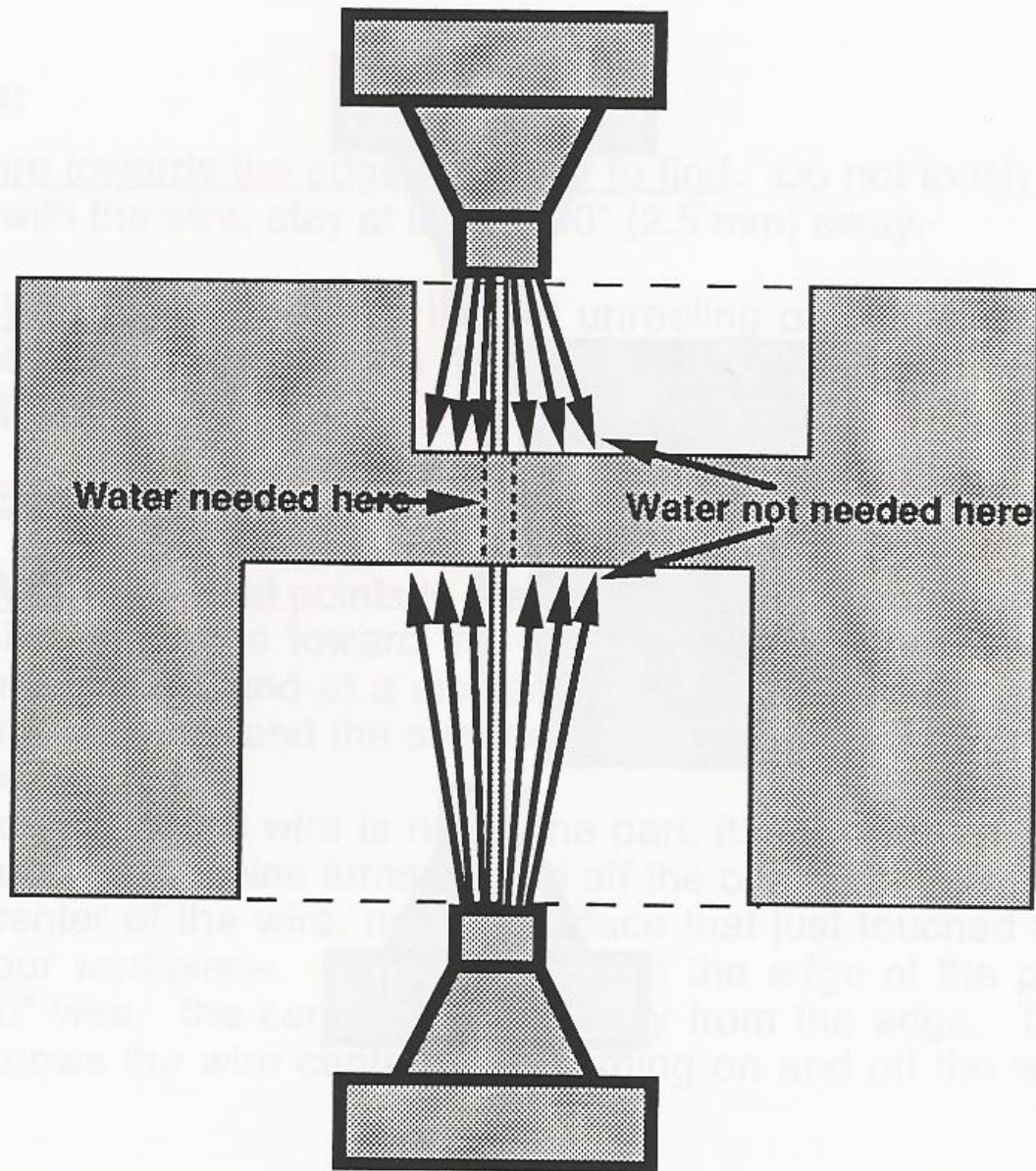
When the workpiece is not flat on top and/or bottom, the ability to flush out the chips is poor. The only way to cut this part is to SLOW DOWN and cut at the efficiency of the flushing conditions.

FINDING THE EDGE OF THE PART FOR LOCATION
The machine needs a good ground edge for the best location

Upper Nozzle

Workpiece

Lower Nozzle
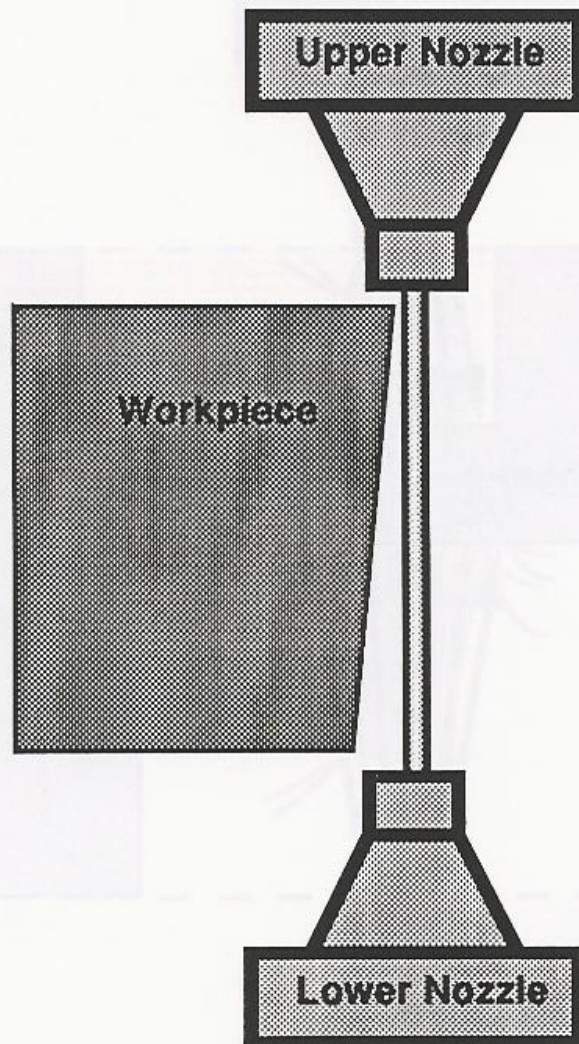
The wire EDM machine can only "see " metal. It will see the edge of this part at the first edge it contacts.   It can see burrs , metal chips, and grease.

In addition, the machine can not "see" rust, dirt, or paint.

EDGE FIND

Use this function to find the edge of a part on the Brother WEDM.

Operation:

<u>Jog the wire towards the edge you want to find</u>. Do not touch the part edge with the wire, stay at least .100" (2.5 mm) away.

<u>Push the **Wire** key</u>. The wire is now unreeling off the wire roll. Your tension should be set high (tap 10 - 18) and your wire speed set low (tap 5 - 10).

<u>Push the **Edge** Key</u>.

<u>Push the **Arrow** key</u> that points to the edge of your workpiece.
The machine will move toward the edge, touch the edge, move away from the edge, and at a slower speed find the edge again. The machine will stop and the surface of the wire is now touching the edge of the metal.
<u>Note</u>: the center of the wire is not at the part, it is the wire radius away. When the machine turns on and off the offset, the machine uses the center of the wire, not the surface that just touched the edge of your workpiece.   When you touch the edge of the part with a .010" wire, the center is .005" away from the edge. The machine knows the wire center when turning on and off the wire offset .

For best results:

The edge should be ground, or at lease free of nicks and burrs.
The edge must be clean and dry with no rust, oil, grease, or water.
If the edge find location is critical, reset the position display to zero, jog away from the edge, and edge find again.

CENTERING HOLE MUST BE SQUARE
FOR GOOD CENTERING.

Upper Nozzle

Workpiece

Lower Nozzle
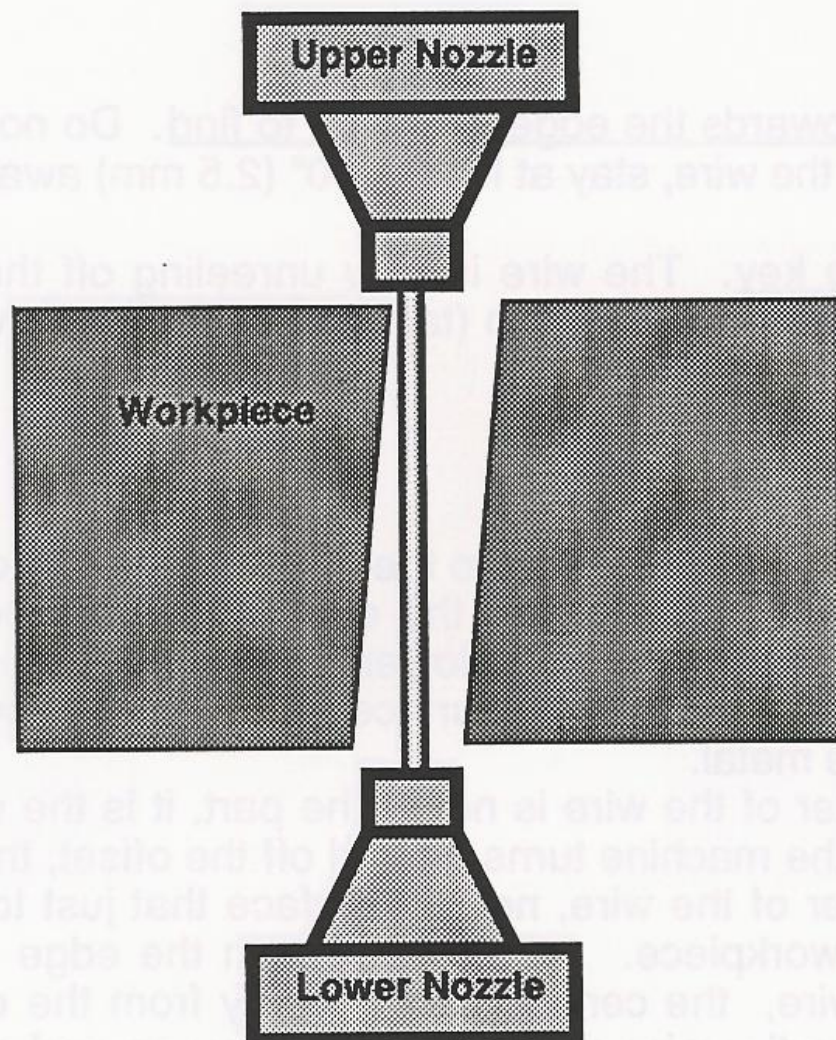
The wire EDM machine can only "see" the metal the wire touches. It can not see that the hole is not square, and will see the center of this hole as midway between the left top edge with the right bottom edge. In addition, the machine can not "see" rust, grease, dirt, or paint. It can see burrs or metal chips.

CENTER FIND
Use this function to find the center of a hole

Operation:

Jog the head to the approximate center of the hole. Thread the wire through the hole. The wire should not touch the part edge.

Push the **Wire** key. The wire is now unreeling from the wire roll. Your tension should be set high (tap 10 - 18) and your wire speed set low (tap 5 - 10).

Push the **Center** key.

Push the **Start** key . The machine will move toward the hole edge, touch the edge, move away from the edge, and at a slower speed find the same edge again. The machine will repeat this operation automatically at 90 degree increments. The machine will stop and the center of the wire will be in the center of the hole.

For best results:

The hole should be ground, or at lease free of nicks and burrs. The hole must be clean and dry. No rust, oil, grease, or water. If the center find location is critical, reset the position display to zero, and center find again.