Common Causes of Mig Torch Failure in Service and their Solutions

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Failures of MIG torches in service are major causes of poor productivity due to stoppages in production, poor weld quality and excessive opreator fatigue. The major causes of these failures are reviewed and illustrated from the writers' experiences. Aspects of and criteria for MIG torch design are examined with particular reference to design of torches for robotic and automated welding applications. Testing of torch design and performance is investigated guidelines are set out for the correct choice of torch and components for particular applications. The advantages and disadvantages of water-cooled torches are discussed.

DESIGN CONSIDERATIONS

In general terms, the major necessary functions of a MIG/MAG (GMAW) torch are :

To conduct the welding current from the power source to the torch neck.

To conduct the wire electrode from wire feeder through the contact tip.

To conduct the shielding gas from the wire feeder through the gas nozzle to provide an effective gas shield over the arc/weld pool area.

To transfer current from the torch neck to the electrode via the contact tip.

To dissipate, or resist the heat created by the welding process at the rated operating current.

Couple these with the preferences of users and employers :

- Flexibility.
- Lightweight, ergonomic design.
- Longevity of consumables.
- Low cost of consumables.

Combining functions in paragraph one with preferences of users and employers must result in several compromises.

Option 1 : AIR-COOLED TORCHES : Typical features of this very common style of torch are :

- A multipart cable assembly, for low cost.
- A strong and usually heavy hand piece, for longevity.

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A simple one piece neck, again to reduce cost. Inexpensive consumables (contact tip, nozzle, etc.).

OPTION 2 : GAS-COOLED TORCHES : Gas-cooled torches use the shield gas to assist in cooling the torch during operation. The two main features of their design are :

A gas-cooled neck : (See Fig. 1) As illustrated, this type of torch neck has two design features which result in cooler running and a reduction in weight, with a corresponding increase in consumable life.

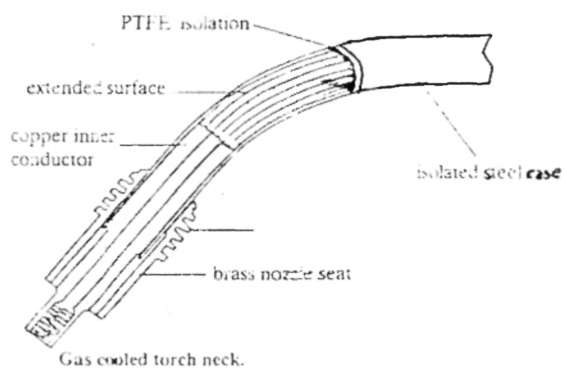


Fig. 1 : Gas cooled torch neck.

Firstly, the shield gas is channelled along an extended surface of the inner conductor, which removes heat conducted away from the contact tip area, and also preheats the shield gas.

Secondaly, the outer case of the neck is electrically isolated from the central conductor allowing direct contact between the gas nozzle and its finned seating area. Thus the temperature of the gas nozzle is prevented from rising to excessive levels during operation.

A single piece cable assembly : (see fig.2) As can be seen from the illustration, this style of cable, because it carries all services coaxially, offers a considerable weight saving over the alternative. This weight reduction has the added advantage of improving the balance of the torch, which can result in a reduction of its subjective weight.

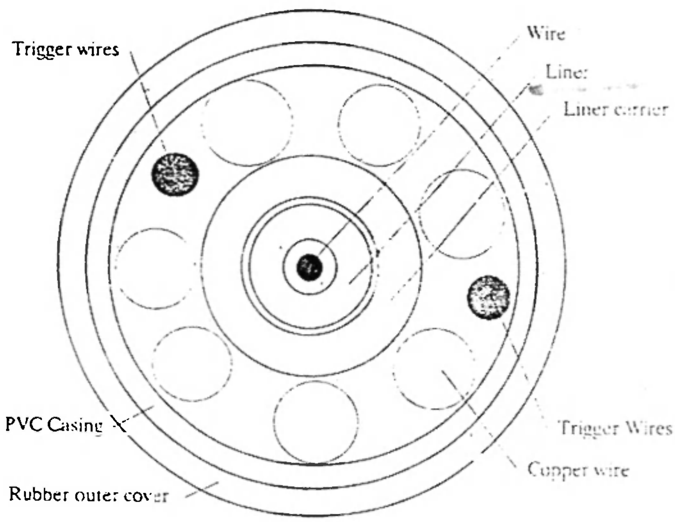
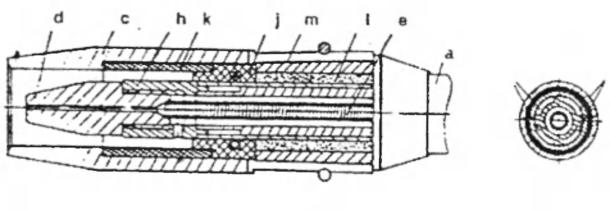


Fig. 2 : Cable Assembly

Option 3 : WATER-COOLED TORCHES : This option is universally accepted as the best solution, but of course, because it necessarily involves a greater investment, is slow to gain acceptance in many countries. Water-cooled torches today incorporate :

A water-cooled power cable : The weight reduction from this (typically 1 kg per 3 metre cable) more than compensates for the necessity of a multipiece cable assembly in this type of torch.

A water-cooled torch neck : (see fig.3) Cools both the inner conductor and the gasnozzle seating.



a) Torch Neck
b) Gas Nozzle Seat
c) Gas Nozzle
d) Contact Tip
e) Wire Feed Liner
f) Coolant Entry
g) Coolant Return
h) Tip Holder
j/k) Gas Diffuser/Insulator
l) Ceramic Insulator

Fig. 3 : Construction of Water-Cooled Torch Neck

One point of interest here is that 70% of the temperature rise of the coolant is due to heat dissipated in the power cable; only 30% being due to the torch neck. Consequently it becomes important to direct the coolant first to the torch neck, passing through the power cable on its return. To reverse the flow would result in trying to cool the torch neck with preheated water.

With these torches, one can see that a lack of coolant will result in rapid failure of the torch cable, and this is cited as the major disadvantage of water cooled torches. (30 seconds' operation at rated current without water is enough for the torch cable to require replacement.) It should therefore be considered essential to fit some kind of fail-safe to ensure that welding cannot take place without water-flow. Another disadvantage cited for water-cooled torches is the expense of water recirculator units. But provided there is a supply of clean water at 2.5 to 3 bar, a total-loss cooling system can be employed, as water consumption is less than 2.5 litres per minute.

Previously, and still today on occasion, one comes across a partial solution which consists of adding a water-cooled nozzle to a torch originally designed for air-cooled operation. This can achieve a minor increase in performance, but is at best a half- way house, as it does nothing to cool the critical contact tip area.

Contact Tip Materials

It is perhaps a good time to mention the various kinds of contact tip which are in use, and a few of those which have been tried in recent years for this critical component.

Hard-Drawn Pure Copper : The most common material in use wordwide. It is cheap plentiful, easily formed, recyclable, has a high thermal and electrical conductivity, and a low surface contact resistance.

Cu-Be 2% : Very hard (up to 200 Hv) and wear resistant. Its conductivity is up to 80% of that of copper. However, prolonged heat causes over-ageing of this alloy which reduces not only its hardness, but its conductivity to 20%. Also, this alloy has a high surface contact resistance.

Cu-B2 0.5% : This alloy has a slightly higher conductivity than Cu-Be-2%, and with a lower surface contact resistance, but not so hard. (-175 Hv). It does not over-age as badly. The main problem with this alloy is its poor availability.

Cu-Cr-Zr : This alloy is now readily available as contact tip raw material. Its conductivity is better than 70% of that copper, and it has a wear resistance which gives tips made from it a life of 4 to 5 times that of pure copper tips when abrasive wires are used. The cost is approximately 50% more than that of pure copper tips.

It should be noted that whilst all the alloys mentioned have higher hardness than pure copper, this advantage is nullified if the tip temperature in service exceeds the softening temperature of the alloy. It is also worth mentioning that all the alloys have a lower fusion temperature than pure copper, so that in conditions of severe overheating, they will fail earlier than their cheaper alternative.

Many other materials and designs have been tried.

For instance : Tungsten with spring loaded copper contacts. Silver-Tungsten (As a sintered powder composite insert.) Curved Tips. Spiral Tips.

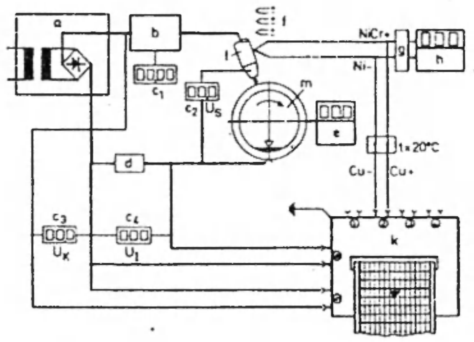
All have one problem. Cost proponents say - look at the life!'. But as we will see there are many other causes of burnback besides tip failure as a primary cause. Any of these alternate causes of burnback can cause premature destruction of the contact tip, which if it falls in the 'Super-Tip' category, can be a costly exercise.

Testing and Rating of Torches

Whilst there are established and internationally accepted test procedures and standards for transformer and welding machines, there are no such standards for torches. So manufacturers of torches have set their own individual internal standards, and carry out their own tests.

Features tested include operating temperatures of nozzles, contact tips, necks and wire feed resistance. For gas-cooled torches testing is usually performed at 60% duty cycle. The cycle time used (for European manufacturers) is five minutes. Water-cooled manual and robotic torches are usually tested at 100% duty cycle. Failure criteria include excessive temperatures of the contact tip, nozzle and handle and excessive or inconsistent wire feed resistance.

It should be remembered that the ambient testing temperature is 20 degrees Celsius and allowances should be made for this when selecting torches for use at higher ambient temperatures.



a) Power Source
b) Wire Drive Unit
c) Wire Speed Indicator
Welding Voltage - measured at torch
Welding Voltage - measured at source
Current Related Voltage
d) Current Shunt
e) Welding Speed Indicator
f) Thermocouple Elements
g) Thermocouple Switch
h) Temperature Switch
k) Multi-channel chart recorder
l) Welding Torch
m) Workpiece

Fig. 4 : Schematic of Test Monitoring System

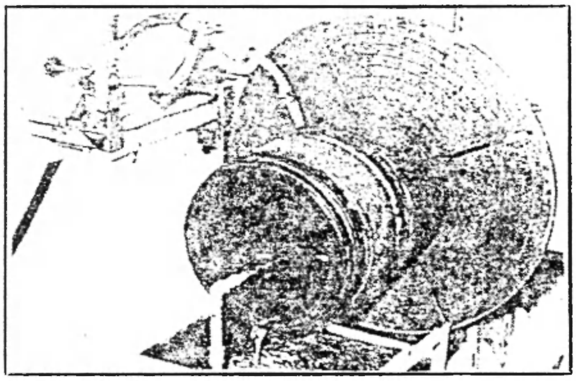


Fig. 5 : Test Jig

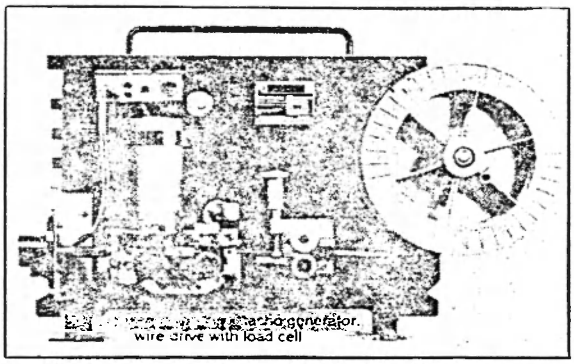


Fig. 6 : Modified Wire Feeder

The manufacturer having carried out such extensive testing we should now have torches which stand up to the conditions the manufacturers have specified. So why do they fail prematurely??

Common Torch Failures

When considering in-service torch failures it is important to remember that the torch has probably been throughly tested by the manufacturer in conditions considerably harsher than those under which it has now failed. Blaming the torch in this situation is akin to your bank blaming your incorrect statement on 'computer error' when we all know they mean 'computer operator error'.

Many causes of failure have similar symtoms. So we'll look at the root causes and show how they manifest themselves with these common symptoms.

Excessive weld spatter : On the gas nozzle : Incorrect welding conditions or lack of cleaning can lead to excessive spatter build-up on the gas nozzle.

Resulting in : Shorting of nozzle to contact tip Porosity due to disturbed gas flow

Excessive weld spatter : On the contact tip : Incorrect conditions can lead to excessive spatter build-up on the contact tip.

Resulting in : Momentary welding between the contact tip, spatter and the electrode wire, causing slowing or stopping of the wire feed, leading to burnback of the wire to the contact tip.

Burnback (from this and other causes) is the singular most common cause of lost productivity in MIG Welding.

Spatter bridging : Between the contact tip and nozzle holder : Due to lack of maintenance or omitting to replace iffuser/insulator can cause spatter to create a short between the tip and nozzle or nozzle holder.

This causes : (i) The gas nozzle becomes electrically live, with the capability of delivering maximum short circuit current of the power source to whatever it should happen to touch. (ii) Poor gas flow and / or porosity.

Poor condition or wrong size of wire drive roller : Due to neglect in regularly checking and changing of drive rollers.

Resulting in : Poor weld quality burnback and reduction of uptime. We only change drive rollers after we experience trouble. How often should we change them, yearly, half yearly, or more frequently? The answer is not a simple one, it depends upon the type and quality of electrode wire used. The most abrasive wires, such as aluminium alloys and flux-cored wires cause the most rapid wear, and would benefit from the use of ceramic rollers which are now available for some models of wire feeders.

Clogging and wear of the wire feed liner

Resulting in : Intermittent wire feeding.

Poor Weld quality : Increase in spatter levels and burnback.

The wirefeed liner is a consumable and should be replaced regularly. As a general rule, a standard steel spiral liner can be expected to give its best service through four 15 kg. spools of wire depending on the type and quality of material being used, and the welding conditions. Regular cleaning and the use of wire wipers can improve the life and feedability but, after a certain time, the liner in the torch neck develops a wear groove. Removal, cleaning and replacement will show a short term revival, but only until the electrode wire 'finds' the groove again. This is clearly uneconomic and will result in reduced uptime.

Note : particularly with soft wires, such as aluminium alloys and flux-cored wires, feed problems caused by 4 and 5 (see above) lead the operator to increase drive roll pressure in an attempt to solve his wire feed problem.

Resulting in : (i) Distortion of the wire to the point that it is so oval that it will not pass through the contact tip. This is manifested by repeated burnbacks at regular intervals, the interval being the time taken to consume a torch-length of wire!

(ii) Shaving or flashing of the wire with the same result as above, or in the case of flux cored wires, opening of the joint, resulting in powder loss, liner clogging and consequent burnback.

Excessive wear of the contact tip : Resulting in : Poor or intermittent contact tip/wire conductivity. This leads to variable arc length and poor weld quality. Internal arcing between the contact tip and the wire, leading to low arc voltage, possibly 'stubbing', and momentary welding of wire to contact tip. Both of which can cause burnback.

Incorrect fitting of the contact tip : Lack of maintenance, surface of contact tip not kept clean and flat, or the contact tip not screwed home properly (see fig. 7) Resulting in : Generation of heat due to electrical resistance, in turn causing overheating of the contact tip from excessive resistance in the thermally conductive path to cooled parts of the torch. In many case, this leads to catastrophic overheating of the contact tip, or thermal runaway resulting in incipient fusion of the contact tip and subsequent 'healing up' of the wire orifice. Conditions such as described above can cause permanent thermal damage to contact tip holder and torch neck area. The inevitable result of all of the above is burnback.

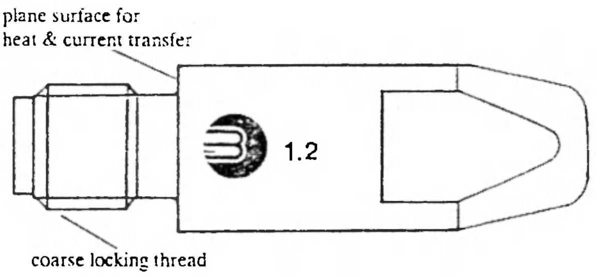


Fig. 7 : Contact tip

Excessive gas flow : Correct gas flow is 12-15 litres per minute with CO2 or 15 to 18 litres per minute with mixed gases (Argon / CO_2). Any more is wasteful and expensive, and causes deterioration to weld quality and torch life.

Overheating of the gas nozzle : A gas nozzle which is too hot (e.g. in excess of 250 degrees celcius) collect more spatter and overheats the shield gas, both of which lead to porosity in the weldment.

Incorrect or insufficient stickout : Resulting in :

Overheating of the gas nozzle and contact tip by increased proximity to the arc and weld pool. Possible contact tip corona, where part of the arc strikes directly between the contact tip and the weld-pool, causing severe overheating of the contact tip, resulting in fusion, healing-up of the wire orifice, wire jamming and burnback.

Note : This is rarely a lone phenomenon and is usually preceded by a series of events. For example : The welder experiences porosity, due to spatter build-up or excessive gas flow. First, he increases the gas flow which causes turbulence and results in more air entrainment. He then reduces stickout and the result is short-term success.

What the welder has in fact achieved are near perfect conditions for MIG torch destruction whilst consuming vast quantities of sheilding gas! Also, in the relatively short time preceding the failure of his torch, the overheating of the nozzle and the almost inevitable tip-corona will make the process a most uncomfortable one.

In the writers' experiences, this chain of events, in varying degrees , is the most common cause of burnback, torch failures and unacceptable weld quality.

Welding Robots and Automats

So we remove the human factor (or do we ?) and employ a robot. Now uptime, because of the high level of capital investment, becomes much important. Robots and automats do exactly what we tell them to do, time after time, without the need for rest.

Therefore it is important for us to consider the welding conditions most carefully so that we do not exceed the specifications of the torch. For example, air and gas-cooled torches are rated at 60% duty cycle whereas robots are usually expected to run at around 80% of more. This is a clear case of use of water-cooled torches. (see fig. 8)

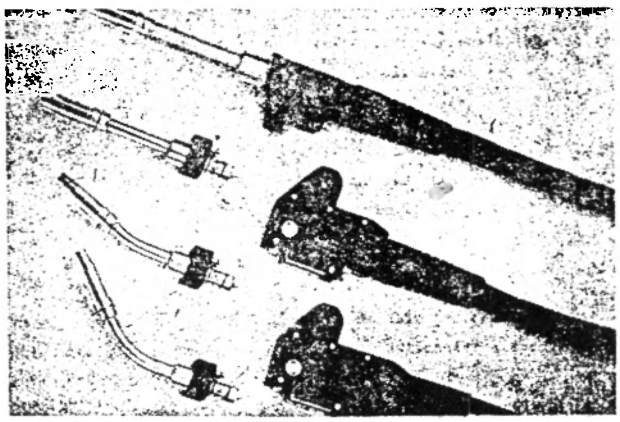


Fig. 8 : Robo 455 & Robo WH455 Torch

Robotic torches need to be manufactured to a degree of precision unnecessary for hand-held torches in order for the robot's rather simplisitic controller to be able to position the torch accurately, both for welding and for other functions, such as nozzle cleaning, wire cutting and even automatic neck changing. (See figs. 9 & 10.) Typical robotic Torches and Peripherals.

The most important thing to remember is that all the operational errors mentioned with regard to manually held torches can be reproduced by a robot, with unerring accuracy !

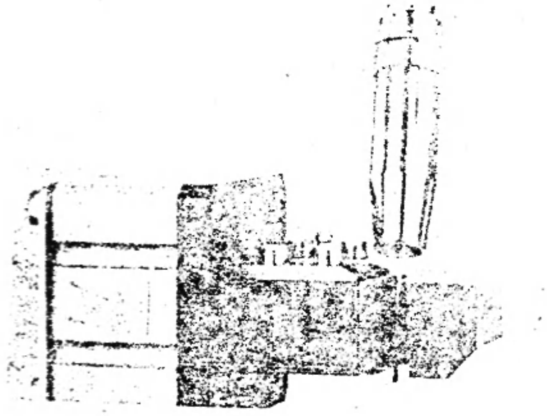


Fig. 9 : Cutting Station

Fig. 10 : Cleaning Station

AN APPEAL TO ALL BRANCHES OF THE INSTITUTE.

In view of the fact that the accounts are not audited and Annual General Meeting is not held in September. We are being penalised each year for the last few years by the Income Tax Authority.

Request kindly ensure that audited Branch Accounts are sent to us at the earliest and by May/June 1993 positively to enable us to file and submit the total accounts to our statutory Auditor here and have the Annual General Meeting held in time in September and avoid paying penalty and fine from the meagre funds i.e. available with us and which is the good money belonging to all the members.

Trust, you will extent your helping hands and assist us to save.

Thank you so much.

— Hony. Secretary