CMR INSTITUTE OF TECHNOLOGY

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Improvement Test

Sub:	Non Traditional Machining							Code:	10ME665
Date:	30 / 05 / 2017	Duration:	90 mins	Max Marks:	50	Sem:	VI	Branch:	Mechanical

Answer Any FIVE FULL Questions

		Marks	OBE	
			CO	RBT
1.(a)	Explain with a neat diagram the Abrasive jet machining process.	[05]	C02	L1
(b)	Explain the working principle of Water jet machining.	[05]	C01	L1
2.	With neat sketch explain the Construction and working principle of PAM.	[10]	C03	L2
3 (a)	With simple sketches explain nozzle geometry in AJM process.	[05]	C01	L1
(b)	Write a note on "generation of plasma" in PAM.	[05]	C02	L1
4.	List and explain any five parameters that effect Abrasive jet machining.	[10]	C01	L1
5.	Explain the parameters that govern the performance of PAM.	[10]	C01	L1
6 (a)	Mention any five advantages and limitation in PAM.	[05]	C02	L1
(b)	What are the advantages, disadvantages and applications of Water jet machining process?	[05]	C01	L1

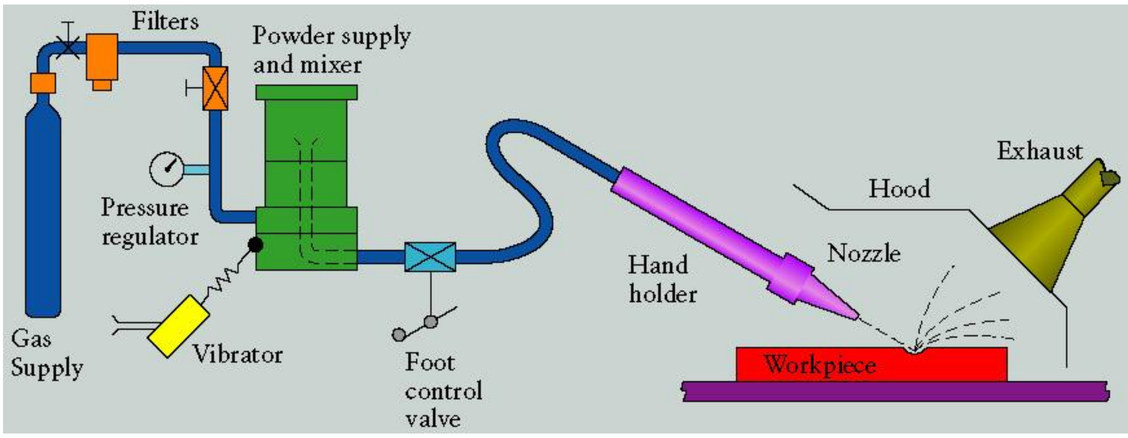
Course Outcomes		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1:	Classify Description and Working principle of various Non Traditional Machining.	2	0	0	0	0	0	0	0	0	1	0	1
CO2:	List the advantages, disadvantages and applications of various non traditional machining processes	2	0	0	0	0	0	0	0	0	1	0	1
CO3:	Compare the process characteristics of various unconventional machining processes	2	0	0	0	0	0	0	0	0	1	0	1

Cognitive level	KEYWORDS
L1	List, define, tell, describe, identify, show, label, collect, examine, tabulate, quote, name, who, when, where, etc.
L2	summarize, describe, interpret, contrast, predict, associate, distinguish, estimate, differentiate, discuss, extend
L3	Apply, demonstrate, calculate, complete, illustrate, show, solve, examine, modify, relate, change, classify, experiment, discover.
L4	Analyze, separate, order, explain, connect, classify, arrange, divide, compare, select, explain, infer.
L5	Assess, decide, rank, grade, test, measure, recommend, convince, select, judge, explain, discriminate, support, conclude, compare, summarize.

PO1 - *Engineering knowledge*; PO2 - *Problem analysis*; PO3 - *Design/development of solutions*; PO4 - *Conduct investigations of complex problems*; PO5 - *Modern tool usage*; PO6 - *The Engineer and society*; PO7- *Environment and sustainability*; PO8 – *Ethics*; PO9 - *Individual and team work*; PO10 - *Communication*; PO11 - *Project management and finance*; PO12 - *Life-long learning*

Non Traditional Machining
IAT-3 Solution

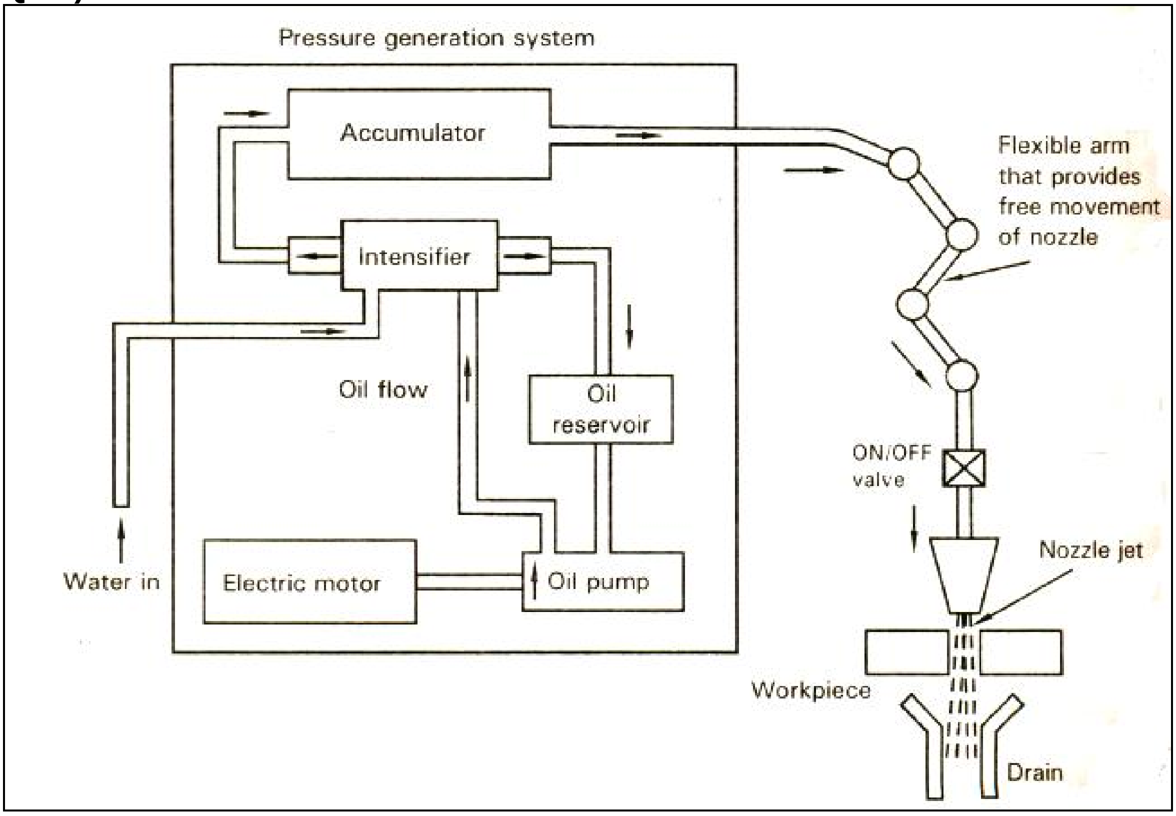
Q1 a)



AJM Operation:

- Figure shows a diagram of working of the process, the filtered gas supplied under a pressure of 2-8 kg/cm^2 to the mixing chamber, containing fine abrasive particles and vibrating at 50Hz.
- The vibrating action of the mixing chamber entrains the abrasive particles into the jet stream. The abrasive and the gas mixture are then passed into the connecting hose. Then, the mixture of pressurized air and abrasive powder then flows to the nozzle.
- The stream of mixture emerging from the nozzle at a high velocity ranging from 150 to 300 m/min, is directed onto the work surface to be machined.
- The impact of the particles on the work surface produce sufficient force to cut a small hole or slot, deburring, trimming or removing oxides and other surface films from the work surface.
- A pressure regulator controls the gas flow and pressure. The abrasive powder feed rate is controlled by the amplitude of vibration of the mixing chamber.
- The nozzle is usually mounted on a fixture. Either the work piece or the nozzle is moved by cams, pantographs or other suitable mechanisms to control the size and shape of the cut.
- A dust hood or vacuum dust collector is sometimes used to draw the dust particles and keep the operators viewing clear**.**

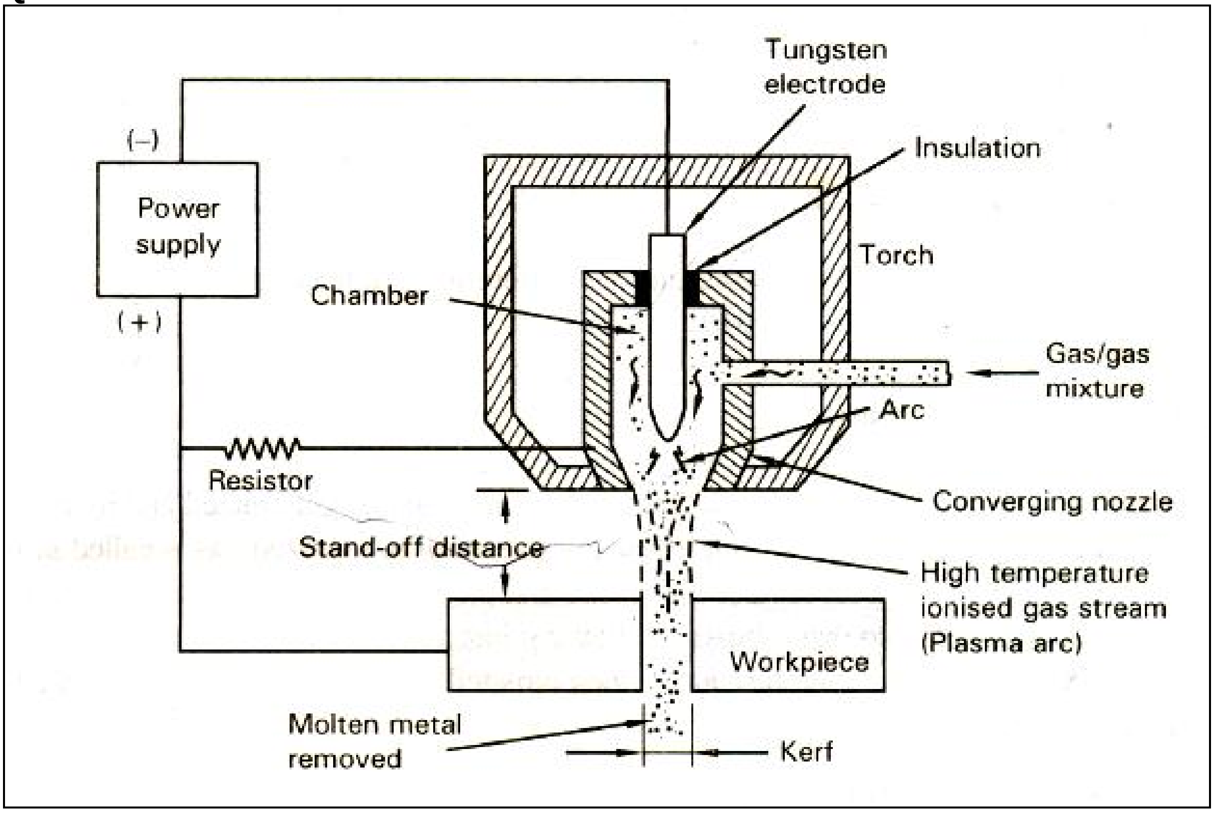
Q1 b)



WJM Operation:

- Filtered water from the water tank enters the hydraulic intensifier, where its pressure is increased to a high value. The intensifier then supplies the high-pressure water to the accumulator (reservoir). The accumulator attenuates the fluctuating fluid pressure and brings the fluid to a constant pressure.
- To begin the cutting operation, the ON/OFF valve is switched to ON position. The high-pressure water from the accumulator enters the nozzle, where the whole of the pressure energy is converted to kinetic energy.
- The high-velocity jet of water forcing out of the nozzle is directed towards the work surface. As the jet strikes the work surface, the kinetic energy of the jet is transformed into mechanical work, which removes material from the work piece by the erosive force of the water.
- The jet of water after doing work enters the catcher, where it loses its energy and finally gets collected in the drain system.

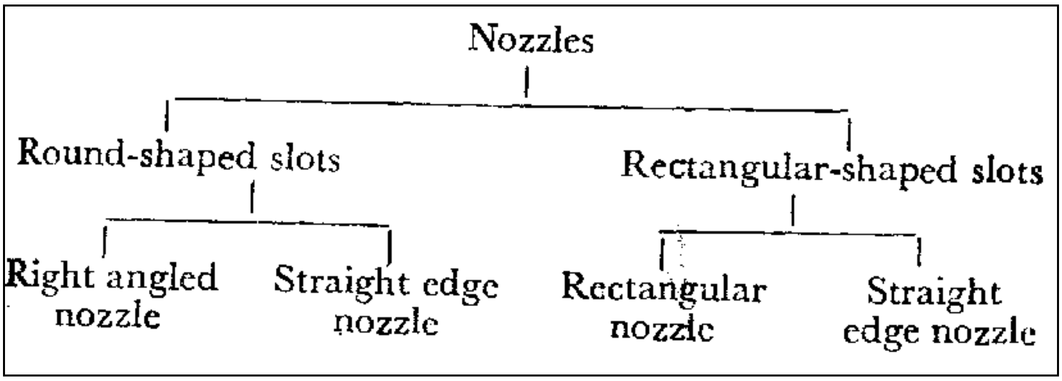
Q2.



<u>PAM Operation</u>:

- In operation, a strong arc is struck between the **tungsten electrode (cathode)** and the **nozzle (anode),** and meanwhile, a suitable ***gas/gas mixture is forced into the chamber.***
- As the gas molecules collide with the high velocity electrons of the arc, the gas gets ionized and a very large amount of heat energy is evolved. This **high velocity stream of hot ionized gas is called *plasma.***
- The maximum velocity of the jet is around **550 m/sec**and the temperature is as high as **28,000°C.** The arc is maintained stable, so that it heats the flowing gas and maintains it in the plasma state.
- **The high-velocity jet of high-temperature gas** is then directed on to the work piece, which cuts by melting and removing the material from the work piece.

Q3 a)



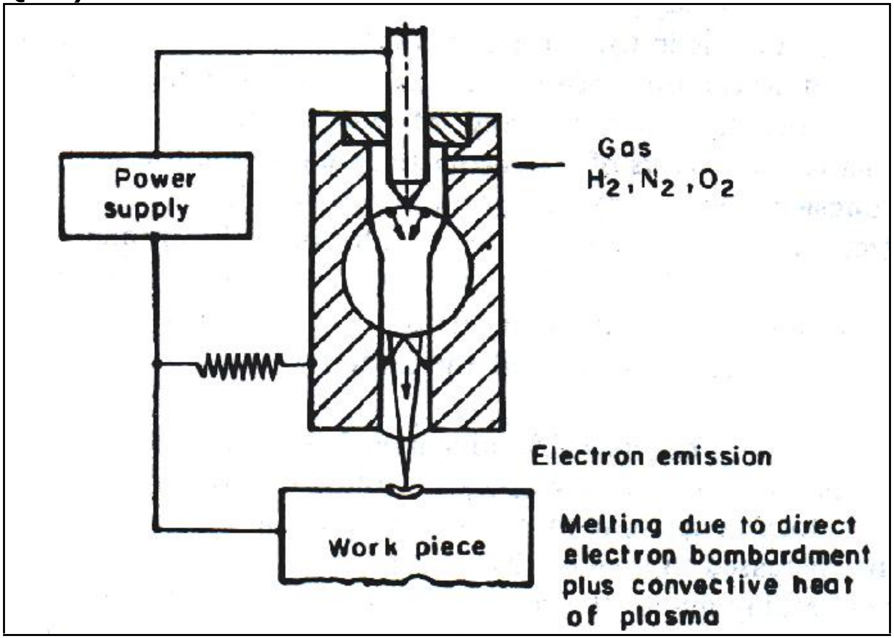
Nozzle Geometry:

- The nozzle has to withstand the erosive action of abrasive particles, and hence must be made of materials that can provide high resistance to wear. The nozzles which are employed in AJM process must be designed precisely with materials which are highly resistant to abrasive particles.
- In general, nozzles are made of tungsten carbide or sapphire having regular orifices or slots as follows depending on the utility.
- The nozzle should be so designed that the pressure loss due to bends, friction etc is as little as possible. Depending on the requirements, the nozzle may be either of circular or rectangular cross sections.

o NOZZLE MATEIAL	Round Shape Nozzle Diameter, mm	Rectangular Shape Slot Dimension, mm	Life of Nozzle, Hrs
Tungsten Carbide	**0.2 to 1.0**	**0.075X0.5 to 0.15X2.5**	**12 to 30**
Sapphire	**0.2 to 0.8**		**300**

For precision machining, the nozzles are provided with extended taper at the tip in order to minimize secondary erosion by abrasive particles that rebound' from the work surface.

Q3 b)



The method of heating the gases by first ionizing them is one of the most popular methods generating hot Plasma. This can be done either by applying a suitable electric field across the gas column or by exposing the gas to ionizing radiation. When gases are heated by an applied electric field, an igniter supplies the initial electrons, which accelerates in the field before colliding and ionizing the atoms. The free electrons, in turn, get accelerated and cause further ionization and heating of the gases.

The actual heating of the gas takes place due to the energy liberated when free ions and electrons recombine into atoms or when atoms recombine into molecules. The bonding energy thus generated in the form of kinetic energy of the atoms or molecule formed by recombination. The energy input for such a mechanism is determined by the enthalpy of gas at the required temperature, thermal conductivity of the gas and loss of energy in the form of radiation.

In this case, the high velocity electrons of the arc collide with the gas molecules and produce dissociation of diatomic molecules followed by ionization of the beam. The plasma forming gas is forced through the nozzle duct in such a manner as to stabilize the arc. Much of the heating of the gas takes place in the constricted region of the nozzle duct, resulting in relatively high exit gas velocity and very high core temperature up to 16,000°c.

Q4

<u>Size of abrasive grain:</u>

- The rate of metal removal depends on the size of the abrasive grain. Finer grains are less irregular in shape, and hence, possess lesser cutting ability. More over, finer grains tend to stick together and choke the nozzle.

The most favorable grain sizes range from 10 to 50µ. Coarse grains are recommended for cutting, whereas finer grains are useful in polishing, deburring etc.

<u>Velocity of the abrasive jet:</u>

- The kinetic energy of the abrasive jet is utilized for metal removal by erosion. Finnie and Sheldon have shown that for erosion to occur, the jet must impinge the work surface with a certain minimum velocity. For the erosion of glass by silicon carbide (grain size 25μ), the minimum jet velocity has been found to be around 150m/s.
- The jet velocity is a function of the nozzle pressure, nozzle design, abrasive grain size and the mean number of abrasives per unit volume of the carrier gas. Graph shows, the effect of nozzle pressure on the rate of metal removal.

Mean number of abrasive grains per unit volume of the carrier gas:

- An idea about the mean number of abrasive grains per unit volume of the carrier gas can be obtained from the mixing ratio M. it is defined as, **M=volume flow rate of the abrasive per unit time/volume flow rate of the carrier gas per unit time.**
- A large value of M should result in higher rates of metal removal but a large abrasive flow rate has been found to adversely influence jet velocity, and may sometimes even clog the nozzle. Thus, for the given conditions there is an optimum mixing ratio that leads to a maximum material removal rate.

Work material:

- AJM is recommended for the processing of metals and alloys particularly sections of hard materials like germanium, silicon, non-metals like glass, ceramics, mica etc.
- Most of the ductile materials are practically unmachinable by AJM. The rate of metal removal has been found to depend upon the mohrs hardness of the material to be machined.

Stand off distance [SOD]:

- Stand off distance is defined as the distance between the face of the nozzle and the working surface of the work. SOD has been found to have considerable effect on the rate of metal removal as well as the accuracy. A large SOD results in the flaring up of the jet which leads to poor accuracy.

Small material removal rate at a low SOD is due to a reduction in nozzle pressure with decreasing distance, whereas a drop in material removal rate at large SOD is due to a reduction in the jet velocity with increasing distance. Stand-off distance plays a very important role in material removal rate in AJM

- The material removal rate increases with the increase of tip distance up to a certain limit after which it remains unchanged for a certain tip distance and then falls gradually.

Q5

- **PAM parameters:**The parameters govern the performance of PAM can be divided three categories:

1. Those associated with the design and operation of torch
2. Those associated with the physical configuration of the set up
3. Environment in which the work is performed

1. **Design of DC plasma Torches:** The plasma torch is designed to obtain maximum thermal output. The increase in efficiency only helps in achieving the better heating of the gas but also in reducing the electrode loses and thereby increases in life of electrode. The design also ensures that the erosion rate of the electrode is kept to minimum.

2. **Physical configuration:** In PAM variable such as torch angle, depth of cut, feed and speed of the work towards the torch are important. The feed and depth of cut determine the volume of metal removal. Fig shows the metal removal as a function as a torch angle.

3. **Work environment:** The environment group of variable for PAM includes any cooling that is done on the cathode, any protective type of atmosphere used to reduce the oxidation of the exposed high temperature machined surface and any means that might utilized to spread out or deflect the and Plasma striking area.

Q6 a)
Advantages:

- Any material, regardless of its hardness and refractory nature can be efficiently and economically machined.
- Faster cutting speeds due to high velocity and high temperature of cutting gas.
- Requires minimal operator training,
- Process variables such as type of gas, power, cutting speed etc., can be adjusted for each metal type.
- Plasma arc cutting produces a high quality, dust free cutting
- Straight as well as curved shapes can be cut easily.
- The corrosion resistance of the stainless steel is not affected when it is cut with plasma arc.The plasma arc cutting is the fastest of all cutting processes.
- The cutting rate in this process is high enough to facilitate this method to be used on almost on all materials.
- Profile cutting of metals can be very easily done by PAM.
- There is no contact between the tool and work piece only a simple supported work piece structure is enough.
- Smooth cuts free from contaminants are obtained in the process.

Disadvantages:

- The high-temperature, high-velocity impinging gas causes metallurgical alterations in the work piece material.
- Shielding and noise protection adds additional equipments, and also burden on the operator's precautions.
- It needs more electrical equipments; hence chances of electrical hazards are more.
- The plasma arc process produces a high noise of the order of 100 db.
- The use of ear plugs or ear muffs to protect the operator is essential.
- The initial costs of process equipments are very high.
- Thus a secondary machining needs to be performed to remove this surface by 1.5mm or more unless it can withstand the hardened and uneven surface.
- Eye shielding and noise protection are necessary for the operation and those in nearby areas.
- Safety precautions are necessary for the operator and those in nearby areas, this adds additional cost.

Q6 b)

Advantages of WJM:

- No noxious gases or liquids are used in water jet machining. In simple words, the process is a dust free process.
- No heat affected zones or mechanical stresses left on the cut surface. Health hazards associated while cutting materials like asbestos and fiberglass are minimized.
- The Omni-directional cutting ability allows complex shapes with almost any radius to be easily machined. The process gives a clean and a sharp cut. Fine surface finish can be obtained.
- Soft materials up to 250 mm thick can be easily machined. The energy transfer media (water) is cheap, non-toxic and easy to dispose off.
- The system has no moving parts, therefore its operating and maintenance costs are low and the process is very safe.
- There is no thermal damage to the work surface as little heat is generated during cutting operation. Surface finish obtained is very good.
- Multi-pass cuts are possible. The process is convenient for cutting soft and rubber like materials.

Limitations of WJM:

- Equipment is quite expensive. Inefficient for thick metals.
- Water, which is re-circulated, should be filtered accurately, which otherwise results in cracks and damage to the nozzle tip. High pressures and noise of the jet of water necessitates safety equipments.
- Slight changes in water chemistry can significantly affect the erosion resistance of some of the components. Jet noise is very high.
- High pressure water vaporizes in to air. Water consumption is high.
- Initial cost of equipment is high. Hard materials cannot be cut easily.

Applications of WJM:

- Water jet machining finds applications in a diverse number of industries from mining to aerospace, where it is used from cutting whisper thin details in stone, glass and metals.
- Rapid hole drilling of titanium. Killing of pathogens in beverages and dips.
- WJM is used for cutting metallic and non-metallic materials and both ferrous and non-ferrous materials can be cut.
- Composites of all kinds, glass, ceramics, and circuit board can be cut.
- The typical thickness of metals cut range from 0.8mm – 100mm and cutting speed ranging from 25mm/min – 50 mm/min. The nozzle orifice range from 0.25 to 0.5mm.