Stepping Towards Eco-friendly Grinding

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The industrial revolution, originating from 16th century, brought a massive change in human society. Eco-friendly environment has essentially become a serious anxiety in the society of the modern era including in manufacturing shops. Eco-friendliness in manufacturing shops can be delineated in terms of environment dirtiness, inconvenience, heath hazardness, noise, material handling process and alertness.

The present article deals mainly with environment friendliness and overall technological benefits in grinding.

Grinding is a well known widely employed engineering process not only for finishing components made of metals, plastics, ceramics, carbides and a variety of other materials, it is also employed to remove bulk material. In finishing touch it is employed due to the advantage of high dimensional accuracy and good surface finish. Produtivity, economy, product quality can be remarkably improved by machining in grinding process. Not only that, in grinding process both convensional and exotic materials can be machined with high Metal Removal Rate and good surface integrity.

In conventional grinding the temperature in the grinding zone is very high than that of machining. To bring down this temperature coolent is used, though only a few percentage of it is being able to reach into the grinding zone. This is due to formation of stiffer layer around the grinding wheel. The formation of air layer is due to the high velocity of the grinding wheel and also for centrifugal action of air due to the porosity of grinding wheel as has been indicated in Fig-1.

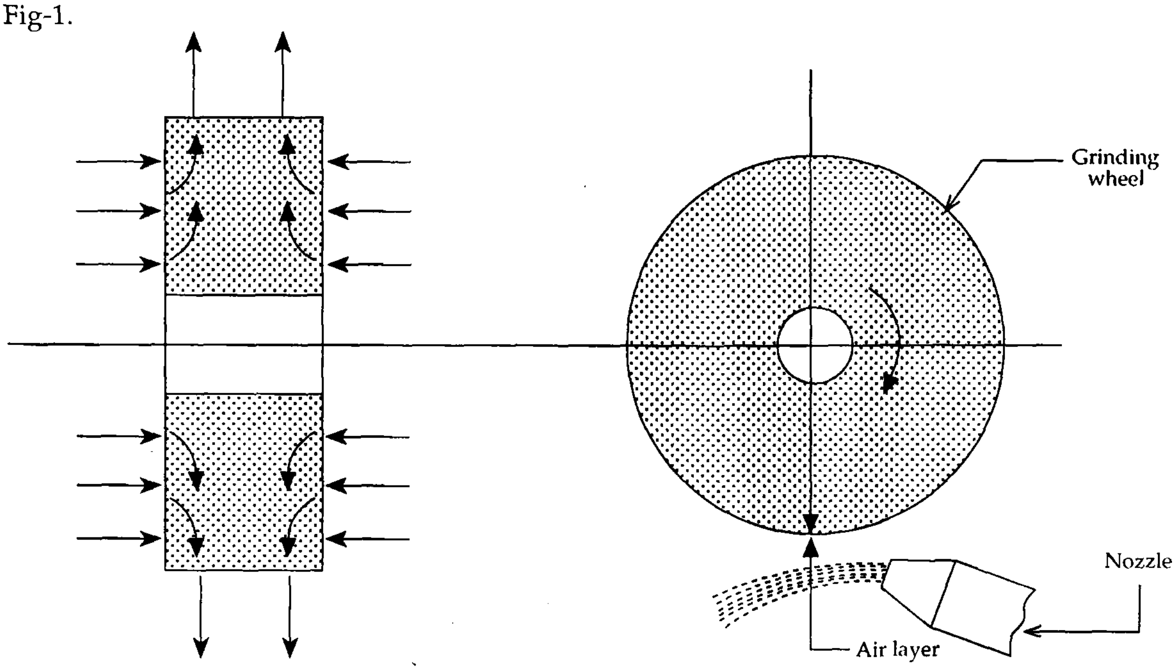

Fig-1 : Formation of stiff air layer due to centrifugal action

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This high temperature that arises at the work-wheel interface, not only reduces dimensional accuracy and wheel life but also increases the grinding force and impairs the surface integrity of the product by oxidation, selective etching, burning and inducing tensile residual stresses, microcracks and heat affected zones on the surface. The problems become more acute when the work materials are very hard, strong, heat resistive and the products are to be used onward under dynamic or shock loading.

The high temperature can be reduced by increasing the ability of cutting fluid to reach into the grit interface. This can be done by obstructing the stiff air layer around the wheel, by means of a scraper board that can be placed just before the coolent nozzle or by painting both the faces of the grinding wheel to resist the centrifugal action of air as indicated in Fig-2.

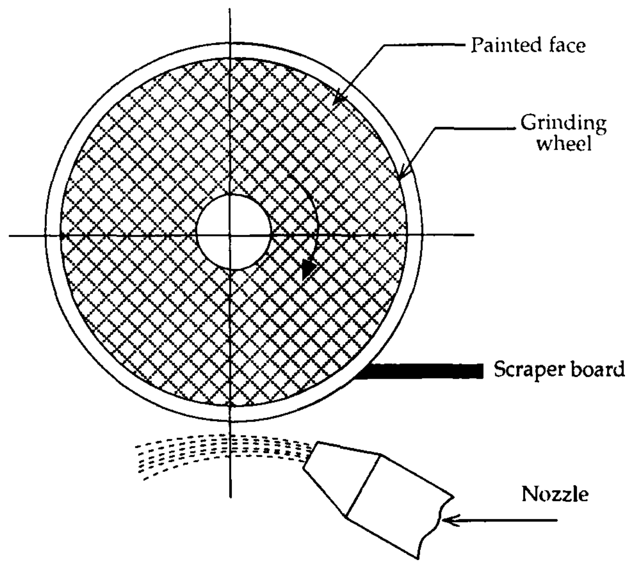

Fig 2 : Reducing technique of stiff air layer formation

The cutting fluid also helps in reducing the friction between the work and wheel interface.

In another method, the cutting fluid can reach grit interface, when applied through the pores of the grinding wheel. Putting coolent through the wheel generally involves pumping a fixed amount of fluid through a recirculating system into a hollow spindle and permitting centifugal force to carry it through the wheel. This technique, known as z-z technique, increases the efficiency of grinding yielding higher grinding ratio, helps to reduce the grinding sensitivity of the workpiece surface to a great extent and also imparts a better surface finish on the workpiece compared to other convensional cooling techniques.

In the above convensional cooling processes the vicinity becomes severely polluted by the harmful gases, smokes and fumes generated due to high heating and boiling of the cutting fluids. The modern organisations are looking solely for reasonable means of pollution free, dry and clean grinding without hurting productivity and product quality.

Ample research works have been carried out and still going on in this field. The cryogenic cooling, shortly termed as cryo-cooling, is appeared to be a quite successful technique in achieving clean and pollution free environment in and around the machine and grinding places. Cryo-cooling is carried out by liquid nitrogen of –196°C temperature. The coolant is applied through high velocity jet/jets towards the grit interface. The specially designed nozzle is positioned at a suitable distance and angle from the work-wheel interface as indicated in Fig-3.

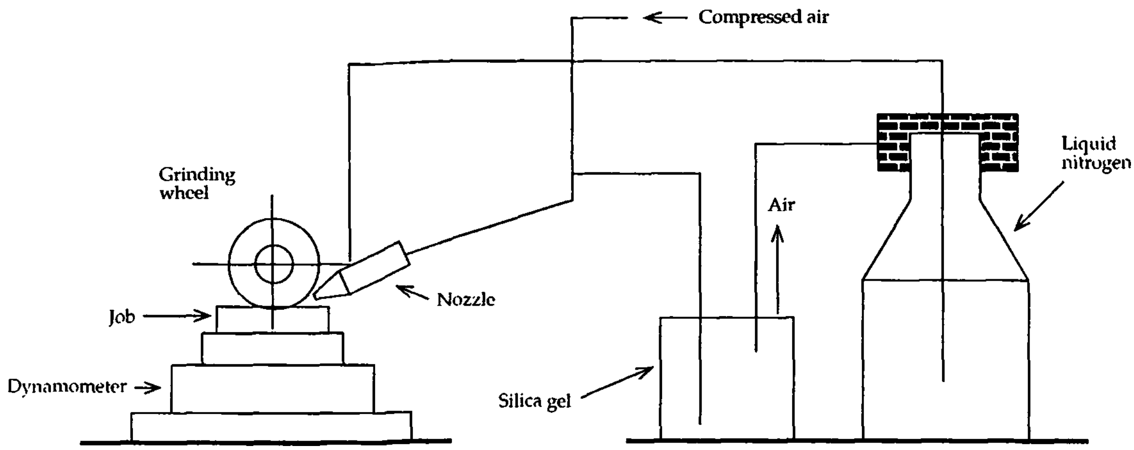

Fig-3 : Cryogenic grinding

If properly employed, the cryogen jet reduces the grinding zone temperature to a great extent and thereby a drastic technological improvement in grindiability depending upon the levels of process parameters. Technological improvement in grindiability is in terms of reduction in grinding forces and specific energy consumption, improvement in wheel life on grinding ratio, better surface finish, drastic reduction of tensile residual stresses, reduction or absence of microcracks on the workpiece surface, favourable modes of chip formation, retention of grit sharpness, absence of wheel loading and better grits-work material interactions.

It can be firmly stated that such a cryo-cooling would be more beneficial and economically viable in the high speed grinding processes of the modern era, particularly when the work material is exotic.

The additional expenses required for cryo-cooling are likely to be sizeably compensated by the saving in space, problems and cost involved with storing, recycling and disposal of fluid generally encountered in dealing with convensional fluid application. Use of cryo-cooling, like any other techniques, will be more justified and well received if the technique does not adversely affect the general techno-economical requirements, rather helps in their improvement. The additional cost for cryocooling application can be reduced to a large extent by controlling the consumption of the cryogen by proper automation and control.

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