TURBINE AND GENERATOR SPECIFICATIONS

Bryan W. Leyland

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I am both pleased and sorry to be talking to you about preparation of specifications for small machines. Pleased, because obviously there is a great interest arising from Gavin McHamish's paper. Sorry, because I believe that there are two very important things in the development of small hydro schemes and which are crucial to their success. One is what I am going to talk to you about - the specification of small machines. The other is related to what Dr Mosonyi said to you yesterday - if the intake is no good, what use is 0.1% efficiency on the turbine. The civil designs of the schemes and particularly of the intakes is vital and it is, if anything, more important than what I am going to talk to you about now.

I'm going to outline what I consider to be the considerations that should be borne in mind by somebody preparing a specification for a small machine. I will tell you what we have learned as a result of experience with around 20 schemes over the last 10 years.

The first thing the consulting engineer must do is make up his mind. First, he must decide on which basis the machines will be supplied. He has the choice of FOB delivery with erection by others (and you will excuse me if I don't talk about anything but export contracts because we have always purchased machines from overseas). Then the option of FOB plus supervision of erection and then, FOB plus complete erection.

Then he must decide if he will buy a turbine and generator separately and match the two together (which is the practice we follow, but an unusual one). Then he must decide if the control systems and auxiliary systems will be included with the turbine or with the generator, or as a separate package and then most important of all, he must decide on what he expects from the machine: whether it must be suitable for isolated operation or not - a vital decision; whether he wants an induction generator or a synchronous generator; whether he needs a governor.

Then he must decide on the general conditions of contract and I would say that the first decision he must make, and it is essential, that he will use standardised general conditions. There are many available - FIDIC, again excuse me, I am only familiar with the English ones, IEE/I Mech E Form A, Form B-1, B-2, B-3, or the United Nations Economic Commission for Europe (UNECE). In my opinion, he must not use his own home grown general conditions, because only if the turbine manufacturer can say when he gets his specification - "these conditions, I know, I don't even need to read them" - can he get on with the important part of the job which is preparing a tender for a good, cheap machine.

He must then decide on the special conditions. Terms of payment, guarantee periods - and here I would say that the B-2 periods must be extended because usually there is considerable delay between delivery of the machine and commissioning and eighteen months ex works is not enough. Also, he must decide on penalties for output, for efficiency and for late delivery. These must not be excessive, but they must be reasonable. If they are too high, then the manufacturers will load the penalty into their tender price.

Then comes a very, very important part of the document which, from my own experience, is one of the most difficult and the one that we, I must admit, often do not do as well as we should. This is the information for tenderers. A description of the scheme so that the tenderer knows what he is up against, what the site is like and what you are trying to achieve. Whether you are trying to make a little bit of power with a cheap machine, or you are prepared to buy an expensive machine to screw every last ounce of power. These things the tenderer know, and the more he knows about the site and your problems, the better the tender will be.

The engineer must also include all the information that is already covered in Page 5 of McHamish's paper, so I don't need to talk about that any more.

The Engineer must decide on the turbine and generator rating. The rated head for the turbine is always lower than the maximum head but the rated output of the generator should in general be the turbine output at the maximum head. This is often forgotten, and often generators are unable to accept the output of the turbine when the river is in flood, yet the cost of increasing a generator size is not great. He must decide on auxiliary voltage, a.c. and d.c. He must say what the power system conditions are - a weak system or high fault levels, voltages, frequency limitations. He must decide on the extent of inspection and progress reporting. He then must set out what the manufacturer's obligations are, especially for the supply of information, and one vital one is getting foundation drawings early so that the powerhouse design can be carried out. What he needs in the way of calculations and, a very important point, to what extent the consultant reserves the right to reject drawings. Our practice is to reserve the right to comment and approve cross section and arrangement drawings of a turbine - but for detailed drawings we will only act if there is something grossly in error. If the manufacturer has to wait three months for drawing approval, three months is added to the delivery period. Three months in small schemes - you can't afford it.

The other point which we find manufacturers are very poor at (and almost without exception) is the supply of operation and maintenance manuals where the contents, binding (believe it or not!) and the time of delivery is often most unsatisfactory. A small point, but a very important one.

We then come to the technical specifications for the turbine. The consulting engineer must decide either that a certain type of turbine is required, and in the case of medium heads whether Francis turbines are used, this is usually not difficult, and I would say that from now on, I am talking mostly of Francis turbines, because if I get into the low head range where there are many types of turbine which can be used, some of the remarks I make will not apply. On low heads, I believe that in general, the consulting engineer should not select the type of turbine - he should lay down the conditions that exist at the site and say what he expects to get from the turbine and let the manufacturer offer what he considers the best.

The arrangement of the turbine must be decided - with the Francis, the options are horizontal or vertical; and whether or not the runner should be overhung from the generator shaft. He must decide on cavitation limits and I would recommend 0.1 D squared - which is a very low cavitation limit. Regarding the runner material - our practice is to say that the main or alternative offer should be of stainless steel. Guide vane material, facing plates - whether the facings are of stainless steel overlay or screwed on - these all have a big effect on the cost of the machine. Seals, and adjustment for alignment must also be covered.

Then there's the governor. The consulting engineer must decide whether a governor is required, define governing stability, state whether a pressure vessel and accumulator or just springs are required - and in general, don't use pressure vessels. Whether black starting is necessary and the type of control system. For the inlet valve, the type of valve may or may not be specified. The closing system must be: the opening system and (very important and often forgotten) the head loss penalty for the inlet valve - that is what determines the economic size of the inlet valve and it is only the manufacturer who can decide, not the consulting engineer.

For the generator, the type must be decided - synchronous, induction, horizontal or vertical. The voltage, and in general the voltage should be at the lower end of the range, because small 11,000 volt generators are often unreliable. Windings - Class F or Class B insulation. Cooling - open or filter ventilated, or water cooled. Bearings - lubrication systems - and for horizontal generators now, it is almost impossible to buy self-lubricating bearings, so a pumping unit is required and these require special considerations because our experience is that generator manufacturers are not good at the design of pumping units.

Excitation system - if the generator is excited from its own terminals and there is a fault on the system, the generator voltage will collapse and the protection won't work. This is not often known but on an isolated system it is very important.

Auxiliary systems, cooling water supply, filtration requirements, sump pumps and piping - will these be included or not. Control systems, auto start, water level control, programme operation, instruments, what instruments you require. Then you come to manufacture, erection and testing - one of the vital things is to get good progress reports from the manufacturer to make sure that he's on time. Painting and surface preparation - often very difficult to achieve - we've had some very, very poor painting and surface preparation.

Inspection - how much and how often - and in general not much, but progress is very important, Model tests - don't have them, you haven't got time, follow what McHamish said. Tender information should be as brief as possible and require only enough information to allow you to assess whether or not this is the best machine. Don't ask for all the information that you need for the final design, he won't design it for you and don't expect him to - don't ask for the number and diameter of the coupling bolts because he hasn't worked it out yet. If he gives you an answer, it's rubbish. Price adjustment, guarantees on efficiency and output, dimensions, weights, inertia, and most important for turbines, an arrangement drawings and a cross section drawing, marked up with the materials used and the arrangement. By comparing all the cross section drawings, you are able to get the best assessment of whether the turbine is good, whether the manufacturer is good, experienced, his level of technology.

Finally, don't accept turbines from a manufacturer who does not have an adequate and recent reference list in the sort of machine that you are buying.