

DUCTILE IRON AND WIND ENERGY : A SYMBIOTIC RELATIONSHIP

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In a global world always requiring more energy but becoming highly conscious about the environment and the effect of human activities on it, renewable sources of energy have become an unavoidable choice for industrial countries, and amongst these renewable sources of energy, wind energy has gained general acceptance. As shown in Figure 1, more than 8,000 MW were installed in 2003 worldwide, and this value is expected to continue to increase steadily in the coming decade. Although development of wind energy was initially concentrated in Europe, it now takes place in all regions of the world. In North America, recent studies indicate that a total of 20,000 MW will be installed during the 2004-2010 period.

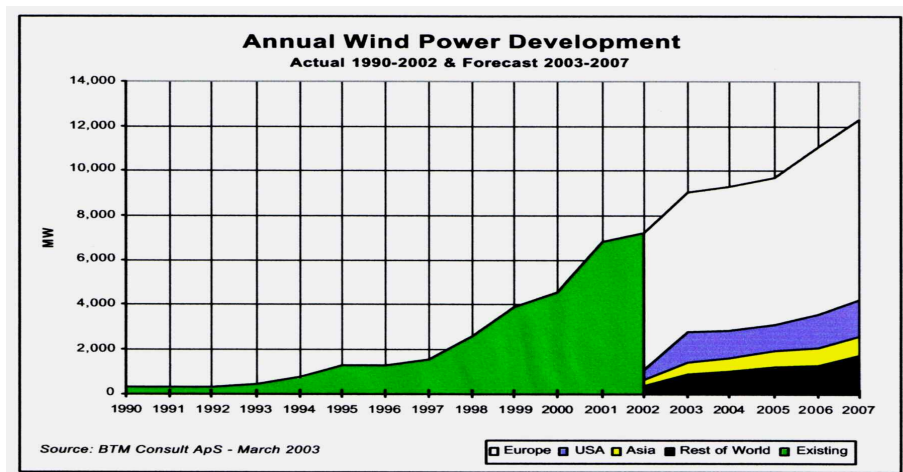


FIGURE 1. Annual Wind Power Development in the World (actual 1990-2002 & forecast 2003-2007) (BTM Consult, March 2003).

Ductile Iron has been identified rapidly as the right material for many wind mill parts, its major advantages versus steel being higher castability, lower density, improved machinability, design flexibility, ... , while offering the required mechanical properties. Although some pearlitic and ADI castings are used for certain parts (eg. gears), most of the Ductile Iron components found in wind energy turbines satisfy the stringent ENG-GJS-400-18-LT specification. A key objective of this material is to achieve, in addition to its 18% tensile elongation minimum, an average Charpy V-notch impact energy of 12 Joules at -20°C . Only the highest quality of ferritic Ductile Iron castings can meet such a requirement. Table 1 presents a typical chemical composition used for the production of as-cast ENG-GJS-400-18-LT castings; Table 2 outlines some current foundry practices used in the production of these castings. It is also worth noting that these heavy section

castings are often manufactured riserless using rigid molds, high metallurgical quality Ductile Iron and carefully controlled foundry parameters.

Table 1
CHEMICAL COMPOSITION OF FERRITIC WIND MILL CASTINGS

Element	wt %
C	3.3 - 3.5
S	0.008 - 0.012
Si	1.9 - 2.2 (preferably < 2.1)
P	< 0.030
Mn	< 0.15
Mg	0.035 - 0.045

Table 2
EXAMPLES OF FOUNDRY PRACTICES

Charge Materials	40% HPI (minimum) High quality steel scrap Ferritic Ductile Iron returns
Melting	Superheat temperature 1500°C Holding time : minimum
Magnesium Treatment	Tundish ladle well adapted Ce-free treatment alloy Ni-Mg often used
Inoculation	0.4 - 0.8% inoculant during transfer 0.1 - 0.2% late inoculation
Pouring Temperature	1370 - 1400°C (riserless castings)
Molding	Rigid molds Chills in critical areas Filters
Shake-out	Critical Long enough to avoid pearlite formation

In 2003, 4,685 MW of electricity were generated by wind in United States; the target is to reach 6% of the total electrical energy in 2020. Between 2002 and 2007, 51,000 MW should be built worldwide. In North America, assuming that the government monetary support continues at the actual level, 8,000 MW are expected to be installed. Considering that 10 to 20 tons of Ductile Iron castings are needed per MW installed depending on the size and design of the wind turbine, it implies that 80,000 to 160,000 tons of castings will be required in North America during that time period. Table 3 lists some wind energy castings and their weight per MW for a commercial 1.0 MW wind turbine. Examples of castings are shown in Figure 2.

Table 3
DUCTILE IRON WIND MILL CASTINGS

Assembly	D.I. Parts	Average Weight t/MW
Rotor System	Hub, blade adapter, bearing	6.44 (hub : 4.5 t/MW)
Shaft	Shaft, bearings	0.44
Turbine Frame	Nacelle, bed plate, yaw ring	3.85 (nacelle: up to 10 t)
Gear Box	Housing, support, bearings	1.71
Others		1.00
Total		13.44

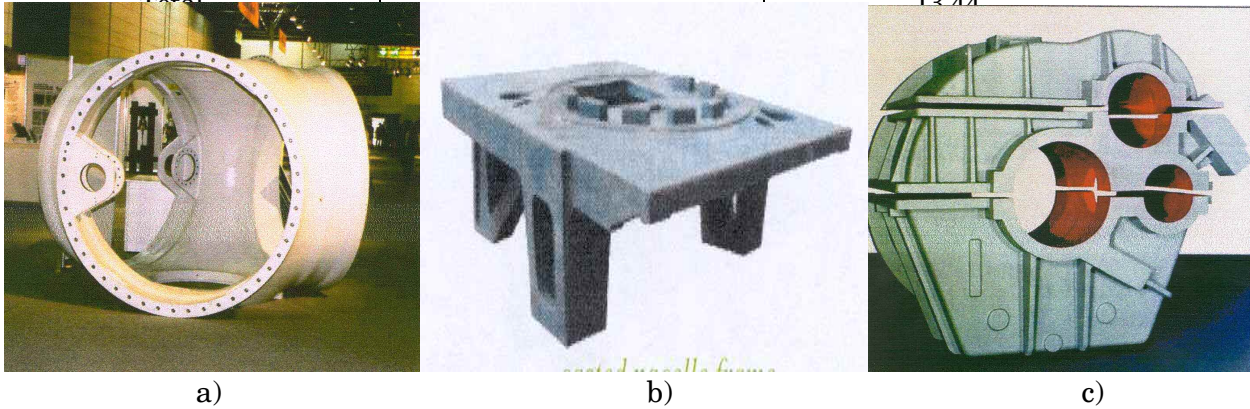


FIGURE 2. Examples of Ductile Iron Castings
a) Hub (9.1 t)
b) Nacelle Frame (15 t)
c) Bearing Housing (3.9 t)

Although most of the wind turbine suppliers are European, the development of the North American wind energy market makes local sourcing of the Ductile Iron components unavoidable. The North American Ductile Iron foundries can produce the high quality level required for these castings and should have a close look to the opportunities that are now opened to them.