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Integrated Transport  
 Review  
 U. D. C.: 656.618  
 Accepted: Jan. 7, 2002  
 Approved: Sep. 30, 2003

## PRINCIPAL TYPES AND CHARACTERISTICS OF HARBOUR TUGS

### ABSTRACT

*Tug today represents irreplaceable part of port infrastructure in all the world harbours and it is almost unthinkable to run a business of some port in international relations without using them. All the world ports intend to get equipped with better equipment in order to be more competitive for cargo handling. Modernization of port includes harbour tugs as well. Their purchase depends on the financial power of the investor in infrastructure, whether the state or a private company which is the common owner of the tugs fleet in the port with which it most often has a "Concession contract" for undertaking the mentioned activities besides the rest of the known contracted ways of cooperation.*

### KEY WORDS

*conventional tug, azimuth stern drive tug, tractor tug, pivot, gob rope, girting, bollard pull, shaft power, admiralty coefficient, displacement*

### 1. INTRODUCTION

In the seamanship a very seldom mentioned and elaborated category of small ships, very useful for the manoeuvring within the ports and on all seas is represented here as the fleet of tugs.

In literature, the effect of these ships on the whole maritime economy is often neglected but in fact their value is of paramount importance in manoeuvring during bad weather conditions in limited areas of a world port in particular.

Each port has its own particular features which determine the way of use of the tugs. Generally, the following conditions are crucial in choosing and using the tugs:

- volume of traffic in the port,
- types of ships serving the port,
- navigational obstacles in the port,
- conditions of environmental protection,
- local laws and habits,
- available sizes and types of tugs,
- experience of crew serving them.

### 2. PRINCIPAL TYPES OF HARBOUR TUGS

There are three basic types of harbour tugs:

- 2.1 Conventional tug;
- 2.2 Azimuth stern drive tug;
- 2.3 Tractor tug.

#### 2.1. Conventional tug

The oldest types of tugs are the conventional ones. They are still present in almost all the world ports, although they are pushed away more and more by contemporary tugs with better manoeuvring capabilities. In the beginning they had steam propulsion, which has been abandoned. Nowadays, they are equipped with diesel engines having one or two propellers respectively. With single propeller, depending on the type, the most common is the right-handed (although left-handed are also quite often met), and are equipped with a classic rudder. The power plant complex is placed at the stern with the towing hook in the middle of the tug.

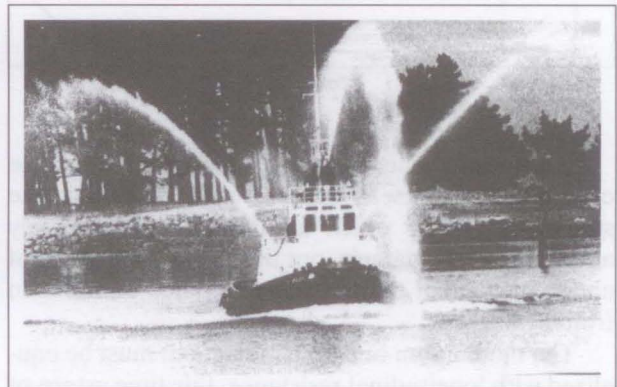


Figure 1 - Conventional tug

The main characteristic of these tugs is high reliability and efficiency of power expressed in the force of "bollard pull".

Deficiencies of conventional tugs are:

- limited manoeuvring capabilities which is demonstrated in slow repositioning of tugs;
- amidships position of tow which results in the possibility of "girting" of the tug along the radius of tow and consequently could result in capsizing of the tug with fatal outcome for the crew. Tragic result of girting is the crew's inability for prompt reaction due to high speed of the girting development.

In proper understanding of manoeuvring capabilities of a tug it is of paramount importance to know the main characteristics in relation to the direction of movement.

The central point in considering the mentioned is taken by position of the tug's turning axis "pivot" which is clearly presented in Figures 3, 4 and 5.

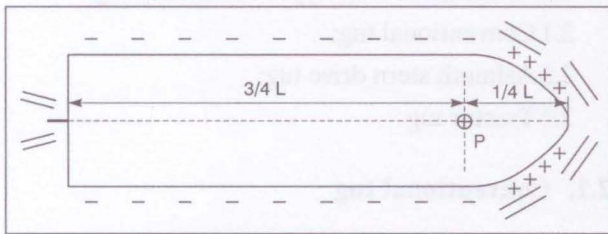


Figure 2 - Tug running ahead

While running ahead two forces occur. The first is the momentum of movement ahead and the second is the longitudinal and residual resistance to the forward movement caused by water mass in front of the tug. Consequently, these two forces reach equilibrium and pivot /axis of rotation/ moves to  $L/4$  of the length from the bow.<sup>1</sup>

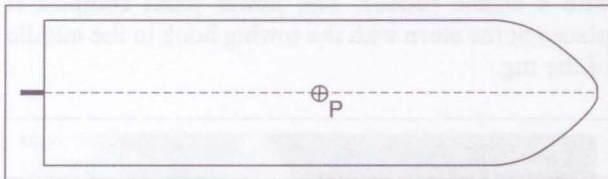


Figure 3 - Tug stopped

If not stated otherwise then the stopped tug on the even keel in calm seas has pivot /turning axis/ in the system of gravity which is situated approximately amidships.<sup>2</sup> It is, namely, not the existing influence of ahead movement neither the resistance of water in front of the bow.

The momentum of astern movement must be equalized with longitudinal resistance, this time astern of the tug. Pivot /axis of rotation/ moves to  $L/4$  distance from the aft.<sup>3</sup>

From the mentioned Figures it is evident that the turning axis-pivot changes in relation to the direction of movement of the tug which is extremely important

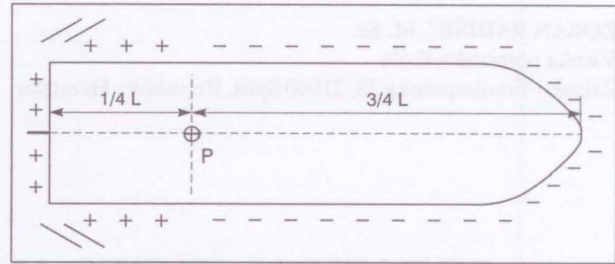


Figure 4 - Tug running astern

to know for the exploitation of the manoeuvring characteristics of the tug.

With movement ahead the pivot is placed at approx.  $L/4$  of the tug's length while with the tow fastened, the same is moved to the position of the towing hook which still gives a good turning lever /distance from the towing hook to the propeller/, and with the mentioned good manoeuvring characteristics are obtained. Namely, from the stated above, it is evident that the bigger the turning lever, e.g. the distance from the propeller to the turning axis-pivot, the better the manoeuvring characteristics of the tug in positioning of the tow. When the tug is towing the ship there is danger of the tug girting along the radius of the tow if the fastened ship is moving too fast or making fast turning to starboard or port side respectively. The greatest danger is represented in mutual combination of the mentioned movements in relation to the fastened tug.

In case of fulfilling of these two conditions it could set in motion the tug girting along the radius of the tow which could result in a collision with the towed ship or very often in capsizing of the tug which located at the side position, representing a very dangerous situation. Avoiding danger is achieved with on-time repositioning of the tow or releasing of the tow. Any delay could be disastrous. Besides the mentioned, in maritime practise the prevention of girting is achieved by using the "gob rope" but then the manoeuvring characteristics are significantly reduced due to the shortened turning lever which is particularly evident with conventional tugs. From the presented Figures it is evident that the areas of increased pressure are in front of the bow i.e. in front of the pivot /running ahead/ while areas of low pressure are behind the pivot in suction areas. When the tug is found in the respective areas, it is pulled out or pulled in respectively, which depends on whether it is located in the front or at the rear of the pivot.

The mentioned positions of the tug in relation to the ship affect their mutual interaction depending on which pressure areas are situated on tug and ship. This leads to the conclusion regarding high importance of dedicated mutual interaction between tug and the ship during the performance of any manoeuvre in the port and the masters should pay particular attention to the mentioned.

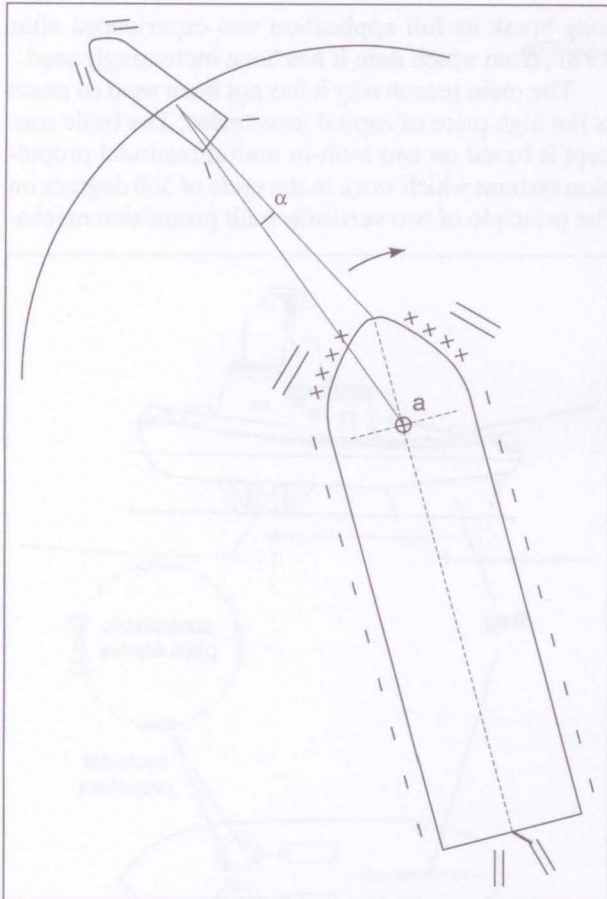


Figure 5 - "GIRTING"

The Figure represents the beginning of girting which should be thwarted by repositioning of the tug on time or by reducing the speed of the towed vessel with the purpose of avoiding danger of capsizing of the tug.

Using the gob rope axis, the turning-pivot of the tug is moved to the point of propulsion i.e. to the point of the propeller and with this annuls the turning lever which results in substantially decreased manoeuvring capabilities of the conventional tugs but it prevents the tug from capsizing caused by fast turning of the towed ship with its increased speed of movement.

Introducing the gob rope on the tow axis, the turning-pivot is on the propeller causing the turning around at this point and with this the repositioning of the stern of the tug into the tow which prevents side-positioning of the tug on tow, thus avoiding danger of coming in the position of girting and consequently of disaster.

Besides the direct tow, conventional tugs can and very often do, use their own weight leaning on the tow for the purpose of realizing manoeuvre undertaken while using their own engine for repositioning of the tug.

## 2.2. Azimuth stern drive tug

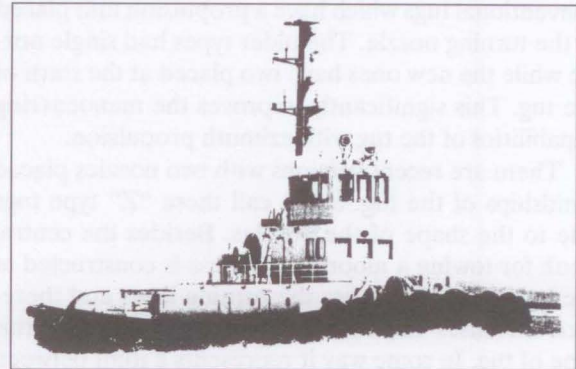


Figure 6 - ASD - TUG

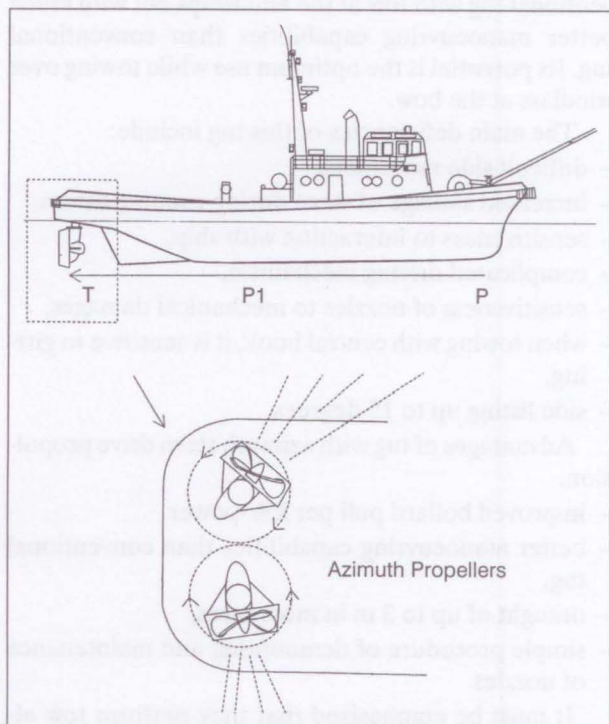


Figure 7 - ASD - tug



Figure 8 - ASD - tug in typical manoeuvre

Figure 7 shows the fundamental difference between tugs with azimuth stern drive propulsion and conventional tugs which have a propulsion unit placed in the turning nozzle. The older types had single nozzle while the new ones have two placed at the stern of the tug. This significantly improves the manoeuvring capabilities of the tug with azimuth propulsion.

There are recent versions with two nozzles placed amidships of the tug. Some call these "Z" type tugs due to the shape of the nozzles. Besides the central hook for towing a mooring windlass is constructed at the bow which increases the turning lever and therefore increases the manoeuvring capabilities of this type of tug. In some way it represents a joint between conventional and tractor tug.

Accordingly, this type of tug could be used as conventional tug with tow at the amidships but with much better manoeuvring capabilities than conventional tug. Its potential is the optimum use while towing over windlass at the bow.

The main deficiencies of this tug include:

- difficult side movement,
- increased sinkage of stern during running astern,
- sensitiveness to interaction with ship,
- complicated driving mechanism,
- sensitiveness of nozzles to mechanical damages,
- when towing with central hook, it is sensitive to girting,
- side listing up to 15 degrees.

Advantages of tug with azimuth stern drive propulsion:

- improved bollard pull per kW-power,
- better manoeuvring capabilities than conventional tug,
- draught of up to 3 m in most cases,
- simple procedure of demounting and maintenance of nozzles.

It must be emphasized that they perform tow almost always on the bow windlass and in that way increase the turning lever thus enabling better manoeuvring capabilities and at the same time avoiding the possibility of unpleasant girting. This can be seen in Figures 7 and 8.

They are well fended with rubber fenders because very often they lean on the ships during manoeuvring, in particular with side approaching- breasting or sailing out-lifting-off.

## 2.4 TRACTOR TUG

The tractor tug represents a completely new and opposite concept of propulsion order and the turning axis-pivot compared to the conventional tug. The historical development of this type of tugs started in 1950 with companies "Schneider" and "Schottel". After a

long break its full application was experienced after 1990, from which date it has been increasingly used.

The main reason why it has not been used so much is the high price of capital investment. The basic concept is based on two built-in multidirectional propulsion systems which work in the cycle of 360 degrees on the principle of two vertically built propulsion mecha-

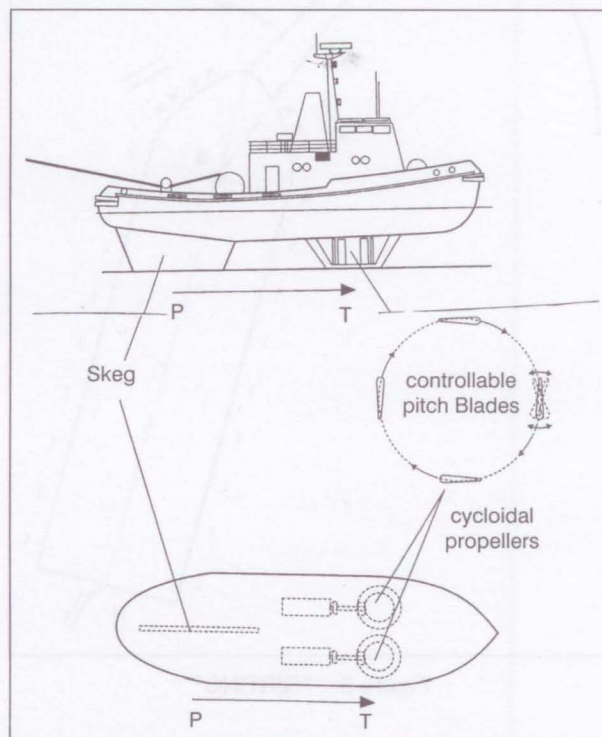


Figure 9

nisms with rotating wings placed below the tug bridge. This type of propulsion system provides excellent manoeuvring characteristics to the tractor tug. The novelty is that the propulsion system is always in front of the tow and in this way the positive turning moment is always present. The great advantage is seen in the fact of direct control of tow from the tug bridge /tensioning or releasing of tow/.

The deficiencies of tractor tugs include:

- sensitiveness to damages of underwater propulsion mechanism,
- side list of up to 21 degrees when towing full speed,
- high capital investment,
- reduced bollard pull per kW,
- bad steering at open seas due to reduced turning lever pivot-propulsion,
- expensive maintenance.

The advantages of tractor tugs include:

- full power at turning 360 degrees,
- excellent manoeuvring capabilities,
- instant application of full power,
- simple control of manoeuvring,

- almost impossible appearance of girting,
- better response with interaction with the hull of the ship,
- reliability of propulsion.

It is more and more in use in developed western countries, in particular in the U.S.A., Japan and North Europe which is understandable regarding their financial potential. Its capabilities are particularly emphasised in narrow passages, canals, and overcrowded harbours where high degree of skilfulness is required. They are very effective in performing the "paravan effect" or indirect tow.

### 3. "BOLLARD PULL FORCE"

Tug bollard pull force is theoretically calculated from the main engine power expressed in shaft horse power or kilowatts where approximately 100 SHP equals 1 mt of bollard pull force.

The above statement is explained in the Table below.

Table 1 - "Bollard pull power"

Shaft horse power	Kilowatts	Bollard pull-MT
1000	740	10
1500	1110	15
2000	1480	20
2500	1849	25
3000	2219	30
3500	2589	35
4000	2959	40
4500	3328	45
5000	3698	50

Source: Author

Practical check-up of the bollard pull is undertaken while the tug is fastened to the shore bollard and engine runs full ahead/astern respectively while all mooring arrangement is connected physically to a dynamometer which records the bollard pull force. Thus we are able to compare the calculated and the actual bollard pull force.

In case we have to maintain the tug max. speed of 12 knots then there is the need to calculate the power of the tug concerned. If we assume that the displacement of tug is 530 mt, the speed of 12 knots and admiralty coefficient of 450, then the calculation of the tug shaft power is as follows:

$$SP = \frac{D^{2/3} \times V^3}{C}$$

where

D = displacement

V = speed

C = admiralty coefficient

SP = shaft power

If we apply the above mentioned variables, then we obtain the following:

$$SP = \frac{520^{2/3} \times 12^3}{450} = 1363,58 \text{ kW} \times 1.352 = 1843,56 \text{ shp}$$

The calculation has shown that our tug needs 1843.56 shaft horsepower to maintain the speed of 12 knots, consequently providing the bollard pull power of 18.4 mt.

### 4. CONCLUSION

Maritime economy occupies a very important place in the world exchange of goods. The starting point of every maritime economy are seaports, main arteries of every import - export economy, with the important segment of maritime economy. In order to provide faster and safer traffic flow in the ports, besides good organization and coordination it is necessary to have advanced transport technology in the ports, which contains besides modern port equipment, advanced sailing units which serve the respective port. Among them are modern tugs, particularly ones with azimuth propulsion and tractor tugs. Today, they enable faster and safer performance of manoeuvring in the world harbours and consequently speed up the flow of goods through the port concerned.

The conventional tugs must not be forgotten as they are significantly represented in most developed harbours such as Rotterdam.

Today there are two reasons for their usage and these are:

- reliability,
- and
- cost effectiveness.

During the long years, they have proved as reliable partners in performing manoeuvres and assistance to the ships because they have good utilization of power. However, they have worse manoeuvring characteristics than azimuth and tractor tugs.

The most common conventional tugs are much cheaper than azimuth stern drive and tractor tugs and therefore, from financial standpoint, they are more cost effective and more easily available to the ports of poor countries in particular.

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**SAŽETAK**

**OSNOVNI TIPOVI I KARAKTERISTIKE LUČKIH  
 TEGLJAČA**

Tegljači danas predstavljaju nezamjenjivi dio lučke infrastrukture u svim svjetskim lukama i gotovo je nezamislivo poslovanje neke luke u međunarodnim okvirima bez njihove upotrebe. Kako brod najviše zarađuje u plovidbi od izuzetne je važnosti što kraće zadržavanje broda u luci. Stoga su sve lučke operacije, kao što su manevar pristajanja, odvez, prekrcaj tereta i komunikacija s kopnom, svedene na minimum. Sve su se svjetske luke nastojale opremiti što boljom opremom kako bi bile što konkurentnije u prijemu tereta.

Modernizacija luke uključila je i lučke tegljače. Njihova kupovina uvjetovana je financijskom moći ulagača u infrastrukturu, bilo da se radi o državi ili privatnoj tvrtki, koja je najčešće i vlasnik flote tegljača u toj luci s kojom najčešće ima koncesijski ugovor za obavljanje spomenute djelatnosti pored ostalih poznatih ugovornih oblika suradnje.

**KLJUČNE RIJEČI**

konvencionalni tegljač, tegljač s krmenim azimutskim pogonom, traktor tegljač, pivot, priteznaica teglja, zavlacenje, povlačenje po bitvi, osovinska snaga, admiralitetni koeficijent, deplasman

**NOTES**

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