Matching a propeller to ROTAX ultralight engines

1) INTRODUCTION

The selection of a propeller for an aircraft is up to the aircraft designer and depends on the given facts of the craft, the available engine performance at a certain determined r.p.m., and other requirements (e.g. noise limits). In every case the propeller resp. the propeller r.p.m. has to be matched with the engine characteristics.

2) THEORETICAL BASIS

2.1. Propeller matching:

The diagram (see page 4) shows the mutual effect between engine and propeller. The propeller needs a drive torque which increases rapidly with increasing r.p.m. (theroretically with the second power).

To accelerate the propeller to a certain speed, the engine must produce a higher torque than the propeller consumes. The propeller speed then increases until there is equilibrium, that means until the engine does not supply more torque than consumed by the propeller.

On prop. curve "A" this is the case at point "N" at full throttle and at point "R" at partial load (cruising speed).

With this configuration as per curve "A" there is a surplus "Ü" of engine torque over the propeller torque consumption below point "N", allowing perfect operational behaviour. If the propeller size, the pitch or the reduction ratio are not appropriate, the propeller curve moves to its disadvantage and creates problems, e.g.: Curves "B" and "C" refer to a propeller too large or with too high pitch. The propeller consumes too much torque and does not allow the engine to reach nominal r.p.m.

In addition, this creates instability because the prop. curve and the engine torque curve are too close to each other, almost parallel, so that at the slightest torque decrease of the engine (e.g. at high ambiant temperature or air density variation) the engine r.p.m. falls down from point "X" to the considerably lower point "Y" and in consequence the propeller performance gets insufficient.

Curve "D" refers to a propeller that does not consume the available torque. The admissible max. r.p.m. is exceeded, creating also a loss in performance.

2.2. Gearbox:

A determined propeller can be matched to the engine r.p.m. range by adapting the gear reduction ratio.

In the case of propeller curve "D", a "faster" speed would be required (e.g. i = 2,3 instead of 2,5), in the case of propeller curve "B" a "slower" speed (e.g. i = 3 instead of i = 2,5) would be required.

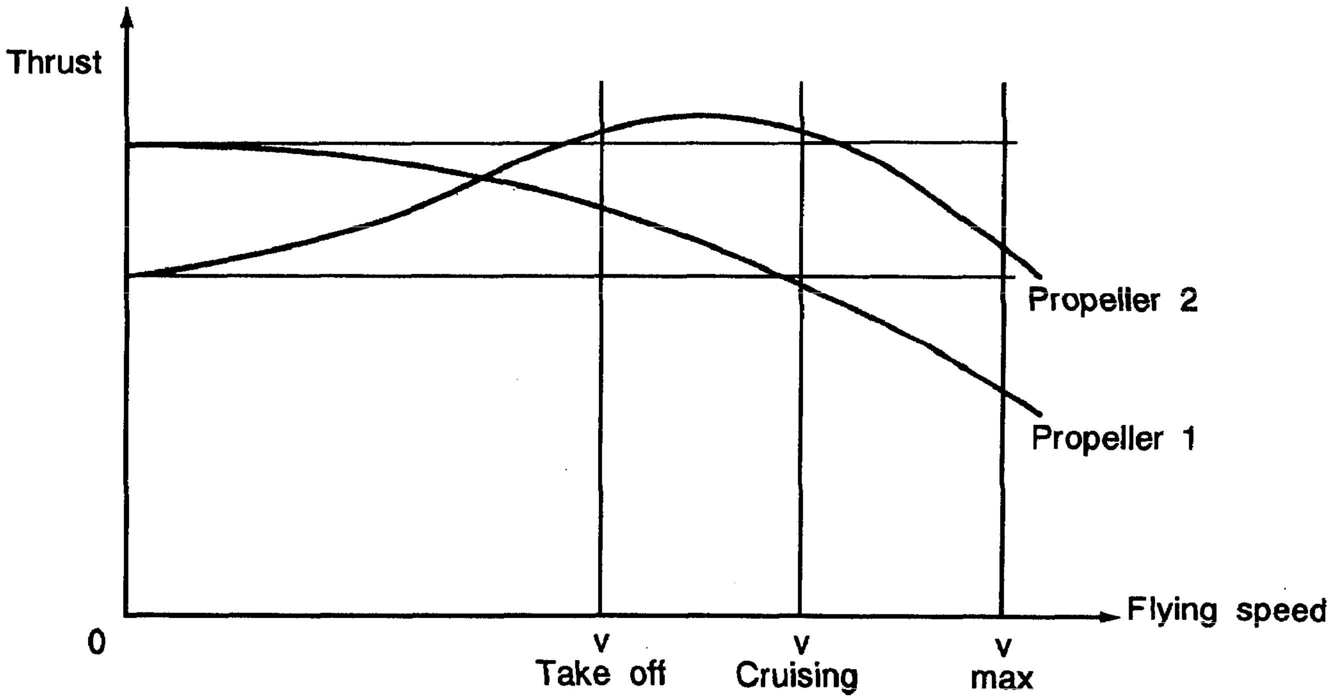
2.3. Thrust:

The propeller thrust is the reactional force of the air mass accelerated towards the rear. The more air and the more acceleration, the more thrust.

The best grade of efficiency is achieved, the lower the speed of the propeller stream is. This means, a great quantity of air is required, therefore big diameter props are more favourable.

Static thrust alone is not sufficient, the propeller must also develop thrust at higher flying speed. Pitch and r.p.m. are the key factors for that.

If the pitch is low, thrust decreases rapidly with speed (prop 1); high pitch decreases static thrust, because the propeller blades work close to a stall condition (prop 2).



3) PROBLEMS

If these fundamental rules are not observed, the following problems arise:

a) Engine does not reach nominal r.p.m.

b) Engine reaches its nominal r.p.m. for a short period but then quickly loses r.p.m. and works with low power at low r.p.m.

c) Engine r.p.m. cannot be kept steady at a certain part load r.p.m.

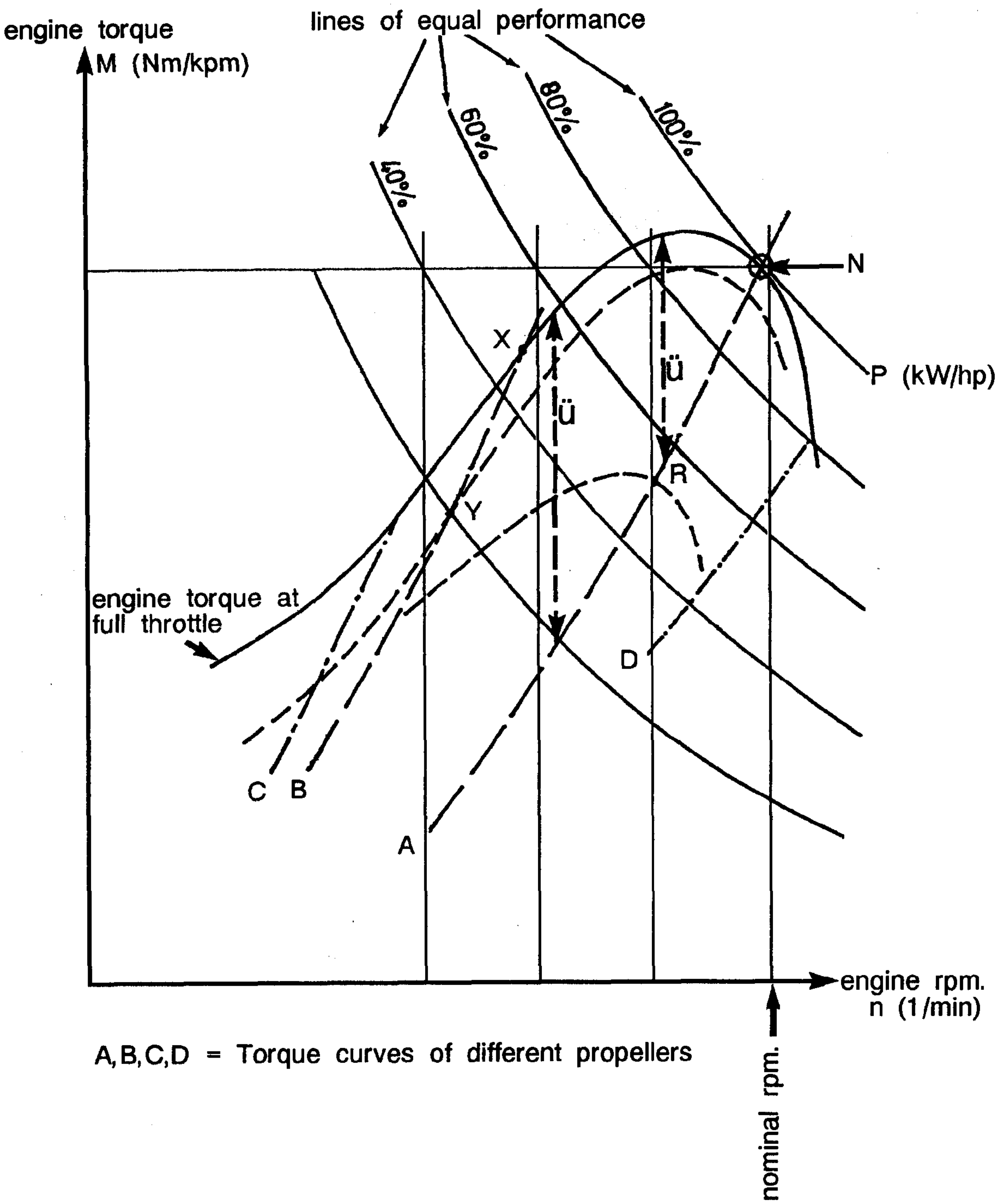
d) As the engine performance depends considerably on ambient temperature, air pressure (air density) and the condition of the engine, the forementioned troubles can arise also after a longer time of satisfactory operation.

e) All above statements are only relevant on condition if the original ROTAX intake- carburetor and exhaust systems are used and the engine is in perfect technical condition.

Attention:

If you wish to run your aircraft for noise reasons or other intentions constantly at reduced engine r.p.m. (limited throttle lever command or carburetor slide opening), you nevertheless have to chose the propeller by testing at the full throttle r.p.m. (fully open carburetor).

DIAGRAM



A,B,C,D = Torque curves of different propellers

THE PROPELLER MUST BE MATCHED TO THE ENGINE!

N ....nominal performance at full throttle
R ....nominal performance at part load
Ü ....torque surplus
A ....propeller torque curve at optimum propeller matching
B/C......propeller curve in case of too large propeller or propeller with too high pitch
D ....propeller with too low power consumption
X/Y .....r.p.m. drop resp. performance drop due to bad propeller matching (see text).